SMS group

Manufacturing instructions
Welding

SN 200-4

ICS 25.160

IMPORTANT !
Please note the corresponding correction/revision !

Supersedes SN 200-4:2016-05

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Introduction

The manufacturing requirements specified in this part of SN 200 are used to achieve the relevant SMS product quality. Consequently, these requirements must always be satisfied unless otherwise stipulated in drawings, purchase order documents, and/or other manufacturing documents. This standard is indicated as a binding document in drawings (title blocks), contracts and/or purchase order documents. If the requirements cannot be fulfilled, SMS group must be consulted.

Edited by:
SMS group
Standards Office

1 Scope

This company standard specifies for SMS group the demands on the production plant, the filler metals, execution of welding on machine-building and fluid-carrying components, heat treatment and inspection of parts produced by welding processes and used as starting material for and/or manufacturing material in products of SMS group.

2 Normative references

The following documents quoted herein either in whole or in part, are required for the application of the present document. Dated references refer only to the edition of the date indicated. Undated references refer to the most recent edition of the respective document inclusive of all revisions.

DIN 2559-2:2007-09	Edge preparation for welding – Part 2: Matching of inside diameter for circumferential welds on seamless pipes
DIN 2559-3:2007-09	Preparation of welds – Part 3: Matching of inside diameters for circumferential welds on welded pipes
DIN 2559-4:1994-07	Preparation of welds – Part 4: Matching of inside diameters for circumferential welds on seamless pipes of stainless steels
DIN 8555-1:1983-11	Filler metals used in surfacing - Solid wires; filler rods, wire electrodes - Designation, technical delivery conditions
DIN 50104:1983-11	Testing of hollow bodies by internal pressure; leak detection up to a certain pressure value; General specifications
DIN EN 1011-1:2009-07	Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding
DIN EN 1011-2:2001-05	Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels
DIN EN 1090-2	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures
DIN EN 10204:2005-01	Metallic products – Types of inspection documents
DIN EN 12502-4:2005-03	Protection of metallic materials against corrosion – Guidance on the assessment of corrosion likelihood in water distribution and storage systems – Part 4: Influencing factors for stainless steels Influencing factors for stainless steels.
DIN EN 13480-5	Metallic industrial piping – Part 5: Inspection and testing
DIN EN 14700	Welding consumables – Welding consumables for hard-facing
DIN EN ISO 2553:2019-12	Welding and allied processes - Symbolic representation on drawings - Welded joints
DIN EN ISO 2560	Welding consumables - Covered electrodes for manual metal arc welding of non-alloy and fine grain steels - Classification
DIN EN ISO 3581	Welding consumables - Covered electrodes for manual metal arc welding of stainless and heat-resisting steels - Classification
DIN EN ISO 3834-3:2021-08	Quality requirements for fusion welding of metallic materials - Part 3: Standard quality requirements
DIN EN ISO 4063:2011-03	Welding and allied processes; Nomenclature of processes and reference numbers
DIN EN ISO 5817:2014-06	Welding; Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels of imperfections
DIN EN ISO 6520-1:2007-11	Welding and allied processes - Classification of geometric imperfections in metallic materials - Fusion welding
DIN EN ISO 9606-1	Qualification testing of welders - Fusion welding - Part 1: Steels
DIN EN ISO 9692-1:2013-12	Welding and allied processes – Types of joint preparation – Part 1: Manual metal-arc welding, gas -shielded metal-arc welding, gas welding, TIG welding and beam welding of steels
DIN EN ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel
DIN EN ISO 10675-1	Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys
DIN EN ISO 11666	Non-destructive testing of welds - Ultrasonic testing - Acceptance levels
DIN EN ISO 13588	Non-destructive testing of welds - Ultrasonic testing - Use of automated phased array technology

DIN EN ISO 13916:2018-03	Welding – measurement of preheat temperature, interpass temperature and preheat maintenance temperature
DIN EN ISO 13920:1996-11	Welding; General tolerances for welded constructions; Dimensions for lengths, and angles, shape and position
DIN EN ISO 14341	Welding consumables - Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels - Classification
DIN EN ISO 14731	Welding coordination – Tasks and responsibilities
DIN EN ISO 15607	Specification and qualification of welding procedures for metallic materials - General rules
DIN EN ISO 15609-1	Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding
DIN EN ISO 15611	Specification and qualification of welding procedures for metallic materials; Qualification based on previous welding experience
DIN EN ISO 15612	Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure
DIN EN ISO 15614-1	Specification and qualification of welding procedures for metallic materials - Welding procedure test – Part 1: Arc welding and gas welding of steels and arc welding of nickel and nickel alloys
DIN EN ISO 16826	Non-destructive testing, ultrasonic testing, examination for discontinuities perpendicular to the surface
DIN EN ISO 16828	Non-destructive testing, ultrasonic testing, time-of-flight diffraction technique as a method for detection and sizing of discontinuities
DIN EN ISO 17635	Non-destructive examination of welds; General rules for metallic materials
DIN EN ISO 17636-1	Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film
DIN EN ISO 17636-2	Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors
DIN EN ISO 17637	Non-destructive testing of welds – Visual testing of fusion-welded joints
DIN EN ISO 17638	Non-destructive testing of welds, Magnetic particle testing
DIN EN ISO 17640	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment
DIN EN ISO 19879	Metallic tube connections for fluid power and general use - Test methods for hydraulic fluid power connections
DIN EN ISO 20378	Welding consumables - Rods for gas welding of non-alloy and creep-resisting steels - Classification
DIN EN ISO 23277	Non-destructive testing of welds – Penetrant testing of welds - Acceptance levels
DIN EN ISO 23278	Non-destructive testing of welds - Magnetic particle testing of welds - Acceptance levels
DIN EN ISO 23279	Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds

ISO 10474:2013-03 Steel and steel products - Inspection documents

DVS-data sheet (Technical Bulletin) 3011 Welding of ferritic-austenitic steel joints

DVS-data sheet (Technical Bulletin) 0937 Root shielding in gas-shielded welding

SN 200-1 Manufacturing Instructions - Requirements and principles
SN 200-8 Manufacturing Instructions - Inspection
SN 402 Surfacing

3 Requirements to be fulfilled by the manufacturing contractor

As a rule, the requirements for welding shops must be fulfilled according to DIN EN ISO 3834-3.
The basic allocations of the respective requirements can be found in Table 1.

In the event that a workshop does not fulfill the requirements listed in Table 1, other national or international regulations/approvals are also recognized. Proof of their equivalence shall be furnished by the workshop before the beginning of manufacture. Manufacturing work shall not start before the proof of equivalence has been examined and written approval granted by a responsible person from SMS group.

Components subject to the Construction Products Regulation 305/2011/EU are identified by drawing indication taking into account the execution classes (EXC1 to 4) according to DIN EN 1090-2 or country-specific standards/regulations. If different or additional requirements are made (e.g. Pressure Equipment Directive 2014/68 EU etc.), these requirements are indicated in the manufacturing documents. As a rule, these requirements must be fulfilled by the workshop.

Table 1 - Qualification of the supplier according to DIN EN ISO 3834-3

Welding activities	
Welding procedure specifications (DIN EN ISO 15609-1)	Requirements and qualification of welding procedures according to DIN EN ISO 15609-1. Valid welding procedure specification / WPS must be available.
Qualification of welding procedures (DIN EN ISO 15607, DIN EN ISO 15611, DIN EN ISO 15612, DIN EN ISO 15614-1)	Requirements and qualification of welding procedures according to DIN EN ISO 15607 for general rules
	Qualification on the basis of existing previous welding experience according to DIN EN ISO 15611
	Qualification by adoption of a standard welding procedure according to DIN EN ISO 15612
	Qualification record based on a welding procedure test/WPQR according to DIN EN ISO 15614-1. **Note:** A WPQR shall be presented only upon request by SMS group.
Welding personnel	
Welding supervisors (DIN EN ISO 14731)	Performance of welding supervision according to DIN EN ISO 14731. The SMS group must be informed of the appointment of a responsible person. The welding supervisor must verify each welder's quality of performance without prior notice. The welding supervisor shall be present during the entire welding procedure. The inspection must be carried out on components from the current production and be documented by indicating the date of inspection, name of the welder, name of the examiner, type of welding, type of inspection carried out and result of the inspection.
Welders and operators (DIN EN ISO 9606-1)	Valid qualification tests of welders according to DIN EN ISO 9606-1 must be available. A welder may only carry out welding work that is covered by the scope of his certificates. A qualification certificate shall be renewed at least every three years. A qualification certificate continues to be valid if the welding supervisor confirms that the welder has worked with the required quality within the original scope. This must be confirmed by the welding supervisor on the qualification certificate every six months.
Personnel for supervision and inspection	
Personnel of non-destructive testing (DIN EN ISO 9712)	Qualified personnel according to DIN EN ISO 9712 must be available.

4 Filler metals

4.1 Basic specifications

Filler metals require approval on the basis of suitability testing. All filler metals shall be stored and handled with care and in compliance with DIN EN 1011-1: 2009-07, item 6.1, and DIN EN 1011-2: 2001-05, item 7
Detailed information on the properties of suitable filler metals can be found in the following standards:
DIN 8555-1:1983-11 (remains valid for SMS group), DIN EN ISO 3581, DIN EN ISO 20378, DIN EN 14700, DIN EN ISO 2560 and DIN EN ISO 14341.

4.2 Ferritic-austenitic steel joints

Ferritic-austenitic steel joints are mixed joints established between unalloyed or alloyed structural steels, on the one hand, and austenitic chromium-nickel steels, on the other hand, by welding with CrNi (Mn, Mo) filler metals.
Mixed joints between steels and nickel or nickel alloys are also regarded as black-white joints because of the use of filler metals on nickel basis. Mixed joints shall be welded in accordance with the specific regulations (e.g. the Technical Bulletin DVS 3011), and the filler metals used must be approved for the given material combination.

5 Welding on machine-building components

5.1 Weld preparation

5.1.1 Basic specifications

The weld preparation (preparation angle, root face thickness etc.) shall be carried out by the workshop in charge as required for the welding process applied according to section 5.1.3. The use of weld types other than those indicated on the drawing are allowed only upon agreement with and written approval by SMS group.
Prior to assembling, the surfaces in the weld area shall be cleaned to remove scale, slag, rust, paint, oil, grease, electro-deposited (e.g. zinc) coats, and moisture. It must be checked and ensured that the weld preparation corresponds to the required weld thickness specified on the drawing.
In order to avoid stray welding currents and their effects (e.g. destruction of electrical ground conductors), the welding current return line must be connected directly to the workpiece to be welded, or to the holder provided for the workpiece (e.g. welding table, welding grids, assembly plates).
Steel structures, rails, pipe lines, bars and similar objects shall not be used as current conductors unless they are the workpiece to be welded.
Tack-welds shall be at least 40 mm long. All cracks, lack-of-fusion spots and clusters of pores in tack welds shall be removed before welding. Trough plates shall be welded oil-tight.

5.1.2 Preheating of weldable steels

The welding areas shall be pre-heated as required for the respective material composition. The minimum pre-heat temperature shall be determined according to DIN EN 1011-2: 2001-05 on the basis of the carbon equivalent CET. When multi-pass welds are used, the term “minimum pre-heat temperature” is synonymous with the term “minimum interpass temperature”. The measuring of the pre-heat, interpass and maintenance temperatures shall be in accordance with DIN EN ISO 13916: 2018-03.

This formula can be used up to a C content of ≤ 0.5

$$CET = C + \frac{Mn + Mo}{10} + \frac{Cr + Cu}{20} + \frac{Ni}{40} \quad \text{in (\%)}$$

5.1.3 Weld preparation selection

The weld preparation shall be selected according to Table 2 based on DIN EN ISO 9692-1:2013-12.

Table 2 - Weld preparation for butt welds (extract from DIN EN ISO 9692-1:2013-12)

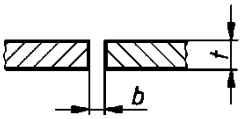
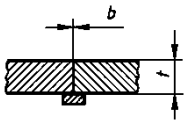
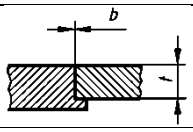
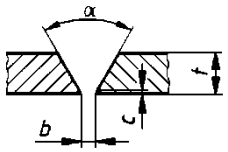
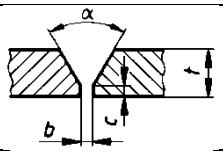
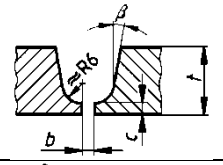
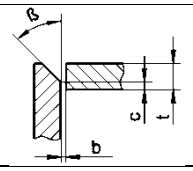
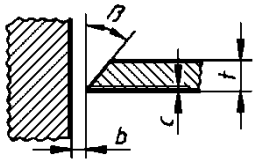
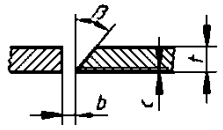
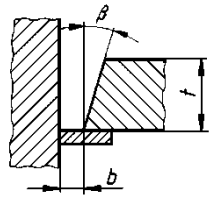
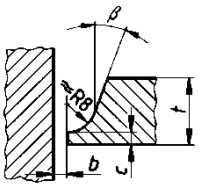
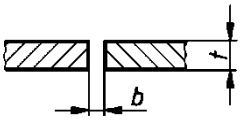
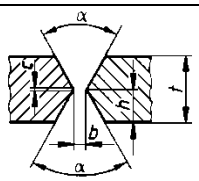
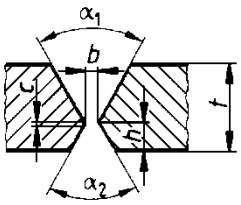
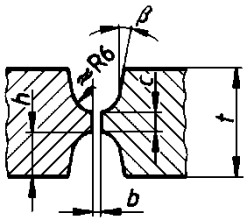
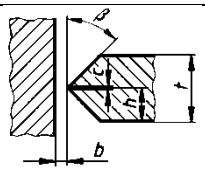
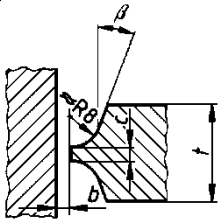
Weld				Edge form					Recommended welding process (as per ISO 4063) [b]	Remarks
Ref. No.	Material thickness t	Designation	Symbol (as per ISO 2553)	Cross-section	Dimensions: Angle α, β	Dimensions: Gap *b*	Dimensions: Root face thickness *c*	Dimensions: Groove face height *h*		
1.2.1	≤ 4	Square groove			-	b ≈ t	-	-	3 111 141	-
1.2.2	3 < t ≤ 8					6 ≤ b ≤ 8 ≈ t			13 141	with backing strip
	≤ 15					≤ 1 0			52	
1.2.3	≤ 100	Square groove with backing strip	-		-	30 [a]	-	-	51 72 [a]	-
1.2.4		Square groove with centering lip	-							
1.3	3 ≤ t ≤ 10	V-groove			40° ≤ α ≤ 60°	≤ 4	≤ 2	-	3 111 13 141	with backing strip, if necessary
	8 < t ≤ 12				6° ≤ α ≤ 8°	-			52	
1.5	5 ≤ t ≤ 40	Single-V groove with broad root face			α ≈ 60°	1 ≤ b ≤ 4	2 ≤ c ≤ 4	-	111 13 141	-
1.8	> 12	Single-U groove			8° ≤ β ≤ 12°	≤ 4	≤ 3	-	111 13 141	-
[a] -	10 ≤ t ≤ 25	Single-bevel groove			35° ≤ β ≤ 60°	2 ≤ b ≤ 4	1 ≤ c ≤ 2	-	-	-
1.9.1	3 < t ≤ 10	Single-bevel groove			35° ≤ β ≤ 60°	2 ≤ b ≤ 4	1 ≤ c ≤ 2	-	111 13 141	-
1.9.2										
1.10	> 16	Steep-flanked single bevel groove			15° ≤ β ≤ 60°	6 ≤ b ≤ 12	-	-	111	with backing strip
						≈ 12			13 141	

Table 2 – Weld preparation for butt welds (extract from DIN EN ISO 9692-1:2013-12) (continued)

Weld				Edge form					Recommended welding process (as per ISO 4063) [b]	Remarks
					Dimensions					
Ref. No.	Material thickness t	Designation	Symbol (ISO 2553)	Cross-section	Angle α, β	Gap *b*	Root face thickness *c*	Groove face height *h*		
1.11	> 16	Single-J groove			$10° \le \beta \le 20°$	$2 \le b \le 4$	$1 \le c \le 2$	-	111 13 141	-
2.1	≤ 8	Square groove			-	$\approx \frac{t}{2}$	-	-	111 141	-
	≤ 15					$\le \frac{t}{2}$ 0	-	-	13 52	
2.5.1	> 10	Double-V groove (X groove)			$\alpha \approx 60°$	$1 \le b \le 3$	≤ 2	$\approx \frac{t}{2}$	111 141	-
					$40° \le \alpha \le 60°$				13	
2.5.2	> 10	Asymmetrical double-V groove			$\alpha_1 \approx 60°$ $\alpha_2 \approx 60°$	$1 \le b \le 3$	≤ 2	$\approx \frac{t}{3}$	111 141	
					$40° \le \alpha_1 \le 60°$ $40° \le \alpha_2 \le 60°$				13	
2.7	≥ 30	Double-U groove			$8° \le \beta \le 12°$	≤ 3	≈ 3	$\approx \frac{t-c}{2}$	111 13 141	This groove can also be asymmetrical, similar to asymmetrical double-V groove
2.9.1	> 10	Double-bevel groove (K-groove)			$35° \le \beta \le 60°$	$1 \le b \le 4$	≤ 2	$h = \frac{t}{2}$ or $h = \frac{t}{3}$	111 13 141	
2.9.2										
2.11	> 30	Double-J groove			$10° \le \beta \le 20°$	≤ 3	≥ 2	$= \frac{t-c}{2}$	111 13 141	
							< 2	$\approx \frac{t}{2}$		

[a] SMS group specification
[b] See Annex C (normative)

5.2 Stiffening with ribs and webs

Stiffening with ribs and webs shall be made according to the variants shown in figures Fig. 1 and Fig. 2. The dimension R in Table 3 has been specified big enough to allow welding through underneath the stiffening rib. The kind of stiffening is shown on the drawings without dimensioning. If the radii and/or the widths of the stiffening plates as per Table 3 are below the permitted values (e.g. when they are attached to sections such as IPB beams, channel sections, etc. or in the event of multi-plate joints), the stiffening plates must be adapted to the contours of the sections in a way that full welding of the stiffening is possible in order to meet the requirements according to DIN EN ISO 12944-3:2018-04, Sections 5.8 and 5.9.

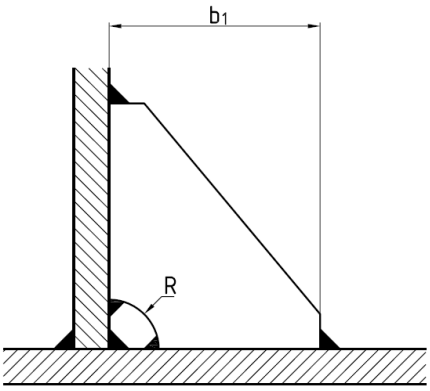


Fig. 1 - Stiffening variant 1

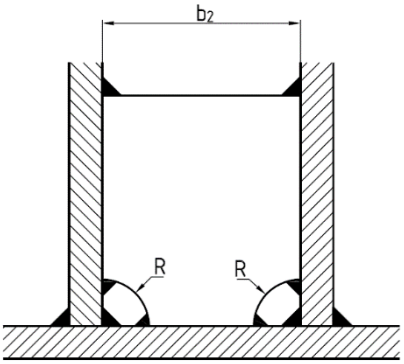


Fig. 2 - Stiffening variant 2

Table 3 – Dimensions of the stiffenings (dimensions in mm)

Plate thickness of the rib	R	b_1 min.	b_2 min.
≥ 10 to ≤ 40	50	100	200
> 40 to ≤ 70	60	125	250
> 70 bis ≤ 150 [a)]	70		
[a)] Dimensions ≥ 150 mm are indicated on the drawing.			

5.3 Execution of welds

5.3.1 Basic specifications

All welds shall be executed according to DIN EN ISO 5817:2014-06, quality level D.
Welds on lifting tackles shall be executed according to quality level C or B depending on the drawing indication by the designer. The welds shall be closed around all corners. Shrinkage stresses resulting from the welding on of parts on one side shall be compensated by counterheating.
Joints on load-bearing components (e.g. lifting lugs) must not be executed as ferritic-austenitic steel (black-white) joints (see 4.2). Other execution needs examination and written approval by the SMS group design department in the individual case.
Auxiliary welds used for stiffening elements, lifting eyes etc. shall be completely removed. The surfaces of the areas concerned shall be ground without marks. Grinding shall not reduce the wall thickness to a dimension below the required wall thickness.

5.3.2 Welds with geometric full penetration

Welds requiring geometric full penetration are specified by the indication (symbol and/or dimension) of the designer at the weld.
If a quality level differing from the SMS group standard level D according to DIN EN ISO 5817:2014-06 is required (e.g. for lifting tackles), the requisite quality level shall be indicated at the weld.
If required for the quality level, the root of geometrically fully penetrated welds on two sides shall be gouged, checked for cracks and counterwelded.

5.3.2.1 Butt weld

In butt welds, the lines of force run with uniform stress distribution.
If no cross-section dimensions are specified for butt welds according to DIN EN ISO 2553:2019-12, full-penetration welding is always required. This means that butt welds shall have geometric full penetration.

5.3.2.2 Additionally required weld joints

Additionally required weld joints are weld joints for plates and sections of the same shape that are not provided in the drawings and need prior consultation with and written approval by the responsible design engineer. Such additional weld joints shall comply with quality level B as in DIN EN ISO 5817:2014-06 and have full penetration.

5.3.3 Plug welding

Plug welding is allowed only for plate thicknesses ≤ 40 mm. The hole diameter corresponds to the plate thickness, but shall be at least 20 mm.

5.3.4 Buildup welding

The individual welds shall be executed according to DIN EN ISO 5817:2014-06, quality level D, limited to the imperfections Nos. 1.1, 1.2, 2.3 to 2.6, and 2.12 according to Table A.1. Surface pores < 2mm are allowed.

5.3.5 Slot welding

The slot width b, see Fig. 3, depends on the plate thicknesses t_1 and t_2 and on the necessary weld junction,
with $t_1 \leq 15$ mm, b min. is 0.5 x t_1 but at least 4 mm,
with $t_1 > 15$ mm, b min. is 15 mm

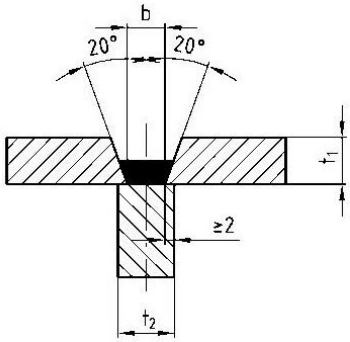


Fig. 3- Slot welding

5.3.6 Weld reinforcement

The max. weld reinforcement (*ü*) is determined by the weld quality, see Fig. 4 and Table 4.

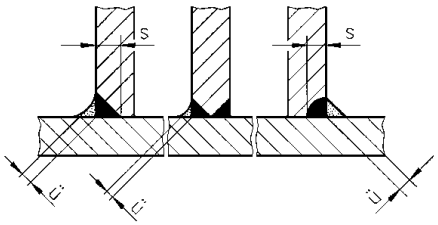


Fig. 4 – Weld reinforcement

Table 4 – Calculation of the weld reinforcement

Quality level [a)]	Calculation of weld reinforcement
D	0.10 to 0.3 × weld depth (s)
B and C	0.15 to 0.3 × weld depth (s)
[a)] Quality levels according to DIN EN ISO 5817:2014-06	

5.3.7 Thickness of fillet welds

In fillet welds the lines of force are diverted. The weld execution according to Fig. 5 is assumed.
Dimension (*a*) depends on the thinner of the two parts to be joined and shall not exceed 12 mm.
Contrary to DIN EN ISO 2553:2019-12, the designation (a) for fillet weld thickness is not used in drawings of SMS group.
Deviating weld thicknesses are indicated on the drawings.
If the inner joint of a two-sided joint is not accessible and cannot be welded, the design department shall be consulted. The fillet weld shall be executed as follows (SMS group specific):

Fillet welds on both sides *a* = 0.3 x thinnest plate thickness, but max. 12 mm;

Fillet welds on one side *a* = 0.6 x thinnest plate thickness, but max. 12 mm

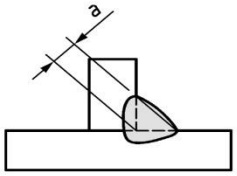


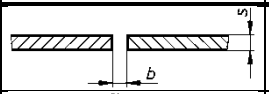
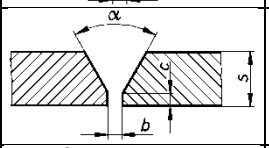
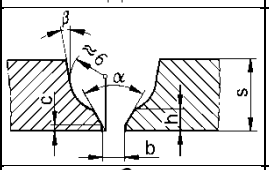
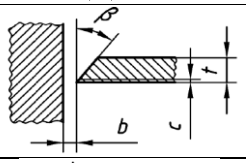
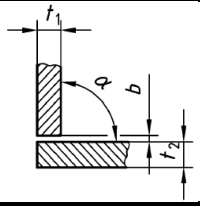
Fig. 5– Throat thickness

6 Welding on fluid-carrying components

6.1 Weld preparation

The surfaces in the weld areas of fluid-carrying components such as pipe lines and vessels, must be cleaned to remove scale, slag, rust, paint, oil, grease and moisture prior to assembling. Cracks, lack-of-fusion areas and clusters of pores in tack welds must be removed before welding over. The weld preparation (preparation angle, root face thickness etc.) shall be carried out by the workshop in charge as required for the welding process to be applied. Deviations from the drawing indications are allowed only if the specified weld-depth and weld-quality requirements are fulfilled.
The weld preparation for butt joints and corner joints is made according to Table 5. This is an SMS group specific regulation.
For the edge misalignment on joints established between pipes of different wall thicknesses, the values of the required quality level apply according to DIN EN ISO 5817:2014-06, imperfection No. 3.1, related to the smaller wall thickness. If the edge misalignment exceeds the permissible values, a tapered transition of ≤ 10° is required, refer to DIN 2559-2 and -3:2007-09 and DIN 2559-4:1994-07.

Table 5 – Welding seam preparation for butt and corner joints

Wall thickness s	Designation	Symbol (ISO 2553:1992-10)	Groove shapes Section	α	β	Root opening [a] b	Web height c	Groove face height h
				Degrees				
up to 2	Square butt weld			-	-	0 to 3	-	-
Over 2 to 25	Single-V butt weld			≈ 60	-	2 to 4	up to 2	-
Over 25	U-butt weld on V-root			≈ 60	≈ 15	2 to 3	2	≈ 4
All	Single-bevel butt weld			-	-	-	-	-
All (permitted only up to max. PN 25)	Fillet weld			-	-	-	-	-

[a] The dimensions apply to the tack-welded condition.

6.2 Execution of the weld

6.2.1 Basic specifications

All butt welds shall be made as specified in section 5.3.2.1. Weld seams on fluid-carrying components shall be made to quality level D for pressure stages ≤ 2,5 MPa and to quality level C for pressure stages > 2,5 MPa as in DIN EN ISO 5817:2014-06. In case of particular requirements, the weld shall be made to quality level B according to the designer's specification irrespective of the pressure stage.

Welding spatter is not allowed on the inner walls of pipelines. It is therefore recommended using TIG welding for the root pass.
For pipes with an outside diameter of ≤ 25 mm, the reduction of pipe cross-section due to root reinforcement of the weld (refer to Table 12 No. 1.11) must not exceed 20 %, and for pipes with an outside diameter of > 25 mm, it must not exceed 15 %, related to the cross-section of flow of the pipe.
Compliance with the above shall be ensured by visual inspection and, if necessary, excess reinforcement shall be removed, e.g. by grinding.
All welds in the interiors of vessels and chambers shall be continuous welds without interruption.
All welds shall be produced in several layers provided that this is allowed by the wall thickness.
For manual arc welding on HP pipes in the interpass and final pass areas, only basic (*b*) electrodes shall be used.
Auxiliary welds used for stiffening elements, lifting eyes etc. shall be completely removed. The surfaces of the areas concerned shall be ground without notches and suitably checked for the absence of cracks.
Grinding shall not reduce the wall thickness to a dimension below the required wall thickness.

6.2.2 Fluid-carrying components in steel

For pressures ≤ 2.5 MPa, all corner joints shall be made at least as fillet welds, for pressures > 2.5 MPa, single-bevel butt welds shall be used.
Note:
In case of TIG welding for root welding on pipeline joints the use of a forming gas is recommended.

6.2.3 Fluid-carrying components in stainless and acid-resistant steel

The corrosion probability of stainless and acid-resistant steels which are exposed to water can be considerably reduced when gaps are avoided in design and welding, see DIN EN 12502-4:2005-03. A gap width over 0.5 mm and a gap depth of less than half the gap width can usually be regarded as uncritical.
Pipelines in stainless and acid-resistant steels shall be flooded with forming gas (e.g. N = 90%, H = 10% or Ar = 90%) both during tack-welding and welding of the root pass (observe Technical Bulletin DVS 0937).

7 Heat treatment

7.1 Basic specifications

Distortion caused by shrinkage stresses shall be compensated by counterheating.
Postweld heat treatment (e.g. stress relief annealing) required for functional reasons shall be indicated on the drawing by the designer.
Postweld heat treatment required for reasons of manufacturing sequence (e.g. stresses resulting from machining) shall be made/arranged for by the workshop in charge.
Heat treatment on quenched and tempered steels shall be made at temperatures 20 to 30 K (Kelvin) below the tempering temperature. The contracting workshop shall obtain information on the tempering temperature used for the material.
Heat treatment required from a welding viewpoint shall be carried out by the manufacturing shop in its own responsibility.
All heat treatments shall be documented by a heat treatment diagram and a record.
The use of other methods of stress relief (e.g. vibratory stress relief) shall be previously agreed with SMS group.
Safety instruction:
When postweld heat treatment is made, the welding shop shall open all hermetically closed hollows prior to annealing by drilling a 10 mm round hole in a suitable place on the neutral axis, even if such measure is not expressly indicated on the drawing. After heat treatment, these round holes shall be closed again. When plates are welded on, a short section shall be left without weld and then closed by welding after heat treatment.

7.2 Non-alloy structural steels

The annealing temperature shall be between 560 °C and 600 °C, for S355, it shall not be higher than 580 °C.
The heating rate shall not exceed 50 K per hour.
The holding time shall be at least 1 minute for each millimeter of workpiece thickness (e.g. 120 minutes for 120 mm thickness).
The cooling rate should not exceed 50 K per hour.

7.3 Austenitic steels

Austenitic steels shall never be heat-treated.
Postweld heat treatment is allowed only in justified cases and upon consultation with and written approval by SMS group.
The heat treatment data such as annealing temperature, holding time, cooling rate shall be agreed upon with SMS group.

7.4 Mixed joints

For heat treatment on black-and-white compounds (see also Technical Bulletin DVS 3011), the regulations specified in section 7.3 apply.
If a component for which stress relief annealing is required has to be provided with non-detachable austenitic steel parts, these parts shall be welded on after annealing.

8 General tolerances

The general tolerance classes to be applied are specified in Table 6 and Table 7. They correspond to the general tolerances of DIN EN ISO 13920:1996-11.

8.1 Linear dimensions

The tolerances of tolerance class *B* stated in Table 6 apply to linear dimensions (external dimensions, inside dimensions, stepped dimensions, widths and central lengths).

Table 6 - Longitudinal dimensional tolerances

Tolerance class	Nominal dimension range										
	2 to 30	> 30 to 120	> 120 to 400	> 400 to 1000	> 1000 to 2000	> 2000 to 4000	> 4000 to 8000	> 8000 to 12000	> 12000 to 16000	> 16000 to 20000	> 20000
B	± 1	± 2	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 14	± 16

8.2 Straightness, flatness and parallelism

The tolerances of tolerance class *F* stated in Table 7 apply to the overall dimensions of a welded part, a welded assembly and to partial lengths.

Table 7 – straightness, flatness and parallelism tolerances

Tolerance class	Nominal dimension range (longer lateral length of the surface)									
	> 30 to 120	> 120 to 400	> 400 to 1000	> 1000 to 2000	> 2000 to 4000	> 4000 to 8000	> 8000 to 12000	> 12000 to 16000	> 16000 to 20000	> 20000
F	1	1.5	3	4.5	6	8	10	12	14	16

8.3 Angular dimensions

For the tolerances on angular dimensions, the shorter leg is used as reference leg. The leg length can also be measured from a particular reference point; in this case the point shall be shown on the drawing, examples are given in Fig. 6. For the conversion of angular dimensions into linear dimensions for measuring purposes, the limits of size of the angles in Table 8 are additionally indicated as tangent values. The maximum permissible deviation in mm is calculated from the tangent value multiplied by the length of the shorter leg.

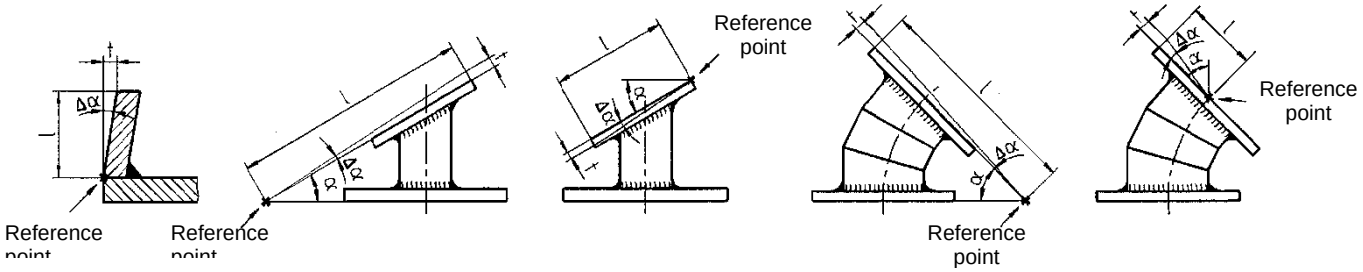


Fig. 6 – Examples of angular tolerances

Table 8 – Angular dimensional tolerances

Tolerance class	Nominal dimension range (length of the shorter leg)					
	Up to 400	> 400 to 1000	> 1000	Up to 400	> 400 to 1000	> 1000
	Permissible deviations in degrees and minutes			Permissible deviations in tangent values		
B	± 0°45'	± 0°30'	± 0°20'	0.013	0.009	0.006

9 Inspection

9.1 Basic specifications

The inspections in the following sections shall be carried out by the welding shop. Before an inspection is carried out, the specifications according to DIN EN ISO 17635 must be observed. When intermediate inspection is specified, the readiness for such inspection shall be reported to the quality assurance department of SMS group. Dimensions having closer tolerances than the general tolerances in section 8 require the documentation of the inspection with indication of the desired and the actual dimensions.
Pressure or leak tests shall be documented with indication of kind of testing, test pressure, testing time and pressure fluid.
When there is no suitable method of non-destructive testing to prove the quality of the weld and the flow cross-section, the acceptance inspector of our quality inspection department reserves the right to sever the pipelines at suitable points for inspection of those welds which are not visible from outside.
Internal two-dimensional imperfections arranged perpendicular to the the test area are difficult to detect by means of the usual angular sound incidence with single-element probes. In case of such imperfections, special examination methods (e.g. tandem examination as per DIN EN ISO 16826, phased array DIN EN ISO 13588, TOFD EN ISO 16828 etc.) can be chosen. The use of these examination techniques shall be stipulated in a specification. This applies in particular to welds in thick-walled components. The use of these special examination techniques will be separately agreed/specified between SMS group and the supplier.
In general the acceptance limits of DIN EN ISO 11666 also apply to welds with geometric full penetration with a thickness of more than 100 mm.
If no complaints are found, the required scope of inspection can be reduced after prior consultation and written approval with the SMS group Quality Inspection department. If complaints are made, the SMS group inspector may extend the scope of inspection to up to 100%.

9.2 Scope of inspection of machine components

Quality level D according to DIN EN ISO 5817:2014-06 is the SMS group standard level.
The limit values for irregularities are specified in Annex A (normative), table A.1 in the relevant the quality levels.
Observe the specifications according to Table 9 and Table 10.

Table 9 - Scope of inspection for welds without geometric full penetration

Limits for imperfections according to DIN EN ISO 5817		Required examinations [a]		
Quality level	**No.**	**Visual check (VT)**	**Ultrasonic testing (UT)**	**Crack testing (MT / PT)**
B (high)	All	100%	--	≥ 25 %
C (medium)				≥ 10 %
D (low)	all [b]			--

[a] The percentage indication of the scope of inspection refers to the length of each weld seam.
[b] For buildup welding, only Nos. 1.1, 1.2, 2.3 to 2.6 and 2.12 apply, see Annex A (normative), Table A.1

Table 10 - Scope of inspection for geometric full penetration welds

Limits for imperfections according to DIN EN ISO 5817		Required examinations [a]		
Quality level	**No.**	**Visual check (VT)**	**Ultrasonic testing (UT)**	**Crack testing (MT / PT)**
B (high)	All	100%	≥ 50 % [c]	≥ 50 % [c]
C (medium)			≥ 25 %	≥ 25 %
D (low)	all [b]		--	≥ 10 %

[a] The percentage indication of the scope of inspection refers to the length of each weld seam.
[b] except for Nos. 2.12 and 2.13 according to quality level C, see Annex A (normative), Table A.1
[c] The scope of inspection of ultrasonic, radiographic and surface crack testing of additionally required joints is 100 % of the weld and the heat-affected zone.

9.3 Scope of inspection on fluid-carrying components

The specifications mentioned in Table 11 must be observed.

Table 11 - Scope of inspection on weld seams on fluid-carrying components

Limits for imperfections according to DIN EN ISO 5817		Required for pressure stage	Required examinations [a]			
Quality level	No.		Visual check (VT)	X-ray testing [b] (RT)	Pressure test	Leak testing
B (high)	All	[d]	100%	≥ 25 %	[e]	
C (medium)		> 2.5 MPa		≥ 10 %		
D (low)	all [c]	≤ 2.5 MPa		--		

[a] The percentage indication refers to the number of welds with 100 % weld inspection.

[b] X-ray testing can be replaced by equivalent radiographic testing methods for testing the internal condition. These radiographic testing methods are required only if the contracting workshop has not secured and documented the qualification of its personnel by suitable statistical methods and procedures. Approval by SMS group must be obtained before the beginning of manufacture.

[c] Except for no. 2.13 according to quality level C, see Annex A (normative), Table A.1

[d] Quality level B shall be applied in case of particular requirements irrespective of the pressure stage.

[e] Only in exceptional cases. Pressure or leak tests are compulsory if:
- components consist of two or more separate chambers or hollows. Testing shall be made on every individual chamber or hollow.
- machining of weld seams has taken place. Upon previous consultation with and written approval by the SMS group department of quality inspection, crack detection can be used instead of leak tightness testing. A drawing indication is required.

9.4 Scope of inspection for load-bearing welds at lifting points

The specifications made in Table 12 apply to load-bearing welds at lifting points, e.g. lifting lugs, lifting trunnions, etc. Load-bearing welds are identified by the quality levels B and C indicated by the designer at the weld in the drawing. Inspection is made by partially grinding the seam prior to closing at the front side. If necessary, closed welds shall be opened for inspection at the front side.

Table 12 - Scope of inspection for load-bearing welds at lifting points

Limits for imperfections according to DIN EN ISO 5817		Required examinations [a]		
Quality level	No.	Visual check (VT)	Ultrasonic testing (UT)	Crack testing (MT / PT)
B (high)	All	100%	--	100 % [b]
C (medium)				

[a] The percentage indication of the scope of inspection refers to the length of each weld seam.

[c] Welded-on lifting points (e.g. lifting lugs, lifting trunnions) shall be examined by a 100 % crack testing of the weld seam and the heat-affected zone. The examination shall be in the form of magnetic particle testing and shall cover at least 10 % of all load-bearing partial penetration welds at the front face at a depth of s + 5 mm (weld depth + 5 mm) .

9.5 Documentation

All tests mentioned below shall be certified on the basis of DIN ISO 17635 and DIN EN ISO 5817 by an inspection certificate 3.1 DIN EN 10204:2005-01 and/or ISO 10474:2013-03:
- Visual testing (VT) according to DIN EN ISO 17637
- Ultrasonic testing according (UT) to DIN EN ISO 11666, DIN EN ISO 23279 and DIN EN ISO 17640
- Radiographic testing (RT) according to DIN EN ISO 10675-1 and DIN EN ISO 17636-1 and -2
- Magnetic particle testing (MT) according to DIN EN ISO 17638 and DIN EN ISO 23278
- Dye-penetrant testing (PT) according to DIN EN ISO 23277
- Pressure testing according to DIN EN 13480-5
- Leak detection according to DIN 50104:1983-11 and DIN EN ISO 19879

Annex A
(Normative)
Assessment of imperfections

A.1 Terms and definitions

For the purposes of table A.1, the following terms according to DIN EN ISO 5817:2014-06 apply:

Quality level

Description of the quality of a weld on the basis of type, size and quantity of selected imperfections.

Fitness-for-purpose

Ability of a product, process or service to serve a defined purpose under specific conditions.

Short imperfection

In welds of 100 mm length or more, imperfections are considered to be short imperfections when the total length of the imperfections is not greater than 25 mm in the 100 mm in which the most imperfections occur. In welds of less than 100 mm length, imperfections are considered to be short imperfections when the length of the imperfection does not exceed 25% of the weld length.

Systematic imperfections

Imperfections which are repeatedly distributed in the weld over the weld length to be examined, with the size of a single imperfection being within the specified limits of acceptance.

Projected area

Area in which the imperfections distributed throughout the volume of the weld under consideration are imaged in two-dimensional manner.

NOTE 1 to entry:
In contrast to the cross-sectional area, the occurrence of imperfections depends on the weld thickness when exposed radiographically; see figure A.1.

Key

1 direction of x-rays
2 4 pores per volume unit
3 6-fold thickness
4 3-fold thickness
5 2-fold thickness
6 1-fold thickness

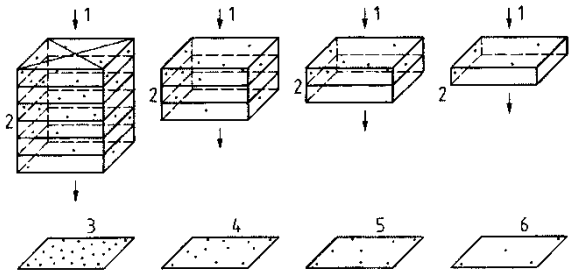


Fig. A.1 - Radiographic films of specimens with identical occurrence of pores per volume unit

A.2 Assessment of imperfections

Table A.1 shows the limits for imperfections for the quality levels as in DIN EN ISO 5817:2014-06.
If microscopic examination is used for the detection of imperfections, only those imperfections shall be considered which can be detected using at the most ten-fold magnification.

This does not apply to 1.5 micro lacks of fusion and 2.2 micro cracks according to table A.1. Systematic imperfections (for the definition, refer to Annex A, page 34) are only permitted in quality level D provided that other requirements according to table A.1 are fulfilled. Every weld shall be evaluated separately for every imperfection, see table A.1, Nos. 1.1 to 3.2. When different types of imperfections are found in a weld section, special evaluation is required, see table A.1, No. 4.1.

The evaluation limits for multiple imperfections shall be applied only if the requirements for the other imperfections are not exceeded.
Any two adjacent imperfections separated by a distance which is smaller than the major dimension of the smaller imperfection shall be regarded as one single imperfection.

The following symbols are used in table A.1:

a nominal throat thickness of the fillet weld (see also DIN EN ISO 2553)

A area surrounding the gas pores

b width of weld reinforcement

d diameter of gas pore

d_A diameter of area surrounding the gas pores

h height or width of imperfection

l length of imperfection in longitudinal direction of the weld

l_p length of the projected or cross-sectional area

s nominal butt weld thickness (see also DIN EN ISO 2553)

t wall or plate thickness (nominal size)

w_p width of the weld or width/height of a cross-sectional area

z leg-length of a fillet weld (see also DIN EN ISO 2553)

α angle of weld toe

β angle of angular misalignment

Table A.1 – Limits for imperfections

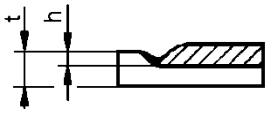
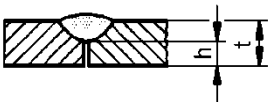
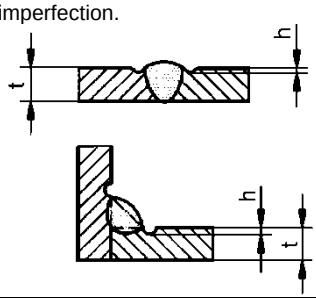
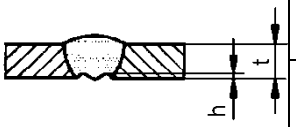
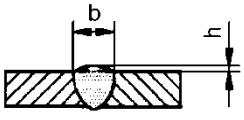
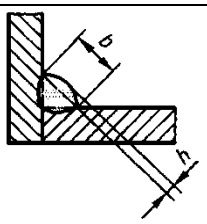
No.	Reference No. acc.to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
1 Surface imperfections							
1.1	100	Crack	-	≥ 0.5	Not permitted	Not permitted	Not permitted
1.2	104	Crater crack	-	≥ 0.5	Not permitted	Not permitted	Not permitted
1.3	2017	Surface pore	Maximum dimension of a single pore for - butt welds - fillet welds	0.5 to 3	d ≤ 0.3 s d ≤ 0.3 a	Not permitted	Not permitted
			Maximum dimension of a single pore for - butt welds - fillet welds	> 3	d ≤ 0.3 s, but max. 3 mm d ≤ 0.3 a, but max. 3 mm	d ≤ 0.2 s, but max. 2 mm d ≤ 0.2 a, but max. 2 mm	Not permitted
1.4	2025	End crater pipe		0.5 to 3	h ≤ 0.2 t	Not permitted	Not permitted
				> 3	h ≤ 0.2 t, but max. 2 mm	h ≤ 0.1 t, but max. 1 mm	Not permitted
1.5	401	Lack of fusion (incomplete fusion)	-	≥ 0.5	Not permitted	Not permitted	Not permitted
		Micro lack of fusion	Detectable only by micro examination		Permitted	Permitted	Not permitted
1.6	4021	Incomplete root penetration	Only for single-side butt welds 	≥ 0.5	Short imperfection: h ≤ 0.2 t, but max. 2 mm	Not permitted	Not permitted
1.7	5011 5012	Continuous weld undercut Intermittent weld undercut	Smooth transition is required. Not regarded as systematic imperfection. 	0.5 to 3	Short imperfection: h ≤ 0.2 t	Short imperfection: h ≤ 0.1 t	Not permitted
				> 3	h ≤ 0.2 t, but max. 1 mm	h ≤ 0.1 t, but max. 0.5 mm	h ≤ 0.05 t, but max. 0.5 mm
1.8	5013	Shrinkage groove	Smooth transition is required. 	0.5 to 3	h ≤ 0.2 mm + 0.1 t	Short imperfection: h ≤ 0.1 t	Not permitted
				> 3	Short imperfection: h ≤ 0.2 t, but max. 2 mm	Short imperfection: h ≤ 0.1 t, but max. 1 mm	Short imperfection: h ≤ 0.05 t, but max. 0.5 mm
1.9	502	Excess weld metal (butt weld)	Smooth transition is required. 	≥ 0.5	h ≤ 1 mm + 0.25 b, but max. 10 mm	h ≤ 1 mm + 0.15 b, but max. 7 mm	h ≤ 1 mm + 0.1 b, but max. 5 mm
1.10	503	Excessive convexity (fillet weld)		≥ 0.5	h ≤ 1 mm + 0.25 b, but max. 5 mm	h ≤ 1 mm + 0.15 b, but max. 4 mm	h ≤ 1 mm + 0.1 b, but max. 3 mm

Table A.1 – (continued) **Limit values for imperfections**

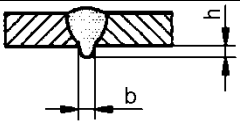
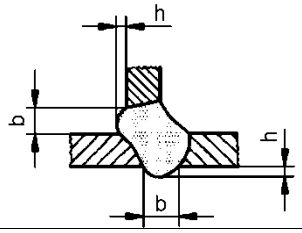
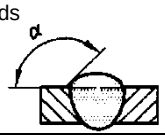
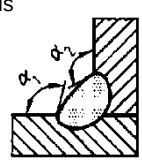
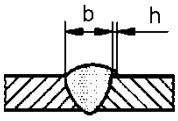
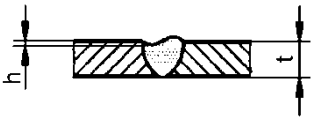
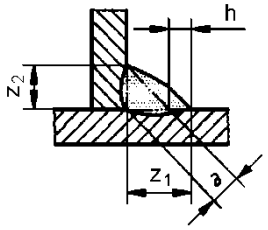
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
1.11	504	Excess penetration		0.5 to 3	h ≤ 1 mm + 0.6 b	h ≤ 1 mm + 0.3 b	h ≤ 1 mm + 0.1 b
				> 3	h ≤ 1 mm + 1.0 b but max. 5 mm	h ≤ 1 mm + 0.6 b but max. 4 mm	h ≤ 1 mm + 0.2 b but max. 3 mm
1.12	505	Incorrect weld toe	- butt welds 	≥ 0.5	α ≥ 90°	α ≥ 110°	α ≥ 150°
			- fillet welds  $a_1 \geq \alpha$ $a_2 \geq \alpha$	≥ 0.5	α ≥ 90°	α ≥ 100°	α ≥ 110°
1.13	506	Overlap		≥ 0.5	h ≤ 0.2 b	Not permitted	Not permitted
1.14	509	Sagging	Smooth transition is required. 	0.5 to 3	Short imperfection: h ≤ 0.25 t	Short imperfection: h ≤ 0.1 t	Not permitted
	511	Incompletely filled groove		> 3	Short imperfection: h ≤ 0.25 t but max. 2 mm	Short imperfection: h ≤ 0.1 t but max. 1 mm	Short imperfection: h ≤ 0.05 t but max. 0.5 mm
1.15	510	Burn through	-	≥ 0.5	Not permitted	Not permitted	Not permitted
1.16	512	Excessive fillet weld asymmetry (excessive unequal leg length)	In cases where an asymmetric fillet weld has not been specified 	≥ 0.5	h ≤ 2 mm + 0.2 a	h ≤ 2 mm + 0.15 a	h ≤ 1.5 mm + 0.15 a

Table A.1 – (continued) **Limit values for imperfections**

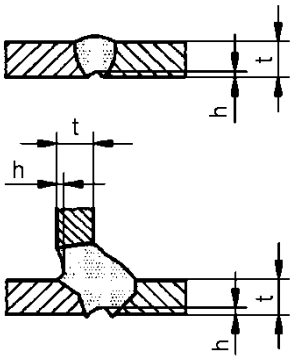
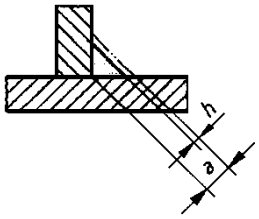
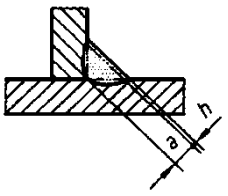
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
1.17	515	Root concavity	Smooth transition is required. 	0.5 to 3	h ≤ 0.2 mm + 0.1 t	Short imperfection: h ≤ 0.1 t	Not permitted
				> 3	Short imperfection: h ≤ 0.2 t, but max. 2 mm	Short imperfection: h ≤ 0.1 t, but max. 1 mm	Short imperfection: h ≤ 0.05 t, but max. 0.5 mm
1.18	516	Root porosity	Spongy formation of weld root due to bubbling of weld metal at the moment of solidification (e.g. lack of gas backing)	≥ 0.5	Locally permitted	Not permitted	Not permitted
1.19	517	Poor restart	-	≥ 0.5	Permitted. The limit depends on the type of imperfection occurred due to restart.	Not permitted	Not permitted
1.20	5213	Insufficient throat thickness	Not applicable to processes with proof of greater depth of penetration. 	0.5 to 3	Short imperfection: h ≤ 0.2 mm + 0.1 a	Short imperfection: h ≤ 0.2 mm	Not permitted
				> 3	Short imperfection: h ≤ 0.3 mm + 0.1 a but max. 2 mm	Short imperfection: h ≤ 0.3 mm + 0.1 a but max. 1 mm	Not permitted
1.21	5214	Excessive throat thickness of fillet weld	The actual throat thickness of the fillet weld is too big. 	≥ 0.5	Permitted	h ≤ 1 mm + 0.2 a, but max. 4 mm	h ≤ 1 mm + 0.15 a, but max. 3 mm
1.22	601	Stray arc	-	≥ 0.5	Permitted if parent-metal properties are not affected.	Not permitted	Not permitted
1.23	602	Welding spatter	-	≥ 0.5	Acceptance depends on application, e.g. material, corrosion protection		

Table A.1 – (continued) **Limit values for imperfections**

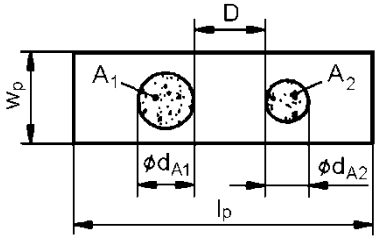
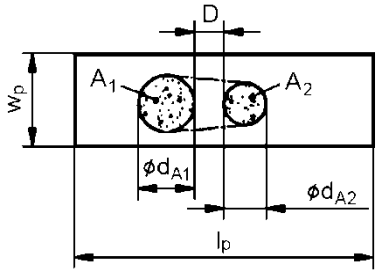
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	C	B
2 Internal imperfections							
2.1	100	Crack	All types of cracks, except microcracks and crater cracks	≥ 0.5	Not permitted	Not permitted	Not permitted
2.2	1001	Microcrack	A crack usually only visible under the microscope. (50 x).	≥ 0.5	Permitted	Acceptance depends on type of parent metal, in particular on crack sensitivity.	
2.3	2011 2012	Pore porosity (uniformly distributed)	The following conditions and limits for imperfections must be fulfilled; see also DIN EN ISO 5817:2014-06 Annex B for information: a1) Maximum dimension of the area of the imperfections (inclusive of systematic imperfection) related to the projected area NOTE The porosity in the projected area depends on the number of layers (volume of the weld)	≥ 0.5	Single layer: ≤ 2.5% For multi-layer: ≤ 5%	Single layer: ≤ 1.5% For multi-layer: ≤ 3%	Single layer: ≤ 1% For multi-layer: ≤ 2%
			a2) Maximum dimension of the cross-sectional area of the imperfections (incl. of systematic imperfection) related to the fracture area (only applicable to production test, welder or procedure qualification tests)	≥ 0.5	≤ 2.5%	≤ 1.5%	≤ 1%
			b) Max. dimension of a single pore for - butt welds - fillet welds	≥ 0.5	d ≤ 0.4 s, but max. 5 mm d ≤ 0.4 a, but max. 5 mm	d ≤ 0.3 s, but max. 4 mm d ≤ 0.3 a, but max. 4 mm	d ≤ 0.2 s, but max. 3 mm d ≤ 0.2 a, but max. 3 mm
2.4	2013	Clustered (localized) porosity	Case 1 ($D > d_{A2}$)  Case 2 ($D < d_{A2}$)  The total of the various porosity areas ($A_1 + A_2 + \ldots$) related to the evaluation area $l_p \times w_p$ (case 1). The reference length for l_p is 100 mm. If D is smaller than d_{A1} or d_{A2}, with the lower value being applicable here, the envelope curve enclosing the clustered porosity areas $A_1 + A_2$ shall be regarded as one area of the imperfection (case 2).				

Table A.1 – (continued) **Limit values for imperfections**

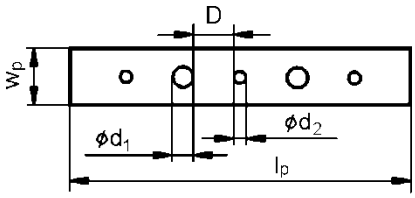
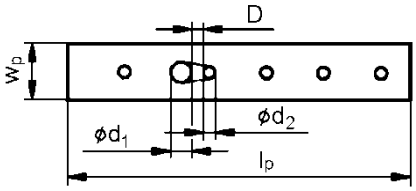
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
2.4	2013	Clustered porosity	The following conditions and limit values for imperfections shall be fulfilled; see also DIN EN ISO 5817:2014-06; Annex A for information:				
			a) Maximum dimension of the summation of the projected area of the imperfection (incl. of systematic imperfection)	≥ 0.5	≤ 16%	≤ 8 %	≤ 4 %
			b) Max. dimension of a single pore for	≥ 0.5			
			- butt welds - fillet welds		d ≤ 0.4 s, but max. 4 mm d ≤ 0.4 a, but max. 4 mm	d ≤ 0.3 s, but max. 3 mm d ≤ 0.3 a, but max. 3 mm	d ≤ 0.2 s, but max. 2 mm d ≤ 0.2 a, but max. 2 mm
2.5	2014	Linear porosity	Case 1 ($D > d_2$)  Case 2 ($D < d_2$)  The summation of the different pore areas $\left(\frac{d_1^2 \cdot \pi}{4} + \frac{d_2^2 \cdot \pi}{4} + \ldots\right)$ related to the evaluation area l_p x w_p (case 1). When D is smaller than the smallest diameter of a neighboring pore, the envelope area of the two pores shall be considered the sum of the imperfection (case 2). The following conditions and limits for imperfections shall be fulfilled; see also DIN EN ISO 5817: 2014-06; Annex A for information:				
			a1) Max. dimension of the surface imperfections (incl. of systematic imperfection) related to the projected area NOTE: The porosity in the projected area depends on the number of layers (volume of the weld)	≥ 0.5	Single layer: ≤ 8% Multi-layer: ≤ 16%	Single layer: ≤ 4% Multi-layer: ≤ 8%	Single layer: ≤ 2% Multi-layer: ≤ 4%
			a2) Maximum dimension of the cross-sectional area of the imperfections (incl. of systematic imperfection) related to the fracture area (only applicable to production test, welder or procedure qualification tests)	≥ 0.5	≤ 8 %	≤ 4 %	≤ 2 %
			b) Max. dimension of a single pore for - butt welds - fillet welds	≥ 0.5	d ≤ 0.4 s, but max. 4 mm d ≤ 0.4 a, but max. 4 mm	d ≤ 0.3 s, but max. 3 mm d ≤ 0.3 a, but max. 3 mm	d ≤ 0.2 s, but max. 2 mm d ≤ 0.2 a, but max. 2 mm

Table A.1 – (continued) **Limit values for imperfections**

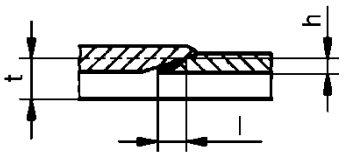
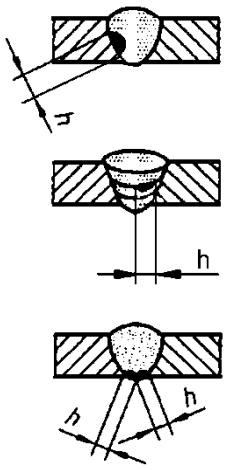
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
2.6	2015 2016	Elongated cavity Wormhole	- butt welds	≥ 0.5	h ≤ 0.4 s, but max. 4 mm l ≤ s, but max. 75 mm	h ≤ 0.3 s, but max. 3 mm l ≤ s, but max. 50 mm	h ≤ 0.2 s, but max. 2 mm l ≤ s, but max. 25 mm
			- fillet welds	≥ 0.5	h ≤ 0.4 a, but max. 4 mm l ≤ a, but max. 75 mm	h ≤ 0.3 a, but max. 3 mm l ≤ a, but max. 50 mm	h ≤ 0.2 a, but max. 2 mm l ≤ a, but max. 25 mm
2.7	202	Shrinkage cavity	-	≥ 0.5	Short imperfection permitted, but not breaking of the surface - butt welds: h ≤ 0.4 s, but max. 4 mm - fillet welds: h ≤ 0.4 a, but max. 4 mm	Not permitted	Not permitted
2.8	2024	Crater pipe	 The bigger of the dimensions h or l shall be measured.	0.5 to 3 > 3	h or l ≤ 0.2 t h or l ≤ 0.2 t but max. 2 mm	Not permitted	Not permitted
2.9	300 301 302 303	Solid inclusion Slag inclusion Flux inclusion Oxide inclusion	- butt welds	≥ 0.5	h ≤ 0.4 s, but max. 4 mm l ≤ s, but max. 75 mm	h ≤ 0.3 s, but max. 3 mm l ≤ s, but max. 50 mm	h ≤ 0.2 s, but max. 2 mm l ≤ s, but max. 25 mm
			- fillet welds	≥ 0.5	h ≤ 0.4 a, but max. 4 mm l ≤ a, but max. 75 mm	h ≤ 0.3 a, but max. 3 mm l ≤ a, but max. 50 mm	h ≤ 0.2 a, but max. 2 mm l ≤ a, but max. 25 mm
2.10	304	Metallic inclusion other than copper	- butt welds	≥ 0.5	h ≤ 0.4 s, but max. 4 mm	h ≤ 0.3 s, but max. 3 mm	h ≤ 0.2 s, but max. 2 mm
			- fillet welds	≥ 0.5	h ≤ 0.4 a, but max. 4 mm	h ≤ 0.3 a, but max. 3 mm	h ≤ 0.2 a, but max. 2 mm
2.11	3042	Copper inclusion	-	≥ 0.5	Not permitted	Not permitted	Not permitted
2.12	401 4011 4012 4013	Lack of fusion (incomplete fusion) Lack of side wall fusion Lack of inter-run fusion Lack of root fusion		≥ 0.5	Short imperfection permitted. - butt welds: h ≤ 0.4 s, but max. 4 mm - fillet welds: h ≤ 0.4 a, but max. 4 mm	Not permitted	Not permitted

Table A.1 – (continued) **Limit values for imperfections**

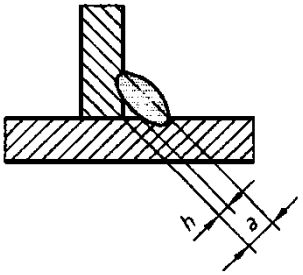
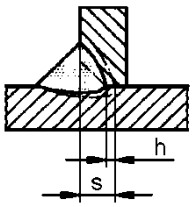
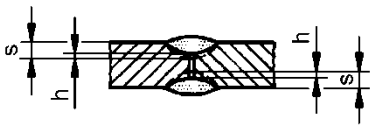
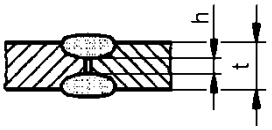
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
2.13	402	Lack of penetration	 T-joint (fillet weld)	> 0.5	Short imperfection: $h \leq 0.2\ a$, but max. 2 mm	Not permitted	Not permitted
			 T-joint (partial penetration)	≥ 0.5	Short imperfection: - butt joint: $h \leq 0.2\ s$, but max. 2 mm - T-joint: $h \leq 0.2\ a$, but max. 2 mm	Short imperfection: - butt weld: $h \leq 0.1\ s$, but max. 1.5 mm - fillet weld: $h \leq 0.1\ a$, but max. 1.5 mm	Not permitted
			 Butt joint (partial penetration)				
			 Butt joint (full penetration)	≥ 0.5	Short imperfection: $h \leq 0.2\ t$, but max. 2 mm	Not permitted	Not permitted

Table A.1 – (continued) **Limit values for imperfections**

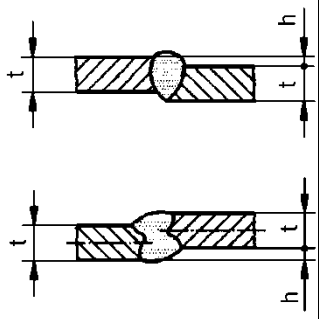
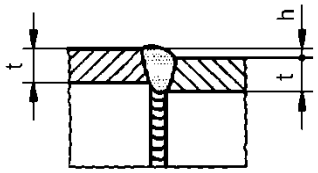
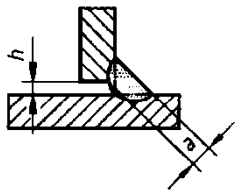
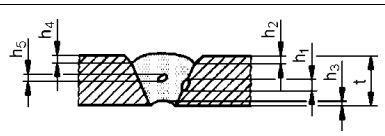
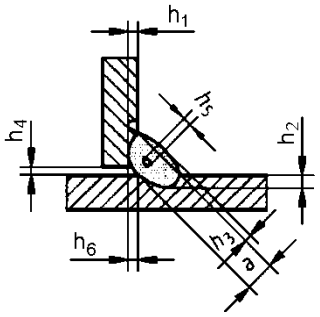
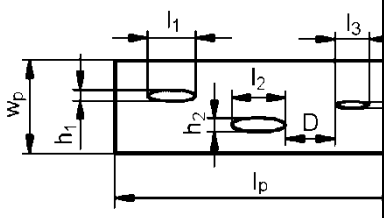
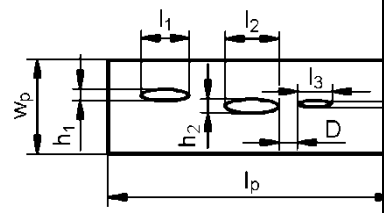
No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
3 Imperfections in joint geometry							
3.1	507	Linear misalignment	The limits relate to deviations from the correct position. Unless otherwise specified, the position is correct if the centerlines are coincident. t refers to the smaller thickness.  Fig. A: Plates with longitudinal welds	0.5 to 3	h ≤ 0.2 mm + 0.25 t	h ≤ 0.2 mm + 0.15 t	h ≤ 0.2 mm + 0.1 t
				> 3	h ≤ 0.25 t, but max. 5 mm	h ≤ 0.15 t, but max. 4 mm	h ≤ 0.1 t, but max. 3 mm
			 Fig. B: Circumferential welds	≥ 0.5	h ≤ 0.5 t, but max. 4 mm	h ≤ 0.5 t, but max. 3 mm	h ≤ 0.5 t, but max. 2 mm
3.2	617	Incorrect root gap for fillet welds	A gap between the parts which are joined. Gaps exceeding the permitted limit may in special cases be compensated by appropriate additional fillet weld thickness.  	0.5 to 3	h ≤ 0.5 mm + 0.1 a	h ≤ 0.3 mm + 0.1 a	h ≤ 0.2 mm + 0.1 a
				> 3	h ≤ 1 mm + 0.3 a, but max. 4 mm	h ≤ 0.5 mm + 0.2 a, but max. 3 mm	h ≤ 0.5 mm + 0.1 a, but max. 2 mm

Table A.1 – (continued) **Limit values for imperfections**

No.	Reference No. acc. to ISO 6520-1	Imperfection Designation	Remarks	t mm	Limits for imperfections for quality level D	 C	 B
4 Multiple imperfections							
4.1	None	Multiple imperfections in any cross-section [a]	 $h_1 + h_2 + h_3 + h_4 + h_5 = \sum h$	0.5 up to 3	Not permitted	Not permitted	Not permitted
			 $h_1 + h_2 + h_3 + h_4 + h_5 = \sum h$	> 3	Maximum total height of imperfections $\sum h \leq 0.4\ t$ or $\leq 0.25\ a$	Maximum total height of imperfections $\sum h \leq 0.3\ t$ or $\leq 0.2\ a$	Maximum total height of imperfections $\sum h \leq 0.2\ t$ or $\leq 0.15\ a$
4.2	None	Projected or cross-sectional area in longitudinal direction	Case 1 ($D > l_3$)  $h_1 \times l_1 + h_2 \times l_2 + h_3 \times l_3 = \sum h \times l$ Case 2 ($D < l_3$)  $h_1 \times l_1 + h_2 \times l_2 + \sum\left(\frac{h_2 + h_3}{2}\right) + h_3 \times l_3 =$				
			The sum of the areas $\sum h \times l$ shall be calculated as a percentage of the evaluation area $l_p \times w_p$ (case 1). If D is smaller than the shorter length of one of the neighbouring imperfections, the full connection of the two imperfections shall be applied to the sum of imperfections (case 2). NOTE: For information see also DIN EN ISO 5817:2014-06, Annex A.	≥ 0.5	$\sum h \times l \leq 16\ \%$	$\sum h \times l \leq 8\ \%$	$\sum h \times l \leq 4\ \%$

[a] see Annex A (normative)

Annex B
(informative)
Representation of weld joints on drawings

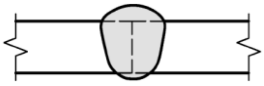
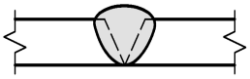
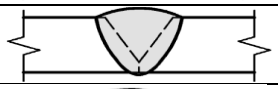
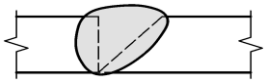
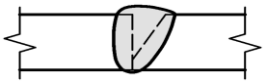
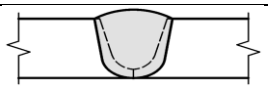
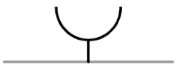
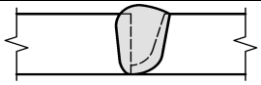
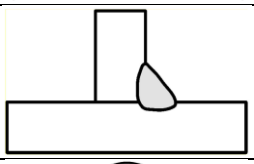
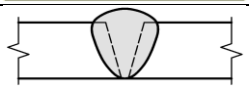
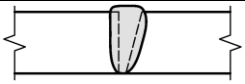
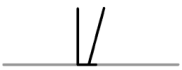
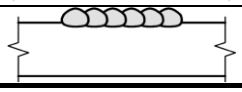
B.1 Indication of welding symbols on drawings

The following welding symbols are shown and used on the basis of DIN EN ISO 2553:2019-12.

B.1.1 Elementary symbols for weld categories

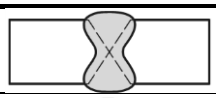
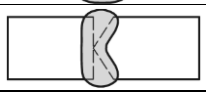
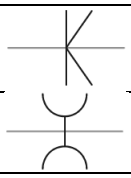
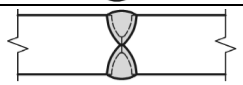
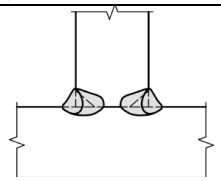
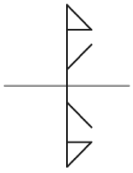
The various weld categories are each characterized by a symbol which, in general, is similar to the shape of the weld to be produced. The symbols characterize the shape, preparation and execution of the weld, see table B.1. The symbols do not determine the welding process to be used. Where necessary, combinations of elementary symbols are used for representation.
Typical examples are given in table B.2.

Table B.1 – Elementary symbols (extract from DIN EN ISO 2553:2019-12)

No.	Identification marking	**Weld representation** (dashed lines show the weld preparation before welding)	**Symbol** [a]
1	I-weld [b]		
2	Single-V butt weld [b]		
3	Single-V butt weld with broad root face [b]		
4	Single bevel butt weld [b]		
5	Single bevel butt weld with broad root face [b]		
6	U-weld [b]		
7	Single-J butt weld; J-groove weld [b]		
10	Fillet weld		
17	Steep-flanked single-V butt weld [b]		
18	Steep-flanked single-bevel butt weld [b]		
21	Surfacing		

[a] The grey line is not part of the symbol. It shows the position of the reference line.
[b] Butt welds shall be welded through unless otherwise indicated by the dimensions at the welding symbol or by reference to other points, e.g. the WPS

Table B.2 – Combinations of elementary symbols (extract from DIN EN ISO 2553:2019-12)

No.	Identification marking	Weld representation [a]	Symbol [b]
1	Double-V butt weld (X weld)		
2	Double-bevel butt weld		
3	Double-U butt weld		
4	Double-bevel tee butt weld with fillet weld		

[a] The necessity of welding through or not shall be indicated by the dimensions at the welding symbol or by reference to other documents, e.g. WPS.
[b] The grey line is not part of the symbol. It shows the position of the reference line.

B.1.2 Supplementary symbols

Elementary symbols may be completed by a symbol characterizing the shape of the surface or the shape of the weld. The absence of a supplementary symbol means that the shape of the surface shall comply with the weld quality indicated. Combinations using more than two supplementary symbols are not allowed. Supplementary symbols, complementary symbols and examples of application are shown in table B.3.

Table B.3 – Supplementary symbols (extract from DIN EN ISO 2553:2019-12)

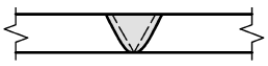
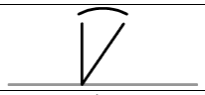
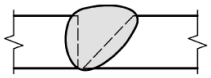
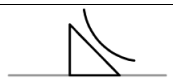
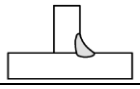
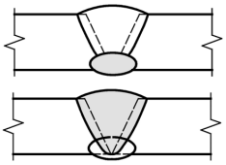
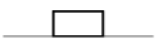
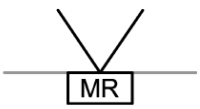
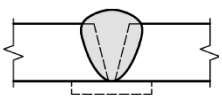
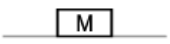
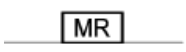
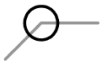
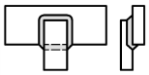
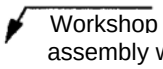
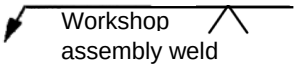
No.	Designation	Symbol [a]	Application example [a]	Weld representation
1	Flat (finished flush) [b]			
2	Convex (curved) [b]			
3	Concave (hollow) [b]			
4	Toes blended smoothly [c]			No example
5	a) Backing run [d] (carried out after single-V butt weld) b) Backing run [d] (carried out before single-V butt weld)			
7a	Backing strip (no details specified)			
7b	Permanent backing strip used [e]			
7c	Removable/non-permanent backing strip used [e]			

Table B.3 (continued) **– Supplementary symbols (extract from DIN EN ISO 2553:2019-12)**

No.	Designation	Symbol [a]	Application example [a]	Weld representation
10	Circumferential weld			
12	Site weld			No example
-	Workshop assembly weld [f]			No example

[a] The gray line is not part of the symbol; the line is used to show the position of the symbol relative to the reference line and arrow line or only to the arrow line.
[b] For welds for which approximately flush or curved surfaces without remachining after welding are specified, the use of the supplementary symbols for flush or convex welds shall be agreed.
For welds which need flush or convex remachining after welding or which need a flat but not flush surface, additional indications shall be made e.g. by adding a note at the forked part of the welding symbol.
For the specification of the surface condition, other symbols according to ISO 1302 can be used.
[c] The toes shall be blended smoothly by welding or surface machining. Details of the weld execution can be given in the work instructions or in the WPS.
[d] The welding bead sequence can be indicated on the drawing e.g. by the use of two or more reference lines, by giving a remark at the fork of the welding symbol or by making reference to a welding procedure specification.
[e] M = the material becomes a part of the finish welded joint;
MR = the material must be removed after welding.
Further information on the material can be given at the welding symbol fork or somewhere else.
[f] SMS group specification in addition to DIN EN ISO 2553; a workshop assembly weld is a weld which is produced during assembling in the workshop

B.2 Types of representation in drawings

The representation of welds in drawings shall be made as specified in DIN EN ISO 2553:2019-12.
The representation with symbols is preferred to the representation as sectional view.

B.2.2 Welds for subsequent machining

When machining takes place after welding, the weld depth shall be dimensioned from the side opposite to the surface to be machined, see Fig. B.3. Thus it is ensured that the desired weld depth is attained after machining.
When the symbols of DIN EN ISO 2553 are used on the weld seams, the specified weld depth shall be ensured after machining.

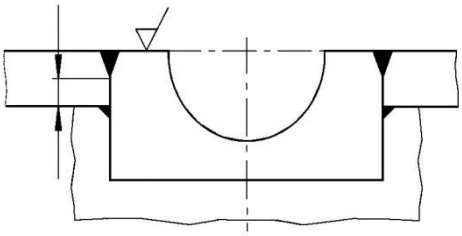


Fig. B.3 – Drawing indication

B.2.3 Surfacing (deposit welding)

For surfacing (deposit welding), see SN 402.

B.2.4 Fillet welds

Fillet welds shall be represented by a filled black triangle  or a welding symbol (see B.1.1 and B.1.2) shown at the weld joints in the sectional view or in the view of the part. All fillet welds shall be continuous welds without interruption.

B.2.5 Butt welds, partly and fully beveled welds

Butt welds, partly and fully beveled welds are represented on drawings in the sectional view or in the view with symbols (see B.1.1 and B.1.2) and with indication of weld depth s.

B.2.6 Welds on pipelines

The operating pressures of pipelines are indicated on the drawings. Symbols (see B.1.1 and B.1.2) or indications as in table 5 are used only in exceptional cases.

B.3 Reference symbols on drawings

B.3.1 Reference symbol

The elements of the reference symbol (system A according to DIN EN ISO 2553:2019-12) and the indications made at the reference symbol are shown in figure B.4.

Elements of the reference symbol:

1 = Weld joint

2 = Arrow line

3a = Reference line (solid line)

3b = Reference line (dashed line)

4 = Forked line for supplementary indications
(drawn only when needed)

Indications at the reference symbol:

① = Main dimensions of weld thickness

② = Symbol

③ = Weld length dimensions

④ = Indications for welding process, quality level, welding position, filter metal

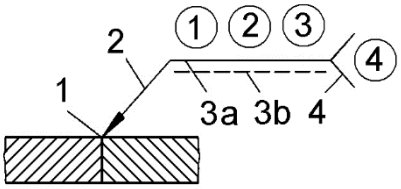


Fig. B.4 – Reference symbol

B.3.2 Position of the symbol relative to the reference line

The symbol is placed either above or below the reference line.

- When the symbol is placed on the side of the solid reference line, the weld is on the arrow side of the joint, see Fig. B.5.
  When the symbol is placed on the side of the dashed reference line, the weld is on the opposite side of the joint, see Fig. B.6
- When the welds are symmetrical, the dashed line is not required, see Fig. B.7.

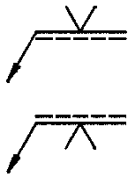


Fig. B.5 – Weld on arrow side

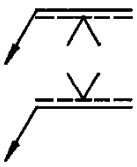


Fig. B.6 – Weld on opposite side

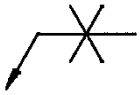


Fig. B.7 – Symmetrical weld

B.3.3 Position and relation between arrow line and joint

The side of the joint to which the arrow line points is called arrow side. The other side of the joint is called opposite side. The arrow line shall preferably point to the ”upper workpiece surface”. The terms are explained by the examples in figures B.8 and B.9.

When the butt welds are not symmetrical, the arrow line shall always point to the non-vertical flank of the joint, i.e. to the workpiece on which groove preparation is required. An example is given in figure B.12b.

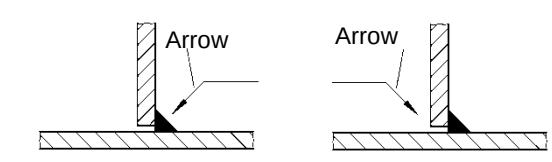


Fig. B.8 –T-joint with a fillet weld

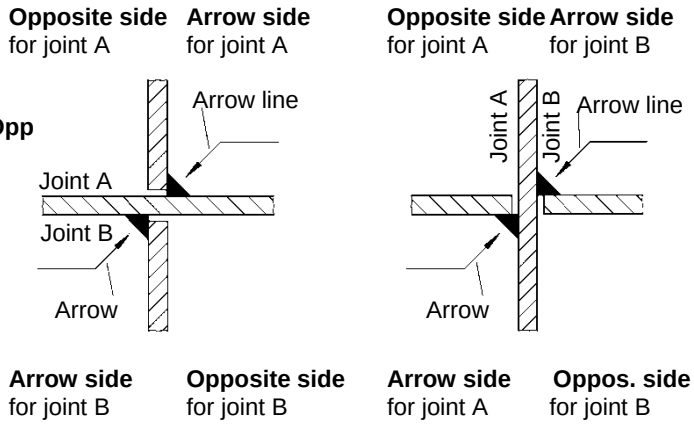


Fig. B.9 – Cruciform T-joint with two fillet welds

B.3.4 Examples of application

Fillet welds are shown in figures B.10 and B.11, butt welds in figures B.12a and B.12b. More examples of application can be found in DIN EN ISO 2553:2019-12.

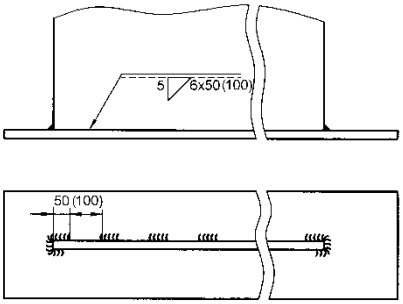


Fig. B.10 – Interrupted fillet weld

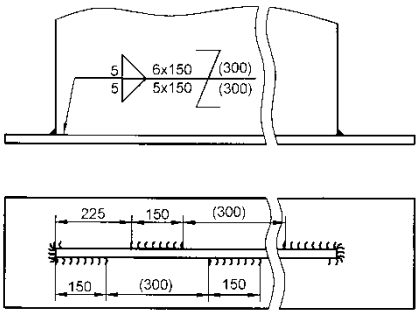


Fig. B.11 – Staggered interrupted fillet weld

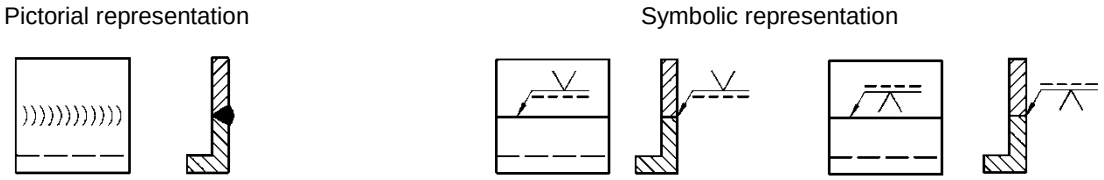


Fig. B.12a – Example 1, butt weld

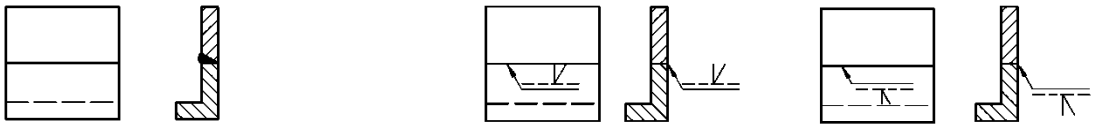


Fig. B.12b – Example 2, butt weld

Annex C
(informative)
Welding processes

Welding processes and their associated individual processes according to DIN EN ISO 4063:2011-03:

- 11 Metal arc welding without gas protection;
  - 111 Manual arc welding ≙ E;
- 12 Submerged arc welding;
- 13 Gas shielded metal arc welding;
  - 135 Metal active gas welding with solid wire electrode ≙ MAG;
  - 136 Metal active gas welding with welding-flux filled wire electrode;
- 14 Gas-shielded tungsten arc welding;
  - 141 Tungsten inert gas welding with solid wire or solid rod filler; TIG welding;
- 15 Plasma arc welding;
- 31 Oxy-fuel gas welding (only for steel);
- 72 Electroslag welding.

Bibliography

DIN EN 1090-1	Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components
DIN EN ISO 3834-1:2006-03	Quality requirements for fusion welding of metallic materials - Part 1: Criteria for the selection of the appropriate level of quality requirements
DIN EN ISO 3834-2:2006-03	Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements
DIN EN ISO 3834-4:2006-03	Quality requirements for fusion welding of metallic materials - Part 4: Elementary quality requirements
305/11/EUV	Regulation laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
2014/68/EU	Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonization of the laws of the member states relating to the making available on the market of pressure equipment
WHG	Water Resources Law

Amendments

Amendments made in comparison with SN 200-4:2016-05:

Editorial revisions	New introduction
	Updating of the normative references
Section 3	Completely revised. Requirements for welding operation specified according to DIN EN ISO 3834-3
Section 5.2	Addition of: Radii of stiffening plates which are below the permitted values according to Table 3, must be adapted;
Section 7.1	Inspection certificate 3.1 has been deleted and replaced by heat treatment diagram and record
Section 9.1	Addition of: For specifications before the inspection is carried out, the DIN EN ISO 17635 must be observed and complied with;
	Text from Section 9.4 "... If no complaints are found, the required scope of inspection can be reduced after prior consultation and written approval with the SMS group Quality Inspection department. Addition of: If complaints are made, the SMS group inspector may extend the scope of inspection to up to 100% ...";
Section 9.2	In Table 10 the scope of ultrasonic testing for quality level D was removed;
Section 9.4	Added for lifting points, table 12 completely new;
Section 9.5	Addition of: ISO 10474:2013, DIN EN ISO 17636 and DIN EN ISO 19879;

Previous editions

SN 200:1971-09, 1975-11,1978-01, 1981-01,1985-01, 1992-03, 1996-03, 1999-09, 2003-09, 2007-02, 2010-09
SN 200-4:2016-05