

船舶入级规范

第二篇 第三章

一九九六年一月

RULES FOR CLASSIFICATION OF SHIPS

PART 2 CHAPTER 3

JANUARY 1996

挪威船级社

DET NORSKE VERITAS

前 言

为方便中国读者，挪威船级社上海办事处安排将本社《船舶入级规范》的部分章节翻译成中文，并逐章发行中英文对照本。若对两种文本发生歧议，应以本社的唯一正式版本——现行英文版为准。

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挪威船级社

一九九六年十一月八日

Preface

For the convenience of Chinese readers, DNV Shanghai Office has arranged to translate some Chapters of our "Rules for Classification of Ships" into Chinese and will publish them as English-Chinese edition chapter by chapter. The current English version, which is the only authentic version, must be followed where any discrepancy exists.

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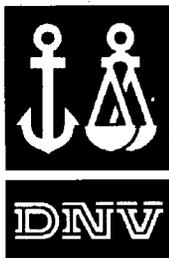
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8th NOV. 1996



DNV
SHANGHAI





**RULES FOR
CLASSIFICATION OF**

SHIPS

NEWBUILDINGS

MATERIALS AND WELDING

PART 2 CHAPTER 3

WELDING

JANUARY 1996

SECTIONS	PAGE
1 General Requirements	1
2 Welding Procedures and Approval of Welders	3
3 Type Approval of Welding Consumables	16
4 Welding of Clad Steel Plates	40

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第 2 篇 第 3 章

焊接

1996年1月

节	页
1. 一般规定.....	1
2. 焊接工艺和焊工的认可.....	3
3. 焊接材料的型式认可.....	16
4. 复合钢板的焊接.....	40

CHANGES IN THE RULES

General

The present edition of the Rules includes additions and amendments decided by the Board as of December 1995, and supersedes the January 1994 edition of the same chapter.

The Rule changes come into force on 1st of July 1996.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in the introduction booklet. The introduction booklet is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the Rules. Buyers of reprints are advised to check the updated list of Rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Main changes

• Sec.2 Welding Procedures and Approval of Welders

- Item B308 has been amended and extended to include extra high strength steel.
- Item B903 has been amended and extended to include extra high strength steel. New Figs. 10-12 have been added.
- Table B2 and B4 have been amended.
- A new table B5 on range of approval for type of joint has been added.

- Table C2 has been amended.
- Item C210 has been amended.
- Table C3 has been amended.
- A new item C500 on HAZ softening has been added.
- A new table C4 has been added.
- A new item D on welding procedures, Ferritic Austenitic Stainless Steel (Duplex) has been added.
- Item E on approval of welders has been amended and extended.

• Sec.3 Welding Consumables

- Item J101 has been amended and extended to include grade A (From IACS UR W23).
- Item J103 has been amended.
- Item J202 has been amended.
- Table J1 has been amended.
- A new table J2 on butt weld test requirements has been added.
- Item L201 on all-weld-metal tests has been amended.
- A new item L202 on butt weld tests for duplex stainless steel wires has been added.
- Item L401 has been supplemented with range of ferrite content.
- Item L501 on pitting and crevice corrosion resistance has been amended.

Corrections and Clarifications

In addition to the above stated rule amendments, some detected errors have been corrected, and some clarifications have been made in the existing rule wording.

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规范更改说明

综述

理事会 1995 年 12 月确定了包括增补和修订在内的现行规范版本, 并以此更换本章的 1994 年 1 月版。

本章规范的更改于 1996 年 7 月 1 日生效。

本章在被新的修订版替换之前有效, 改版前对规范所作的少量修正和勘误, 仅列表刊载在序言分册中, 序言分册通常于每年 1 月及 7 月修订。

修正过的各章将发给本规范的所有订户, 建议再版本的购买者核对刊印在第 0 篇第 1 章第 1 节规范各章的最新目录, 以确认该章为现行版本。

主要更改

● 第 2 节 焊接工艺和焊工的认可

- B308 已修正并扩充到超高强度钢。
- B903 已修正并扩充到超高强度钢, 增加新的图 10-12。
- 表 B2 和 B4 已修正。
- 增加新的表 B5 连接形式认可范围。

- 表 C2 已修正。
- C210 已修正。
- 表 C3 已修正。
- 增加新的对 HAZ 软化的 C500。
- 增加新的表 C4。
- 增加新的对铁素体奥氏体(双联)不锈钢焊接工艺的 D。
- 对有关焊工认可的 E 作了修正和扩充。

● 第 3 节 焊接材料

- J101 已修正并扩充到 A 级(从 IACS UR W23)。
- J103 已修正。
- J202 已修正。
- 表 J1 已修正。
- 增加新的表 J2 对接焊试验要求。
- L201 对全熔质试验已修正。
- 增加新的 L202 双联不锈钢线材的对接焊试验。
- L401 已补充铁素体含量的范围。
- 对抗麻点腐蚀和裂缝腐蚀的 L501 已作修正。

勘误和澄清

除了上述的规范修正外, 还对规范中某些已发现的错误作了改正, 对原规范的措词也作了一些澄清。

CONTENTS

SEC. 1 GENERAL REQUIREMENTS	1	C 400 Annual tests	24
A. General	1	C 500 Upgrading	24
A 100 Scope	1	D. Combinations for Use in One-side Automatic Welding Processes	25
A 200 Basic requirements	1	D 100 General	25
A 300 Welding shops and -contractors	1	D 200 One-run welding	25
A 400 Welding consumables	1	D 300 Multi-run welding	26
B. Testing	1	D 400 One-and multi-run welding	26
B 100 General	1	D 500 Testing	26
B 200 Tensile testing at ambient temperature	1	D 600 Requirements	26
B 300 Bend testing	2	D 700 Annual tests	26
SEC. 2 WELDING PROCEDURES AND APPROVAL OF WELDERS	3	D 800 Upgrading	27
A. General	3	E. Wires and Wire/Gas Combinations for Metal Arc Welding	27
A 100 Scope	3	E 100 General	27
A 200 Definitions	3	E 200 Semi-automatic multi-run welding	27
B. Welding Procedures, Steel	3	E 300 Automatic multi-run welding	28
B 100 Welding procedure specification, WPS	3	E 400 Two-run welding	29
B 200 Welding procedure qualification test, WPQT	3	E 500 Annual tests	30
B 300 WPQT for butt welds on plates	3	E 600 Upgrading	30
B 400 WPQT for butt welds on tubes	5	F. Combinations for Use in Electro-slag and Electro-gas Welding Processes	30
B 500 WPQT for full penetration T-, Y-, and K- joints	6	F 100 General	30
B 600 WPQT for tubular joints	6	F 200 Initial tests	30
B 700 WPQT for fillet welds	7	F 300 Annual tests	31
B 800 Retesting	7	G. Welding Consumables for Welding of Steel Grades NV 2-4, NV 2-4L, NV 4-4 and NV 4-4L for Low-Temperature Applications	31
B 900 Validity of qualified welding procedures	7	G 100 General	31
B 1000 Welding procedure qualification record, WPQR	9	G 200 Additional requirements	31
B 1100 WPQT for liquefied gas systems	10	G 300 Annual tests	31
C. Welding Procedures, Aluminium	11	H. Welding Consumables for Low-Alloy, Heat-Resisting Steels (NV 0,3Mo, NV 1Cr 0,5Mo and NV 2,25Cr 1Mo)	32
C 100 General	11	H 100 General	32
C 200 WPQT for butt welds	11	H 200 Additional requirements	32
C 300 WPQT for fillet welds	13	H 300 Chemical composition	32
C 400 Retesting	13	H 400 Annual tests	33
C 500 HAZ softening adjacent to welds	13	I. Welding Consumables for Welding of Steel Grades NV 1,5Ni, NV 3,5Ni, NV 5Ni and NV 9Ni	33
D. Welding procedures, Ferritic-Austenitic Stainless Steel (Duplex)	14	I 100 General	33
D 100 General	14	I 200 Additional requirements	33
D 200 Additional testing	14	I 300 Annual test	34
D 300 Validity of a qualified welding procedure	14	I 400 Other welding consumables	34
E. Approval of Welders	14	J. Welding Consumables for Welding of Extra High Strength Steels	34
E 100 General	14	J 100 General	34
E 200 Standards for approval testing	14	J 200 Additional requirements	34
E 300 Certification	15	J 300 Annual tests	35
SEC. 3 TYPE APPROVAL OF WELDING CONSUMABLES	16	K. Welding Consumables for Welding of Austenitic Stainless Steels	35
A. General	16	K 100 General	35
A 100 Scope	16	K 200 All-weld-metal test	36
A 200 Approval procedure	16	K 300 Chemical composition	36
A 300 Approval testing	17	K 400 Possible additional tests	36
A 400 Changes	17	K 500 Annual tests	36
A 500 Basic groups and grades	17	L. Welding Consumables for Welding of Ferritic-Austenitic Stainless Steels (Duplex Steels)	38
A 600 Testing procedure	17	L 100 General	38
A 700 Test specimens	17	L 200 Test assemblies	38
A 800 Hydrogen test	18	L 300 Chemical composition	38
A 900 Re-testing	18	L 400 Microstructural examination	38
B. Covered Electrodes for Shielded Metal Arc Welding of Normal and High Strength Steels	18	L 500 Corrosion test	38
B 100 General	18	L 600 Annual tests	38
B 200 All-weld-metal test	18	M. Welding Consumables for Welding of Aluminium Alloys for General and Low-Temperature Service	38
B 300 Butt-weld test	19	M 100 General	38
B 400 Hydrogen test	20	M 200 Test assemblies	38
B 500 Covered electrodes for fillet welding	20	M 300 Testing	38
B 600 Covered electrodes for gravity or contact welding	21	M 400 Annual tests	39
B 700 Deep penetration electrodes	21	SEC. 4 WELDING OF CLAD STEEL PLATES	40
B 800 Annual tests	22		
B 900 Upgrading	22		
C. Wire/Flux Combinations for Submerged Arc Welding	22		
C 100 General	22		
C 200 Multi-run technique	22		
C 300 Two-run technique	24		

目 录

第1节 一般规定.....	1	C 200 多道焊工艺.....	22
A. 通则.....	1	C 300 双道焊工艺.....	24
A 100 适用范围.....	1	C 400 年度试验.....	24
A 200 基本要求.....	1	C 500 升级.....	24
A 300 焊接车间和承包商.....	1	D. 用于单面自动焊过程的配合.....	25
A 400 焊接材料.....	1	D 100 一般要求.....	25
B. 试验.....	1	D 200 单道焊.....	25
B 100 一般要求.....	1	D 300 多道焊.....	26
B 200 常温下的拉力试验.....	1	D 400 单道和多道焊.....	26
B 300 弯曲试验.....	2	D 500 试验.....	26
第2节 焊接工艺和对焊工的认可.....	3	D 600 要求.....	26
A. 通则.....	3	D 700 年度试验.....	26
A 100 适用范围.....	3	D 800 升级.....	27
A 200 定义.....	3	E. 用于金属埋弧焊的焊丝和焊丝/气体配合.....	27
B. 钢材焊接工艺.....	3	E 100 一般要求.....	27
B 100 焊接工艺规程, WPS.....	3	E 200 半自动多道焊.....	27
B 200 焊接工艺合格试验, WPQT.....	3	E 300 全自动多道焊.....	28
B 300 板材对接焊缝的 WPQT.....	3	E 400 双道焊.....	29
B 400 管材对接焊缝的 WPQT.....	5	E 500 年度试验.....	30
B 500 全熔深 T、Y-和 K-型接头的 WPQT.....	6	E 600 升级.....	30
B 600 管状接头的 WPQT.....	6	F. 用于电渣焊和气电焊的配合.....	30
B 700 填角焊缝的 WPQT.....	7	F 100 一般要求.....	30
B 800 重复试验.....	7	F 200 初次试验.....	30
B 900 合格焊接工艺规程的有效性.....	7	F 300 年度试验.....	31
B 1000 焊接工艺合格记录, WPQR.....	9	G. 焊接低温用 NV 2-4、NV 2-4L、NV 4-4 和 NV 4-4L 级钢的焊接材料.....	31
B 1100 液化气体系统的 WPQT.....	10	G 100 一般要求.....	31
C. 铝材的焊接工艺.....	11	G 200 附加要求.....	31
C 100 一般要求.....	11	G 300 年度试验.....	31
C 200 对接焊缝的 WPQT.....	11	H. 低合金钢、耐热钢 (NV 0.3Mo、NV 1Cr 0.5Mo 和 NV 2.25Cr. 1Mo) 用焊接材料.....	32
C 300 填角焊缝的 WPQT.....	13	H 100 一般要求.....	32
C 400 重复试验.....	13	H 200 附加要求.....	32
C 500 邻近焊缝的热影响区(HAZ)的软化.....	13	H 300 化学成份.....	32
D. 铁素体-奥氏体(双联)不锈钢焊接工艺.....	14	H 400 年度试验.....	33
D 100 一般要求.....	14	I. 焊接 NV1.5Ni、NV 3.5Ni、NV 5Ni 和 NV 9Ni 级钢的焊接材料.....	33
D 200 附加试验.....	14	I 100 一般要求.....	33
D 300 合格焊接工艺的有效性.....	14	I 200 附加要求.....	33
E. 焊工的认可.....	14	I 300 年度试验.....	34
E 100 一般要求.....	14	I 400 其他焊接材料.....	34
E 200 认可试验的标准.....	14	J. 焊接超高强度钢的焊接材料.....	34
E 300 证书.....	15	J 100 一般要求.....	34
第3节 焊接材料的型式认可.....	16	J 200 附加要求.....	34
A. 通则.....	16	J 300 年度试验.....	35
A 100 适用范围.....	16	K. 焊接奥氏体不锈钢的焊接材料.....	35
A 200 认可程序.....	16	K 100 一般要求.....	35
A 300 认可试验.....	17	K 200 全熔质试验.....	36
A 400 变更.....	17	K 300 化学成份.....	36
A 500 基本组别和等级.....	17	K 400 可能的附加试验.....	36
A 600 试验程序.....	17	K 500 年度试验.....	36
A 700 试样.....	17	L. 焊接铁素体-奥氏体不锈钢(双联钢)的焊接材料.....	38
A 800 测氢试验.....	18	L 100 一般要求.....	38
A 900 重复试验.....	18	L 200 试件.....	38
B. 普通强度和高强度钢气体保护金属电弧焊用药皮焊条.....	18	L 300 化学成份.....	38
B 100 一般要求.....	18	L 400 微观结构检验.....	38
B 200 全熔质试验.....	18	L 500 腐蚀试验.....	38
B 300 对接焊试验.....	19	L 600 年度试验.....	38
B 400 测氢试验.....	20	M. 焊接常温和低温用铝合金的焊接材料.....	38
B 500 填角焊用药皮焊条.....	20	M 100 一般要求.....	38
B 600 重力焊或接触焊用药皮焊条.....	21	M 200 试件.....	38
B 700 深熔焊条.....	21	M 300 试验.....	38
B 800 年度试验.....	22	M 400 年度试验.....	39
B 900 升级.....	22	第4节 复合钢板的焊接.....	40
C. 埋弧焊用焊丝/焊剂配合.....	22		
C 100 一般要求.....	22		

A. General 40
A 100 Scope 40

B. Welding 40
B 100 Welding methods — deposited metal 40
B 200 Groove preparation 40
B 300 Welding procedure 40

A.
A

A. 通则.....	40	B. 焊接.....	40
A 100 适用范围.....	40	B 100 焊接方法—熔敷金属.....	40
		B 200 坡口制备.....	40
		B 300 焊接工艺.....	40

SECTION 1 GENERAL REQUIREMENTS

Contents

A. General

- A 100 Scope
- A 200 Basic requirements
- A 300 Welding shops and -contractors
- A 400 Welding consumables

B. Testing

- B 100 General
- B 200 Tensile testing at ambient temperature
- B 300 Bend testing

A. General

A 100 Scope

101 This Chapter specifies the requirements for welding shops and -contractors, welders, welding consumables and welding procedures in general as well as procedures and methods for welding of clad steel plates and liquefied gas systems.

A 200 Basic requirements

201 Welding of important structures: hull, superstructure and deckhouse, machinery installations: boilers, pressure vessels and pipe systems and equipments: sternframes, rudders, rudder stocks and rudder horn are to be carried out by approved welders, with approved welding consumables and at welding shops and -contractors recognized by the Society. Manufacturers of boilers and pressure vessels Class I—II are to obtain the approval according to a detailed programme, available by the local surveyor.

A 300 Welding shops and -contractors

301 Welding shops and -contractors will have to prove their qualifications for the welding operations in question.

302 It is assumed that the welding shops and -contractors make use of the necessary equipment for carrying out inspection of the welding operations in a satisfactory manner.

303 Important welding operations are to be carried out under daily supervision of an inspector, who has the experience and qualifications which enable him to judge this type of work. The work of each welder is to be regularly examined.

304 The welding shops and -contractors are to keep a card index or register of all approved welders. The register is to give information on training of the welders and date and results of qualification tests. Information about the base metal, type of welding consumable, joint design and welding positions is to be stated in the event of re-qualification tests. The surveyor is to be allowed to examine the register at any time.

A 400 Welding consumables

401 Consumables for welding of ships, mobile offshore units, fixed offshore installations and other structures intended for classification are to be approved by the Society.

402 Type approval of welding consumables will be considered subject to compliance with the requirements given in Sec.3.

403 All brand names under which a tested and approved welding consumable is marketed, are to be registered by the Society. In order to avoid duplication of tests, the man-

ufacturer is to certify that the welding consumables marketed under alternative brand names are identical with the consumables tested for approval.

B. Testing

B 100 General

101 Testing of welds is to be carried out as specified in 200 to 300. Reference is also made to relevant paragraphs in Ch.1 Sec.2.

B 200 Tensile testing at ambient temperature

201 For tensile testing of all-weld-metal and butt welds two different types of test specimens may be used, round test specimens or flat test specimens (see Fig.1) as described below:

A — Deposited metal tensile test

Normally, round test specimens with the following dimensions are to be used:

- $d = 10 \text{ mm}$
- $L_o = 50 \text{ mm}$
- $L_c = 60 \text{ mm}$
- $R \geq 5 \text{ mm}$

B — Butt weld tensile test for testing of the weld as a whole

Flat test specimens with the weld machined flush with the surface of the plate, are to be used. The dimensions are to be as follows:

- $a = \text{thickness of plate, } t$
- $b = 25 \text{ mm}$
- $L_o = L_c = 3t \text{ or } 2t + \text{width of weld, whichever is the greatest}$
- $R = 25 \text{ mm}$

C — Butt weld tensile test

Flat test specimens with the weld machined flush with the surface of the plate, are to be used. The dimensions are to be as follows:

- $a = \text{thickness of plate, } t$
- $b = 30 \text{ mm}$
- $L_o = 6 \text{ mm} + \text{width of weld} + 6 \text{ mm}$
- $R = 50 \text{ mm}$

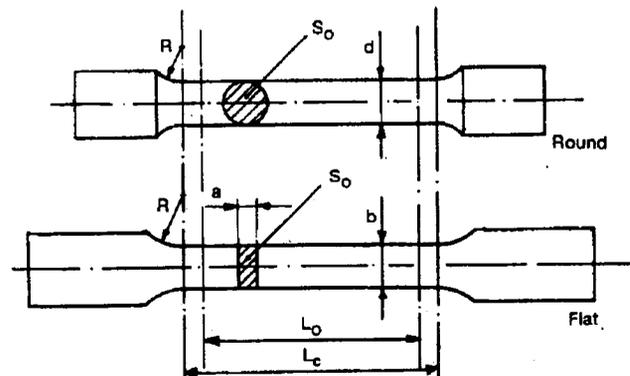


Fig. 1
Tensile test specimen

第1节 一般规定

目 录

- A. 通则
 - A 100 适用范围
 - A 200 基本要求
 - A 300 焊接车间和承包商
 - A 400 焊接材料
- B. 试验
 - B 100 一般要求
 - B 200 常温下的拉力试验
 - B 300 弯曲试验

A. 通 则

A 100 适用范围

101 本章规定了对焊接车间及其承包商, 焊工, 焊接材料和焊接工艺以及对复合钢板和液化气系统焊接工艺和方法的要求。

A 200 基本要求

重要结构(船体、上层建筑和甲板室), 机械装置(锅炉、受压容器和管系)以及设备(尾框架、舵、舵杆、舵板)的焊接应由合格的焊工采用认可的焊接材料, 在本社认可的焊接车间及分包厂内进行。I - II 级锅炉和受压容器的制造厂应按当地验船师确认的具体程序操作方可获得认可。

A 300 焊接车间和承包商

301 焊接车间及其承包商应具备拟进行焊接工作的资格。

302 假定焊接车间及其承包商是采用了必要设备进行检查, 焊接作业是以令人满意的方式进行的。

303 重要的焊接作业应在检验员的日常监督下进行。检验员应具有-定的经验和资格使之能对这类工作加以评判。应定期考核每个焊工的工作。

304 焊接车间及其承包商应保存所有合格焊工的索引卡或登记卡, 该登记卡应提供焊工培训和资格考试日期和结果的资料。如进行过资格复审, 应注明母体金属、焊接材料种类、接头设计和焊接位置等内容。应允许验船师随时查阅这些登记卡。

A 400 焊接材料

401 拟入级的船舶、海上移动式平台、海上固定式平台和其他结构物所采用焊接材料应经本社认可。

402 焊接材料的型式认可应符合第3节所述要求。

403 已经试验和认可的焊接材料销售中所用的牌号应由本社

加以记录, 为了避免重复试验, 制造厂商应证明以其他牌号销售的焊接材料和经认可试验的焊接材料完全相同。

B. 试 验

B 100 一般要求

101 焊接试验应按 200 至 300 规定要求进行, 亦可参照第 1 章第 2 节的有关条款。

B 200 常温下的拉力试验

201 对全熔质和对接焊缝的拉力试验, 可采用两种不同类型的试样, 圆形试样或板状试样(见图 1)如下所述

A - 熔敷金属拉力试验

通常应采用具有下列尺寸的圆形试样:

- d = 10 mm
- L₀ = 50 mm
- L_c = 60 mm
- R > 5 mm

B - 对整个焊缝进行试验的对接焊缝拉力试验

应采用板状试样, 其焊缝经机加工与板表面齐平。试样尺寸规定如下:

- a = 板厚, t
- b = 25 mm
- L₀ = L_c = 3t 或 2t + 焊缝宽度, 取大者
- R = 25 mm

C - 对接焊缝拉力试验

应采用板状试样, 其焊缝经机加工与板表面齐平。试样尺寸规定如下:

- a = 板厚, t
- b = 30 mm
- L₀ = 6 mm + 焊缝宽度 + 6 mm
- R = 50 mm

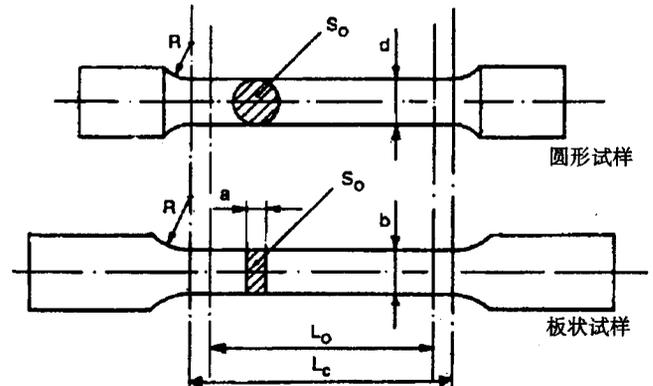


图 1 拉力试样

B 300 Bend testing

301 Flat bend test specimens, as given in Fig.2 are to be used. Edges on tension side to be rounded to a radius of 1 to 2 mm.

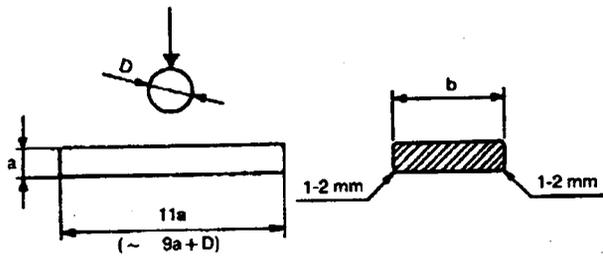


Fig. 2
 Bend test specimen

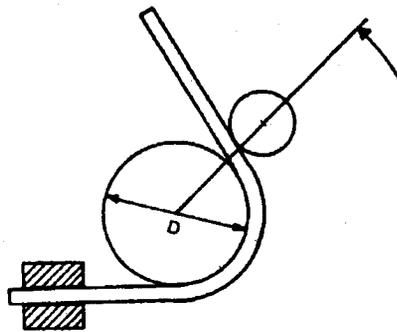


Fig. 3
 Wrap around bend test

302 When the wrap around bend test, exemplified in Fig. 3, is used, e.g. for the side bend test of a weld, the length of the test specimen has to be greater than the length $11a$ in Fig. 2.

303 For butt weld bend test specimens, the weld is to be machined flush with the surface of the plate.

304 For transverse face-bend and root-bend test specimens for butt weld test the dimensions are to be as follows:

- a = as rolled thickness t of the plate
- b = 30 mm

If the as rolled thickness t is greater than 25 mm, it may be reduced to 25 mm by machining on the compression side of the test specimen.

305 For transverse side-bend test specimens for butt weld test the dimensions are to be as follows:

- a = 10 mm
- b = as rolled thickness t of the plate

If $t \geq 40$ mm, the side-bend test specimen may be provided, each part being at least 20 mm wide.

306 When a longitudinal face-bend or root-bend test is required, a test specimen according to an appropriate standard will be accepted.

B 300 弯曲试验

301 应采用如图 2 所示的板状弯曲试样. 受拉面的边缘应加工成半径为 1-2mm 的圆弧形:

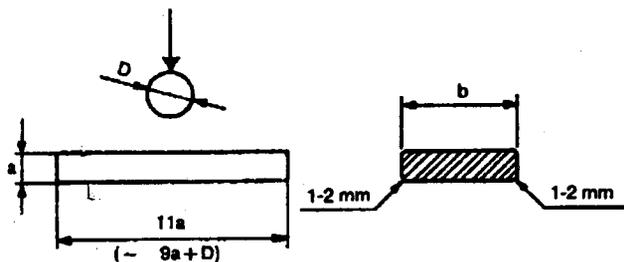


图 2 弯曲试验试样

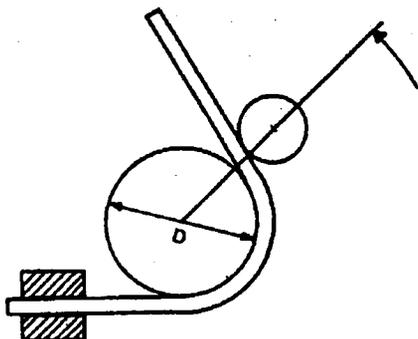


图 3 靠模弯曲试验

302 如采用如图 3 所示的靠模弯曲试验(例如用于焊缝侧面弯曲试验时), 试样长度应大于图 2 所示的长度 11a.

303 对于对接焊缝弯曲试样, 其焊缝应机加工到与板材表面齐平:

304 对于对接焊缝试验用的横向正弯试样和反弯试样, 其尺寸规定如下:

a = 板材轧制厚度 t

b = 30 mm

如轧制厚度 t 大于 25 mm, 则可对试样的受压面进行机加工, 使其厚度减薄到 25 mm.

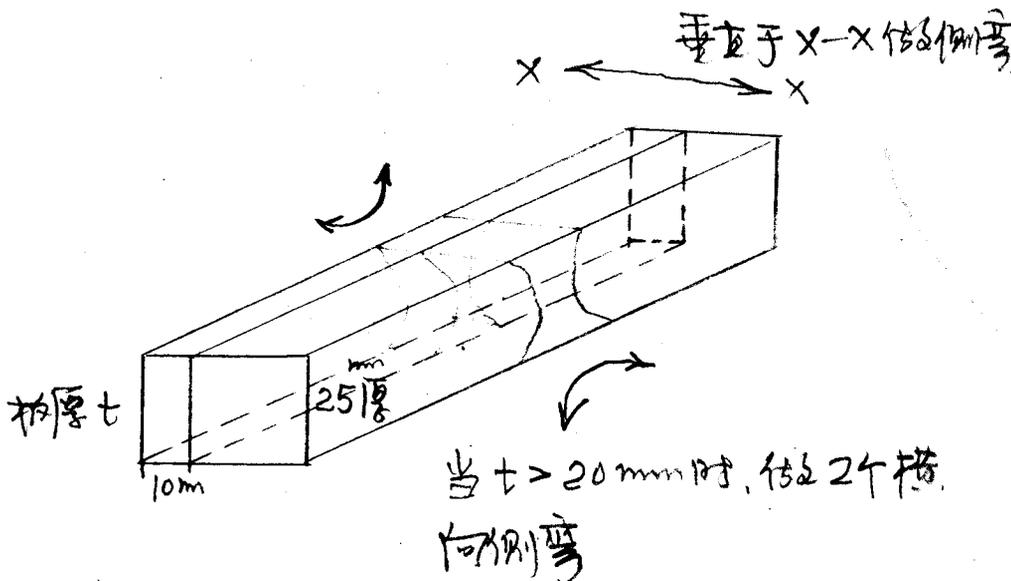
305 对于对接焊缝试验用的横向侧弯试样, 其尺寸规定如下:

a = 10 mm

b = 板材轧制厚度 t

如 t > 40 mm, 侧弯试样可以剖开, 每块宽度至少为 20mm.

306 当要求对接焊缝作纵向正弯或反弯试验时, 允许采用符合相应标准的试样.



SECTION 2 WELDING PROCEDURES AND APPROVAL OF WELDERS

Contents

A. General

- A 100 Scope
- A 200 Definitions

B. Welding Procedures, Steel

- B 100 Welding procedure specification, WPS
- B 200 Welding procedure qualification test, WPQT
- B 300 WPQT for butt welds on plates
- B 400 WPQT for butt welds on tubes
- B 500 WPQT for full penetration T-, Y-, and K- joints
- B 600 WPQT for tubular joints
- B 700 WPQT for fillet welds
- B 800 Retesting
- B 900 Validity of qualified welding procedures
- B 1000 Welding procedure qualification record, WPQR
- B 1100 WPQT for liquefied gas systems

C. Welding Procedures, Aluminium

- C 100 General
- C 200 WPQT for butt welds
- C 300 WPQT for fillet welds
- C 400 Retesting
- C 500 HAZ softening adjacent to welds

D. Welding procedures, Ferritic-Austenitic Stainless Steel (Duplex)

- D 100 General
- D 200 Additional testing
- D 300 Validity of a qualified welding procedure

E. Approval of Welders

- E 100 General
- E 200 Standards for approval testing
- E 300 Certification

A. General

A 100 Scope

101 This Section specifies the requirements for welding procedures and welding procedure qualification tests as well as approval of welders.

A 200 Definitions

201 Welding procedure specification (WPS): A specification of materials, detailed methods, practices and parameters employed in the welding of a particular joint.

202 Welding procedure qualification test (WPQT): A test carried out in order to demonstrate that a weld made according to a specific procedure specification meets the given requirements.

203 Welding procedure qualification record (WPQR): The record of the actual parameters employed during welding of the qualification test piece, and results from the non-destructive testing and mechanical testing.

204 Non-destructive testing (NDT): Visual inspection, radiographic testing, ultrasonic testing, magnetic particle testing, penetrant testing and other non-destructive methods for revealing defects and irregularities.

B. Welding Procedures, Steel

B 100 Welding procedure specification, WPS

101 WPS subjected to approval is to contain as a minimum the following information as relevant for the welding operation:

- material: standard, grade and modification
- nominal thickness/diameter range (dimensions)
- welding process
- joint/groove design
- welding position and direction
- welding consumables: trade name, electrode/wire diameter, shielding gas, flux and recognized classification
- welding sequence (number and order of passes/layers)
- welding parameters: voltage, current, polarity and welding speed
- preheat and interpass temperature
- post weld heat treatment.

B 200 Welding procedure qualification test, WPQT

201 When WPQT is required, the tests must be performed in the environment applicable to the actual production and meet the specified minimum requirements prior to commencing the production welding.

202 The qualification test is to be witnessed by the surveyor.

B 300 WPQT for butt welds on plates

301 The test assembly consists of two plates welded together. As far as possible the plates are to have a size which can simulate the heat transfer during the production welding.

For manual or semiautomatic welding, a test assembly according to Fig.1 is to be carried out with:

$$l_{\min} = 300 \text{ mm}$$
$$L_{\min} = 350 \text{ mm}$$

For automatic welding, the dimensions are to be:

$$l_{\min} = 400 \text{ mm}$$
$$L_{\min} = 1000 \text{ mm}$$

Edge preparation and fit-up are to be as detailed in the WPS.

The plates are to be joined and held by tack welds to provide the correct gap for the edge preparation used.

50 mm of each end of the test piece is to be discarded.

302 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % radiographic or ultrasonic testing
- 100 % surface crack detection (dye penetrant or magnetic particle testing)

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

303 The following mechanical tests are required from each assembly (see Fig.2):

- 1 tensile test (flat specimen transverse to the weld)

第2节 焊接工艺和对焊工的认可

目 录

A. 通则

A 100 适用范围

A 200 定义

B. 钢材焊接工艺

B 100 焊接工艺规程, WPS

B 200 焊接工艺合格试验, WPQT

B 300 板材对接焊缝 WPQT

B 400 管材对接焊缝 WPQT

B 500 全熔深 T-, Y-和 K-型接头的 WPQT

B 600 管状接头的 WPQT

B 700 填角焊缝的 WPQT

B 800 重复试验

B 900 合格焊接工艺规程的有效性

B 1000 焊接工艺合格记录, WPQR

B 1100 液化气体系统的 WPQT

C. 铝材的焊接工艺

C 100 一般要求

C 200 对接焊缝的 WPQT

C 300 填角焊缝的 WPQT

C 400 重复试验

C 500 邻近焊缝的热影响区(HAZ)的软化

D. 铁素体-奥氏体(双联)不锈钢焊接工艺

D 100 一般要求

D 200 附加试验

D 300 合格焊接工艺的有效性

E. 焊工的认可

E 100 一般要求

E 200 认可试验的标准

E 300 证书

A. 通 则

A 100 适用范围

101 本节规定了适用于焊接工艺和焊接工艺合格试验以及对焊工认可的要求。

A 200 定义

201 焊接工艺规程(WPS): 对特定焊接接头采用的材料、焊接方法、操作和各种参数的规定。

202 焊接工艺合格试验(WPQT):

为证实按具体的工艺规程进行的焊接确实符合规定要求而进行的试验。

203 焊接工艺合格记录(WPQR)

在焊制合格试件时选用的实际参数的记录和无损探伤试验及机械试验的结果。

204 无损探伤试验(NOT): 目视检验, 放射线探伤试验, 超声波试验, 磁粉探伤试验, 渗透试验和其他无损揭示焊缝缺陷和瑕疵的方法。

B. 钢材焊接工艺

B 100 焊接工艺规程, WPS

101 经认可的 WPS 至少应包括下述与焊接操作有关的资料:

- 材料: 标准、等级和处理
- 标称的厚度/直径范围(尺寸)
- 焊接工艺
- 接头/坡口设计
- 焊接位置和方向
- 焊接材料: 商标, 焊条/焊丝直径, 保护气体, 焊剂和认可的等级
- 焊接顺序(焊道/焊层的次数和顺序)
- 焊接参数: 电压、电流、极性和焊接速度
- 预热和层间温度
- 焊后热处理。

B 200 焊接工艺合格试验, WPQT

201 当要求进行 WPQT 时, 该试验应在与实际生产相适应的环境下进行, 并符合施焊前规定的最低要求。

202 合格试验应有验船师见证。

B 300 板材对接焊缝的 WPQT

301 该试件由焊在一起的两块板组成, 这两块板的尺寸, 应尽可能使之能模拟施焊时的热传递过程。

对手工焊或半自动焊, 其试件按图 1 制备:

$$l_{\min} = 300\text{mm}$$

$$L_{\min} = 350\text{mm}$$

对自动焊, 其试件尺寸为:

$$l_{\min} = 400\text{mm}$$

$$L_{\min} = 1000\text{mm}$$

坡口型式及其装配要求详述于 WPS。

两块板应连结起来并用定位焊固定, 以便在采用的坡口处留有适当的间隙。

试件每端的 50mm 长度应予以截弃。

302 应按实际生产该焊件的规定进行无损探伤试验, 其试验范围如下:

- 100% 目视检验
- 100% 放射线探伤试验或超声波试验
- 100% 表面裂缝探测(着色渗透剂或磁粉探伤试验)
- 焊缝的坚固性应与本规范有关章节要求相符。

303 每个试件要求进行下述机械试验: (见图 2)

- 一次拉力试验(横切焊缝的板状试件)

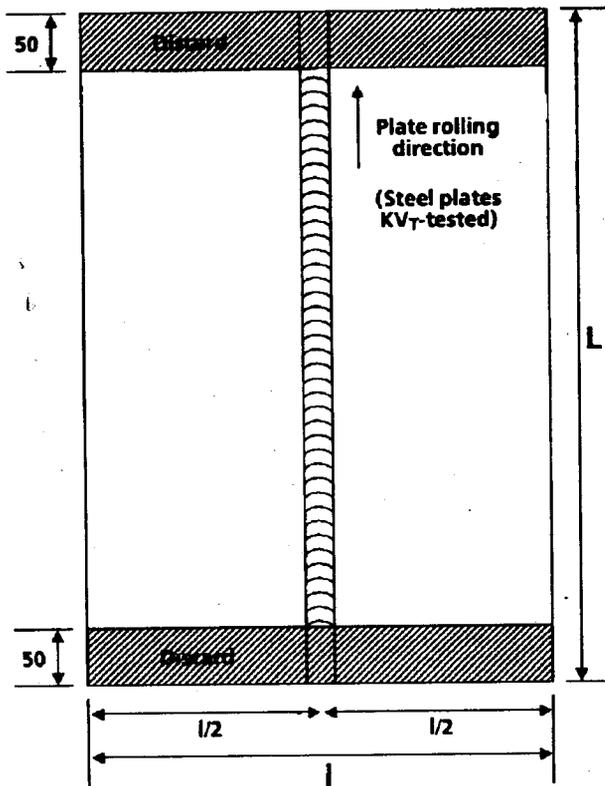


Fig. 1
Test assembly for butt welds on plates

- 1 root and 1 face bend tests when $t \leq 20$ mm and 2 side bend tests when $t > 20$ mm
- when the welding consumable is not approved, 1 extra tensile test (round specimen from the weld metal)
- 12 Charpy V-notch tests with the notch location as given in 308
- 1 macrosection test (metallographic examination + hardness measurements).

304 Specimens for transverse tensile testing are to be in accordance with Sec.1 B201, type B.

The tensile strength is not to be below the specified minimum tensile strength for the steel grade in question.

305 The round tensile specimen is to be machined to the dimensions shown in Sec.1 B201, type A, care being taken that the longitudinal axis coincides with the intersection between the midplane of the weld, and the midplane of the plates. If the section area of the weld metal is too small to allow sampling of the round specimen, an all-weld-metal tensile test is to be carried out according to the requirements given in Sec.3.

306 Transverse side bend, root bend and face bend specimens are to be machined to the dimensions shown in Sec.1 B300.

For a mixed or heterogeneous butt joint one longitudinal bend test specimen may be used instead of root and face or side bend tests.

The test specimens are to be bent on a mandrel with diameter $4xt$, where t is the thickness of the specimen, except for extra high strength steels grades 550, 620, and 690 where the diameter is to be $5xt$.

The bending angle is to be at least 120° . After bending, the test specimens are not to reveal any open defects in any direction greater than 3 mm. Defects appearing at the corners

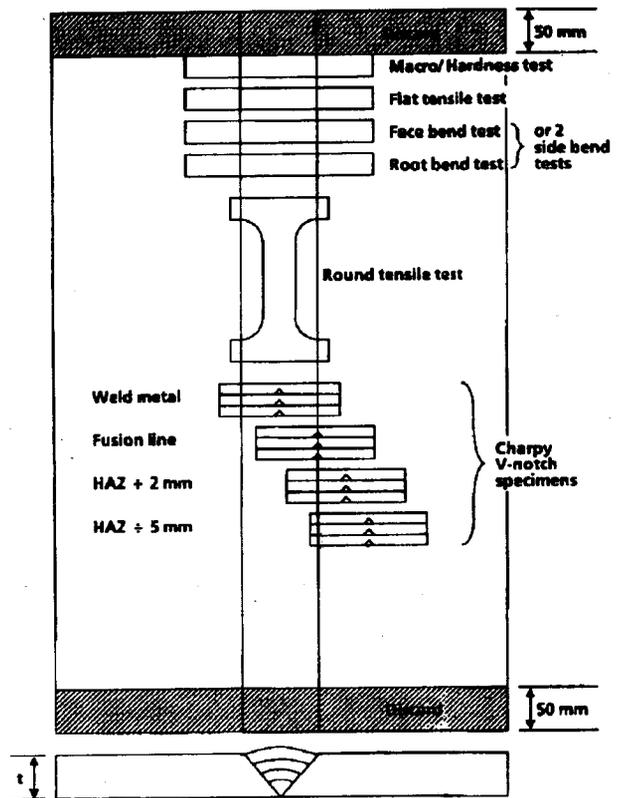


Fig. 2
Sampling of test specimens on plates

of a test specimen during testing are to be ignored in the evaluation.

307 The macrosection is to include about 10 mm of unaffected base material and is to be prepared and etched on one side to clearly reveal the fusion line and the HAZ. Cracks and lack of fusion are not accepted.

The welded joints are to have a regular profile with smooth transitions to the base materials and without significant or excessive reinforcement.

308 The Charpy V-notch specimens are to be machined in accordance with the requirements given in Ch.1 Sec.2 (ISO 148). The specimens are to be sampled 2 mm below the surface of the parent material and transverse to the weld.

12 Charpy V-notch specimens are to be localized in the welded joint as follows:

- 3 specimens with the notch along the weld metal centre-line
- 3 specimens with the notch in the fusion line
- 3 specimens with the notch in the HAZ, 2 mm from the fusion line (Note 1)
- 3 specimens with the notch in the HAZ, 5 mm from the fusion line (Note 1).

Guidance note:

HAZ impact test specimens are normally not required for grade NVA steels. If tested the average value for absorbed energy in weld metal, fusion line and HAZ is not to be less than 27 J at 20°C .

—e-n-d—o-f—G-u-i-d-a-n-c-e—n-o-t-e—

The V-notch is to be perpendicular to the plate surface.

For plate thicknesses >50 mm and for one side welded assemblies with plate thickness >20 mm, one additional set of specimens is to be taken in the weld metal root area.

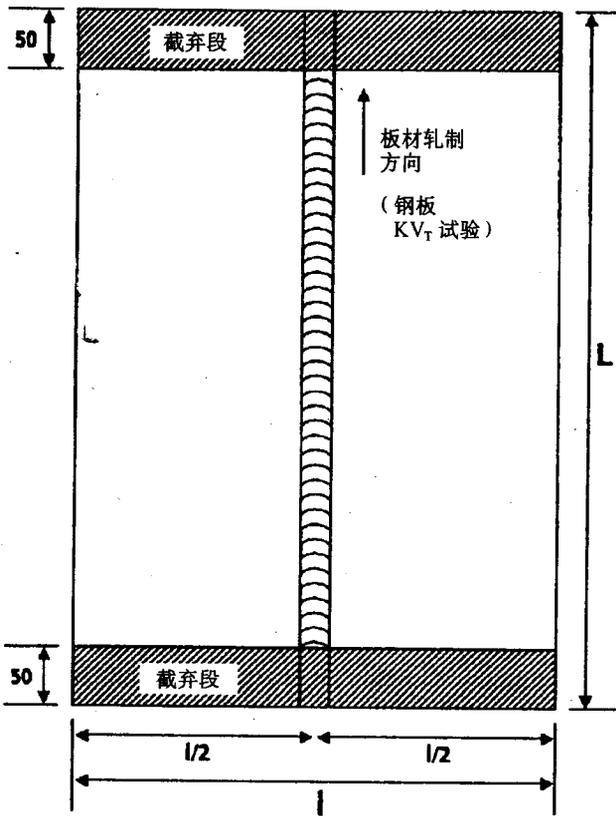


图1 板材对接焊缝试件

- 当 $t < 20\text{mm}$ 时进行一次反弯试验和一次正弯试验，当 $t > 20\text{mm}$ 时进行2次侧弯试验。
- 如焊接材料未获认可，应增作一次拉力试验(从焊接金属截取圆形试样)
- 进行12次夏比V型缺口冲击试验，其缺口位置按308的规定。
- 1次宏观截面试验(金相图检查+硬度测量)。

304 横向拉力试验的试样应按第1节B201B型截取。

试样的抗拉强度应不低于上述钢级规定的最低抗拉强度。

305 圆型拉力试样应机加工达到第1节B201A型所示尺寸，应注意试样的纵轴要与焊缝的中平面与板材中平面的相交线重合，如全熔质的横剖面积太小，不能制备圆型试样，则应按第3节要求进行全熔质拉力试验。

306 横向侧弯试样、反弯试样和正弯试样应经机加工达到第1节B300所示尺寸。

对复合的或非匀质材料的对接接头，可采用一个纵向弯曲试样替代反弯和正弯或侧弯试样；

试样应绕直径为试样厚度4倍的芯棒弯曲。对于等级为550、620和690的超高强度钢其直径为试样厚度的5倍。

弯曲角度至少为 120° ，弯曲后试样在任何方向上应不出现大于3mm的明显的缺陷。在试验时，出现在试样角隅处的缺陷不予计入。

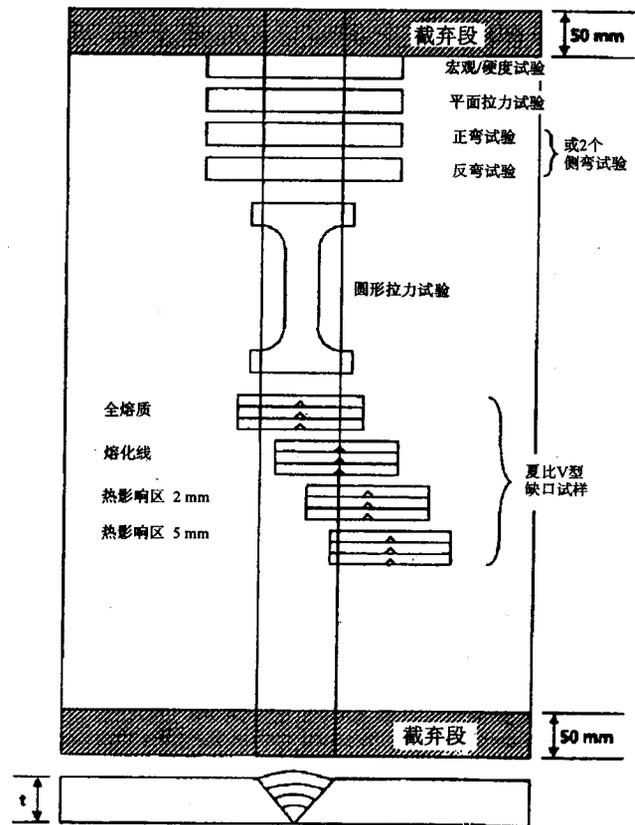


图2 板材试样的截取

307 宏观分段截面试样应制备成包含约10mm的不受热影响的母体材料，并对焊缝一边进行腐蚀处理以清晰显示出熔合线和热影响区(HAZ)。不允许出现裂缝或熔合的缺陷。

焊接接头应有规则的外形，缓和平顺地过渡到母体材料，无明显的或过份的补强情况。

308 夏比V型缺口冲击试样应按第1章第2节(ISO148)要求进行机加工。

应在母体材料表面下2mm和横切焊缝截取试样。

应在焊缝下列位置截取的12个夏比V型缺口冲击试样，其中：

- 3个试样的缺口位于全熔质中心线上；
- 3个试样的缺口位于熔合线上。
- 3个试样的缺口在热影响区距熔合线2mm处(注1)；
- 3个试样的缺口在热影响区距熔合线5mm处(注1)。

指导性意见：

对NVA钢级通常不必制备热影响区(HAZ)冲击试样。如进行冲击试验，其焊缝金属、熔合线和热影响区(HAZ)的平均吸收功值，在 20°C 时应不小于27J。

- 指 - 导 - 性 - 意 - 见 - 结 - 束 -

V型缺口应垂直于板的表面。

对板厚 $> 50\text{mm}$ 的试件和板厚 $> 20\text{mm}$ 单面焊的试件，应在焊缝根部区域截取一组附加的试样。

Hull construction

The test temperature and absorbed energy are to be in accordance with the following requirements:

Impact test temperatures:

- +20°C for grades B, A27S, A32, A36 and A40
- 0°C for grades D, D27S, D32, D36 and D40
- 20°C for grades E, E27S, E32, E36 and E40
- 40°C for grades F32, F36 and F40

The average value for absorbed energy in weld metal, fusion line and HAZ is not to be less than:

- for manual and semi-automatic welding in all welding positions except vertical:
≥ 47 J
- for automatic welding:
≥ 34 J (NV 40 grades ≥ 41 J)
- for manual and semi-automatic welding in vertical position:
≥ 34 J (NV 40 grades ≥ 41 J).

For extra high strength structural steels the Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ are to be the same as required for the base material.

Pressure vessels and production/drilling plants related equipment, structures and systems

The Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ are to be the same as required for the base material.

309 In the case of reduced Charpy V-notch test specimens (10 x 7,5 mm and 10 x 5 mm), the impact energy values to be obtained are to satisfy the following table:

Table B1 Impact energy requirement for subsize specimens	
Dimensions of Charpy V-notch test specimen	Impact energy
10 x 10 mm	KV
10 x 7,5 mm	5/6 KV
10 x 5 mm	2/3 KV

310 The average impact requirements are to be satisfied for each notch location, but one single value of three values from specimens from the same notch location may be below the average requirements, but not below 70 % of minimum average.

311 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken.

The results obtained are to be combined with the original results to form a new average which, for acceptance, is to be not less than the required value. Additionally, for these combined results not more than two individual values are to be less than the required average value, and of these, not more than one is to be less than 70 % of the average value.

Further re-tests may be made at the surveyor's discretion, but these are to be made on a new welded assembly (revised WPS) and are to include all tests required for the original assembly, even those which were previously satisfactory.

312 The hardness testing is to be in accordance with ISO 6507/1 or equivalent, and is only required for grades NV27S and higher. Normally, the Vickers method (HV5 or HV10) is used.

Indentations are to be made along traverses in the weld, HAZ and the parent metal approximately 1 mm below the surface. For each traverse a minimum of 3 indentations are to be made in the weld, HAZ (both sides) and parent metal (both sides). For HAZ the first indentation is to be placed as close to the fusion line as possible.

The values are to be reported for consideration.

313 When a butt weld is made between two plates of different grades, the test temperature and achieved impact energy are to comply with the minimum specified requirements for the lower steel grade (see 308).

In the same way, the tensile strength to be obtained on the welded assembly is to be in agreement with the requirements relating to the plate steel having the lower strength.

As an example the test temperature, impact energy and tensile strength for the butt welded joints given in Fig.3 are those required for the plate of grade D in the left assembly and for the plate of grade E in the right assembly.

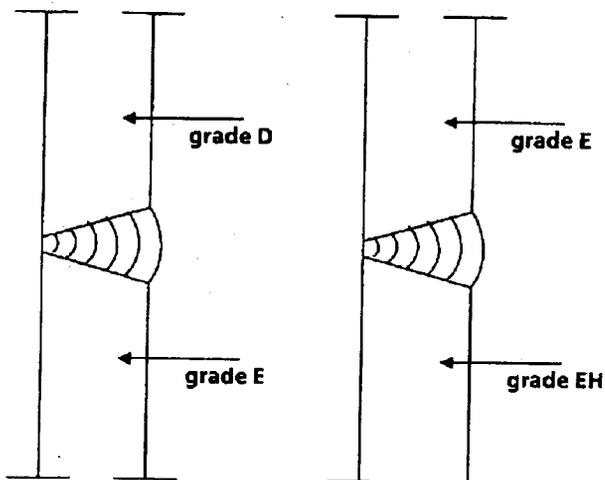


Fig. 3 Butt welded plate joints of different grades

B 400 WPQT for butt welds on tubes

401 The test assembly is to be in accordance with Fig.4.

Edge preparation and fit-up as detailed in the WPS

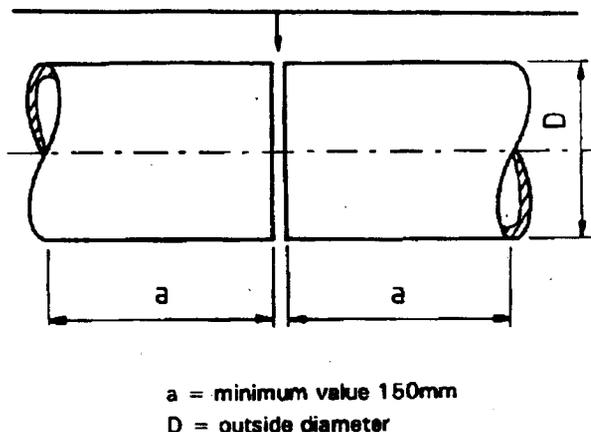


Fig. 4 Test assembly for butt welds on tubes

船体结构

试验温度和吸收的冲击功应符合下述要求:

冲击试验温度

+20 ℃ 对 B, A27S、A32、A36 和 A40 级

0 ℃ 对 D, D27S、D32、D36 和 D40 级

-20 ℃ 对 E, E27S、E32、E36 和 E40 级

-40 ℃ 对 F32、F36 和 F40 级

在全熔质和熔合线和热影响区中吸收冲击功的平均值应不小于:

— 手工焊和半自动焊, 除垂直方向外, 所有施焊的部位:

> 47J

— 自动焊

> 34J (NV40 级 > 41J)

— 手工焊和半自动焊的垂直部位施焊

> 34J (NV40 级 > 41J)

对超高强度结构钢, 夏比 V 型缺口冲击试验温度和在全熔质熔合线及热影响区的吸收平均功值应与母体材料要求的相同。

受压力容器和有关采油 / 钻探装置的设备、结构和系统。

夏比 V 缺口冲击试验温度和全熔质、熔合线和热影响区吸收的冲击功平均值与母体材料要求的相同。

309 对减小尺寸的夏比 V 缺口试验的试样(10 × 7.5mm 和 10 × 5mm)其冲击功应符合下表要求:

表 B1 小尺寸试样要求的冲击功	
夏比 V 缺口试样尺寸	冲击功
10 × 10mm	kv
10 × 7.5mm	5/6kv
10 × 5mm	2/3kv

310 每个位置的缺口试样应满足平均冲击功值要求, 同一缺口位置 3 个试样中的 1 个冲击功值可低于规定的平均值, 但不得低于于最小平均值的 70 %。

311 当一组 3 个冲击试样的试验结果不符合要求时, 则允许再取一组 3 个附加冲击试样进行复试。

这 3 个冲击试样的试验结果和原有试样结果相加求得新的平均值, 该值应不小于规定值时试验就可接受。此外低于规定平均值的单值不得超过 2 个, 其中只允许 1 个单值小于规定平均值的 70 %。

如验船师认为必要时可进一步进行重复试验, 但该试验应采用在新的焊件试样(修正 WPS)并进行对原试样要求的所有试验, 包括那些原本已满足要求的试验。

312 应按 ISO6507/1 或相当标准进行硬度试验, 但仅对 NV27S 或更高等级材料有此要求。通常采用维氏硬度测试法(HV5 或 HV10)。

沿焊缝、热影响区和母体材料的横方向, 在试样表面上压下约 1mm 深的压坑, 在每个横方向焊缝、热影响区两边和母体材料两边最少应压 3 个压坑, 对热影响区, 其第一个压坑应尽可能接近熔合线。

该试验结果应列入报告供考虑。

313 当对两块不同等级的板材进行对接焊时, 其试验温度和测出的冲击功值应符合较低等级钢材规定的最低要求, (见 308), 同样该焊接试件的抗拉强度应符合对强度较低钢板的要求。

例如, 图 3 左面试件只要求符合对 D 级板对接焊缝试验温度、冲击功值和抗拉强度的要求; 右面试件只要求符合对 E 级板的有关要求。

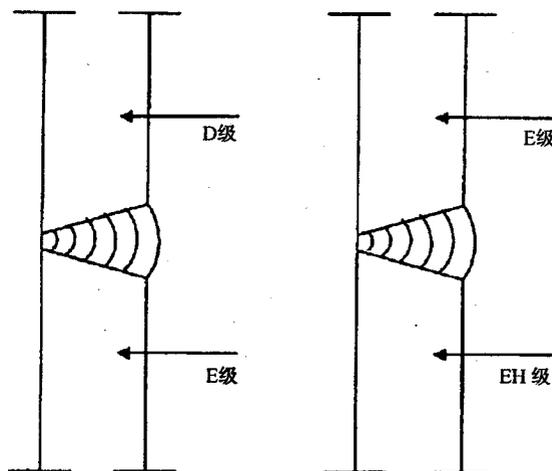
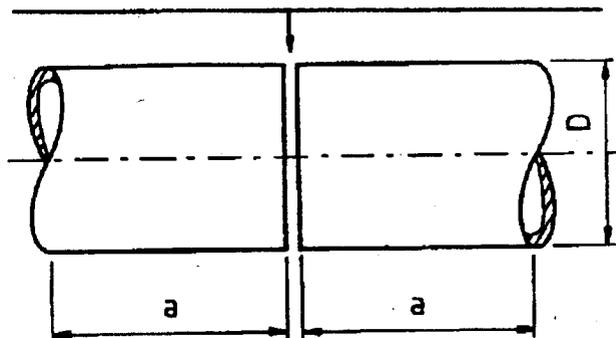


图 3 不同等级板材的对接焊缝

B 400 管材对接焊缝的 WPQT

401 应按图 4 要求制备试件。

按 WPS 的要求进行坡口制备和装配



a = 最小值 150mm

D = 外径

图 4 管材对接焊试件

402 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % radiographic or ultrasonic testing
- 100 % surface crack detection (dye penetrant or magnetic particle testing)

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

403 The following mechanical tests are required from each assembly (see Fig.5):

- 1 tensile test (flat specimen transverse to the weld)
- 1 root and 1 face bend tests when $t \leq 20$ mm and 2 side bend tests when $t > 20$ mm
- 12 Charpy V-notch tests with the notch location as given in 308
- 1 macrosection test (metallographic examination + hardness measurements).

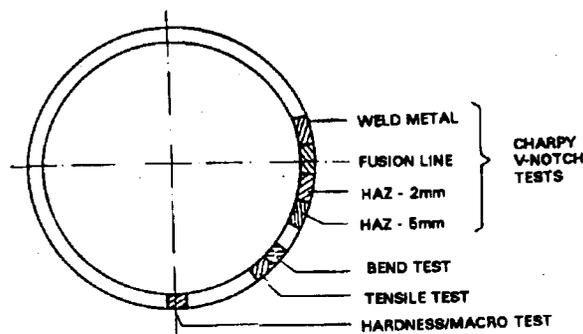


Fig. 5
Sampling of test specimens on tubes

404 The results of mechanical testing are to comply with the relevant requirements given in 300.

B 500 WPQT for full penetration T-, Y-, and K- joints

501 WPQT's for full penetration groove welds between plates at right angles or inclined, i.e. T- or Y- and K-configurations, are to cover a weld length of minimum 350 mm (see Fig.6).

502 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % ultrasonic testing
- 100 % surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

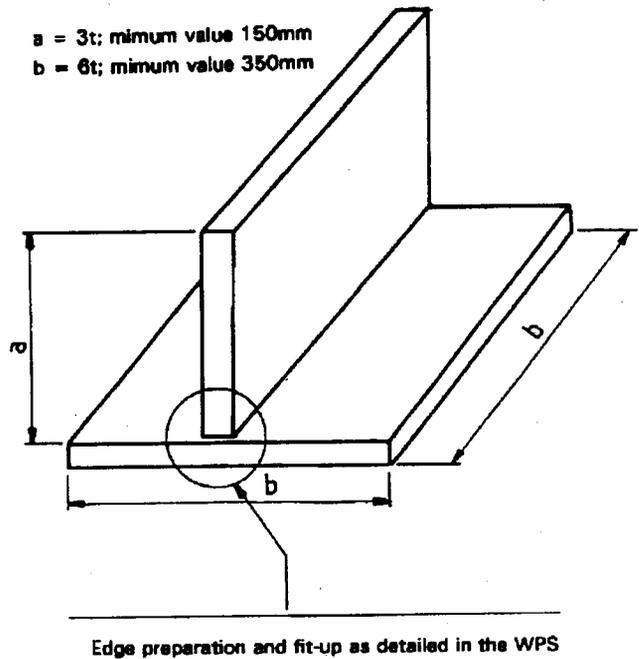


Fig. 6
Test assembly for full penetration T-joints

503 The following mechanical tests are required from each assembly (see Fig.7):

- 12 Charpy V-notch tests with the notch location as given in 308
- 1 macrosection test (metallographic examination + hardness measurements).

504 The results of mechanical testing are to comply with the relevant requirements given in 300.

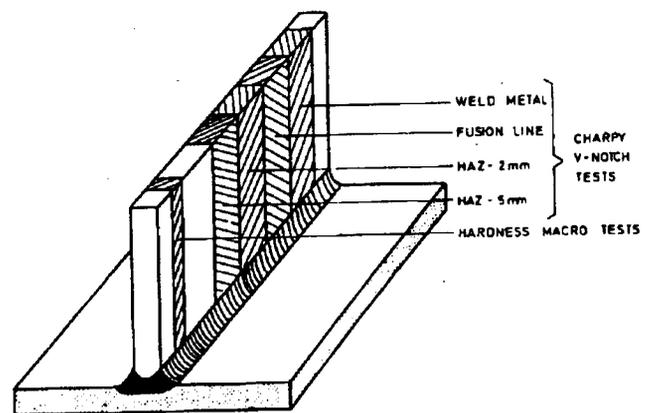


Fig. 7
Sampling of test specimens on full penetration T-joints

B 600 WPQT for tubular joints

601 The test assembly is to be in accordance with Fig.8.

602 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % ultrasonic testing

402 应按有关该生产焊接的规定进行无损探伤试验, 其试验范围如下:

- 100 % 目视检验
- 100 % 放射线探伤试验或超声波试验
- 100 % 表面裂缝探测(着色渗透或磁粉探伤试验).

焊接的坚固性应符合本规范有关部分要求.

403 每个试件应进行下述机械试验(见图 5):

- 1 次拉力试验 (横切焊缝的平面试样)
- 当 $t < 20\text{mm}$ 进行 1 次反弯试验和 1 次正弯试验, 当 $t > 20\text{mm}$ 进行 2 次侧弯试验
- 12 次夏比 V 缺口冲击试验, 缺口的位置按 308 的要求
- 1 个宏观分段截面试验(金相图检查 + 硬度试验)

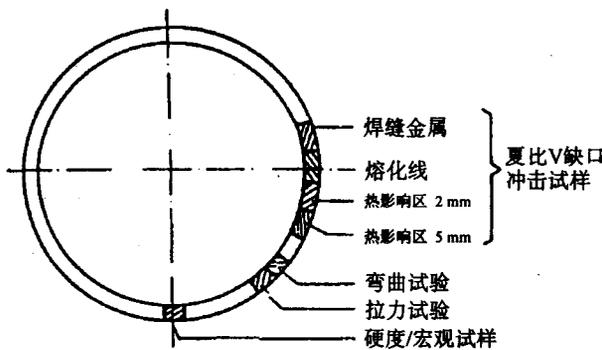


图 5 管材试样的截取

404 机械试验结果应符合 300 中有关要求.

B 500 全熔深 T-、Y-和 K-型接头的 WPQT

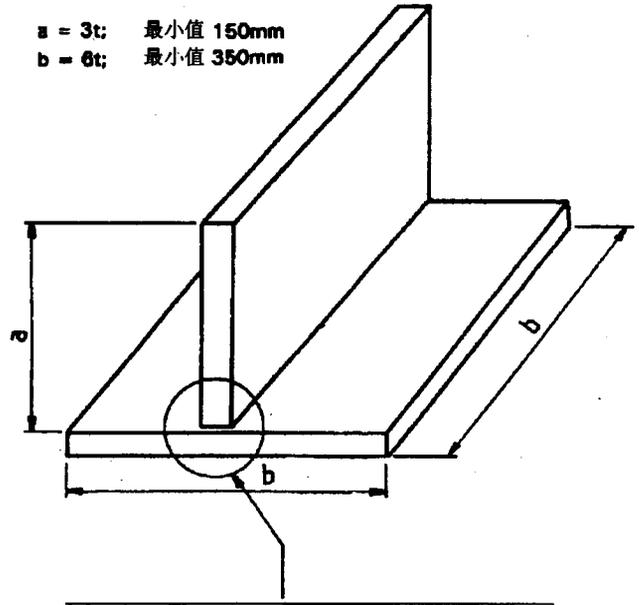
501 板材直角或倾斜开坡口焊接即 T 或 Y 和 K 型全熔深焊的 WPQT, 其焊缝长度最小值应为 350mm(见图 6).

502 应按有关该生产焊接的规定进行无损探伤试验, 其试验范围如下:

- 100 % 目视检验
- 100 % 超声波试验
- 100 % 表面裂缝探测(着色渗透或磁粉探伤试验).

焊接的坚固性应符合本规范有关部分的要求.

$a = 3t$; 最小值 150mm
 $b = 6t$; 最小值 350mm



按焊接工艺规程进行的边缘处理和装配

图 6 全熔深 T 型接头的试件

503 每个试件应进行下述机械试验(见图 7):

- 12 个夏比 V 缺口冲击试验, 试样缺口位置按 308 要求
- 1 次宏观分段截面试验(金相图检查 + 硬度试验).

504 机械试验的结果应符合 300 中有关要求.

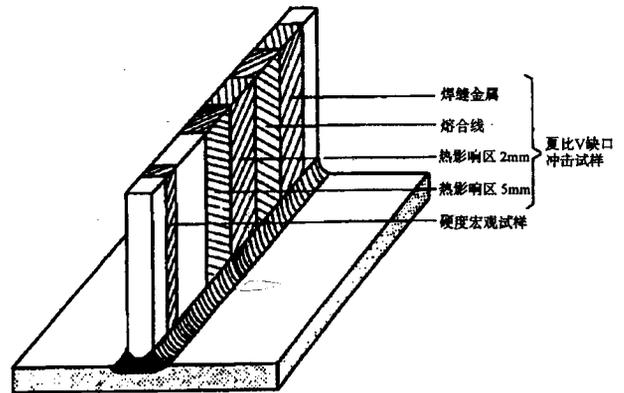


图 7 T 型接头全熔深焊缝试样的截取

B 600 管状接头的 WPQT

601 试件应符合图 8 的要求.

602 应按有关该生产焊接的规定进行无损探伤试验, 其试验范围如下:

- 100 % 目视检验
- 100 % 超声波试验

- 100 % surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

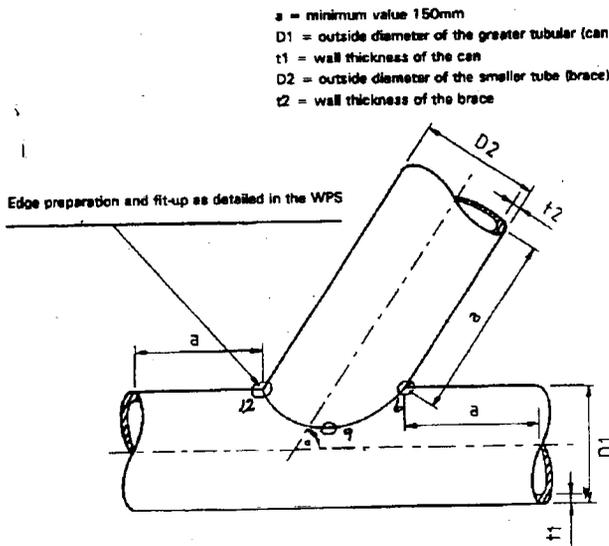


Fig. 8
Test assembly for tubular joints

603 The following mechanical tests are required from each assembly (see Fig.8):

- 12 Charpy V-notch tests sampled at 9 o'clock and with the notch location as given in 308
- two macrosection tests (metallographic examination + hardness measurements) at 12 and 6 o'clock.

604 The results of mechanical testing are to comply with the relevant requirements given in 300.

B 700 WPQT for fillet welds

701 The two plates are assembled and positioned edgewise so as to constitute a tee-assembly with no clearance. As far as possible the plates are to be of a sufficient size to ensure a reasonable heat distribution.

For fillet welds the test assembly is to be as defined in Fig.9.

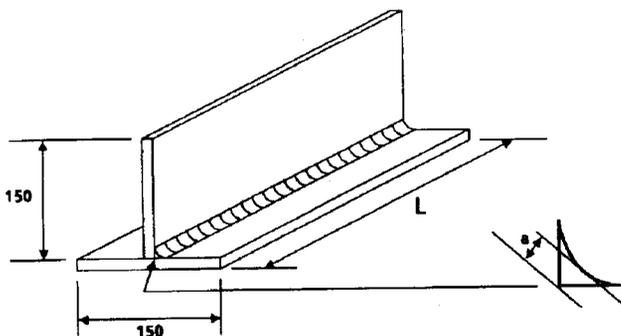


Fig. 9
Test assembly for fillet welds

For manual and semi-automatic welding the length of the test piece is to be:

$$L_{\min.} = 350 \text{ mm}$$

For automatic welding the length is to be:

$$L_{\min.} = 1000 \text{ mm}$$

Weld and fit-up are to be as detailed in the WPS.

The test assembly is to be welded on one side only. For manual and semi-automatic welding, the stop/restart position is normally to be included in the test length and is to be clearly marked for subsequent examination.

The ends of the specimen are exempted from examination over a length of 50 mm.

702 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld is to comply with the specified requirements given in the relevant parts of the Rules.

If the stop/restart spot is included in the test length, special attention is to be paid to this position with respect to profile, proper fusion and absence of crater defects.

703 The following tests are to be performed:

- two macrosection tests (metallographic examination, hardness measurements).

One of the macrosections is to be taken at the marked position of the stop/restart (for more details see 307).

For hardness testing, see 312.

B 800 Retesting

801 If the WPQT fails to comply with any of the requirements for NDT one extra WPQT is to be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS is to be considered as not qualified and a respecification of the WPS is to be made prior to a new qualification test.

B 900 Validity of qualified welding procedures

901 The validity of a qualified welding procedure is to be restricted to the workshop performing the qualification. Workshops or workshop branches under the same technical management and working in accordance with the same QA-program and -procedures are considered as one workshop.

902 Qualification of a welding procedure remains valid provided the parameters are kept within the qualified ranges during production welding. The qualified ranges are given in 903. When one or more variations outside the qualification ranges occur, the welding procedure qualification is to be considered invalid, and the welding procedure is therefore to be respecified and requalified.

903 A qualified welding procedure is to be used within the ranges of the parameters below.

Base material

The following changes are to lead to a new qualification:

- In general, significant change of material properties which will obviously affect the weldability and mechanical properties.
- More specifically, structural steels are grouped in three categories:
 - Normal strength steel, grades A, B, D and E or equivalent structural steels with tensile strength 400–490 N/mm².

— 100 % 表面裂缝探测(着色渗透或磁粉探伤试验).

焊接的坚固性应符合本规范有关部分的要求.

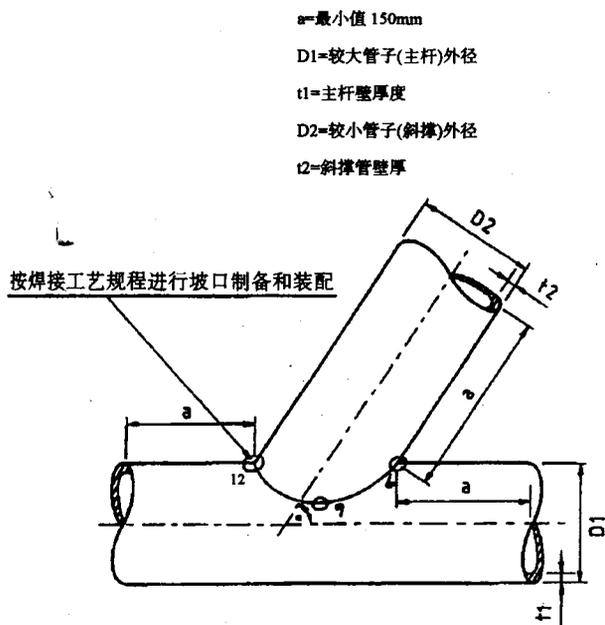


图8 管状接头的试件

603 每个试件应进行下述机械试验(见图8):

- 12 个夏比 V 缺口冲击试验, 在 9 点钟位置上抽样, 其缺口位置按 308 要求
- 2 次宏观分段截面试验(金相试验 + 硬度试验), 其位置分别为 12 点钟和 6 点钟处.

604 机械试验结果应符合 300 中有关要求.

B 700 填角焊缝的WPQT

701 用两块板其中一块的边缘放在另一块上组合成无间隙的 T 型试件, 试件应有足够大的尺寸, 以保证合理的热量分布.

填角焊缝试件应按图 9 要求制备.

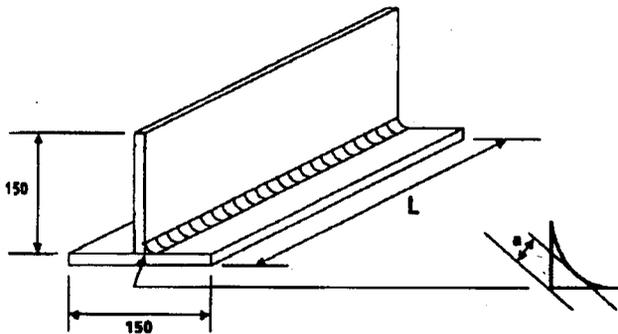


图9 填角焊试件

对手工焊和半自动焊其试件长度应为:

$$L_{\min} = 350 \text{ mm}$$

对自动焊, 其试件长度应为:

$$L_{\min} = 1000 \text{ mm}$$

应按焊接工艺规程进行焊接和装配.

仅在一边施焊焊制试件. 对手工焊和半自动焊, 其终止点/重新起焊点, 通常应包含在试验长度中, 并应有明显的标志供后续检验.

试件两端 50 mm 长度内可免于检验.

702 应按有关该生产焊接的规定进行无损探伤试验, 其试验范围如下:

- 100 % 目视检验
- 100 % 表面裂缝探测(着色渗透或磁粉探伤试验).

焊接的坚固性应符合本规范有关部分的要求.

若焊缝终止点/重新起焊点包括在试验长度内, 应特别注意这一位置的外型、熔合情况和应无坑凹缺陷.

703 应进行下述试验:

- 2 次宏观分段截面试验(金相图检查、硬度测量).

宏观分段截面试验之一应取在终止点/重新焊接点作了标志的位置处(详见 307).

硬度试验见 312.

B 800 重复试验

801 如 WPQT 不符合无损探伤试验的任何一项要求, 则应再进行一次 WPQT 的焊接和进行相同的试验. 如附加的试验不符合有关要求, 则实际的焊接工艺规程应视为不合格, 在进行新的验证试验前应重新制定焊接工艺规程.

B 900 合格焊接工艺规程的有效性

901 合格焊接工艺规程的有效性仅对完成了合格焊接的车间而言. 在同一技术管理下的按同一质量管理(QA)程序和过程操作的车间或工段应视为一个车间.

902 如施焊时其参数保持在有效范围内, 则焊接工艺规程的合格性保持有效. 合格范围如 903 所示. 当一个或多个参数偏离合格范围时, 则该焊接工艺规程的合格性视为无效. 因此该焊接工艺规程应重新制定和重新检验其合格性.

903 合格的焊接工艺规程应在下述参数范围内采用.

母体材料

下述变化应进行重新检验:

- a) 一般当材质有明显改变, 从而影响材料的可焊性和机械性能时;
- b) 特别是三种类型的钢结构:
 - i) A、B、D 和 E 级普通强度钢或抗拉强度为 400~490 N/mm² 相当的结构钢.

- ii) High strength steel, grades A27S, D27S, E27S, A32, D32, E32, F32, A36, D36, E36, F36, A40, D40, E40, F40 or equivalent structural steels with minimum specified yield strength 265–390 N/mm².
- iii) Extra high strength steels, grades A-F 420, A-F 460, A-F 500, A-F 550, A-F 620, A-F 690 or equivalent structural steels with minimum specified yield strength 420–690 N/mm².

The qualification on steel grades of higher toughness requirements will qualify the grades of lower toughness but not vice versa.

Thickness

Thickness, *t*, is defined as follows:

- a) For a butt weld:

The base metal thickness, which for welds between dissimilar thicknesses *s* is that of the thinner material.

- b) For a fillet weld:

The base metal thickness, which for welds between dissimilar thicknesses is that of the thicker material. However, for each thickness range qualified, as in Table B2 there is an associated range of qualified throat thickness as given below.

- c) For a set-on tubular joint:

The thickness of the brace

- d) For a set-in or set-through tubular joint:

The thickness of the can

- e) For a T-butt joint in plate:

The thickness of the prepared plate

The requirements to qualified thickness range for butt welds are to be as given in Table B2.

Thickness <i>t</i> in mm of test piece	Qualification range ¹⁾	
	for single run or single run from both sides	for multi-run welding and all fillet welds
$t < 12$	0,8 <i>t</i> to 1,1 <i>t</i>	up to 2 <i>t</i>
$12 \leq t \leq 100$	0,8 <i>t</i> to 1,1 <i>t</i>	0,5 <i>t</i> to 2 <i>t</i> (max. 150)
$t > 100$	0,8 <i>t</i> to 1,1 <i>t</i>	0,5 <i>t</i> to 1,5 <i>t</i>

1) The qualification range for vertical downward position is 0,5 *t* to 1,1 *t*

The requirements to qualified thickness range for fillet welds are in addition to the requirements of Table B2, that the throat thickness, *a*, is to be in the range 0,75 *a* to 1,5 *a*. However, a throat thickness of 10 mm or more is to give qualification for all throat thicknesses above or equal to 10 mm.

Diameter of tubes and tubular joints

The qualification of a welding procedure test on diameter *D* is to include qualification for diameters in the following ranges as given in Table B3.

Diameter of the test piece <i>D</i> (mm) ^{1) 2)}	Qualification range
$D \leq 168,3$	0,5 <i>D</i> to 2 <i>D</i>
$D > 168,3$	$\geq 0,5 D$ and plates

1) *D* is the outside diameter of the tube or outside diameter of the brace.
2) Qualification given for plates also covers tubes when the outside diameter is greater than 500 mm.

Angle of tubular joints

A WPQT carried out on a tubular joint with angle α is to qualify all tubular joint angles in the range of $\alpha \leq \alpha_1 \leq 90^\circ$

Welding consumables

The following changes are to lead to a new qualification:

- any change in consumable grading
- change of consumable name when impact testing is required at temperatures below -20°C
- any significant change of mixture/composition (e.g. change from argon/mixed gas to CO₂ gas), flow rate, filling time and filling volume for shielding and backing gases.

Welding positions

The following changes are to lead to a new qualification.

- Change from one principal welding position (see Figs. 10, 11, 12) to another, unless complying with Table B4.

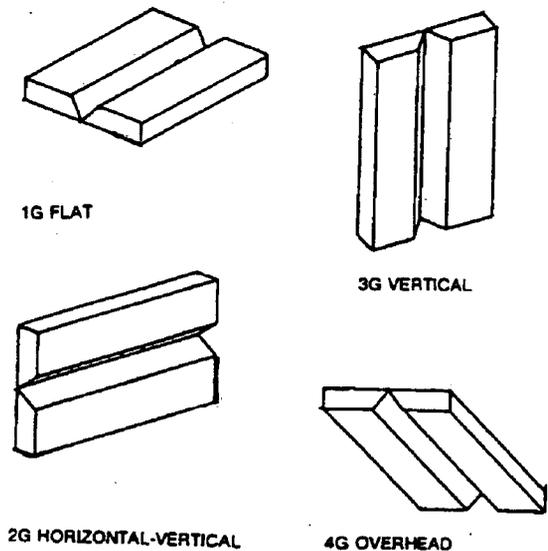


Fig. 10
Plate test positions