



Education and Culture

Leonardo da Vinci

Course: Quality Assurance

Module 7

Table of Contents

MODULE 7.....	3
Visual Inspection (VT)	3
Defects/imperfections in welds - porosity.....	5
Identification.....	5
Cause and prevention.....	5
Distributed porosity and surface pores.....	5
Fig. 1. Uniformly distributed porosity.....	6
Fig. 2. Surface breaking pores (T fillet weld in primed plate).....	6
Prevention.....	6
Wormholes.....	7
Elongated pores or wormholes.....	7
Prevention.....	7
Crater pipe.....	7
Prevention.....	8
Porosity susceptibility of materials.....	8
Principal gases causing porosity and recommended cleaning methods.....	8

MODULE 7

Objective:

Know about imperfections in welds.

Scope:

- *Origin of imperfections: parent metal; welding process; welder; joint preparation*
- *Survey of specific weld imperfections and their cause*
- *Influence of weld imperfections on product performance*
- *Influence of the weld geometry on the fatigue life of the product*

Expected results:

- *Identify and describe the cause of: gas pores, incomplete penetration, lack of fusion and cracks (see also the specific modules “S” on welding processes .*

Non destructive examination (NDE) methods of inspection make it possible to verify compliance to the standards on an ongoing basis by examining the surface and subsurface of the weld and surrounding base material. Five basic methods are commonly used to examine finished welds: visual, liquid penetrant, magnetic particle, ultrasonic and radiographic (X-ray). The growing use of computerization with some methods provides added image enhancement, and allows real-time or near real-time viewing, comparative inspections and archival capabilities. A review of each method will help in deciding which process or combination of processes to use for a specific job and in performing the examination most effectively.

Visual Inspection (VT)

Visual inspection is often the most cost-effective method, but it must take place prior to, during and after welding. Many standards require its use before other methods, because there is no point in submitting an obviously bad weld to sophisticated inspection techniques. The ISO 5817 states, "Welds subject to non-destructive examination shall have been found acceptable by visual inspection." Visual inspection requires little equipment. Aside from good eyesight and sufficient light, all it takes is a pocket rule, a weld size gauge, a magnifying glass, and possibly a straight edge and square for checking straightness, alignment and perpendicularity. Before the first welding arc is struck, materials should be examined to see if they meet specifications for quality, type, size, cleanliness and freedom from defects. Grease, paint, oil, oxide film or heavy scale should be removed. The pieces to be joined should be checked for flatness, straightness and dimensional accuracy. Likewise, alignment, fit-up and joint preparation should be examined. Finally, process and procedure variables should be verified, including electrode size and

type, equipment settings and provisions for preheat or postheat. All of these precautions apply regardless of the inspection method being used.

During fabrication, visual examination of a weld bead and the end crater may reveal problems such as cracks, inadequate penetration, and gas or slag inclusions. Among the weld defects that can be recognized visually are cracking, surface slag inclusions, surface porosity and undercut.

On simple welds, inspecting at the beginning of each operation and periodically as work progresses may be adequate. Where more than one layer of filler metal is being deposited, however, it may be desirable to inspect each layer before depositing the next. The root pass of a multipass weld is the most critical to weld soundness. It is especially susceptible to cracking, and because it solidifies quickly, it may trap gas and slag. On subsequent passes, conditions caused by the shape of the weld bead or changes in the joint configuration can cause further cracking, as well as undercut and slag trapping. Repair costs can be minimized if visual inspection detects these flaws before welding progresses.

Visual inspection at an early stage of production can also prevent underwelding and overwelding. Welds that are smaller than called for in the specifications cannot be tolerated. Beads that are too large increase costs unnecessarily and can cause distortion through added shrinkage stress.

After welding, visual inspection can detect a variety of surface flaws, including cracks, porosity and unfilled craters, regardless of subsequent inspection procedures. Dimensional variances, warpage and appearance flaws, as well as weld size characteristics, can be evaluated.

Before checking for surface flaws, welds must be cleaned of slag. Shot-blasting should not be done before examination, because the peening action may seal fine cracks and make them invisible.

Visual inspection can only locate defects in the weld surface. Specifications or applicable codes may require that the internal portion of the weld and adjoining metal zones also be examined. Non-destructive examinations may be used to determine the presence of a flaw, but they cannot measure its influence on the serviceability of the product unless they are based on a correlation between the flaw and some characteristic that affects service. Otherwise, destructive tests are the only sure way to determine weld serviceability.

Visual Inspection should be carried out by the welder itself as a part of the own approval of the work.

- However due to industrial and standard requirements that it also is a special task for the Visual Inspector verifying that the job done by the welder is appropriate.

The ISO 5817:2003 provides quality levels of imperfections in fusion-welded joints (except for beam welding) in all types of steel, nickel, titanium and their alloys. It applies to material thickness above 0,5 mm. This standard is a reference standard used within the scope of the Visual Inspection.

Three quality levels are given in order to permit application to a wide range of welded fabrication. They are designated by symbols B, C and D. Quality level B corresponds to the highest requirement on the finished weld. The quality levels refer to production quality and not to the fitness-for-purpose of the product manufactured.

ISO 5817:2003 applies to:

- unalloyed and alloy steels;
- nickel and nickel alloys;
- titanium and titanium alloys;

- manual, mechanized and automatic welding;
- all welding positions;
- all types of welds, e.g. butt welds, fillet welds and branch connections;
- the following welding processes and their defined sub-processes in accordance with ISO 4063:
 - 11 metal-arc welding without gas protection;
 - 12 submerged-arc welding;
 - 13 gas-shielded metal-arc welding;
 - 14 gas-shielded welding with non-consumable electrodes;
 - 15 plasma arc welding;
 - 31 oxy-fuel gas welding (for steel only).

In addition the ISO 6520 Welding and allied processes -- Classification of geometric imperfections in metallic materials -- Part 1: Fusion welding gives an in depth specification of the welding defect and the accept criteria.

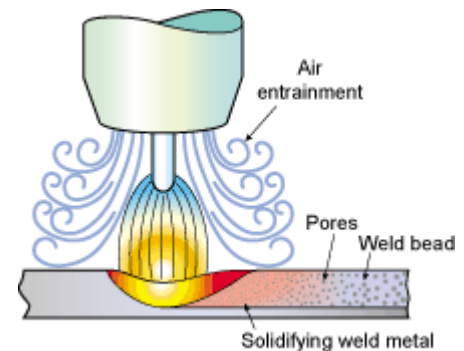
Defects/imperfections in welds - porosity

The characteristic features and principal causes of porosity imperfections are described. Best practice guidelines are given so welders can minimise porosity risk during fabrication.

Identification

Porosity is the presence of cavities in the weld metal caused by the freezing in of gas released from the weld pool as it solidifies. The porosity can take several forms:

- distributed
- surface breaking pores
- wormhole
- crater pipes



Cause and prevention

Distributed porosity and surface pores

Distributed porosity (*Fig. 1*) is normally found as fine pores throughout the weld bead. Surface breaking pores (*Fig. 2*) usually indicate a large amount of distributed porosity

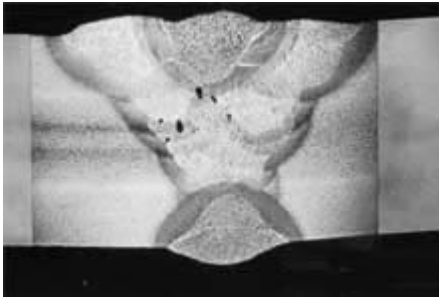


Fig. 1. Uniformly distributed porosity

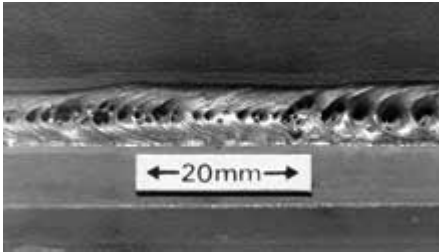


Fig. 2. Surface breaking pores (T fillet weld in primed plate)

Cause

Porosity is caused by the absorption of nitrogen, oxygen and hydrogen in the molten weld pool which is then released on solidification to become trapped in the weld metal.

Nitrogen and oxygen absorption in the weld pool usually originates from poor gas shielding. As little as 1% air entrainment in the shielding gas will cause distributed porosity and greater than 1.5% results in gross surface breaking pores. Leaks in the gas line, too high a gas flow rate, draughts and excessive turbulence in the weld pool are frequent causes of porosity.

Hydrogen can originate from a number of sources including moisture from inadequately dried electrodes, fluxes or the workpiece surface. Grease and oil on the surface of the workpiece or filler wire are also common sources of hydrogen.

Surface coatings like primer paints and surface treatments such as zinc coatings, may generate copious amounts of fume during welding. The risk of trapping the evolved gas will be greater in T joints than butt joints especially when fillet welding on both sides. Special mention should be made of the so-called weldable (low zinc) primers. It should not be necessary to remove the primers but if the primer thickness exceeds the manufacturer's recommendation, porosity is likely to result especially when using welding processes other than MMA.

Prevention

The gas source should be identified and removed as follows:

Air entrainment

- seal any air leak
- avoid weld pool turbulence
- use filler with adequate level of deoxidants
- reduce excessively high gas flow
- avoid draughts

Hydrogen

- dry the electrode and flux
- clean and degrease the workpiece surface

Surface coatings

- clean the joint edges immediately before welding
- check that the weldable primer is below the recommended maximum thickness

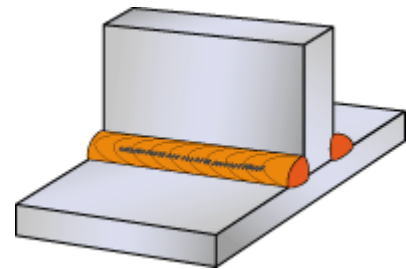
Wormholes

Characteristically, wormholes are elongated pores (*Fig. 3*) which produce a herring bone appearance on the radiograph.

Cause

Wormholes are indicative of a large amount of gas being formed which is then trapped in the solidifying weld metal. Excessive gas will be formed from gross surface contamination or very thick paint or primer coatings. Entrapment is more likely in crevices such as the gap beneath the vertical member of a horizontal-vertical, T joint which is fillet welded on both sides.

Elongated pores or wormholes



When welding T joints in primed plates it is essential that the coating thickness on the edge of the vertical member is not above the manufacturer's recommended maximum, typically 20µm, through over-spraying.

Prevention

Eliminating the gas and cavities prevents wormholes.

Gas generation

- clean the workpiece surfaces
- remove any coatings from the joint area
- check the primer thickness is below the manufacturer's maximum

Joint geometry

- avoid a joint geometry which creates a cavity

Crater pipe

A crater pipe forms during the final solidified weld pool and is often associated with some gas porosity.

Cause

This imperfection results from shrinkage on weld pool solidification. Consequently, conditions which exaggerate the liquid to solid volume change will promote its formation. Switching off the welding current will result in the

rapid solidification of a large weld pool.

In TIG welding, autogenous techniques, or stopping the wire before switching off the welding current, will cause crater formation and the pipe imperfection.

Prevention

Crater pipe imperfection can be prevented by removing the stop or by welder technique.

Removal of stop

- use run-off tag in butt joints
- grind out the stop before continuing with the next electrode or depositing the subsequent weld run

Welder technique

- progressively reduce the welding current to reduce the weld pool size
- add filler (TIG) to compensate for the weld pool shrinkage

Porosity susceptibility of materials

Gases likely to cause porosity in the commonly used range of materials are listed in the Table.

Principal gases causing porosity and recommended cleaning methods

<i>Material</i>	<i>Gas</i>	<i>Cleaning</i>
C-Mn steel	Hydrogen, Nitrogen and Oxygen	Grind to remove scale coatings
Stainless steel	Hydrogen	Degrease + wire brush + degrease
Aluminium and alloys	Hydrogen	Chemical clean + wire brush + degrease + scrape
Copper and alloys	Hydrogen, Nitrogen	Degrease + wire brush + degrease
Nickel and alloys	Nitrogen	Degrease + wire brush + degrease