Acceptance limits for weld imperfections

TRK

Surface imperfections and imperfections in joint geometry, visual inspection

1 Identify the imperfection from the sketch

2 Measure as the arrows show

3 Read off the maximum permitted size

D lowest requirement

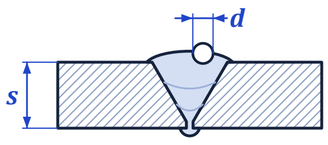
C intermediate

B highest requirement

× Not permitted in any quality level

1.1 Crack 100	1.2 Crater crack 104	1.5 Lack of fusion 401	1.15 Burn-through 510

1.3 Surface pore — ISO 2017



MEASURE Greatest dimension *d* of the pore in the surface.

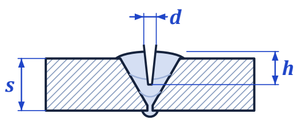
d ≤	D	C	B
t 0,5–3	0,3 s(a_A)	not permitted	not permitted
t > 3	0,3 s(a_A) max 3 mm	0,2 s(a_A) max 2 mm	not permitted

s mm	2	3	5	8	10	15
D	0,6	0,9	1,5	2,4	3	3
C	×	×	1	1,6	2	2
B	×	×	×	×	×	×

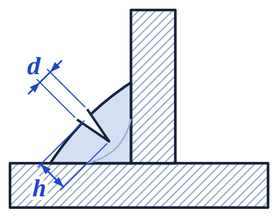
Butt weld, t = s. Fillet weld: read a_A instead of *s*.

1.4 End crater pipe — ISO 2025

Butt weld (BW)



Fillet weld (FW)



MEASURE Depth *h* and greatest dimension *d* of the crater. Both limits apply.

NOTE Cannot be measured by non-destructive testing. Once seen, grind it out.

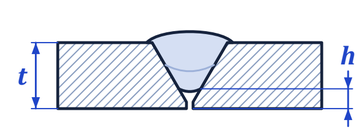
	D	C	B
h ≤ t 0,5–3	0,2 s(a_A)	not permitted	not permitted
h ≤ t > 3	0,2 s(a_A) max 2 mm	0,1 s(a_A) max 1 mm	not permitted
d ≤ t 0,5–3	0,3 s(a_A)	not permitted	not permitted
d ≤ t > 3	0,3 s(a_A) max 3 mm	0,2 s(a_A) max 2 mm	not permitted

s mm	2	3	5	8	10	15
D	0,4/0,6	0,6/0,9	1/1,5	1,6/2,4	2/3	2/3
C	×	×	0,5/1	0,8/1,6	1/2	1/2
B	×	×	×	×	×	×

Values *h* / *d* in mm. Butt weld, t = s.

1.6 Incomplete root penetration — ISO 4021

SHORT IMPERFECTIONS ONLY



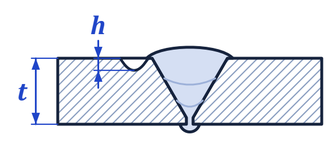
MEASURE Unfilled root depth *h*. Single-sided butt weld.

h ≤	D	C	B
all t BW	0,2 t max 2 mm	not permitted	not permitted

t mm	2	4	6	8	10	15
D	0,4	0,8	1,2	1,6	2	2
C	×	×	×	×	×	×
B	×	×	×	×	×	×

1.7 Undercut — ISO 5011/5012

SHORT IMPERFECTIONS ONLY
Applies to t 0,5–3 mm.

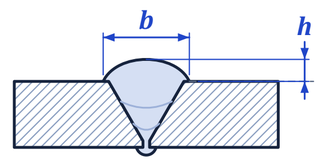


MEASURE Depth *h* perpendicular to the plate surface.

h ≤	D	C	B
t 0,5–3	0,2 t	0,1 t	not permitted
t > 3	0,2 t max 1 mm	0,1 t max 0,5 mm	0,05 t max 0,5 mm

t mm	2	3	5	8	10	15
D	0,4	0,6	1	1	1	1
C	0,2	0,3	0,5	0,5	0,5	0,5
B	×	×	0,25	0,4	0,5	0,5

1.9 Excess weld metal, butt weld — ISO 502

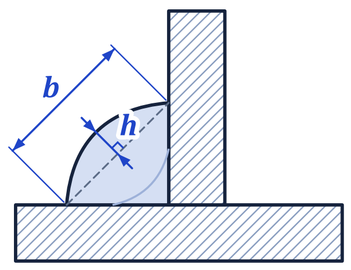


MEASURE Height *h* above the plate surface. *b* = width of the reinforcement.

h ≤	D	C	B
all t BW	0,25 b + 1 mm max 10 mm	0,15 b + 1 mm max 7 mm	0,1 b + 1 mm max 5 mm

b mm	5	8	10	15	20	30
D	2,25	3	3,5	4,75	6	8,5
C	1,75	2,2	2,5	3,25	4	5,5
B	1,5	1,8	2	2,5	3	4

1.10 Excessive convexity, fillet weld — ISO 503

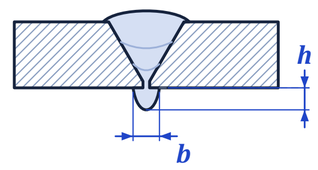


MEASURE Convexity *h* perpendicular to the line between the weld toes.

h ≤	D	C	B
all t FW	0,25 b + 1 mm max 5 mm	0,15 b + 1 mm max 4 mm	0,1 b + 1 mm max 3 mm

b mm	5	8	10	15	20	30
D	2,25	3	3,5	4,75	5	5
C	1,75	2,2	2,5	3,25	4	4
B	1,5	1,8	2	2,5	3	3

1.11 Excessive penetration — ISO 504



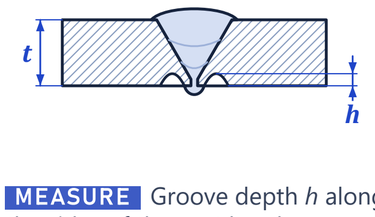
MEASURE Height *h* of the excess penetration. *b* = width of the root bead.

h ≤	D	C	B
t 0,5–3	0,6 b + 1 mm	0,3 b + 1 mm	0,1 b + 1 mm
t > 3	1,0 b + 1 mm max 5 mm	0,45 b + 1 mm max 4 mm	0,2 b + 1 mm max 3 mm

b mm t>3	2	3	5	8	10	15
D	3	4	5	5	5	5
C	1,9	2,35	3,25	4	4	4
B	1,4	1,6	2	2,6	3	3

1.8 Shrinkage groove — ISO 5013

SHORT IMPERFECTIONS ONLY

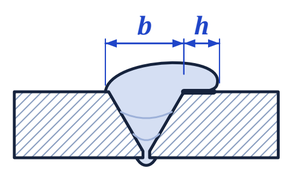


MEASURE Groove depth *h* along the sides of the root bead.

h ≤	D	C	B
t 0,5–3	0,1 t + 0,2 mm	0,1 t	not permitted
t > 3	0,2 t max 2 mm	0,1 t max 1 mm	0,05 t max 0,5 mm

t mm	2	3	5	8	10	15
D	0,4	0,5	1	1,6	2	2
C	0,2	0,3	0,5	0,8	1	1
B	×	×	0,25	0,4	0,5	0,5

1.13 Overlap — ISO 506



MEASURE How far *h* the weld metal overhangs beyond the weld toe.

h ≤	D	C	B
all t	0,2 b	not permitted	not permitted

b mm	5	8	10	15	20	30
D	1	1,6	2	3	4	6
C	×	×	×	×	×	×
B	×	×	×	×	×	×

Acceptance limits for weld imperfections

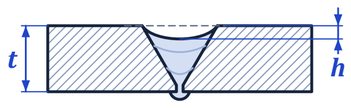
TRK

Surface imperfections and imperfections in joint geometry, visual inspection

1.14 Sagging, incompletely filled groove

ISO 509/511

SHORT IMPERFECTIONS ONLY



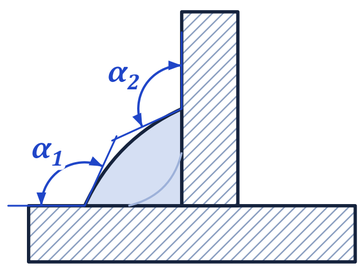
MEASURE How far *h* the weld surface lies below the plate surface.

h ≤	D	C	B
t 0,5–3	0,25 t	0,1 t	not permitted
t > 3	0,25 t max 2 mm	0,1 t max 1 mm	0,05 t max 0,5 mm

t mm	2	3	5	8	10	15
D	0,5	0,75	1,25	2	2	2
C	0,2	0,3	0,5	0,8	1	1
B	×	×	0,25	0,4	0,5	0,5

1.12 Incorrect weld toe

ISO 505



MEASURE The angle α is a minimum value. Does not apply to the root.

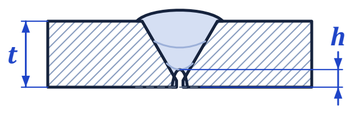
	D	C	B
all t BW	α ≥ 90°	α ≥ 110°	α ≥ 150°
all t FW	α ≥ 90°	α ≥ 100°	α ≥ 110°

1.17 Root concavity

ISO 515

SHORT IMPERFECTIONS ONLY

Level C at t 0,5–3 mm. All levels at t > 3 mm.



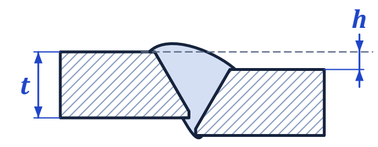
MEASURE Concavity *h* of the root, from the underside of the plate.

h ≤	D	C	B
t 0,5–3	0,1 t + 0,2 mm	0,1 t	not permitted
t > 3	0,2 t max 2 mm	0,1 t max 1 mm	0,05 t max 0,5 mm

t mm	2	3	5	8	10	15
D	0,4	0,5	1	1,6	2	2
C	0,2	0,3	0,5	0,8	1	1
B	×	×	0,25	0,4	0,5	0,5

3.1 Linear misalignment, plates

ISO 5071



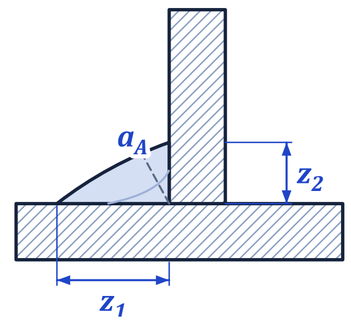
MEASURE Level difference *h*. *t* = the thinner plate.

h ≤	D	C	B
t 0,5–3	0,25 t + 0,2 mm	0,15 t + 0,2 mm	0,1 t + 0,2 mm
t > 3	0,25 t max 5 mm	0,15 t max 4 mm	0,1 t max 3 mm

t mm	2	3	5	8	10	15
D	0,7	0,95	1,25	2	2,5	3,75
C	0,5	0,65	0,75	1,2	1,5	2,25
B	0,4	0,5	0,5	0,8	1	1,5

1.16 Excessive asymmetry of fillet weld

ISO 512



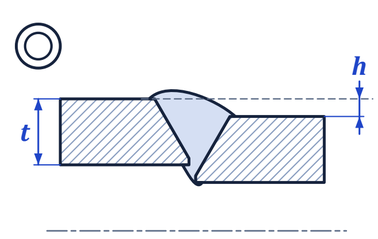
MEASURE $h = |z_1 - z_2|$. Applies where asymmetry is not specified.

h ≤	D	C	B
all t FW	0,2 a_A + 2 mm	0,15 a_A + 2 mm	0,15 a_A + 1,5 mm

a_A mm	3	4	5	6	8	10
D	2,6	2,8	3	3,2	3,6	4
C	2,45	2,6	2,75	2,9	3,2	3,5
B	1,95	2,1	2,25	2,4	2,7	3

3.1 Linear misalignment, tubes

ISO 5072



MEASURE Circumferential welds in tubes. *t* = the thinner wall.

h ≤	D	C	B
all t	0,5 t max 4 mm	0,5 t max 3 mm	0,5 t max 2 mm

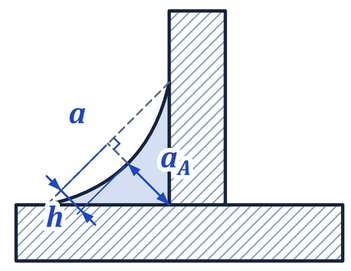
t mm	2	3	5	8	10	15
D	1	1,5	2,5	4	4	4
C	1	1,5	2,5	3	3	3
B	1	1,5	2	2	2	2

1.20 1.21 Throat thickness

ISO 5213/5214

SHORT IMPERFECTIONS ONLY

Applies to too small throat thickness.



MEASURE Throat thickness, perpendicular from the root to the weld face.

Too small throat thickness ISO 5213

h ≤	D	C	B
t 0,5–3 FW	0,1 a + 0,2 mm	0,2 mm	not permitted
t > 3 FW	0,1 a + 0,3 mm max 2 mm	0,1 a + 0,3 mm max 1 mm	not permitted

Too large throat thickness ISO 5214

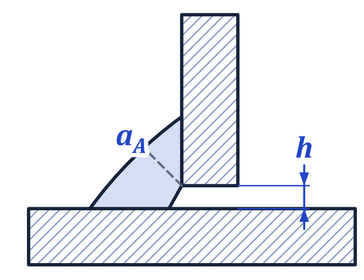
all t FW	permitted	0,2 a + 1 mm max 4 mm	0,15 a + 1 mm max 3 mm

a mm t>3	3	4	5	6	8	10
D	−0,6/free	−0,7/free	−0,8/free	−0,9/free	−1,1/free	−1,3/free
C	−0,6/+1,6	−0,7/+1,8	−0,8/+2	−0,9/+2,2	−1/+2,6	−1/+3
B	×/+1,45	×/+1,6	×/+1,75	×/+1,9	×/+2,2	×/+2,5

Permitted deviation from *a* in mm: below / above.

3.2 Root gap, fillet weld

ISO 617



MEASURE Gap *h* at the root. May be compensated by a larger throat thickness.

h ≤	D	C	B
t 0,5–3 FW	0,1 a_A + 0,5 mm	0,1 a_A + 0,3 mm	0,1 a_A + 0,2 mm
t > 3 FW	0,3 a_A + 1 mm max 4 mm	0,2 a_A + 0,5 mm max 3 mm	0,1 a_A + 0,5 mm max 2 mm

a_A mm t>3	3	4	5	6	8	10
D	1,9	2,2	2,5	2,8	3,4	4
C	1,1	1,3	1,5	1,7	2,1	2,5
B	0,8	0,9	1	1,1	1,3	1,5

Symbols

t	material thickness
s	butt weld thickness
a	nominal throat thickness
a_A	actual throat thickness
b	width, reinforcement/root
h	height/depth of imperfection
d	diameter of pore
z	leg length, fillet weld
α	weld toe angle

Depends on the application

	D	C	B
1.5 Micro lack of fusion *4014*	permitted	permitted	no
1.18 Root porosity *516*	application	no	no
1.19 Poor restart *517*	permitted[1]	no	no
1.22 Stray arc *601*	permitted[2]	no	no
1.23 Spatter *602*	depends on material and corrosion protection		
1.24 Temper colours *610*	depends on material and corrosion protection		

[1] Assess the imperfection the restart produced. [2] Provided the parent material is not affected.

Good to know

Short imperfections: total length not more than 25 mm in any 100 mm of weld. Weld shorter than 100 mm: not more than 25 % of its length.

Systematic imperfections are permitted only in level D.

Two adjacent imperfections count as one if the distance between them is less than the greatest dimension of the smaller one.