

# A non-destructive testing atlas— Classification of defects in metallic fusion welds, with explanations

## INTRODUCTION

This document has been prepared by Commission V 'Testing, measurement and control of welds' with assistance from Commission VI 'Terminology'.

Some departures have been made from the terminology for defects given in the IIW Multilingual Collection of Terms published in 1955.

Commission V realises that the list is not perfect and intends to review it from time to time as imperfections are brought to its attention.

These notes apply to the tables which follow :

(a) Defects are classified into six groups :

- 1 Cracks
- 2 Cavities
- 3 Solid inclusions
- 4 Lack of fusion and penetration

5 Imperfect shape

6 Miscellaneous defects not included in Groups 1-5.

(b) Column 1 gives a three figure reference number for each principal defect and a four figure reference number for sub-terms.

(c) Column 2 gives the letter designation for defects at present used in the IIW Collections of Reference Radiographs.

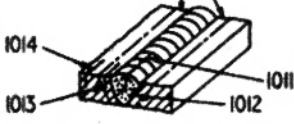
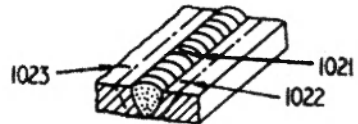
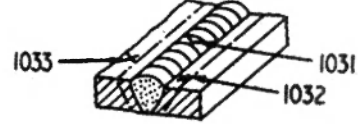



(d) Column 3 gives the designation or name of each defect.

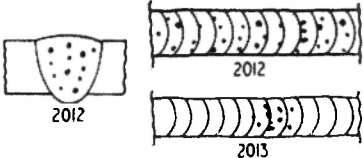
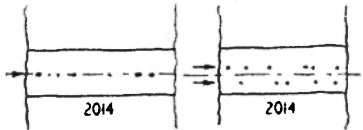
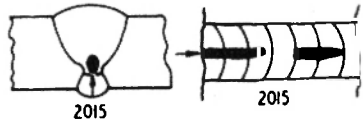
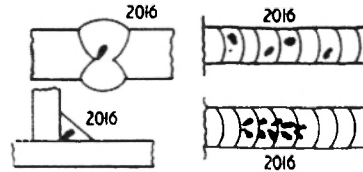
(e) Column 4 gives the explanation.

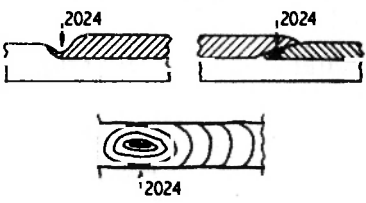
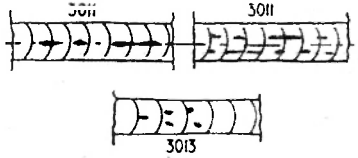
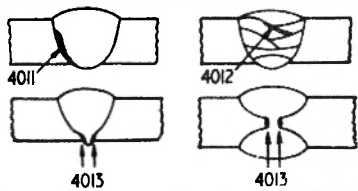
(f) Illustrations are provided where necessary to supplement the explanations.

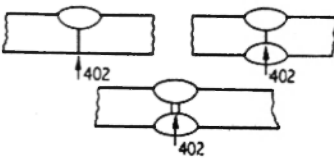
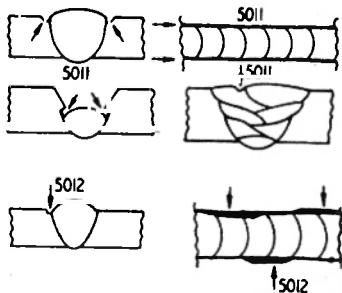
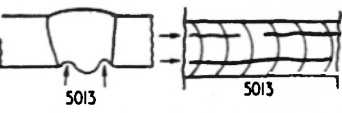
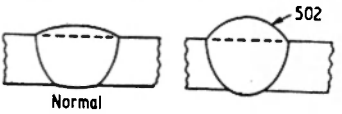
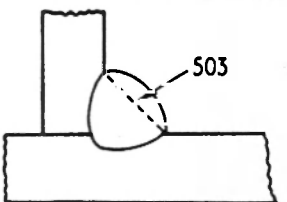
<i>References No.</i>	<i>IIW reference radiographs</i>	<i>Designation</i>	<i>Explanations</i>
1	2	3	4
100	E	GROUP No. 1 CRACKS	A discontinuity produced by a local rupture which may arise from the effect of cooling or stresses.
1001		Microfissure (micro-crack)	When a crack has microscopic dimensions, it is known as a microfissure or microcrack.

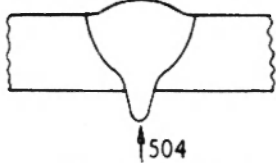
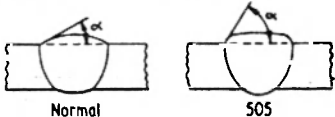
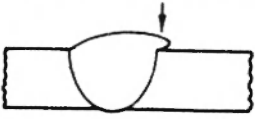
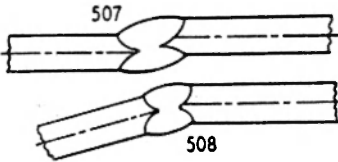
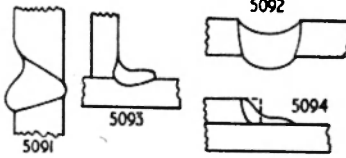
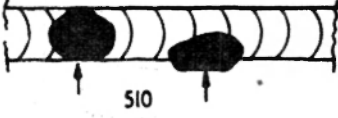
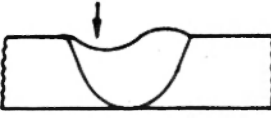
\*Doc. IIW 340-69 (ex doc. V-360-67) drawn up by Commission V "Testing, measurement and control of welds" in the IIW but not committing the IIW as a whole. Reproduced from *Welding in the World*, 1969, 7, 4.

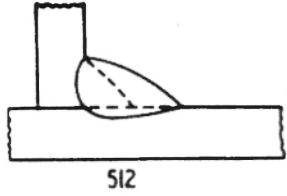
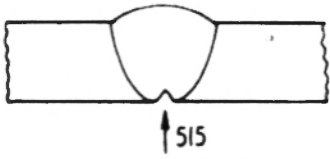
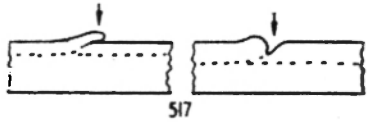
References No.	IIW reference radiographs	Designation	Explanations	
1	2	3	4	
101 1011 1012 1013 1014	Ea	Longitudinal crack	A crack substantially parallel to the axis of the weld. It may be situated: in the weld metal, at the weld junction, in the heat affected zone, in the parent metal.	Heat affected zone 
102 1021 1022 1023	Eb	Transverse crack	A crack substantially transverse to the axis of the weld. It may be situated: in the heat affected zone, in the weld metal, in the parent metal.	
103 1031 1032 1033	E	Radiating cracks	Cracks radiating from a common point. They may be found: in the weld metal, in the heat affected zone, in the parent metal. <i>Note:</i> Small cracks of this type are known as star cracks.	
104 1041 1042 1043	Ec	Crater crack	A crack in the end crater of a weld which may be: longitudinal, transverse, star cracking.	
105 1051 1052 1053	E	Group of disconnected cracks	A group of disconnected cracks which may be situated: in the weld metal, in the parent metal.	
106 1061 1062 1063	E	Branching cracks	A group of connected cracks originating from a common crack and distinguishable from disconnected cracks (105) and from radiating cracks (103). They may be situated: in the weld metal, in the heat affected zone, in the parent metal.	
GROUP NO. 2 CAVITIES				
201	A	Gas cavity	A cavity formed by entrapped gas.	
2011	Aa	Gas pore	A gas cavity of essentially spherical form.	

References No.	IIW Reference radiographs	Designation	Explanations
1	2	3	4
2012 2013		Uniformly distributed porosity. Localised (clustered) porosity	A number of gas pores distributed in a substantially uniform manner throughout the weld metal ; not to be confused with linear porosity (2014). Group of gas cavities.
			
2014		Linear porosity	A line of gas pores situated parallel to the axis of the weld.
			
2015	Ab	Elongated cavity	A large non spherical cavity with its major dimension parallel to the axis of the weld.
			
2016	Ab	Worm-hole	A tubular cavity in weld metal caused by release of gas. The shape and position of worm-holes is determined by the mode of solidification and the sources of the gas and they may be distributed in a herringbone formation.
			
2017		Surface pore	A small gas pore which breaks the surface of a weld.
202	K	Shrinkage cavity	A cavity due to shrinkage during solidification.
2021		Interdendritic shrinkage	An elongated shrinkage cavity formed between dendrites during cooling which may contain entrapped gas. Such a defect is generally to be found perpendicular to the weld face.
2022		Microshrinkage	Shrinkage only visible under the microscope.
2023		Interdendritic microshrinkage	Interdendritic shrinkage only visible under the microscope.

References No.	IIW Reference radiographs	Designation	Explanations
1	2	3	4
2024	K	Crater pipe	The depression due to shrinkage at the end of a weld run and not eliminated before or during the deposition of subsequent weld passes. 
300		<b>GROUP NO. 3</b> SOLID INCLUSIONS Solid inclusion	Solid foreign substances entrapped in the weld metal.
301	Ba	Slag inclusion	Slag entrapped in the weld metal. According to the circumstances of their formation such inclusions may be : 
3011 3012 3013			linear, isolated, others.
302	G	Flux inclusion	Flux entrapped in the weld metal. According to circumstances such inclusions may be :
3021 3022 3023			linear, isolated, others.
			See 3011-3013
303	J	Oxide inclusion	Metallic oxide trapped in the weld metal during solidification.
3031		Puckering	In certain cases especially in aluminium alloys, gross oxide film enfoldment can occur due to a combination of unsatisfactory protection from atmospheric contamination and turbulence in the weld pool.
304	H	Metallic inclusion	A particle of foreign metal trapped in the weld metal. It may be of : tungsten, copper, other metal.
3041 3042 3043			
401		<b>GROUP NO. 4</b> LACK OF FUSION AND PENETRATION Lack of fusion (incomplete fusion)	Lack of union between weld metal and parent metal or weld metal and weld metal. It will be one of the following: 

References No.	IIW Reference radiographs	Designation	Explanations
1	2	3	4
4011 4012 4013			lack of side wall fusion lack of inter-run fusion lack of fusion at the root of the weld. <i>Note (1) :</i> In certain countries one uses the terms 'collage noir' and 'collage blanc' depending on the presence or absence of oxide inclusions together with the lack of fusion.
402	D	Lack of penetration (incomplete penetration)	Lack of fusion between parent metal and parent metal due to failure of weld metal to extend into the root of the joint. 
500		GROUP NO. 5 IMPERFECT SHAPE Imperfect shape	Imperfect shape of the external surfaces of the weld or defective joint geometry.
5011	F	Undercut	A groove at the toe(s) of a weld run due to welding. Undercut may be continuous (term 5011) or intermittent (term 5012) but in English such a distinction is not normally made. 
5012	F	Undercut	
5013		Shrinkage groove	A shallow groove in the root caused by contraction in the weld metal along each side of the penetration bead. (See also 515). 
502		Excessive reinforcement	An excess of weld metal at the face (s) of the butt weld. 
503		Excessive convexity	An excess of weld metal at the face of a fillet weld. 

References No.	IIW Reference radiographs	Designation	Explanations
1	2	3	4
504		Excessive penetration	Excess weld metal protruding through the root of a weld made from one side or through weld metal previously deposited from either side of a multi-run joint.
			
5041		Goutte	Local excessive penetration (no equivalent term in English).
505		Bad reinforcement angle	Too large an angle ( $\infty$ ) between the plane of the parent metal surface and a plane tangential to the weld bead surface at the toe.
			
506		Overlap	Excess of weld metal at the toe of a weld covering the parent metal surface but not fused to it.
			
507		Linear misalignment	Misalignment between two welded pieces such that whilst their surface planes are parallel their projected surfaces are not at the required level.
508		Angular misalignment	Misalignment between two welded pieces such that their surface planes are not parallel (or at the intended angle).
			
509		Effondrement	<i>Note</i> : Weld metal collapse due to gravity. An equivalent term is not used in English.
5091			
5092			
5093			
5094			
			
510		Burn through	A collapse of the weld pool resulting in a hole in the weld or at the side of the weld.
			
511		Incompletely filled groove	A longitudinal continuous or intermittent channel in the surface of a weld due to insufficient deposition of weld metal.
			

<i>References No.</i>	<i>IIW Reference radiographs</i>	<i>Designation</i>	<i>Explanations</i>
1	2	3	4
512		Asymmetrical fillet weld	Explanations not necessary.
			
513 514		Irregular width Irregular surface	Explanations not necessary.
515		Root concavity	A shallow groove due to shrinkage of a butt weld at the root. (see also 5013).
			
516		Rochage	Term not used in English.
517		Poor restart	A local surface irregularity at a weld restart.
			
600		<b>GROUP NO. 6 MISCELLANEOUS DEFECTS</b> Miscellaneous defects	All defects which cannot be included in groups 1-5.
601		Stray flash or arc strike	Local damage to the surface of the parent metal adjacent to weld resulting from accidental arcing or striking the arc outside the weld groove.
602		Spatter	Globules of weld metal or filler expelled during welding and adhering to the surface of parent metal or solidified weld metal.
6021		Tungsten spatter	Particles of tungsten transferred from the electrode to the surface of parent metal or solidified weld metal.
603		Torn surface	Surface damage due to the removal by fracture of temporary welded attachments.
604		Grinding mark	Local damage due to incorrect grinding.
605		Chipping mark	Local damage due to incorrect use of a chisel.
606		Underflushing	Reduction in thickness of metal due to excessive grinding.