

DISCONTINUITIES AND DEFECTS

Training Workbook



HOBART INSTITUTE

OF WELDING TECHNOLOGY

An explanation of welding discontinuities and defects
in relation to welding procedure variables.

EW-512-4

DISCONTINUITIES AND DEFECTS

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the Staff of Hobart Institute
of Welding Technology

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GLOSSARY OF WELDING TERMS

Base metal – the metal or alloy that is to be welded, brazed, soldered, or cut.

Clamps – A device designed to bind, constrict or press two or more parts together so as to hold them firmly. (See also fixtures.)

Codes – A system of principles or rules.

Contaminants – To make unfit or unclean. Implies intrusion of or contact with dirt or foulness from an outside source.

Concavity – The maximum distance from the face of a concave fillet weld perpendicular to a line joining the weld toes.

Convexity – The maximum distance from the face of a convex fillet weld perpendicular to a line joining the weld toes.

Electrode – A component of the electrical circuit that terminates at the arc, molten conductive slag, or base metal.

Face of Weld – (See weld face.)

Filler Metal – The metal or alloy to be added in making a brazed, soldered or welded joint.

Fillet Weld – A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint.

Fixture – A device designed to hold and maintain parts in proper relation to each other. (See also clamps.)

Groove Weld – A weld made in a weld groove between two members to be joined, on a workpiece surface between workpiece edges, between workpiece surfaces, or between workpiece edges and surfaces.

Holding Ovens – A heated oven used for storage of electrodes.

Interpass Temperature – In a multipass weld, the temperature (minimum or maximum as specified) of the deposited weld metal before the next pass is started.

Postheat – The application of heat to an assembly after a welding, brazing, soldering, thermal spraying or cutting operation.

Preheat – The application of heat to the base metal immediately before welding, brazing, soldering, thermal spraying, or cutting, immediately before these operations are performed, to attain and maintain preheat temperature.

Procedure – The detailed elements or series of steps of a process or method, followed in a definite order, used to produce a specific result.

Root of a Weld – (See weld root.)

Shielding Gas – Protective gas used to prevent or reduce atmospheric contamination.

Specifications – A detailed precise presentation of rules or information, or of a plan or proposal for composition or construction.

Throat (Actual) – The shortest distance between the weld root and the face of a fillet weld.

Toe of Weld – (See weld toe.)

Travel Angle – The angle less than 90 degrees between the electrode axis and a line perpendicular to the weld axis, in a plane determined by the electrode axis and the weld axis. This angle can also be used to partially define the position of guns, torches, rods, and beams.

Weld Face – The exposed surface of a weld on the side from which welding was done.

Weld Root – The points, shown in cross section, at which the weld metal intersects the base metal and extends furthest into the weld joint.

Weld Toe – The junction of the weld face and the base metal.

Work Angle – The angle less than 90 degrees between a line perpendicular to the major workpiece surface and a plane determined by the electrode axis and the weld axis. In a T-joint or corner joint, the line is perpendicular to the nonbutting member. This angle can also be used to partially define the position of guns, torches, rods, and beams.

Workmanship Samples – Finished quality samples of how a weld or part should visually look when complete.

Based on Standard Welding Terms and Definitions, AWS 3.0. American Welding Society.

WELD INSPECTOR RESPONSIBILITIES RELATED TO DISCONTINUITIES AND DEFECTS

OBJECTIVE

To list the specific responsibilities or duties that welding inspectors assume as related to discontinuities and defects.



Evaluating for discontinuity



Discontinuity, Undercut



Defect

INTRODUCTION

This section includes the responsibilities of the welding inspector as they relate to the evaluation of weldments; the identification and classification of discontinuities; and the conditions that exist when evaluating discontinuities in order to decide whether they are acceptable or unacceptable.

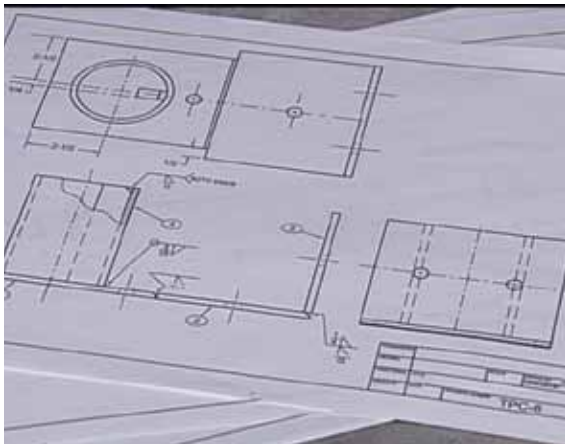
DEFINITIONS

The term discontinuity has many meanings, but for purposes here, we will refer to it as an interruption of the typical structure of a weld or a weldment; this means that the weld or weldment lacks uniformity in mechanical, metallurgical, or physical characteristics. A discontinuity is not necessarily a defect unless it is unable to meet minimum acceptance standards or specifications.

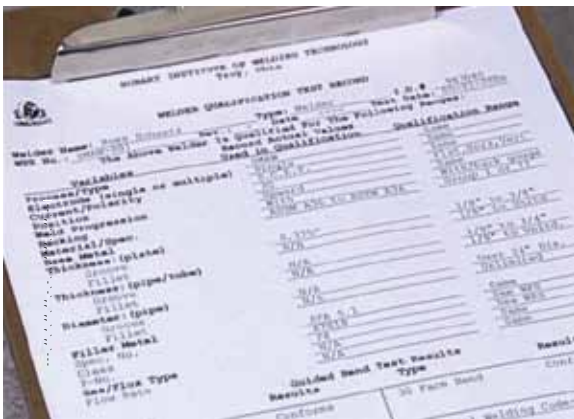
The term defect means the unacceptability of a weld or weldment.

QUALITY

Quality has many meanings. A quality weld will successfully sustain the service it encounters. The quality of welds must be based on codes and standards that anticipate the service of the product. For some, there are no applicable codes or specifications. For these products, the producer must maintain quality in order to compete. The success of maintaining the balance between quality requirements and cost factors is decided in the field and in the marketplace. The responsibility for producing quality products rests on engineers, designers, welding supervisors, welders, and quality control and inspection personnel.



Read engineering drawings.



Maintain reports.



Proper joint fit-up.

WELDING INSPECTOR RESPONSIBILITIES

The responsibilities of the welding inspector are many. Perhaps the most important responsibility is the ability to read and understand all welding drawings and written specifications. Also, the welding inspector should review all documented instructions such as codes, construction details, welding procedures, material specifications, and any special procedures required for the weldment.

The inspector's duty is to assure that the proper evaluation of test results is accomplished. With the use of codes and standards as a guide, the inspector can determine the results. Documented workmanship standards, based on codes, are used as a guide for evaluating weldments. Maintaining and preparing reports for records is another of the inspector's jobs. The reports should state general characteristics of the job, the job's conformity to the code, and any difficulties that may have occurred, with a clear and descriptive statement of any defects.

The inspector examines yet-to-be-welded joints to confirm their conformity to the weld joint detail included in the procedure. Proper joint fit-up and edge preparation are equally important. The alignment and root opening of parts must be inspected to determine their conformance to the construction of joint detail.

Weld Speed	Volts	Travel Speed	Joint Details
180	26	8	
200	27	10	
200	27	11	
200	27	9	
200	27	11	

Verify procedures.



Verify correct purchasing of material.



Investigate for proper workmanship.

A common cause for many weld failures is the use of inadequate welding procedures, the inaccurate interpretation of procedures, or not using procedures during production. The inspector must verify the procedures are correct and properly implemented. The inspector should maintain records of qualified welders and weld operators. A weld can meet all standards, but if the welder or operator is not qualified to do the work, the weld may be rejected.

The inspector must verify the correct purchasing of welding materials and consumables. To assist in making selections, filler metals are specified by the American Welding Society (AWS), and base materials are commonly specified by the American Society of Testing and Materials (ASTM). The inspector must identify and verify the materials received, verify the chemical composition and mechanical properties of the material, and check for imperfections and deviations that might cause problems during production. The inspector also verifies correct storage of filler materials according to specifications.

Special procedures may be written for post-weld heat treatments, assembly, and final finishing. The inspector verifies the condition of equipment to be used for welding and testing, and any special equipment required for other treatments. The capability, calibration and safety of equipment should be accurately investigated to prevent possible nonconforming workmanship in weld-fabricated parts.

SUMMARY

Many weld defects can be eliminated before they occur if the inspector knows and accepts his/her responsibilities.

TOPIC 1

REVIEW QUESTIONS

1. What is the difference between a discontinuity and a defect?

2. On what documents is weld quality often based?

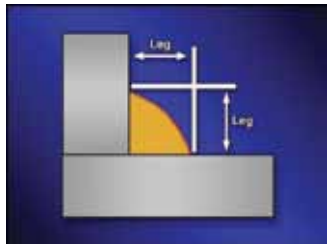
3. List the responsibilities of a welding inspector.

TOPIC 2

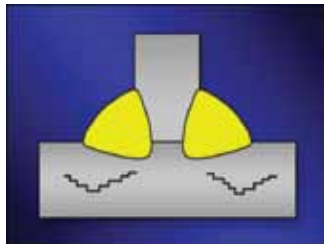
THE IDENTIFICATION AND DEFINITION OF WELD DISCONTINUITIES AND DEFECTS

OBJECTIVE

To be able to identify and define the various types of discontinuities and defects.



Shape, size, and contour.



Internal consistency of welds.



Structural discontinuities.



Reinforcement.



Size.



Profile



Excessive face reinforcement



Excessive root reinforcement



Groove size

INTRODUCTION

In order to evaluate weldments, the weld inspector should have the ability to identify weld discontinuities. Discontinuities can be grouped into three classes. The first group relates to shape, size, and contour, which are the external dimensions of a weld. The second group relates to the internal consistency of welds, and is referred to as structural discontinuities. The third group is weld and base metal properties, which relates to the match between weld metal and base metal.

SHAPE, SIZE AND CONTOUR

Shape, size and contour can be broken down further to welds with excessive reinforcement, incorrect size, incorrect profile, and incorrect final weldment dimensions.

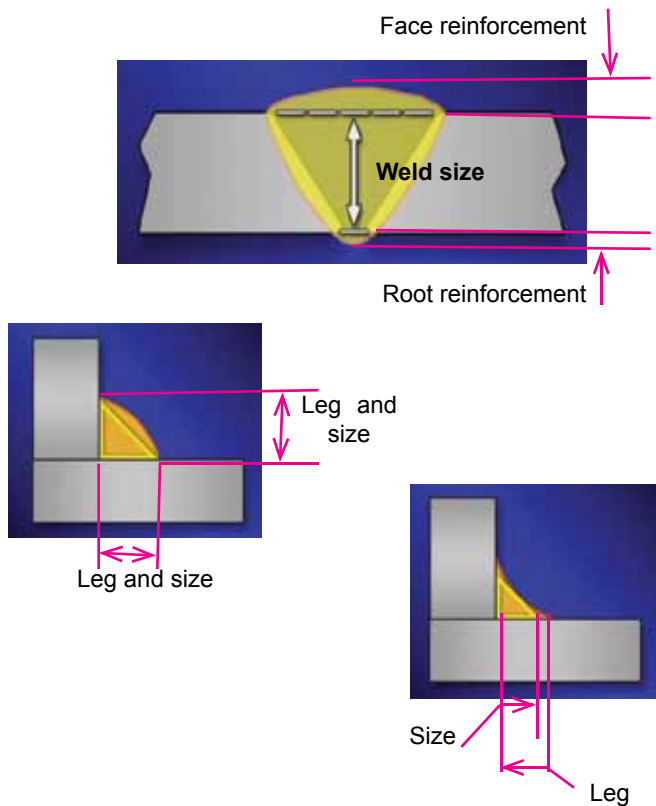
Excessive Weld Reinforcement

Excessive face reinforcement is extra metal deposited in a weld, forming a highly convex contour on the side of the joint from which welding is done.

Excessive root reinforcement is extra weld metal deposited in the root of the weld. It is more common with joint designs which have root openings.

Incorrect Weld Size

The size of a groove weld is measured by the shortest distance from the root of a weld to its face, less any reinforcement. It is generally equal to the base metal thickness, on full penetration welds. When the plates are of unequal thickness, the thickness of the thinner plate determines the size of the groove weld. A slight reinforcement is usually specified.



Excessive reinforcement is not only wasteful, but decreases the working strength of the joint due to the concentration of stresses at the toes.

The size of a fillet weld is designated as its shortest leg length, a measurable dimension used to deposit the weld. The leg is the distance from the root of the joint to the toe. For strength, the size of a fillet weld is the leg length of the largest isosceles right triangle that can be inscribed within the weld. The effective size for strength for flat and convex welds is equal to the leg size, but for concave welds it is less than the actual leg length. Incorrect size welds may be determined visually with gages or by comparison with approved workmanship samples.

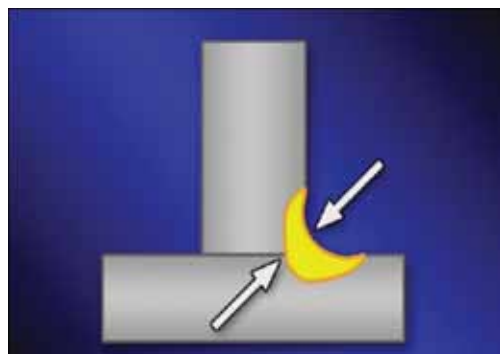


Overlap of a weld

Incorrect Weld Profile

Incorrect weld profile is a weld that does not meet the requirements for size or contour.

Overlap is the bulging or protruding portion of a weld that extends beyond the toe, face, or root. In both fillet and groove welds, it can reduce the size and strength, and concentrate stresses at the weld toes.



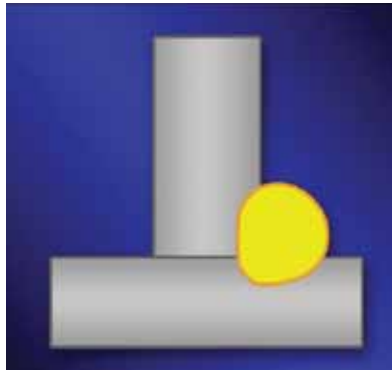
Insufficient throat or underfill

Insufficient throat or underfill is a weld face or root that is depressed or extends below the adjacent base metal surfaces.



Undercut

Undercut is a groove melted into the base metal adjacent to the toe or root of a weld, and left unfilled. It is usually found at the side wall or face of a groove, at the edge of a weld or layer, or at the toes of the cover pass, resulting in a reduction of base metal thickness at the point of undercut. In fillet welds, it tends to reduce the size and strength of the weld, as well as promoting stress concentrations at the toes.



Excessive convexity

Excessive convexity is a highly convex contour formed by excessive reinforcement.



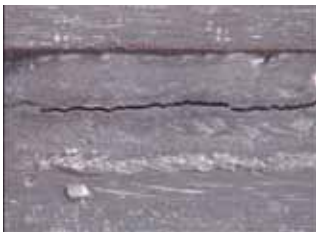
Distortion



Warpage

Incorrect Final Weldment Dimensions

Distortion and warpage are caused by the nonuniform expansion and contraction of weld and base metal during the heating and cooling process of welding. If warpage changes the required dimensions of the total weldment, the weldment may not be acceptable.



Cracks



Porosity

INTERNAL INCONSISTENCIES OR IRREGULARITIES

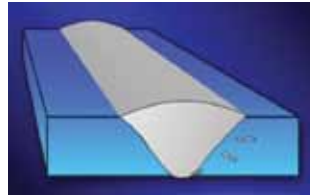
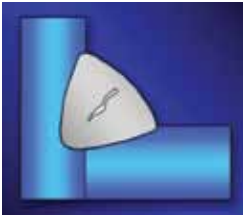
Internal inconsistencies are cracks, porosity, slag inclusions, tungsten inclusions, incomplete fusion, and inadequate joint penetration.



Inclusions



Inadequate joint penetration



Cracks are fractures that cause an opening or a split in the weld or base metal. They can be classified as hot cracks, which occur at high temperatures during solidification, or cold cracks, which occur after solidification is complete. Both types can be categorized by physical relationships, which is their location within the weld or weldment.

Cracks are fractures that cause an opening or a split in the weld or base metal.



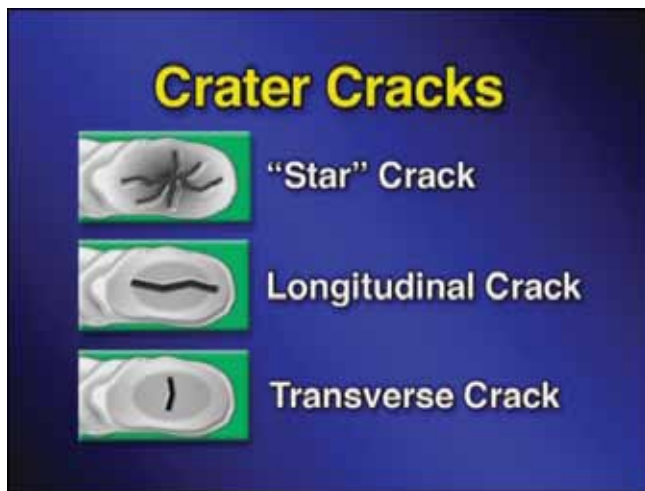
Longitudinal crack.



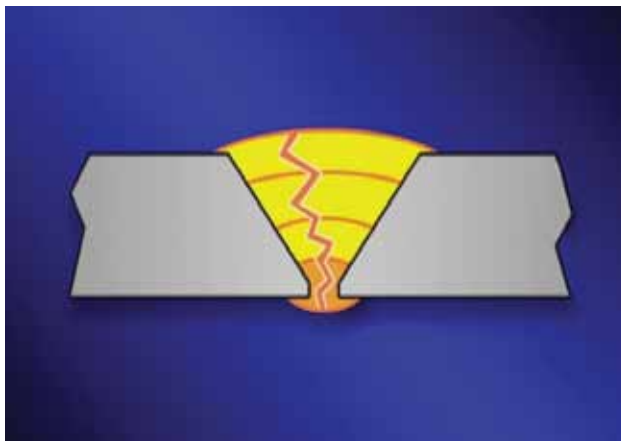
Transverse crack.

A longitudinal crack runs along parallel to the axis of the weld.

A transverse crack runs perpendicular to the axis of the weld. It is often located near or in poor restarts or other internal discontinuities.

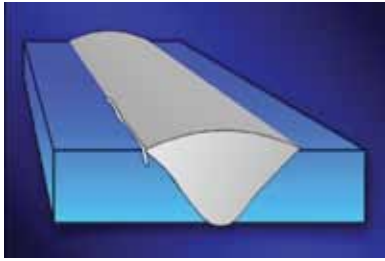


Crater cracks occur in the depression left at the termination of the weld bead. Crater cracks are serious when located near the end of a weld because they can lead to other cracks. They can be star-shaped or in a single direction, either longitudinal or transverse.



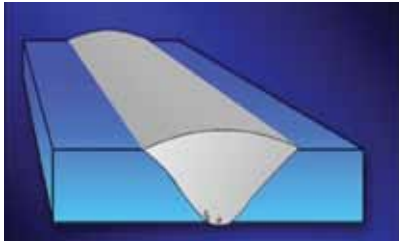
Weld metal crack

Weld metal cracks are longitudinal in the weld and originate from the face or root.



Toe crack

Toe cracks originate and grow from the toe of the weld where high amounts of stress are most common.



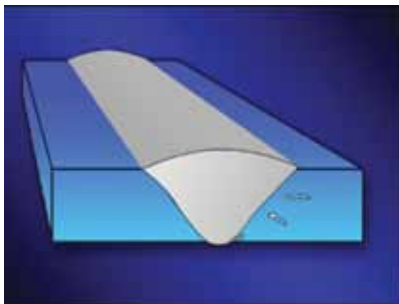
Root crack

Root cracks are located along the root of the weld.



Arc strike

An arc strike is a heat-affected surface, any localized remelted metal surface, or change in surface profile caused by an arc. Arc strikes are often considered as blemishes but can be serious and lead to cracking of the weld or weldment if not removed by sufficient grinding.



Heat affected zone cracks

Heat-affected zone cracks or underbead cracks occur during the cooling cycle after solidification of the weld and normally do not extend to the surface of the weldment. They are short but can connect with others to become continuous cracks. They can occur after a part is in service because of the embrittlement of the weld and the heat-affected zone.



Uniformly scattered porosity

Porosity is entrapped gas cavities formed during solidification of the weld. Uniformly scattered porosity is found throughout the weld.