Welding Terms and Inspection

Learning Outcome

When you complete this module you will be able to:

Define welding terms and describe methods of weld inspection.

Learning Objectives

Here is what you will be able to do when you complete each objective:

1. Define the common terms used in welding.

2. Discuss the commonly used methods of weld inspection and testing.
INTRODUCTION

Welding consists of joining two or more pieces of metal by the application of heat and sometimes pressure.

In arc welding the heat comes from an electric arc and no pressure is employed to fuse the metal parts. Often the heat from the arc is used to melt and fuse the parts together without adding extra metal. In most applications of arc welding, however, molten metal is added to the joint and usually this joint is specially prepared to receive such metal.

Since welding is a joining process, the student should first have a knowledge of joints themselves, what they look like, what they are called, how they are prepared and what their uses are, and be familiar with the language used in the welding industry.

WELDING TERMS

Arc Welding

Welding processes where fusion (or coalescence) is obtained by heating with an electric arc.

Axis of Weld

An imaginary line through the length of a weld, perpendicular to the cross section, at its center of gravity.

Backfire

The retreat of the flame into the torch tip, followed by its immediate reappearance, accompanied by noise and possible flameout.

Backing Pass

A pass made to deposit a backing weld behind the root pass.

Backing Ring

Backing strip in the form of a ring placed inside piping or vessels to facilitate obtaining a sound, nonporous weld at the root.
Backing Strip

Backing in the form a strip of flat bar, placed behind the root before welding.

Backing Weld

Backing in the form of a weld. See Fig. 1.

![Figure 1: Backing Weld](image)

Bare Electrode

A filler metal electrode with no coating.

Base Metal

The metal to be welded or cut.

Bevel Angle

The angle between the prepared edge and a plane, perpendicular to the surface of the metal.

Blowhole

A gas pocket or weld cavity caused by gas or moisture trapped in the weld.
Boxing

Continuing a fillet weld around a corner. See Fig. 2.

![Figure 2]

Braze

To solder with a nonferrous alloy that melts at a lower temperature than that of the metals being joined. Used extensively in repair of cast-iron parts.

Butt Joint

A joint between two plates or parts that lie approximately in the same plane. See Fig. 3.

![Figure 3]

Carbon Arc Cutting

An electric arc cutting process where a metal is cut with the heat of an arc between a carbon electrode and the base metal.
Coalescence

Unite two pieces of metal into one.

Coated Electrode

A “covered electrode” consisting of a rod with light or heavy covering to protect the molten metal from the atmosphere and to stabilize the arc.

Crater

A depression or hole at the end of an arc welding bead.

Downhand

Welding is performed from the upper side of the joint. The weld face is approximately horizontal.

Filler Metal

Metal to be added in making a weld, for example, electrodes or rod.

Flux

Granular substance deposited with the weld metal during welding which helps deoxidize and cleanse the molten weld metal, then rises to the top of the weld and forms a protective slag over the surface of the new weld.

Forehand Welding

A gas welding technique using the flame directed in the direction of weld progress.

Fusion

The melting together of filler rod and base metal.
Lap Joint

A joint between two overlapping members. See Fig. 4.

![Lap Joint](image)

Figure 4
Lap Joint

Lead Angle

The angle that the electrode makes in advance of a line perpendicular to the weld axis.

Machine Welding

Welding with equipment that performs the operation, under the observation and control of a trained operator.

Manual Welding

Welding where the entire operation is performed by hand.

Neutral Flame

A gas flame which is neither oxidizing nor reducing; that is, it is neither rich in oxygen nor acetylene.

Oxyacetylene Cutting

An oxygen cutting of metal is caused by the chemical reaction of oxygen with the base metal at high temperatures. The necessary heat is provided being by burning acetylene with oxygen.

Plug Weld

A weld made through a hole in one plate of a lap joint, joining that plate or member to the other. See Fig. 5.
Porosity

Gas pockets or voids in metal or welds.

Postheating

Adding heat to a welded part immediately after welding to prevent cracking by slowing the cooling rate of the weld and heat-affected zone.

Preheating

Heating the base metal or plates immediately before welding to slow the cooling rate of the weld and prevent cracking.

Procedure Qualifications

The approval of a welding procedure by the governing authority to be used for a specific application. Approval is granted when it is satisfactorily demonstrated by testing that welds made using a proposed procedure will meet the required standards.

Reaction Stress

Residual stress created by welding restrained parts which are not free to shrink during cooling after welding.

Reducing Flame

A flame rich in acetylene.
Residual Stress

Stress remaining in a structure, as a result of welding.

Reverse Polarity

The negative lead is clamped to the work.

Root Crack

A crack originating in a weld root. See Fig. 6.

Figure 6
Root Crack

Shielded Metal Arc Welding

Welding by use of a covered metal electrode where heat created by an arc between the electrode and the base metal causes fusion or coalescence of the parts. Shielding is obtained by the decomposition of the covering of the electrode. See Figs. 7(a) and (b).

Figure 7(a)
Basic Shielded Metal Arc Welding Circuit
Slag Inclusion

Solid nonmetallic material entrapped in the weld.

Slugging

Adding unspecified pieces of rod or metal in a joint before or during welding, resulting in an unacceptable joint. See Fig. 8.

Spatter

Metal particles sprayed out during welding which do not form part of the weld.
Spot Welding

Joining two thin plates at spots by the heat obtained from the resistance to the flow of current through the work parts which are held together under pressure by electrodes.

Tack Weld

A weld made to hold parts together in the correct alignment until the final welds can be made.

Toe Crack

A crack in the plate at the edge of a weld. See Fig. 9.

![Figure 9](image)

**Figure 9**  
*Toe and Underbead Cracks*

Underbead Crack

A crack in the heat-affected zone, generally not extending to the surface of the weld or base metal. See Fig. 9.

Undercut

A groove melted into the plate at the toe or side of the weld. See Fig. 10.
Weave Bead

A weld bead made with transverse oscillation of the rod. See Fig. 11.

Weld Bead

A weld deposit resulting from a pass with a welding rod.

Welding Transformer

An electrical transformer used for supplying ac current for welding.
WELD FAULTS

Faults in welding may range from faulty metallurgical characteristics to such physical imperfections as cracks, porosity, slag inclusions, lack of fusion, undercut, lack of penetration, and dimensional defects. The importance of weld defects, however, both as to type and quality, is relative to the type of weld and the service required. An imperfection harmful in one joint, need not be so in a different joint which may have different loading or stress.

The service conditions must be known before a suitable welding inspection method can be chosen. For example, in nuclear power plant pressure vessel construction, the maximum in weld quality is essential.

The power engineer will meet welding inspectors on power plant or field construction sites. This welding inspector may be a representative of the manufacturer, purchaser, or a government agency such as the Provincial Boilers Branch.

NON-DESTRUCTIVE METHODS FOR TESTING WELDS

The methods commonly used in testing and inspecting welds for the defects previously listed are of two types: nondestructive and destructive. The terms in themselves are descriptive and it is obvious that nondestructive testing could include visual, radiographic, and ultrasonic methods. The term destructive might erroneously be interpreted as destructive of the whole weld fabrication by means of an overload test. This, however, is not so and the word is commonly used to mean some form of mechanical test applied to a typical sample of a weld or to a section cut from a weld. Destructive testing methods are tensile, shear, bend, fracture, impact, hardness, metallographic, sectioning, corrosion, and chemical analysis.

Only nondestructive tests will be discussed in this module

1. Visual Inspection

Visual inspection is of great importance because it constitutes the principal basis of acceptance for many types of weldments. It is the most extensively used method of inspection because it is easy to apply, is quick, is relatively inexpensive, and gives very important information with regard to the welds and general conformity of the weldment to specification requirements.
This type of inspection usually begins prior to fabrication and includes drawings, specifications, welding procedures, and materials. Such defects as laminations, scabs, seams, scale, or other harmful surface conditions may be detected prior to use. After the parts are assembled for welding, the inspector can note incorrect root openings, improper edge preparation and alignment, and other features of joint preparation that may affect the quality of the finished welded joint.

Visual inspection is also used to check details of the work while welding is in progress, and also, to check items involved in the welding procedure. To complete the visual inspection cycle, inspection before and during welding must be followed by inspection after welding. It can be readily applied at all stages of production and has no equal in avoiding errors and detecting faults while they are still easily rectified.

2. Liquid Dye Penetrant Inspection

**Fluorescent Penetrant**

The fluorescent penetrant principle of determining weld defects that extend to the surface is often used to examine nonmagnetic materials and magnetic materials. The process employs a penetrating fluid which is fluorescent under “black” or near ultraviolet light. This fluid is applied to the surface being checked and, after allowing a short time for absorption into the flaw, the surplus fluid is wiped or washed off. “Black” light is then beamed on the area so treated, which reveals the defect by means of the fluorescent material absorbed in the flaw.

Detection of leaks by fluorescent penetrant through welded joints in tanks and containers is very effective and widely used. The operator applies the penetrant on one side of the weld and, after a suitable time, the penetrant travels through any leak passages which are revealed by scanning the opposite side under black light.

In addition to the normal detection of cracks and leaks, this method is particularly suited to revealing micro cracks in welds and has also been used in lieu of linear tightness tests and in the inspection of welds made in attaching corrosion resistant linings to vessel walls.

**Dye Penetrant**

Dye penetrant inspection is a simplified version of the fluorescent penetrant method. It too is a mechanical detection method for locating defects that extend to the surface. It indicates surface discontinuities or surface openings on metal parts as bright red lines or dots on a white background.
It requires an absolute minimum of equipment: three bottles or cans of noncorrosive liquids, the dye penetrant, the solvent and the developer compound, and three brushes. Briefly, the process consists of the following:

(i) The surface to be inspected is thoroughly cleaned.

(ii) A low viscosity, high capillarity fluid containing a red dye is applied to the surface by brushing, spraying, or dipping. An interval of five to fifteen minutes permits the penetrant to soak into surface imperfections.

(iii) At the end of the penetration time, the excess penetrant is removed from the surface by washing with the solvent, followed immediately by a thorough water rinse.

(iv) The surface is then dried and a developer compound is applied in an even, fine spray, with a paint spray gun.

(v) The developer will then draw, by capillary attraction, the red penetrant from any hidden flaws, revealing such flaws by the “bleedout” of the red dye against the white background of the developer.

In some welded tanks, large pipelines, and other similar objects, Dye Penetrant Testing can be used for locating porosity or other defects and leaks by applying the penetrant on one side and the developer on the other (similar to fluorescent penetrant leak detection). If porosity or cracks extend through the weld, the developer will pull the penetrant through such defects to reveal the flaw. In other words, the red penetrant will show up on the side opposite to that on which it was originally applied.

3. Radiographic Inspection

Radiography is a nondestructive test method that shows defects in the interiors of welds that would not be visible to the eye.

This inspection method makes use of the ability of short wavelength radiations, such as x-rays or gamma rays, to penetrate the weld. The rays penetrate objects opaque to ordinary light, and like ordinary light can affect sensitized photographic paper. Therefore, if a source of such radiation is placed on one side of the welded joint, and a sensitized photographic paper placed on the other side it will be affected by the radiation coming through the plate and the weld. A certain amount of the radiation is absorbed by the metal and the amount depends on the thickness and the type of metal. Any cracks, porosity, or light slag inclusion in the weld, more light will come through at that point and the film will be darker as a result of this extra light. Thus an image or shadow of the defect is revealed on the film.
When using gamma rays for radiography, a radioactive material such as radium or cobalt is used. The gamma rays emitted by this material pass through the weld metal and register on a film located on the opposite side of the weld and any defects in the weld will be evident.

To control the quality and reliability of the test, strips of metal called penetrameters are used during the radiographic inspection of a weld. These are made of the same materials as the welded parts. Usually several small holes are drilled in the penetrameter and it is placed adjacent to the weld. When the radiographic “picture” of the weld is taken, the outline of the penetrameter will be visible on the film and this will give an indication of the sensitivity and clarity of the radiograph.

4. Ultrasonic Inspection

Ultrasonic inspection is a nondestructive method of detecting defects in welds. High frequency vibrations are more sensitive to fine cracks and defects than the other common inspection methods such as x-rays. The frequencies cannot be heard by the human ear, hence the word, ultrasonic. The sound waves or vibrations are directed into the metal to be tested, and are reflected back and measured. The wave signal is visible on a small screen to the operator guiding the hand held instrument over the weld. Ultrasonic inspection may be used to detect flaws in all types of welded joints such as nozzles, manholes, tubeplates to shell, etc. Ultrasonic inspections may be carried out on boilers, pressure vessels, and piping systems which are in service during the inspection.

Rules for the uses of Radiographic and Ultrasonic Inspections are covered in the Power Boiler Code, Section 1, paragraph PW-51.

Fig. 12 illustrates weld defects detected by the various non-destructive inspection methods.
Figure 12
Weld Faults

Reference Material

For more information on this topic, the following are recommended:

