

Weld imperfections

Imperfections are deviations in the quality of the manufacturing of a product, such as should normally not arise. Their development is influenced by the base material, the welding process, the welder and the weld preparation. In this respect, they may be more or less distinct. If the imperfections exceed the permissible limits, they are defects which may lead to the failure of a whole structure. The welding coordinator must decide whether it is possible to repair such a defect or the part must be rejected.

Standards

In the trilingual standard ISO 6520-1 imperfections are defined and they are given reference numbers. Example from ISO 6520-1:

Table 1 (continued) Tableau 1 (suite) Tabelle 1 (fortgesetzt)			
Reference No. Référence n° Referenz-Nr.	English Description Beschreibung	Français Description Beschreibung	Deutsch Beschreibung Beschreibung
2016	worm-hole cavity in weld metal caused by release of gas. The shape and position of worm-holes are determined by the mode of solidification and the sources of the gas. Generally, they are grouped in clusters and distributed in a herringbone formation. Some worm-holes can break the surface of the weld.	soufflure verminé cavité en forme de galère de ver dans le métal fondu, résultant du dégagement du gaz. La forme et la position de ces soufflures sont déterminées par le mode de solidification et l'origine du gaz. Elles sont généralement groupées en nids et disposées en arêtes de poisson. Certaines soufflures performent la surface de la soudure.	Schlüsselpore schmetterförmiger Hohlraum im Schweißgut, hervorgerufen durch ausgetretenes Gas. Die Form und Lage von Schlüsselporen werden bestimmt durch den Ablauf der Erstarrung und durch die Herkunft des Gases. Im allgemeinen sind sie zu Nestern gruppiert und schmetterförmig verteilt. Einige Schlüsselporen dringen auf die Oberfläche der Schweißnaht.
2017	surface pore gas pore that breaks the surface of the weld	piqûre soufflure débouchant en surface de la soudure	Oberflächenpore zur Oberfläche offene Pore in der Schweißnaht
2017			
2018	break the surface of the weld	multitudes, qui cassent la surface de la soudure	Oberfläche offene Poren in der Schweißnaht
202	shrinkage cavity cavity due to shrinkage during solidification	retraitement cavité due au retrait du métal pendant la solidification	Lunker Hohlraum infolge Schrumpfung beim Erstarren

In ISO 5817 imperfections are grouped into quality levels.

QUALITY LEVEL	DEMANDS
D	low demands on the welded joint
C	medium demands on the welded joint
B	high demands on the welded joint

Example from ISO 5817:

Table 1 — Limits for imperfections						
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	D	Limits for imperfections for quality levels C B
1.1	100	Crack	—	> 0.5	Not permitted	Not permitted
1.2	104	Crater crack	—	> 0.5	Not permitted	Not permitted
1.3	2017	Surface pore	Maximum dimension of a single pore for — butt weld — fillet welds	0.5 to 3 d ≤ 0.3 s d ≤ 0.3 a	Not permitted	Not permitted
1.4	2020	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels D C B
1.5	401	Surface pore	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
1.6	4021					

t = plate thickness, s = butt weld thickness, a = throat thickness, d = diameter of pore

The DVS 0703 technical bulletin makes it easier for welding coordinators and testing bodies to assess the executed welds and provides notes about the development and avoidance of imperfections when these welds are manufactured.

Frequent imperfections and their causes

SURFACE IMPERFECTIONS AND THEIR CAUSES	
excess weld metal 	<ul style="list-style-type: none">welding speed too lowwrong weld build-upwrong bead sequence in the cover passvoltage too low in the case of GMA and SA welding
incompletely filled groove 	<ul style="list-style-type: none">amperage too highwelding speed too greatarc length too greatwrong weld build-upshielding gas quantity too great
undercut 	<ul style="list-style-type: none">amperage too higharc length too greatarc manipulation on one side
incomplete penetration 	<ul style="list-style-type: none">torch angle wrongheat input too low
root concavity 	<ul style="list-style-type: none">welding speed too highheat input of the first filler pass too great (in the PE position)root gap too smalltacking point with root concavity not melted completelywelding filler not „pressed through“
excessive penetration 	<ul style="list-style-type: none">root gap too largewelding speed in the root bead too lowamperage too highwelding attachment too large in the case of gas fusion weldingunsuitable welding rod class
INTERNAL IMPERFECTIONS AND THEIR CAUSES	
pores 	<ul style="list-style-type: none">unsuitable welding fillerwelding filler or welding consumables dirtyshielding gas composition wrongshielding gas quantity too high / too lowshielding gas envelope affected by draughtsshielding gas nozzle of the torch dirty or defectivearc too longdistance between the workpiece and the torch nozzle too greatoverheated weld deposit
cracks 	<ul style="list-style-type: none">in the existing conditions, base material not weldable or to a limited extent only (e.g. high C, P and S contents)welding filler unsuitablecovered stick electrodes, flux or shielding gas moistattention not paid to the ambient temperaturein the case of an interruption, welded cross section too smallshrinkage restraintoverheatingcooling speed too high (t_{8/5} time too short)
shrinkage cavity 	<ul style="list-style-type: none">in the case of Process Group 12, ratio of the bead width to the bead height not complied withshrinkage forces too highcontaminated base material (segregation zone)cooling speed too high (t_{8/5} time too short)
lack of fusion 	<ul style="list-style-type: none">poor or wrong weld preparationweld pool flowing ahead (deposition efficiency and welding speed not adjusted)torch inclination or angle not correctamperage not sufficientmagnetic arc blow
incomplete root penetration 	<ul style="list-style-type: none">poor or wrong weld preparationamperage not adjustedin the case of pass / cap pass welding, misalignment of both weld poolsin the case of Process Groups 12 and 13, welding voltage too high
solid inclusion (oxide, slag, flux) 	<ul style="list-style-type: none">interpass cleaning inadequateamperage too lowcovering type of stick electrodes or welding flux type has an inadequate rinsing effectreinforcement of the previously welded bead too greatreaction of the tip of the welding rod or of the end of the wire electrode with atmospheric oxygen

In order to avoid any imperfections, it is necessary to pay attention to the following points:

- Base material: surface condition, workpiece thickness and material finish
- Weld preparation: exact, clean and appropriate for the workpiece thickness and the welding process
- Welding process: correct sequence and right parameters
- Welder: manual skills
- Welding filler material: appropriate for the material and the welding process
- Environment: draughts, ambient temperature, humidity ...

