

ii) A27S、D27S、E27S、A32、D32、E32、F32、A36、D36、F36、A40、D40、E40、F40 级高强度钢或标称屈服强度最小值为 265~390 N/mm² 的相当的结构钢。

iii) A-F420、A-F460、A-F500、A-F550、A-F620、A-F690 级超高强度钢或标称屈服强度最小值为 420-690N/mm² 的相当的结构钢。

对较高强度要求的钢材等级的合格证，可适用于较低强度要求的钢材等级，反之则不适用。

厚度

厚度 t 定义如下：

a) 对焊接

对不同厚度材料施焊时，应取用较薄的材料的厚度作为母体材料厚度；

b) 填角焊

对不同厚度材料施焊时，应取用较厚的材料的厚度作为母体材料厚度，但是如表 B2 所示，对每一合格的厚度范围，就有一个如下所述的与之相对应的焊喉厚度的范围

c) 对外接管状接头

其厚度取斜撑的厚度

d) 对嵌入或贯穿管状接头

其厚度取主杆壁的厚度

e) 对板材 T 型接头

其厚度取加工过的板的厚度

对接焊缝认可厚度范围的要求列于表 B2 中。

试件厚度 t mm	认可范围 ¹⁾	
	单道焊或双面单道焊	多道焊和全填角焊
t < 12	0.8t 至 1.1t	至 2t
12 < t < 100	0.8t 至 1.1t	0.5t 至 2t(最厚为 150)
t > 100	0.8t 至 1.1t	0.5t 至 1.5t

1) 对垂直向下焊位其认可范围为 0.5t 至 1.1t

对填角焊缝认可厚度范围要求除按表 B2 的要求外，其焊喉厚度 a 应在 0.75t 至 1.5t 范围内。但是，对所有等于或大于 10mm 的焊喉厚度要求，10mm 或以上的焊喉厚度即应予以认可。

管子和管状接头的直径

对直径 D 的焊接工艺试验认可包括了表 B3 规定的下述直径范围的认可。

试件直径 D (mm) ^{1) 2)}	认可范围
D < 168.3	0.5D 至 2.0D
D > 168.3	> 0.5D 和板厚

1) D 为管子的外径或斜撑的外径。
2) 当外径大于 500mm 时，对板材的认可也包括对管子认可。

管状接头的角度

对具有 α 夹角的管接头进行的 WPQT 应对所有具有夹角为 α < α₁ < 90° 的管接头都可采用。

焊接材料

如有下述变化，应予重新验证：

- 焊接材料等级的变化
- 当要求在 -20℃ 以下进行冲击试验时，改变焊接材料名牌
- 任何混合气/成分的显著变化(例如从氩/混合气改变为 CO₂)，电流变化，防护气体和背面保护气体的时间长短和数量的变化。

施焊位置

如有下述变化，应予重新验证：

- 从一种主要施焊位置(见图 10、11、12)改变到另一种施焊位置，符合表 B4 规定者除外。

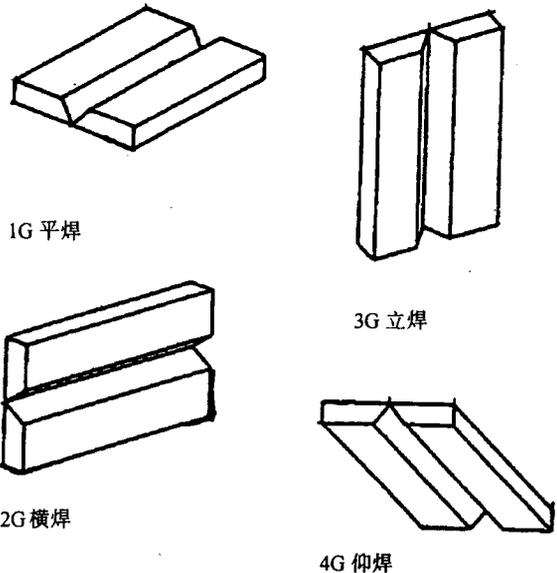


图 10 板材的试验位置

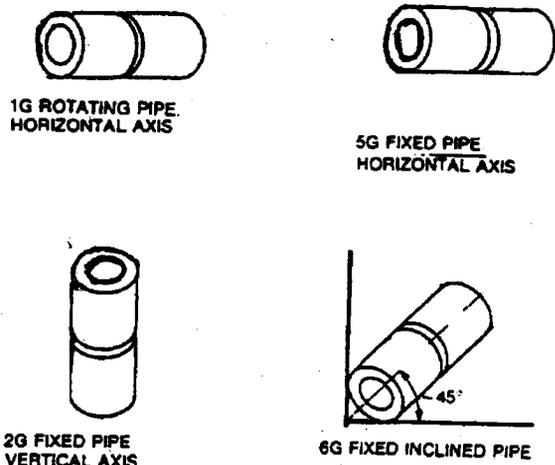


Fig. 11
Pipe test positions

Type of joint

The range of approval for type of joint is given in Table B5. In addition the following changes are to lead to a new qualification:

- change from fillet weld to butt weld
- change of specified type of groove, root face and gap which may significantly affect penetration, fusion and delution of the weld.

Welding condition

The following changes are to lead to a new qualification:

- any change of welding process
- change from spray arc to short arc or pulsed arc or vice versa

- change beyond $\pm 15\%$ for voltage and current, and change of more than $\pm 10\%$ for travel speed
- change of preheating/interpass temperature beyond $\pm 25^\circ\text{C}$
- change of post weld heat treatment parameters.

B 1000 Welding procedure qualification record, WPQR

1001 The parameters used during qualification welding, NDT-records and mechanical testing reports are to be presented in a WPQR for each qualification test. The WPQR is to contain sufficient references to establish where, when, how and by whom the test welding, NDT- and mechanical testing were performed.

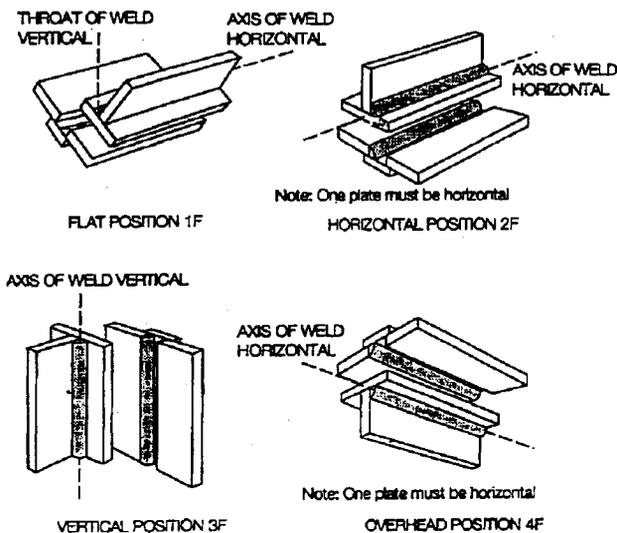


Fig. 12
Positions of test plate for fillet welds

Table B4 Qualified principal positions for butt welds and fillet welds				
Test weld Type of joint 1) 2)	Principal positions	Qualified positions 3)		
		Butt welds		Fillet welds Plates/tubes
		Plates	Tubes	
Butt welds on plates	2G+3G 1G 2G 3G 4G	All 1G 1G, 2G, 4G 3G 1G, 4G	All 1G 1G, 2G Not applicable 1G	All 1F 1F, 2F, 4F 3F 1F, 4F
Butt welds on tubes	2G + 5G = 6G 1G 2G 5G	All 1G 1G, 2G, 4G All	All 1G 1G, 2G 1G, 5G	All 1F 1F, 2F, 4F All
Fillet welds	2F+3F 1F 2F 3F 4F 5F			All 1F 1F, 2F, 4F 3F 1F, 4F All

1) Tubes with OD > 500 mm are considered equivalent to plates (apply only to the can in tubular joints)
2) Tubular joints are to be qualified separately.
3) The vertical downwards position is to be qualified separately.



图 11 管子试验位置

接头的形式

接头形式的认可范围列于表 5。

此外，如有下述变化，应予重新验证：

- 由填角焊变为对接焊
- 可能明显地影响熔深，焊接的熔敷和虚焊的原定坡口形式的变化，根部面积和间隙的变化。

焊接条件

如有下述变化，应予重新验证：

- 焊接工艺的任何变化
- 从喷弧变到短弧或脉冲弧，反之亦然

- 电压和电流超过 $\pm 15\%$ 的变化范围和焊接速度变化大于 $\pm 10\%$
- 预热/焊道间温度变化超出 $\pm 25\%$ 。
- 焊后热处理参数的变化。

B 1000 焊接工艺合格记录，WPQR

1001 对于每次验证试验，验证焊接中用参数，无损探伤试验记录和机械试验记录均应列入 WPQR。该 WPQR 的内容应包括足够参考资料以了解何地、何时、如何和由谁进行了这焊接试验、无损探伤试验和机械试验。

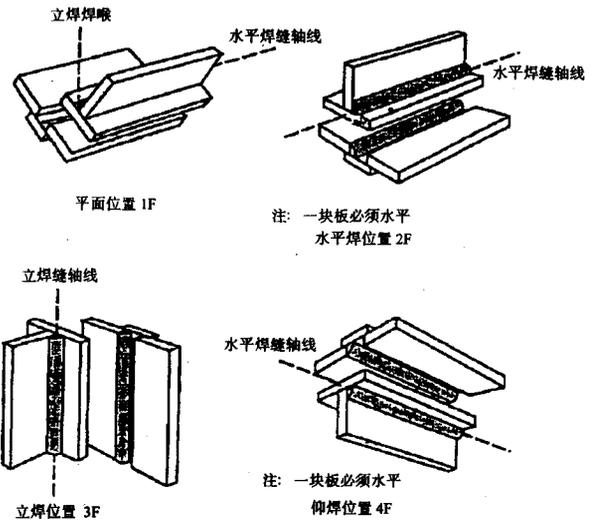


图 12 填角焊的各种试验板材位置

表 B4 验证对接焊缝或填角焊缝的主要位置

试验焊缝的接头 型式 ^{1) 2)}	主要焊接位置	验证位置 ³⁾		
		对接焊缝		填角焊缝 板材/管材
		板材	管材	
板材上的对接焊缝	2G+3G	全部	全部	全部
	1G	1G	1G	1F
	2G	1G、2G、4G	1G、2G	1F、2F、4F
	3G	3G	不适用	3F
	4G	1G、4G	1G	1F、4F
管子对接焊缝	2G+5G=6G	全部	全部	全部
	1G	1G	1G	1F
	2G	1G、2G、4G	1G、2G	1F、2F、4F
	5G	全部	1G、5G	全部
填角焊缝	2F+3F			全部
	1F			1F
	2F			1F、2F、4F
	3F			3F
	4F			1F、4F
	5F			全部

1) 管材外径 OD > 500mm，视为相当于板材(仅适用于管接头中之过渡接头)。

2) 管接头应分别验证。

3) 垂直向下焊应分别验证。

Type of joint in approval test piece			Range of approval							
			Butt welds on plate				T butt welds on plate		Buttwelds on pipe	
			Welded from one side		Welded from both sides		Welded from one side	Welded from both sides	Welded from one side	
			With backing	No backing	With gouging	No gouging			With backing	No backing
Butt weld on plate	Welded from one side	With backing	*	-	x	x	-	x	-	-
		No backing	x	*	x	x	x	x	-	-
	Welded from both sides	With gouging	-	-	*	x	x	x	-	-
		No gouging	-	-	-	*	-	x	-	-
Butt weld on pipe	Welded from one side	With backing	x	-	x	x	-	x	*	-
		No backing	x	x	x	x	x	x	x	*
T butt weld on plate	Welded from one side		-	-	-	-	*	x	-	-
	Welded from both sides		-	-	-	-	-	*	-	-

Key:
* indicates the WPS which is approved in the approval test
X indicates those welds for which the WPS is also approved
- indicates those welds for which the WPS is not approved

B 1100 WPQT for liquefied gas systems

1101 Welding shops which intend to build welded cargo tanks, process pressure vessels and/or piping systems for liquefied gases are to carry out WPQT for all types of butt welds in the construction.

1102 For butt welds in tanks and pressure vessels, the test assemblies consist of two plates, each having a width of at least 150 mm and a length sufficient for making all necessary test specimens described in 1105. The test assemblies are to be so prepared that the principal direction of rolling is parallel to the direction of welding.

Guidance note:

The test plates must be of such dimensions that the cooling condition as far as possible will be the same as for the production welding.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e---

1103 For butt welds in piping systems the test assemblies are made by welding together two approximately 150 mm long pipes with the same diameter as the pipes used in the system to be represented.

1104 The test assemblies are to be subjected to radiographic testing after welding. X-rays, fine-grained film and lead screens are to be used for this testing. The radiographs are at least to meet the requirements in Pt.5 Ch.5 Sec.5 and Pt.5 Ch.5 Sec.6. Concerning magnetic particle, dye penetrant and ultrasonic testing reference is made to Pt.5 Ch.5 Sec.5.

Hardness testing is to be performed on weld metal, heat affected zone and parent material. The values are to be reported for consideration.

The weld is to be etched through the whole cross-section and is to show normal structure and penetration. The etching is to be done in such a way that the fusion line is clearly seen.

1105 From each test assembly for plates the following specimens are to be taken:

- one transverse weld tensile test specimen
- two side bend test specimens.

The test specimens are to be cut transverse to the longitudinal axis of the weld. The thickness of the test specimen is to be 10 mm and width equal to the plate thickness. If the plate thickness exceeds 40 mm the test sample may be divided into two, each having a width of at least 20 mm

- five sets of Charpy V test specimens (each set consists of 3 specimens)
- macrosection, microsection and hardness survey may also be required.

The Charpy V test specimens are to be cut with their longitudinal axis transverse to the longitudinal axis of the weld. When practicable, the test specimen is to be taken at a place half the distance from the centre to the surface of the plate. The notch is to be cut in a face of the test specimen originally perpendicular to the rolled surface. The specimens are to be taken at the following locations:

- 3 specimens with the notch in the centre line of the welds
- 3 specimens with the notch in the fusion line
- 3 specimens with the notch 1 mm from the fusion line
- 3 specimens with the notch 3 mm from the fusion line
- 3 specimens with the notch 5 mm from the fusion line.

For austenitic chromium-nickel steels, only 3 tests with the notch in the centre of the welds are required for design temperature below -105°C.

1106 From each test assembly for tubes, the following test specimens are to be taken:

- one transverse weld tensile test specimen
- two side bend test specimens.
The test specimens are to be cut transverse to the longitudinal axis of the weld. The thickness of the test specimen is to be 10 mm and the width equal to the wall thickness. If the wall thickness is less than 10 mm the side bend test is to be replaced by root bend test
- five sets of Charpy V test specimens (each set consists of 3 specimens). The test specimens are to be cut as stipulated in 1105
- macrosection, microsection and hardness survey may also be required.

表 B5 接头型式的认可范围

认可试样的接头型式			认可范围							
			板材对接焊缝				板材T型对接焊缝		管材对接焊缝	
			单面焊		双面焊		单面焊	双面焊	单面焊	
			有衬垫	无衬垫	有坡口	无坡口			有衬垫	无衬垫
板块对接焊	单面焊	有衬垫	*	-	x	x	-	x	-	-
		无衬垫	x	*	x	x	x	x	-	-
	双面焊	铲边	-	-	*	x	x	x	-	-
		未铲边	-	-	-	*	-	x	-	-
管材对接焊	单面焊	有衬垫	x	-	x	x	-	x	*	-
		无衬垫	x	x	x	x	x	x	x	*
板材T型对接焊	单面焊	-	-	-	-	*	x	-	-	
	双面焊	-	-	-	-	-	*	-	-	

解释
 * 表示在认可试验中经认可的焊接工艺规程
 x 表示其焊接工艺规程已经认可的焊接型式
 - 表示其焊接工艺规程未认可的焊接型式

B 1100 液化气系统的WPQT

1101 拟制作焊接液货舱柜、加工受压容器和/或液化气管系的焊接车间，应对结构中的所有对接焊缝进行 WPQT。

1102 舱柜和受压容器的对接焊缝，其试件由二块板材组成，每块板材至少宽 150mm 长度应足以制备 1105 要求的试样。应在焊接方向和轧制方向一致的情况下截取该试件。

指导性意见:

在冷却状态下试板的尺寸应尽可能与施焊的尺寸相同。

- 指 - 导 - 性 - 意 - 见 - 结 - 束 -

1103 对管系的对接焊缝，其试件应由可代表该系统的两根长约 150mm 等直径管子焊制。

1104 焊制后试件应进行放射线探伤检验。该试验应采用 X-射线、精细晶粒照片和铝屏。放射线探伤至少应符合第 5 篇第 5 章第 5 节和第 5 篇第 5 章第 6 节的要求。磁粉探伤、着色渗透和超声波试验应参照第 5 篇第 5 章第 5 节的要求进行。

硬度试验应在焊缝处、热影响区和母体材料上进行，其值应列入报告以供参考。

焊缝应对整个横截面进行腐蚀处理以显示正常的结构和熔深。经腐蚀处理后应使熔合线清晰显示。

1105 应从板的每一个试件中截取下列试样:

- 1 个横切焊缝拉力试样
- 2 个侧弯试样。

截取的试样应横跨焊缝纵轴。试样厚度应为 10mm，其宽度等于板厚。如板厚 > 40mm，该试样可分成两块，每块宽至少为 20mm。

- 5 组夏比 V 缺口冲击试样 (每组由 3 个试样组成)

- 可要求进行宏观分段截面检验、微观分段检验和硬度测量。

截取夏比 V 缺口冲击试样时应使其纵轴横跨焊缝纵轴。如有可能，该试样取自从中线至板材表面一半地方。缺口所在平面应垂直于原轧制面。在下列位置截取这些试样:

- 3 个缺口在焊缝中心线上
- 3 个缺口在熔合线上
- 3 个缺口在离熔合线 1mm 处
- 3 个缺口在离熔合线 3mm 处
- 3 个缺口在离熔合线 5mm 处。

对设计温度低于 -105℃ 的奥氏体铬-镍钢，仅要求截取 3 个缺口在焊缝中心线上的试样。

1106 应从管材的每个试件截取下述试样:

- 1 个横跨焊缝的拉力试样

- 应横跨焊缝纵轴截取该试样，试样厚度应为 10mm，其宽度等于板厚。

- 5 组夏比 V 缺口冲击试样 (每组由 3 个试样组成)。该试样应按 1105 要求截取

- 可要求进行宏观分段截面试验，微观分段截面试验和硬度测量。

For austenitic chromium-nickel steels, only 3 tests with the notch in the centre of the welds are required if the design temperature is below -105°C .

1107 The butt weld tensile test is to comply with the following requirements:

Generally, the tensile strength is not to be less than the specified minimum tensile strength for the parent material. In cases where the Society has approved the use of welding consumables which give lower tensile strength in the weld metal than that required for the parent material, the approved value for the welding consumable in question applies. The position of fracture is to be reported.

1108 The bend test specimens are to be capable of withstanding bending through an angle of 180° over a former with diameter four times the thickness of the specimen. The tests can be considered as complying with the requirements if, after bending, no crack or other open defects exceeding 3 mm in dimension can be seen on the outer surface.

1109 Charpy V testing is to be conducted at the temperature prescribed for the base material. See Pt.5 Ch.5 Sec.2. When specimens of 10 x 10 mm cross-section are used, the average value from 3 tests is not to be less than 27 J for weld metal. One single test may give a value below the required average but not lower than 19 J.

For fusion line and heat affected zone the requirement for minimum average value is the same as for the base material. Only one individual value may be below the specified average value provided it is not less than 70 % of that value.

For testing of thin materials where it is impossible to use a standard test specimen 10 x 10 mm, the larger of the following specimens is to be used:

10 x 7,5 mm, 10 x 5 mm, 10 x 2,5 mm.

The impact values are then reduced to respectively 5/6, 2/3 and 1/2 of the required values of the standard test specimen.

C. Welding Procedures, Aluminium

C 100 General

101 Requirements for liquefied gas systems are stated in special Programmes in Certification Notes No. 2.1.

102 Qualified welding procedures are required for all important joints in hulls and structures which are to be classed with Det Norske Veritas. The procedure tests are to be representative of the following:

- each base material/alloy and temper used in production
- the thickness and diameter range in question (see Tables B2 and B3)
- each type of consumable and welding process
- welding position (see Table C1)
- joint/groove design
- number of passes
- preheat (if any)
- volt-ampere characteristics
- shielding gas.

Table C1 Qualified principal positions for butt welds and fillet welds

Test weld Joint configuration	Principal positions	Qualified positions ¹⁾		
		Butt welds, plates	Butt welds, tubes	Fillet welds
Butt welds on plates	1G 2G 3G 4G	1G 1G, 2G, 3G 1G, 2G, 3G All	1G	1F 1F, 2F, 3F 1F, 2F, 3F All
Butt welds on tubes	1G 2G 5G	1G 1G, 2G, 3G All	1G 2G 1G, 5G	1F 1F, 2F, 3F All
Fillet welds	1F 2F 3F 4F 5F			1F 1F, 2F, 3F 1F, 2F, 3F All All

1) The vertical downwards position is to be qualified separately.

C 200 WPQT for butt welds

201 Each test assembly consists of 2 plates with dimensions 300 x 150 mm. The plates are to be joined with a longitudinal butt weld. For extruded sections and pipes the assembly is to consist of 2 sections each 150 mm long (see Figs.13 and 14).

202 The welding is to be carried out in accordance with the procedure to be used during production. Welding consumables are those recommended in Table C2.

203 The joint configurations are to comply with those intended to be applied for the production welding.

204 If back-sealing run is to be laid, this run is to be laid in the same position as for the respective weld.

205 The welds are to be subjected to visual inspection, dye penetrant testing and ultrasonic- or X-ray testing.

The requirements to quality level for imperfections are to be as given in ISO 10042.2 level B.

206 Side-bend tests are to be carried out for thickness equal to and above 10 mm. Two bend specimens are to be taken from each of the welded assemblies.

对奥氏体铬-镍钢, 如设计温度低于-105℃, 仅要求进行3个缺口在焊缝中心线上的试样的冲击试验。

1107 对接焊缝的拉力试验应符合下述要求:

一般, 试样的抗拉强度不得小于母体材料规定的最小抗拉强度。如本社认可的焊接材料, 其全熔质的抗拉强度比母体材料要求的抗拉强度低, 则上述的焊接材料的认可值适用。裂缝的位置应列入报告。

1108 弯曲试样应能在直径为试样厚度4倍的靠模上承受180°的弯曲。弯曲试验后, 如在外表面上没有出现超过3mm大小的裂纹或其他缺陷, 则该试验视为合格。

1109 夏比V缺口冲击试验应在母体材料规定的温度下进行, 见第5篇第5章第2节。

当采用10×10mm截面试样时, 对焊缝处3次试验的平均功值应不小于27J, 其中一次试验的功值可低于规定的平均值但不得小于19J。

对熔合线和热影响区, 所要求的最小平均功值与母体材料的规定相同, 只允许一个值低于规定平均值, 但不得小于该值的70%。

对于不可能使用10×10mm标准试样的薄型材料, 其试验, 可采用下述较大的试样:

10×7.5mm、10×5mm、10×2.5mm。

因此他们的冲击功值, 可分别降低到标准试样规定值的5/6、2/3和1/2。

C. 铝材的焊接工艺

C 100 一般要求

101 液化气系统要求在发证说明NO.2.1上作出具体说明。

102 拟入DNV船级社船级的所有船体和结构物的重要接头, 均要求具有合格的焊接工艺。工艺试验可用下述内容表述:

- 用于生产的每种母体材料/合金和热处理
- 上述材料的厚度和直径范围(见表B2和B3)
- 每种焊接材料和焊接工艺
- 焊接位置(见表C1)
- 接头/坡口设计
- 焊接道数
- 予热情况(如有)
- 电压-电流特性
- 保护气体。

表 C1 合格的对接焊缝和填角焊缝的主要位置

试验焊缝接头 结构形式	主要位置	认可位置 ¹⁾		
		板材对接焊缝	管材对接焊缝	填角焊缝
板材对接焊缝	1G	1G	1G	1F
	2G	1G、2G、3G		1F、2F、3F
	3G	1G、2G、3G		1F、2F、3F
	4G	全部		全部
管材对接焊缝	1G	1G	1G	1F
	2G	1G、2G、3G	2G	1F、2F、3F
	5G	全部	1G、5G	全部
填角焊缝	1G			1F
	2G			1F、2F、3F
	3G			1F、2F、3F
	4G			全部
	5G			全部

1) 对垂直下行焊接位置应单独检验

C 200 对接焊缝的WPQT

201 每个试件由两块尺寸为300×150mm的板组成。该试板应采用纵向对接焊连接。对挤压成形的型钢和管子, 其试件由每根长150mm的型钢组成(见图13和14)。

202 按生产时采用的工艺进行的施焊, 应采用如表C2推荐的焊接材料。

203 接头结构形式应与施焊时拟采用的接头的结构形式一致。

204 如要求进行封底焊时, 则对各次焊接, 其封底焊应布置在同一位置。

205 焊缝应进行目视检验、着色渗透试验和超声波或X射线试验。缺陷的质量等级要求应符合ISO10042.2 B级的水平。

206 试件厚度>10mm, 应进行侧弯试验, 应从每个焊制的试件截取2个弯曲试样。

Base Metal Alloy	NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	NV-5083 NV-5383	NV-6060, NV-6061 NV-6063, NV-6005A NV-6082
NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183
NV-5083, NV-5383	5356, 5556, 5183	5183 ¹⁾	5356, 5556, 5183
NV-6060, NV-6061 NV-6063, NV-6005A NV-6082	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183

Note:
All consumables here are covered by the AWS specification. The prefix «ER» is omitted.
1) Other consumables may be used if allowable stresses are reduced, see Table C4.

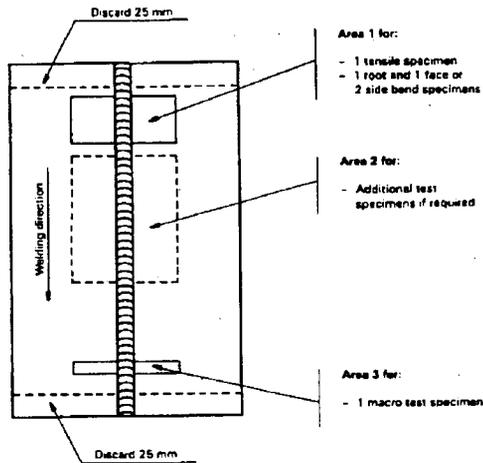


Fig. 13
Location of test specimens for a butt weld on plate

207 For thickness below 10 mm one face bend and one root bend test specimens are to be taken. The width is to be 30 mm and the thickness equal to the plate thickness. The diameter of the bending mandrel is to be as given in Table C3.

Base metal alloy	Condition			
	0, H111	H116, H32, H321, H34	T4	T5, T6
NV-5052, NV-5754 NV-5154, NV-5454	4t	4t	-	-
NV-5086, NV-5083, NV-5383	6t	6t	-	-
NV-6060, NV-6061 NV-6063, NV-6005A NV-6082	-	-	6t	7t

208 Requirement:
No cracks or open defects exceeding 3 mm measured on the convex surface after bending are accepted. Smaller cracks developing from the edges of the specimens are not normally considered as significant, unless there is definite evidence that they result from inclusions or other defects.
«Wrap around» bending as shown in Fig.15 is the preferred bending method.

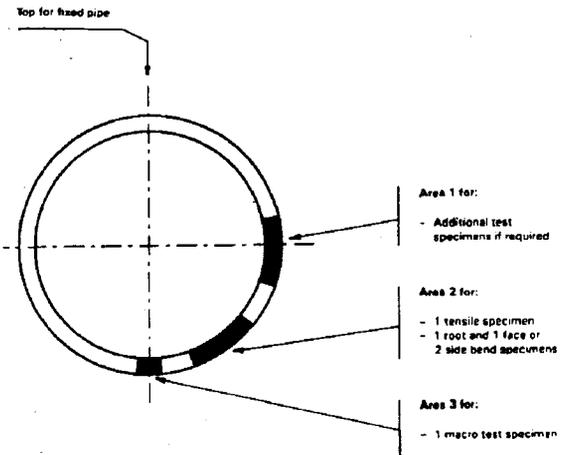


Fig. 14
Location of test specimens for a butt weld in pipe

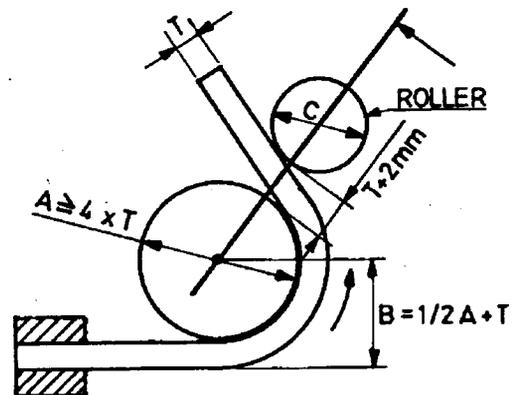


Fig. 15
«Wrap around» bending

209 One tensile specimen is to be taken from each of the welded assemblies. The test specimen, 25 mm wide and with full plate thickness and orientated transverse to the weld, is shown in Fig.16.

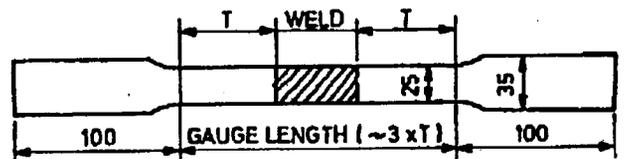


Fig. 16
Tensile test specimen

表 C2 适合铝合金连接用的焊接材料的选用

母体金属合金	NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	NV-5083 NV-5383	NV-6060, NV-6061 NV-6063, NV-6005A NV-6082
NV-5052, NV-5754 NV-5154, NV-5454 NV-5086	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183
NV-5083, NV-5383	5356, 5556, 5183	5183 ¹⁾	5356, 5556, 5183
NV-6060, NV-6061 NV-6063, NV-6005A NV-6082	5356, 5556, 5183	5356, 5556, 5183	5356, 5556, 5183

说明:

AWS 规定复盖了表中所有的焊接材料, 其前缀《ER》省略。

1) 如许用应力减小也可采用其他焊接材料, 见表 C4。

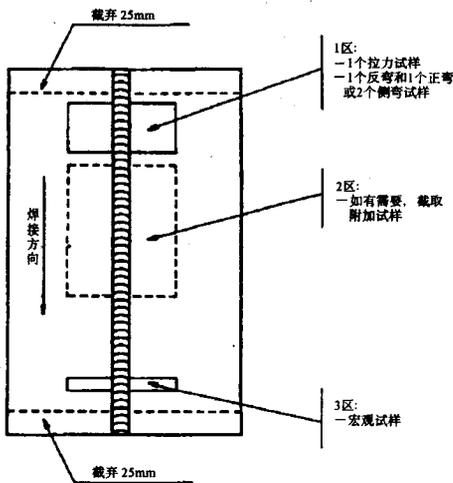


图 13 板材对接焊缝试样位置

207 对厚度小于 10mm 的试样, 应截取 1 个正弯试样和 1 个反弯试样。这些试样的宽度应为 30mm, 厚度等于板厚, 其弯曲芯棒直径应符合表 C3 的规定:

表 C3 弯曲试验芯棒直径

母体合金金属	条件			
	0, H111	H116, H32 H321, H34	T4	T5, T6
NV-5052, NV-5754 NV-5154, NV-5454	4t	4t	-	-
NV-5086, NV-5083, NV-5383	6t	6t	-	-
NV-6060, NV-6061 NV-6063, NV-6005A NV-6082	-	-	6t	7t

208 要求:

弯曲后在凸表面上没有出现超过 3mm 大小的裂纹和显著缺陷, 则认为合格。在试样的边缘上出现较小的裂纹, 通常认为是无关重要的。除非有充分的证据证实裂纹是由于夹渣或其他缺陷所引起的。

图 15 所示的《缠绕》弯曲是推荐的弯曲试验法。

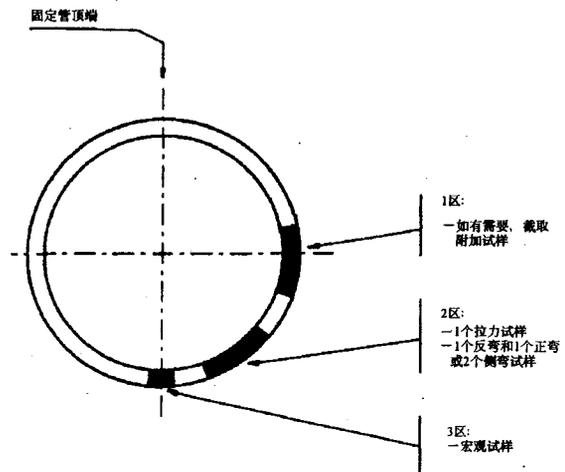


图 14 管材对接焊缝试样位置

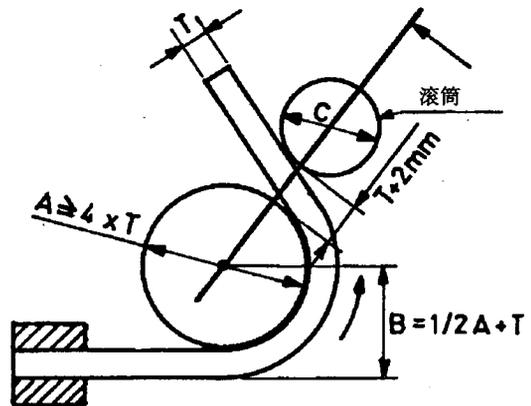


图 15 《缠绕》弯曲

209 从每个焊制的试件中截取 1 个拉力试样。该试样 25mm 宽, 整个板厚, 且横切焊缝, 如图 16 所示。

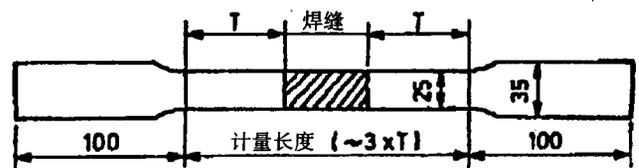


图 16 拉力试样

210 The tensile strength of the test specimens is not to be less than specified for the parent alloy in Table C4.

211 One macrosection is to be prepared from the test assembly to reveal the weldment macro structure. The macrosection is to be visually inspected using a magnification of 5 to 10X. The macrosection is to show a regular weld profile with a smooth transition to the base material without significant undercut or excessive reinforcement and show thorough fusion between adjacent layers of weld metal and base metal. There are to be no cracks, lack of fusion and incomplete penetration.

C 300 WPQT for fillet welds

301 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.

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.

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 % surface crack detection (dye penetrant).

The soundness of the weld is to comply with ISO 10042.2 level B.

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.

303 The following tests are to be performed:

2 macrosection tests (metallographic examination).

One of the macrosections is to be taken at the marked position of the stop/restart (for more details see B307).

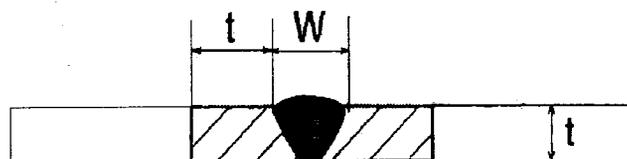
C 400 Retesting

401 If any of the tests do not satisfy the specified requirements, new procedure tests in duplicate may be carried out. The results of both retests are to meet the specified requirements, otherwise the test is to be rejected.

C 500 HAZ softening adjacent to welds

501 The strength of a weldment is a function of the welding process, filler metal and the aluminium alloy in question. For design purposes it is assumed that around each weld there is a zone, the HAZ, in which the strength is reduced. The extent of the HAZ is assumed to have the same width as the weldment plus the plate thickness in each direction of the weld as shown in Fig.17.

If the yield strength is to be measured for information this is to be carried out on a gauge length $2t + W$ of the weld (approximately 3 t).



t = plate thickness
W = width of weld

Fig. 17
Extent of HAZ

210 试样的抗拉强度应不小于表 C4 母体合金材料的规定值。

211 从试件上制备一个宏观分段截面以显示焊件的宏观结构。应将该宏观分段截面在放大 5~10 倍后, 进行目视检验。该宏观分段截面应显示出规则的焊缝形状并顺利地过渡到母体材料而没有显著的削底或过份的补强, 并在全熔质和邻近的母体金属之间显示出完全的熔合。没有开裂、熔合的缺陷和未焊透的情况。

C 300 填角焊缝的 WPQT

301 把两块板组装起来时, 把一块的边缘放在另一块上, 从而形成没有间隙的 T 型试件。该试板应尽可能有足够大的尺寸以保证热量能合理散布。

填角焊试件应按图 9 规定制备。

对手工焊或半自动焊, 其试样的长度应为:

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

对自动焊, 其试样的长度应为:

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

应按焊接工艺规程进行施焊和装配。

试件仅要求进行单面焊。对手工焊和半自动焊, 终止/重新起焊点通常应包括在试件长度内并应标出明显的标志以备后续的检验。

试样两端在 50mm 长度上可免于检验。

302 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 % 表面裂纹探测(着色渗透试验)

焊缝的坚固性应符合 ISO10042.2B 级要求。

如终止/重新起焊点被包括在试件长度内, 则应特别注意该处的形状、是否熔合良好和不存在凹陷的缺陷。

303 应进行下述试验:

2 个宏观分段截面试验(金相图检查);

其中一个宏观分段截面应在标志有终点/重新起焊点处截取(详见 B307)

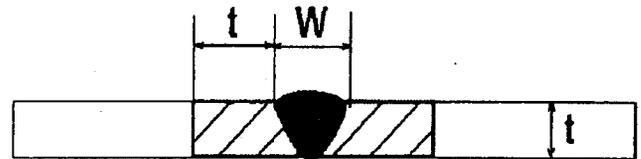
C 400 重复试验

401 如试验结果有任何未符合规定的要求, 则应进行两次重复试验, 两次重复试验结果均应符合规定要求, 否则该试验拒收。

C 500 邻近焊缝的热影响区(HAZ)的软化

501 焊件的强度是焊接工艺、填充金属和上述铝合金的函数。就设计而言, 假定每个焊缝的周围有一个热影响区, 在热影响区内其强度是降低了。热影响区范围假定是焊缝的宽度加上焊缝的每个方向的板厚, 如图 17 所示。

当进行测量屈服强度以供参考时, 应在计量长度 $2t + \text{焊缝 } W$ (约 $3t$) 范围内进行该测量。



t = 板厚

w = 焊缝宽度

图 17 热影响区(HAZ)范围

Table C4 Mechanical properties in the welded condition

Alloy	Temper	Filler	Tensile strength R_m , minimum (N/mm^2)	Yield strength in HAZ, $R_{p0.2}$ minimum (N/mm^2)
NV-5052	0,F, H111, H32, H34	5356	170	65
NV-5754	0,F, H111, H24	5356-5183	190	80
NV-5154A	0, H111	5356-5183	215	85
NV-5454	0,F, H111, H34,	5356-5183	215	85
NV-5086	0,F, H111, H116, H32, H34	5356-5183	240	100
NV-5083	0, F t < 6 mm	5183	270	125
	0, F t > 6mm	5356-5183	270	115
	H116, H321	5356	270	115
	H116, H321	5183	270	125
NV-5383	0, H111, H116, H321	5183	290	140
NV-6060	T5	5356-5183	95	65
NV-6061	T4	5356-5183	165	115
	T5 or T6		165	115
NV-6063	T5	5356-5183	100	65
	T6		100	65
NV-6005A	T5 or T6	5356-5183	165	115
NV-6082	T4 T5 or T6	5356-5183	170	110
			170	115

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

D 100 General

101 Welding shops which intend to build welded cargo tanks, parts of hull structure, process pressure vessels or piping systems in Ferritic-Austenitic stainless steels are to carry out WPQT for all types of butt welds and essential fillet welds in the construction. See Ch.3 Sec.1.

102 The WPQT's are to cover all relevant dimensions, positions and material combinations. Details regarding essential variables, validity of the procedure and mechanical testing are to be as described in B with additional requirements as listed in 200.

D 200 Additional testing

201 Butt welds and fillet welds are to be corrosion tested according to ASTM G48-76 Method A. The test specimen is to be in the as welded state after normal weld cleaning operation. The test specimens are to be exposed to the solution at a constant temperature of 20°C for 24 hours.

Test requirements :

- no pitting attack is to be visible on the test face(s)
- general weight loss is not to exceed 20 mg.

Guidance note:

Welds between Ferritic-Austenitic steels and other grades of stainless or C/Mn steels may not need to be corrosion tested.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e---

202 Impact testing as described in B300. Impact test temperature -20°C. The average value for absorbed energy is not to be less than 27 J.

203 Microstructural examination

The test samples are to comprise the weld metal, heat affected zone and base metal. The microstructure is to be

suitably etched and examined at 400X magnification and is to be free from grain boundary carbides and precipitates.

The ferrite content in the weld metal root and unheated weld cap is to be determined in accordance with ASTM E 562 and be in the range of 25-70%.

D 300 Validity of a qualified welding procedure

301 Reference is made to B900 and any change in the following additional essential variables which are to lead to a new qualification :

- variation in the heat input greater than $\pm 15\%$.

E. Approval of Welders

E 100 General

101 These requirements apply to the Society's approval of welders for fusion welding of steel and non-ferrous metals. The welding processes for which qualifications are required include those which are designated as manual or partly mechanized welding. Welders are to pass an approval testing in accordance with 200. Yards and workshops are required to keep records of the welders' qualifications and, when required, furnish copies of valid welders' certificates.

102 Welding operators using fully mechanized or fully automatic processes need generally not pass an approval testing. However, operators are to receive adequate training in setting or programming and operating the equipment. Appropriate records of training are to be maintained. Yards and workshops may be required to furnish valid approval test certificates.

E 200 Standards for approval testing

201 Welders are to be tested to a standard recognised by the Society, e.g. EN 287, ISO 9606, ASME Section IX, ANSI/AWS D1.1.