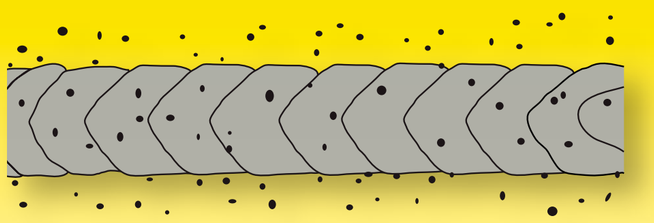
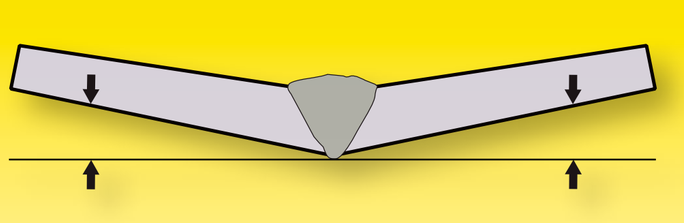
WELDING PROBLEMS AND DEFECTS – **CAUSES AND REMEDIES**



Spatter

Causes
- Welding current too high.
- Arc too long.
- Incorrect polarity – arc blow.
- Insufficient gas shielding.

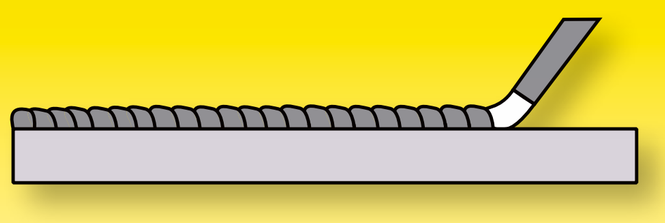
Remedies
- Reduce welding current.
- Reduce arc length.
- Check use of correct polarity for the consumable in question.
- Check shielding gas type and flow rate. Clean gas nozzle. Increase torch to plate angle.



Deformation

Causes
- Unsuitable welding sequence.
- Too many and too thin beads, usually because the electrode is too small.
- Poor plate fit-up before welding.
- Plates clamped insufficiently.

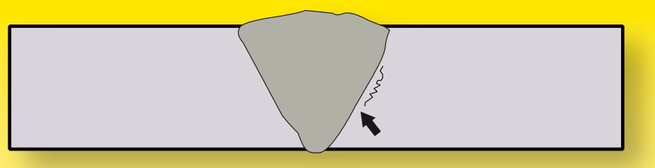
Remedies
- Weld from both sides of the joint. Weld from the centre out, in opposite directions.
- Use a larger electrode. If possible, a high recovery type.
- Compensate for shrinkage by fixing the work pieces with a counter-angle.
- Clamp.



Arc blow

Causes
- Arc deflection as a result of magnetic effects into the opposite direction of the earth lead clamp.
- Arc deflection as a result of magnetic effects in the direction of heavy parts of the work piece (with magnetic materials) – especially at corners and edges.

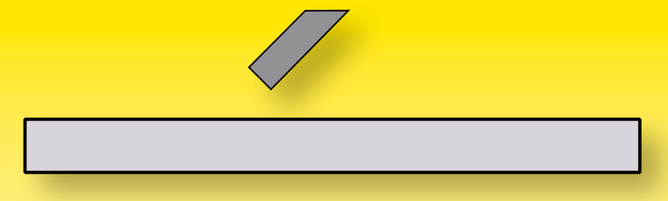
Remedies
- Use an AC electrode where possible.
- Try welding away from the earth clamp connection. Try splitting the earth clamp and connect to both sides of the joint.
- Position earth lead clamp such that it counteracts the influence of heavy work piece parts. Keep arc as short as possible.



Longitudinal cracks in the heat affected zone

Causes
- The base material is prone to hardening (because of a high C content or other alloying elements).
- Weld cools down too rapidly.
- Hydrogen in the weld e.g. because of wet weld edges, wrong or damp electrodes or shielding gases.

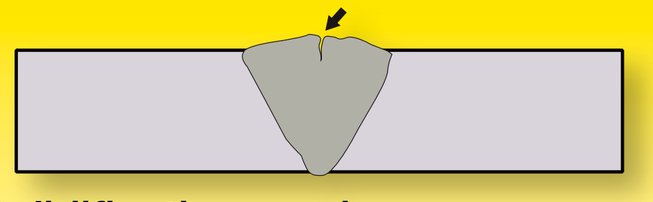
Remedies
- If possible, choose a material with a better weldability. If not, apply and maintain preheat and interpass temperature and delayed cooling.
- Apply a higher preheat temperature.
- Remove moisture from welding zone. Use low-hydrogen consumables from moisture protective VacPac, or rebake welding consumables.



Arc striking difficulties

Causes
- Welding current too low.
- Arc voltage too low.
- Earth lead is not connected properly.
- Low mains voltage.

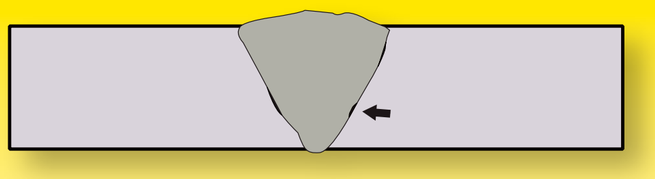
Remedies
- Increase welding current.
- Use power source with a higher open circuit voltage.
- Ensure proper earth lead connection.
- Uncover striking end and touch-strike.



Solidification cracks

Causes
- Formation of phases with a low melting point in the weld, due to P, S, Cu – mostly from the parent metal).
- Unfavourable joint geometry – width/depth ratio <1.
- Weld pool too large.
- Travel speed too high (weld solidifies in an arrow shape).
- Tack welds or root passes not sufficiently strong for shrinkage forces, in case of restrained joints.

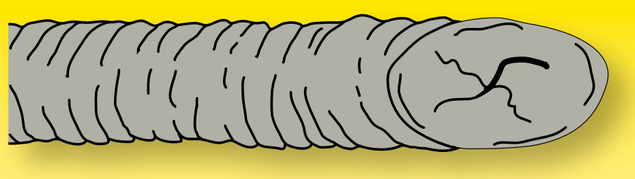
Remedies
- Select cleaner parent material or buffer plate edges.
- Increase joint angle, use lower welding current.
- Use smaller electrode, use lower welding current. Apply stringer bead technique.
- Lower the travel speed until weld solidifies in an elliptical form.
- Apply stronger tacks and bottom passes.



Lack of fusion defects

Causes
- Heat input too low.
- Weld pool too large and running ahead of the arc.
- Joint included angle too small
- Electrode or torch angle is incorrect.
- Unfavourable bead positioning

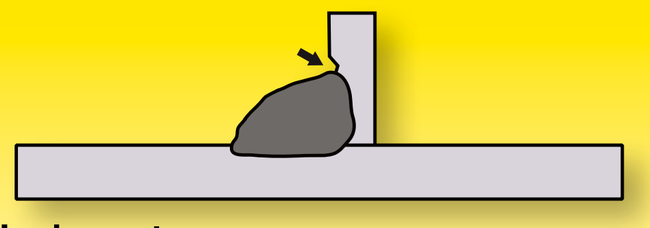
Remedies
- Increase welding current and lower travel speed.
- Reduce deposition rate and/or increase travel speed.
- Increase joint included angle.
- Position electrode or torch in such a way that the plate edges are melted.
- Position beads in such a way that sharp angles with other beads or plate edges are avoided.



Crater cracks

Causes
- The welding ended far too abruptly. The crack begins at a void in the welding crater, caused by the solidification shrinkage.

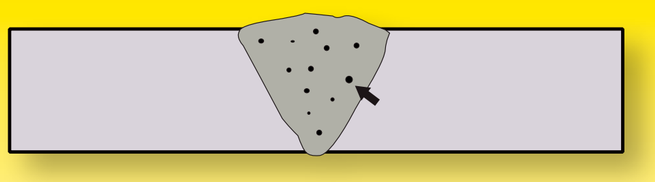
Remedies
- When finishing, move back the electrode to fill-up the crater.
- With root pass welding, quickly move the arc from the weld pool to the plate edge.
- Increase crater fill time on power source.
- Use run off plate.



Undercut

Causes
- Arc voltage too high.
- Arc too long.
- Incorrect electrode use or electrode angle.
- The electrode is too large for the plate thickness in question.
- Travel speed too high

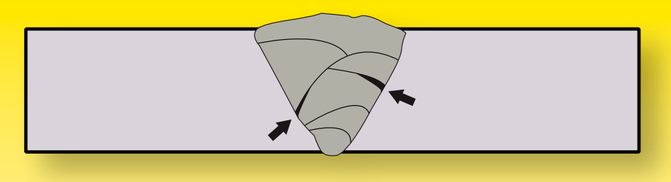
Remedies
- Lower arc voltage.
- Reduce arc length.
- Apply electrode angle of 30° to 45° with the standing leg. Weld lightly trailing.
- Use a smaller diameter electrode.
- Reduce travel speed.



Porosity

Causes
- Moisture, for example from incorrectly stored electrodes or fluxes, humid shielding gas or leaks in water-cooled welding torches.
- Moisture, rust, grease or paint on the plate edges.
- Insufficient gas shielding.
- Welding onto small gaps filled with air.

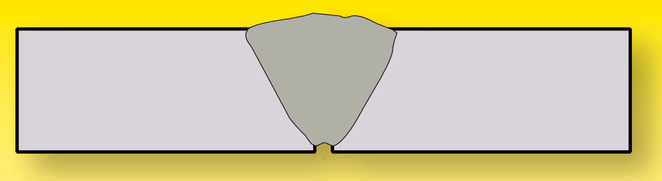
Remedies
- Rebake or use fresh welding consumables, connect new gas bottle, check welding torch for leaks.
- Dry or clean plate edges.
- Check shielding gas type and flow-rate. Clean gas nozzle. Ensure torch to plate angle is not too small.
- Increase welding gap. When possible, apply butt joints instead of fillet or overlap welds.



Slag inclusions

Causes
- Slag runs ahead of the weld
- Insufficient de-slagging between passes
- Convex passes which produce slag pockets.
- Unfavourable bead sequence.

Remedies
- Increase the travel speed or electrode angle.
- Remove slag carefully, grind if necessary.
- Avoid sharp angles or grooves between beads and layers. Increase arc voltage.
- Plan bead sequence such that sharp corners are avoided. Apply stringer bead technique.



Lack of root penetration

Causes
- Root gap too small.
- Electrode size to big.
- Travel speed too high.
- Incorrect use of electrode.
- Poor set up.

Remedies
- Use wider root gap.
- Use electrodes with a diameter of approximately the gap width.
- Apply lower travel speed.
- Weave between plate edges. Weld on ceramic backing at high currents.

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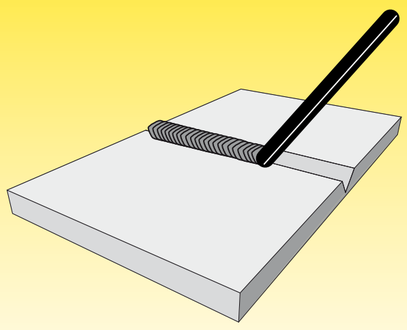
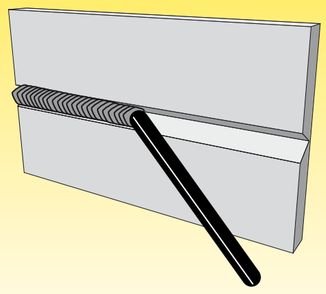
EN AND ASME
WELDING POSITIONS

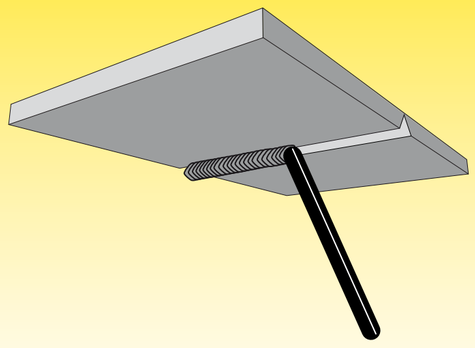
Butt welds in plate



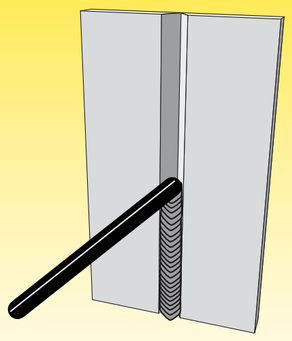
Downhand: PA/1G



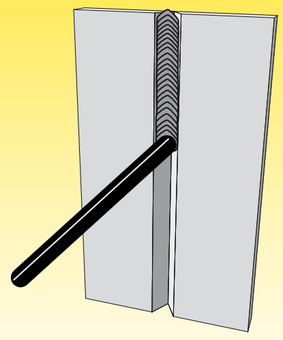
Horizontal-vertical: PC/2G



Overhead: PE/4G

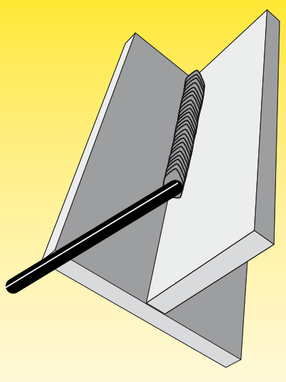


Vertical-up: PF/3G

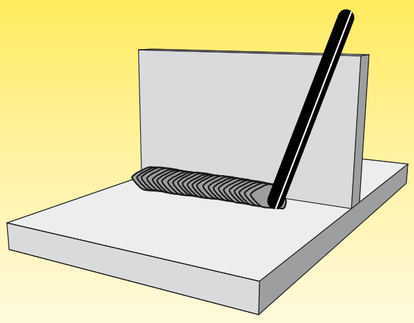


Vertical-down: PG/3G

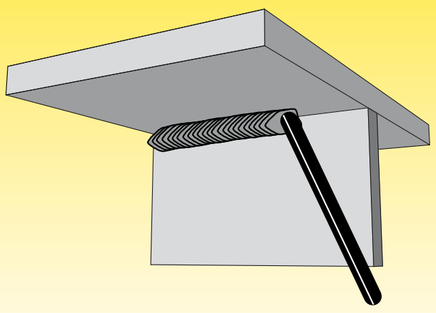
Fillet welds in plate



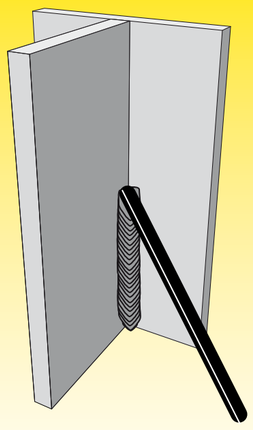
Downhand: PA/1F



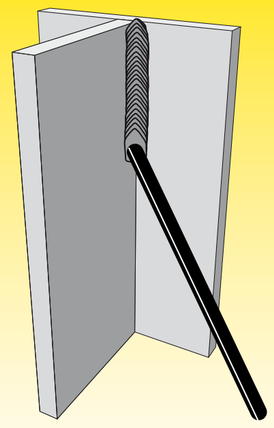
Horizontal: PB/2F



Overhead: PD/4F

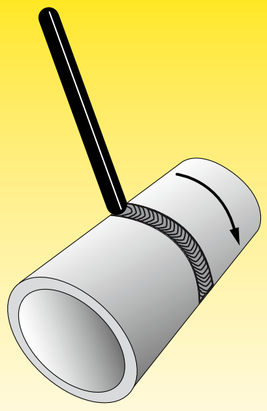


Vertical-up: PF/3F

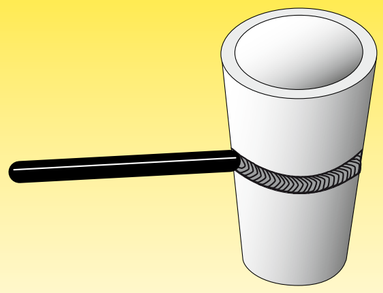


Vertical-down: PG/3F

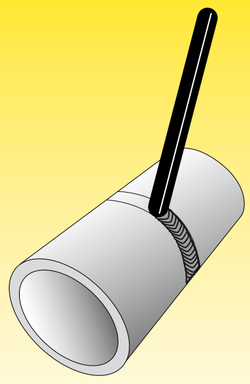
Butt welds in pipe



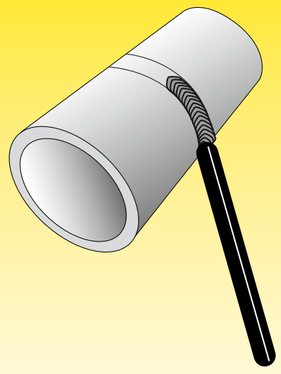
Pipe rotates with axis horizontal, welding downhand: PA/1G



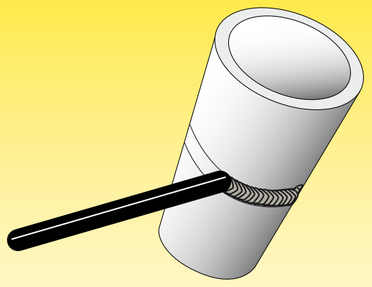
Pipe fixed with axis vertical, welding horizontal-vertical: PC/2G



Pipe fixed with axis horizontal, welding upwards: PH/5G

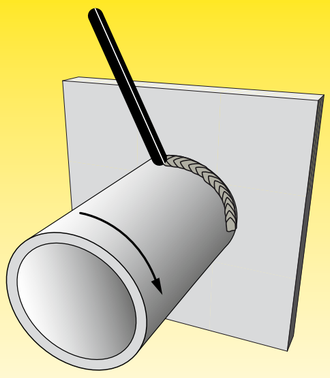


Pipe fixed with axis horizontal, welding downwards: PG/5G

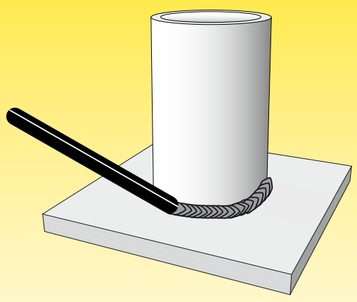


Pipe fixed with axis under 45° angle, welding upwards: H-LO45/6G

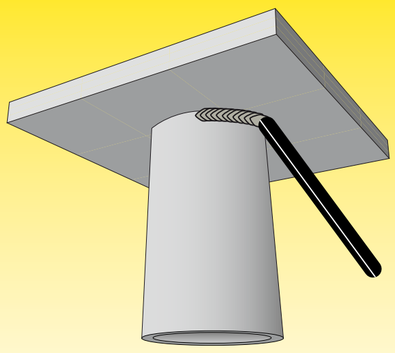
Fillet welds pipe to plate.



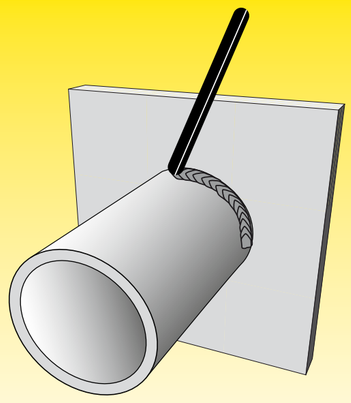
Pipe rotates with axis horizontal, welding downhand: PB/2FR



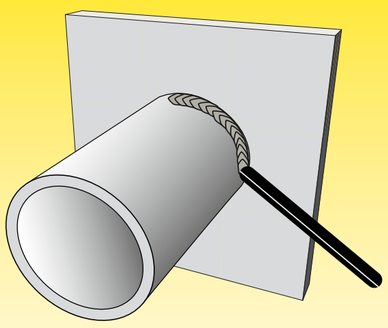
Pipe fixed with axis vertical: PB/2F



Pipe fixed with axis vertical, welding overhead: PD/4F



Pipe fixed with axis horizontal, welding upwards: PH/5F



Pipe fixed with axis horizontal, welding downwards: PJ/5F

RECOMMENDED
WELDING CONSUMABLES

Base material	MMA	MIG/MAG	FCAW	FCAW	TIG	SAW
	OK	OK AristoRod, OK Autrod	OK Tubrod (metal-cored)	OK Tubrod (rutile)	OK Tigrod	OK Autrod + OK Flux
Unalloyed steel (EN 10025-2)						
S235xxx, S275xxx, S355xxx	48.00	12.50, 12.51	14.11, 14.13	15.14	12.64	12.10 or 12.20+10.71
Normalised fine grain steel (EN 10025-3)						
S275N, S355N, S420N	48.00	12.50, 12.51	14.11, 14.13	15.14	12.64	12.22+10.71
S460N	55.00	12.63, 12.64	14.02	15.14	12.64	12.22+10.71
S275NL, S355NL, S420NL	48.08, 55.00	13.28, (12.63, 12.64)*	14.04	15.11, (15.17)*	13.28	12.32+10.62
S460NL	48.08, 55.00	13.28, (12.63, 12.64)* *) -40 °C		15.11, (15.17)* *) -40 °C	13.28	12.32+10.62
Thermo-mechanically treated fine grain steel (EN 10025-4)						
S275M, S355M, S420M	48.00	12.50, 12.51	14.11, 14.13	15.14	12.64	12.22+10.71
S460M	55.00	12.63, 12.64	14.02	15.14	13.28	12.32+10.71
S275ML, S355ML, S420ML	48.08, 55.00	13.28, (12.63, 12.64)*	14.04	15.11, (15.17)*	13.28	12.32, 13.27+10.62
S460ML	48.08, 55.00	13.28, (12.63, 12.64)* *) -40 °C		15.11, (15.17)* *) -40 °C	13.28	12.32, 13.27+10.62
Weather resistent steel (EN 10025-5)						
S235J0W, S235J2W	73.08	13.26	14.01	15.11	13.26	13.36+10.71
S355J0WP (e.g. COR-TEN A), S355J2WP	73.08	13.26	14.01	15.11	13.26	13.36+10.71
S355J0W, S355J2W (e.g. COR-TEN B)	73.08	13.26	14.01	15.11	13.26	13.36+10.71
High strength steel (EN 10025-6)						
S460Q, S460QL	48.08	12.63, 12.64	14.02	15.17	13.28	12.32, 13.27+10.62
S500Q, S500QL	74.70	55	14.02	15.11	13.13	13.24+10.62
S550Q, S550QL	74.78	55	14.03	Dual Shield 55		13.40+10.62
S620Q, S620QL	75.75	62	14.03	Dual Shield 62		13.40+10.62
S690Q, S690QL (e.g. WELDOX 700 D or E)	75.75	69	14.03	15.09		13.43+10.62
S890Q, S890QL (e.g. WELDOX 900 D or E)	75.78	89	Coreweld 89			
Ultra high strength steel (Rautaruukki)						
Optim 900 QC	75.78	89	Coreweld 89			
Optim 960 QC	75.78 *	89 *	Coreweld 89 *			
Optim 1100 QC	75.78 *	89 *	Coreweld 89 *			
	* Undermatching weld metal					
Creep resistent plate (EN 10028-2) or pipe (EN 10216-2)						
P235GH...P355GH	48.00	12.50, 12.51	14.11, 14.13	15.14	12.64	12.22+10.71
16Mo3	74.46	13.09	14.02	Dual Shield MoL	13.09	12.24+10.62
13CrMo4-5	76.18	13.12		Dual Shield CrMo1	13.12	13.10SC+10.62
10CrMo9-10	76.28	13.22		Dual Shield CrMo2	13.22	13.20SC+10.62
X10CrMoVNb9-1	76.98	13.38			13.38	
Wear resistent steel						
e.g. Hardox 400 ... 600						
If there is no demand regarding the matching of strength and hardness:						
Use unalloyed consumables	48.00	12.50, 12.51	14.11, 14.13	15.14	12.64	12.22+10.71
If corresponding hardness or strength are required: Hardness	83.53	13.91	15.50			
Strength	75.75	13.29	14.03	15.09		13.43+10.62
Austenitic stainless steel						
18Cr-8Ni steel				Shield-Bright (positional welding, downhand welding)		
1.4306 (304L), 1.4307 (304L), 1.4301 (304) etc.	61.30	308LSi	15.30	308L, 308L X-tra	308LSi	308L+10.93
1.4541 (321), 1.4550 (347)	61.30, 61.81	308LSi, 347	15.30	308L, 308L X-tra	308LSi, 347	308L, 347+10.93
18Cr-12Ni-3Mo steel				Shield-Bright		
1.4404 och 1.4432 (316L), 1.4401 och 1.4436 (316) etc.	63.30	316LSi	15.31	316L, 316L X-tra	316LSi	316L+10.93
High alloyed austenitic stainless steel						
1.4438 (317L)	64.30	317L			317L	317L+10.93
1.4539 (e.g. 904L)	69.33	385			385	385+10.93
1.4547 (e.g. 254SMO)	92.45	19.82			19.82	19.82+10.16
1.4652 (e.g. 654SMO)	92.59	19.81			19.81	19.81+10.16
Austenitic-ferritic duplex stainless steel						
1.4162 (e.g. Outokumpu LDX2101)	67.56 *, 67.50	2307 *, 2209	15.37	14.27	2307 *, 2209	2307 *, 2209+10.93
1.4462 (e.g. Avesta 2205)	67.50	2209	15.37	14.27	2209	2209+10.93
1.4410 (e.g. SAF 2507)	68.53	2509		14.28	2509	2509+10.94
	* Matching composition					
Aluminium and aluminium alloys						
1050A (Al99,5), 1070A (Al99,7), 1200 (Al99,0)		1070			1070	
4045 (AlSi10)		4043, 4047			4043, 4047	
5019 (AlMg5), 5086 (AlMg4), 5454 (AlMg2,5)		5356			5356	
5083 (AlMg4,5Mn0,7)		5183			5183	
6060 (AlMgSi), 6061 (AlMg1SiCu), 6063 (AlMg0,7Si)		4043, 5356 (5356 for anodising)			4043, 5356 (5356 for anodising)	
6082 (AlSi1MgMn)		4043, 5356			4043, 5356	
7021 (AlZn5,5Mg1,5Si), 7029 (AlZn4,4Mg1Si)		5556			5556	
Cast iron						
Different types	92.18, 92.58			Nicore 55		
Dissimilar steels (black and white)						
Unalloyed and low-alloyed to austenitic stainless steel.				Shield-Bright (positional welding, downhand welding)		
For service temperature below 300° C without stress relieve treatment.	67.45, 67.60, 67.70	16.95, 309LSi, 309MoL	15.34	309L, 309L X-tra	309LSi, 309MoL	16.97, 309L+10.93
For service temperature above 300° C with or without stress relieve treatment.	92.26	19.85			19.85	19.85+10.16
Repair welding						
Difficult to weld steels, steels with unknown composition	68.81, 67.45	312, 16.95		OK Tubrodur 14.71	312, 16.95	312, 16.95+10.93
and steels prone to hardening.	92.26	19.85			19.85	

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