Radiograph Interpretation - Welds

In addition to producing high quality radiographs, the radiographer must also be skilled in radiographic interpretation. Interpretation of radiographs takes place in three basic steps: (1) detection, (2) interpretation, and (3) evaluation. All of these steps make use of the radiographer's visual acuity. Visual acuity is the ability to resolve a spatial pattern in an image. The ability of an individual to detect discontinuities in radiography is also affected by the lighting condition in the place of viewing, and the experience level for recognizing various features in the image. The following material was developed to help students develop an understanding of the types of defects found in weldments and how they appear in a radiograph.

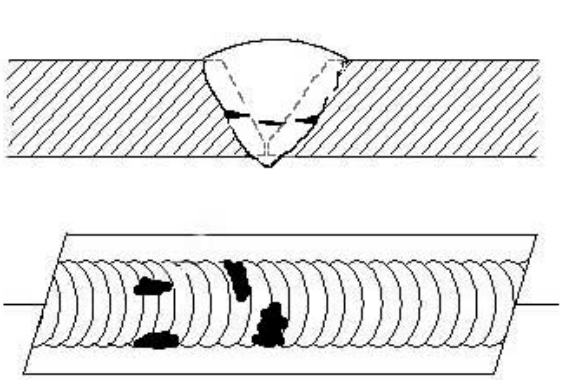
Discontinuities

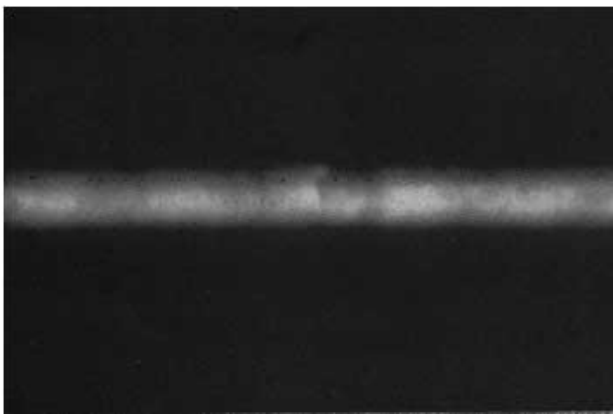
Discontinuities are interruptions in the typical structure of a material. These interruptions may occur in the base metal, weld material or "heat affected" zones. Discontinuities, which do not meet the requirements of the codes or specifications used to invoke and control an inspection, are referred to as defects.

General Welding Discontinuities

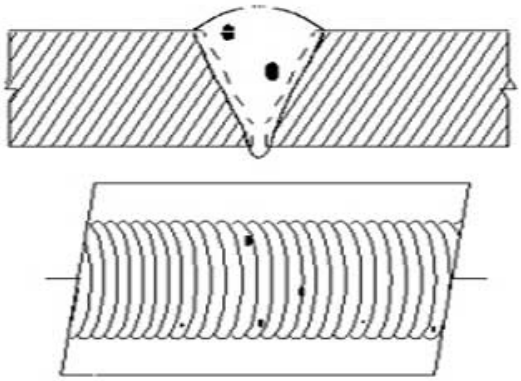
The following discontinuities are typical of all types of welding.

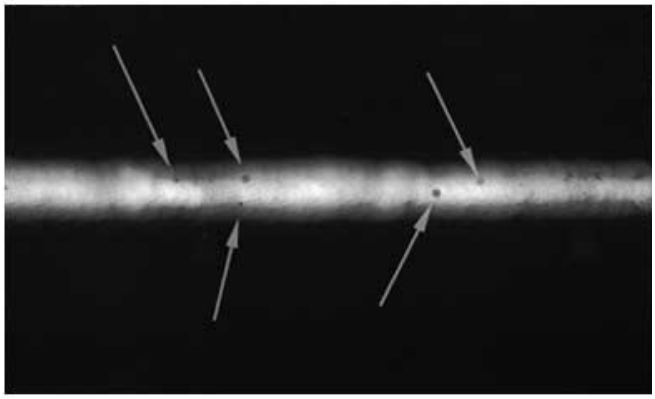
Cold lap is a condition where the weld filler metal does not properly fuse with the base metal or the previous weld pass material (interpass cold lap). The arc does not melt the base metal sufficiently and causes the slightly molten puddle to flow into the base material without bonding.





Porosity is the result of gas entrapment in the solidifying metal. Porosity can take many shapes on a radiograph but often appears as dark round or irregular spots or specks appearing singularly, in clusters, or in rows. Sometimes, porosity is elongated and may appear to have a tail. This is the result of gas attempting to escape while the metal is still in a liquid state and is called wormhole porosity. All porosity is a void in the material and it will have a higher radiographic density than the surrounding area.





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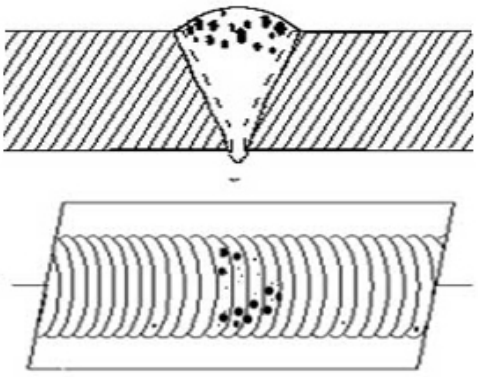
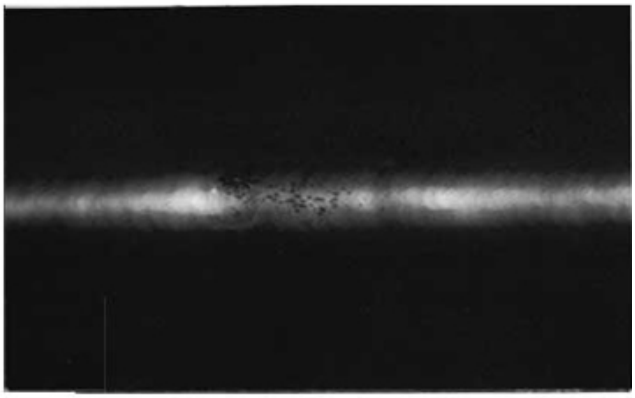
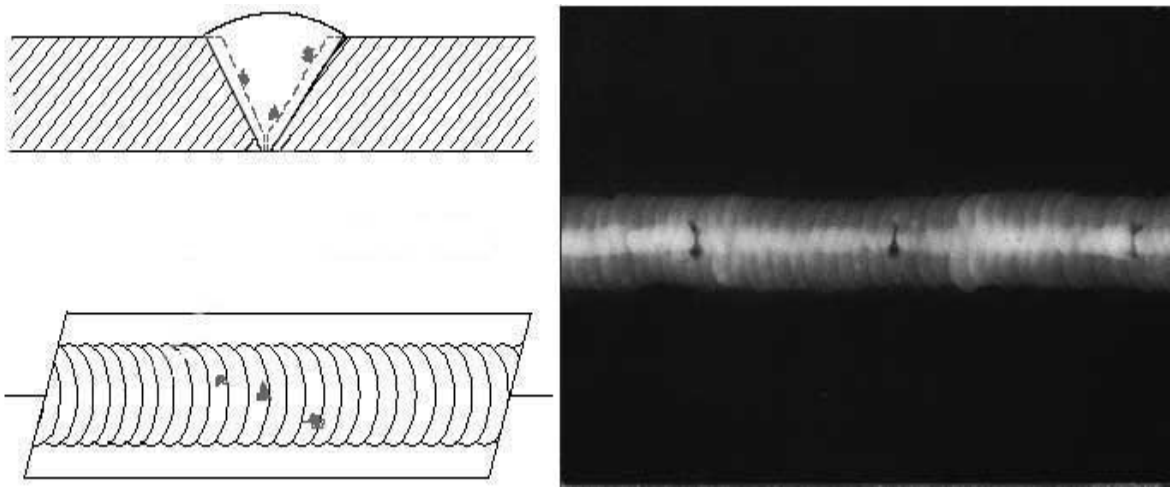
Cluster porosity is caused when flux coated electrodes are contaminated with moisture. The moisture turns into a gas when heated and becomes trapped in the weld during the welding process. Cluster porosity appears just like regular porosity in the radiograph but the indications will be grouped close together.

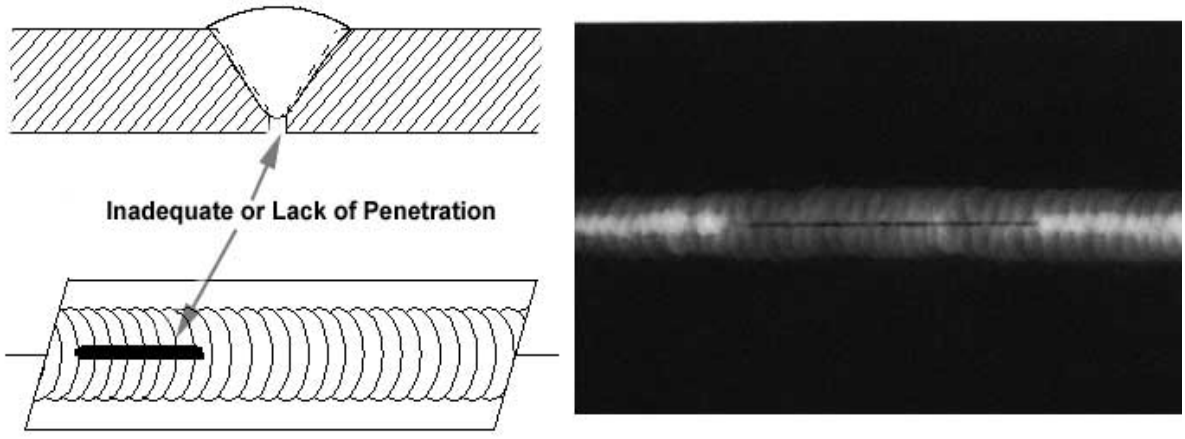




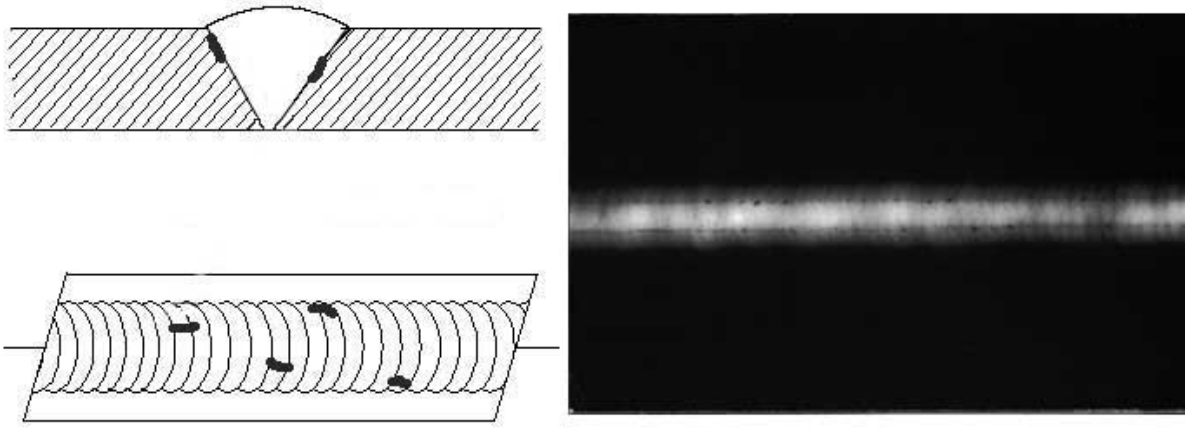
Slag inclusions are nonmetallic solid material entrapped in weld metal or between weld and base metal. In a radiograph, dark, jagged asymmetrical shapes within the weld or along the weld joint areas are indicative of slag inclusions.



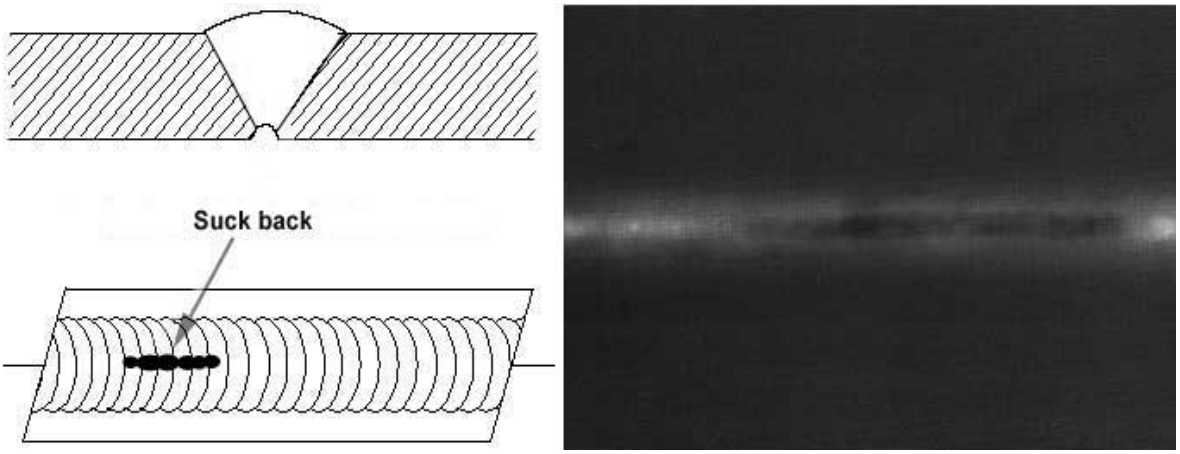
Incomplete penetration (IP) or lack of penetration (LOP) occurs when the weld metal fails to penetrate the joint. It is one of the most objectionable weld discontinuities. Lack of penetration allows a natural stress riser from which a crack may propagate. The appearance on a radiograph is a dark area with well-defined, straight edges that follows the land or root face down the center of the weldment.



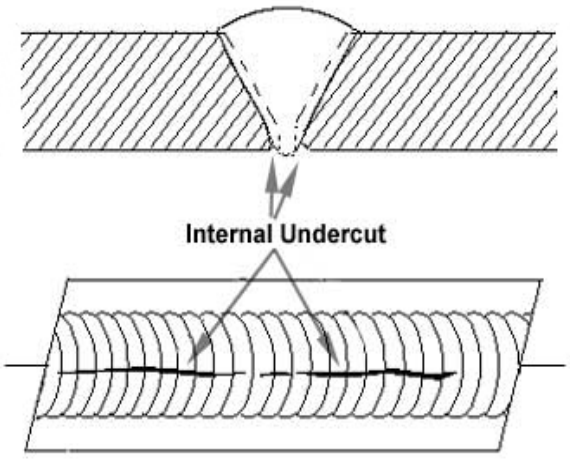
Incomplete fusion is a condition where the weld filler metal does not properly fuse with the base metal. Appearance on radiograph: usually appears as a dark line or lines oriented in the direction of the weld seam along the weld preparation or joining area.

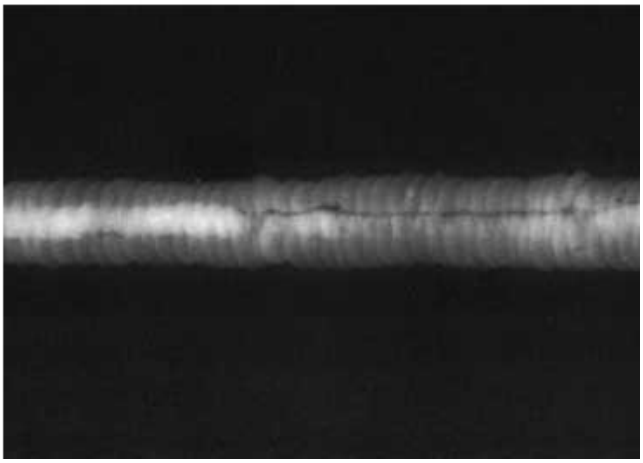


Internal concavity or suck back is a condition where the weld metal has contracted as it cools and has been drawn up into the root of the weld. On a radiograph it looks similar to a lack of penetration but the line has irregular edges and it is often quite wide in the center of the weld image.

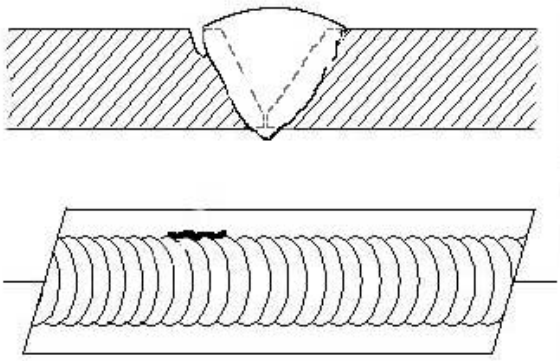


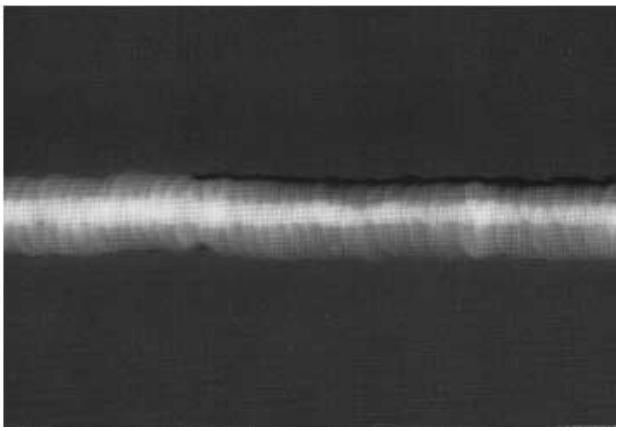
Internal or root undercut is an erosion of the base metal next to the root of the weld. In the radiographic image it appears as a dark irregular line offset from the centerline of the weldment. Undercutting is not as straight edged as LOP because it does not follow a ground edge.



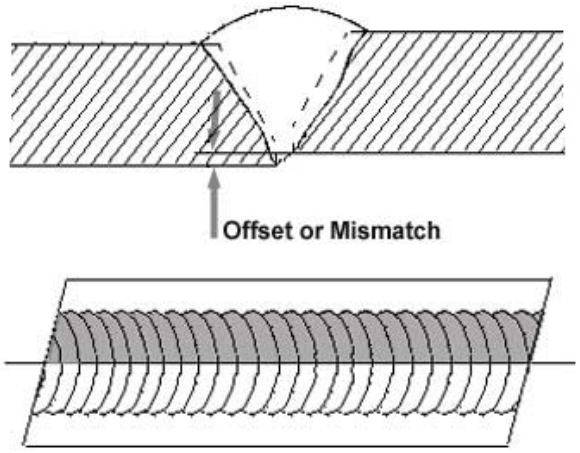


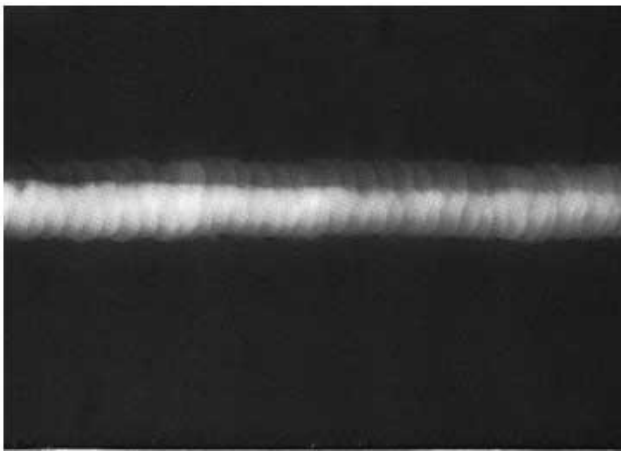
External or crown undercut is an erosion of the base metal next to the crown of the weld. In the radiograph, it appears as a dark irregular line along the outside edge of the weld area.



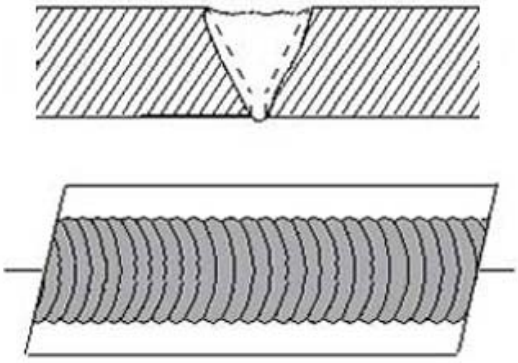


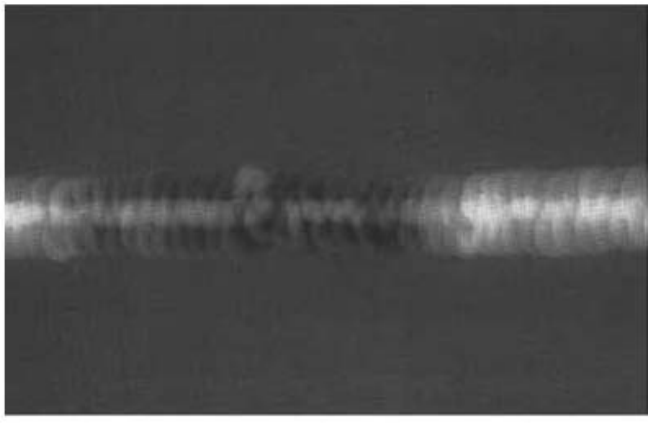
Offset or mismatch are terms associated with a condition where two pieces being welded together are not properly aligned. The radiographic image shows a noticeable difference in density between the two pieces. The difference in density is caused by the difference in material thickness. The dark, straight line is caused by the failure of the weld metal to fuse with the land area.



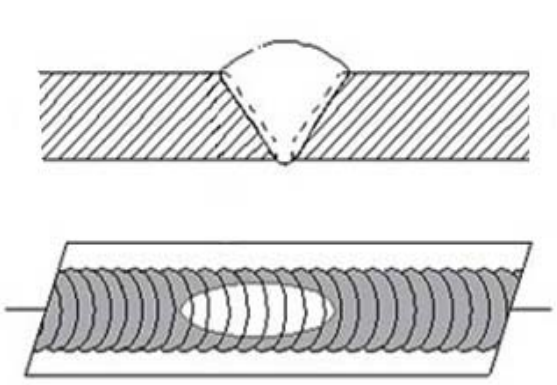


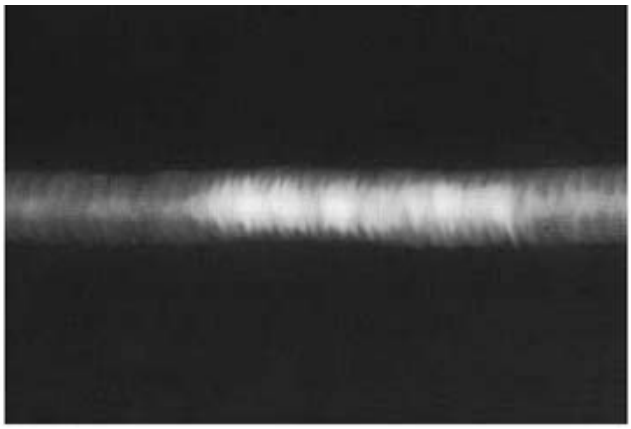
Inadequate weld reinforcement is an area of a weld where the thickness of weld metal deposited is less than the thickness of the base material. It is very easy to determine by radiograph if the weld has inadequate reinforcement, because the image density in the area of suspected inadequacy will be higher (darker) than the image density of the surrounding base material.



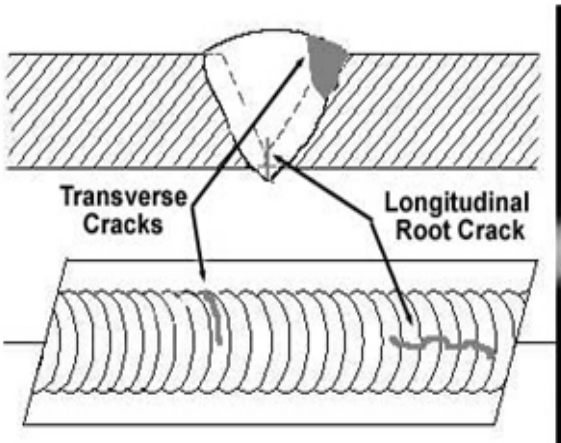


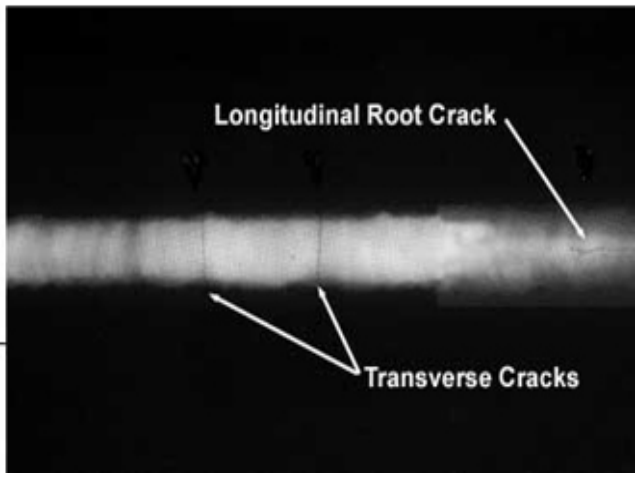
Excess weld reinforcement is an area of a weld that has weld metal added in excess of that specified by engineering drawings and codes. The appearance on a radiograph is a localized, lighter area in the weld. A visual inspection will easily determine if the weld reinforcement is in excess of that specified by the engineering requirements.





Cracks can be detected in a radiograph only when they are propagating in a direction that produces a change in thickness that is parallel to the x-ray beam. Cracks will appear as jagged and often very faint irregular lines. Cracks can sometimes appear as "tails" on inclusions or porosity.

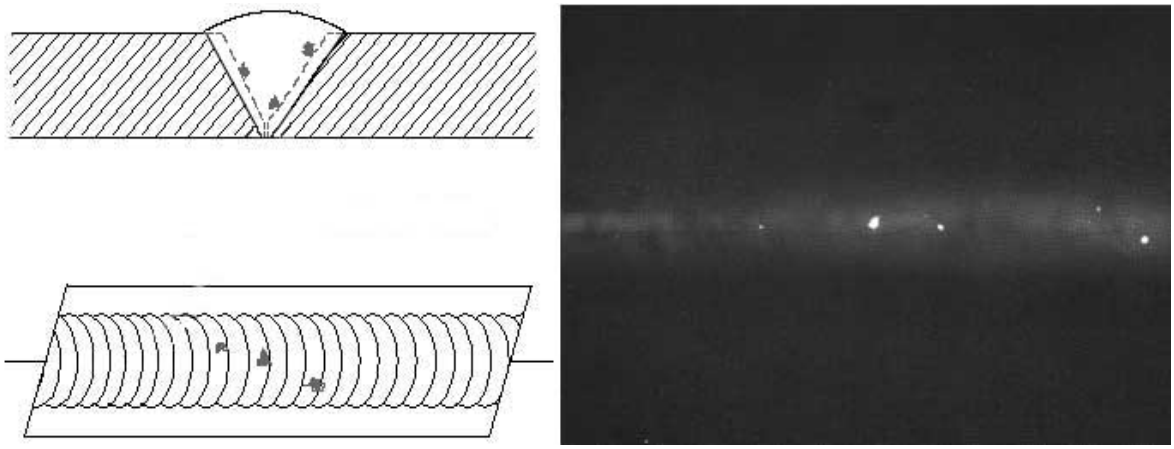




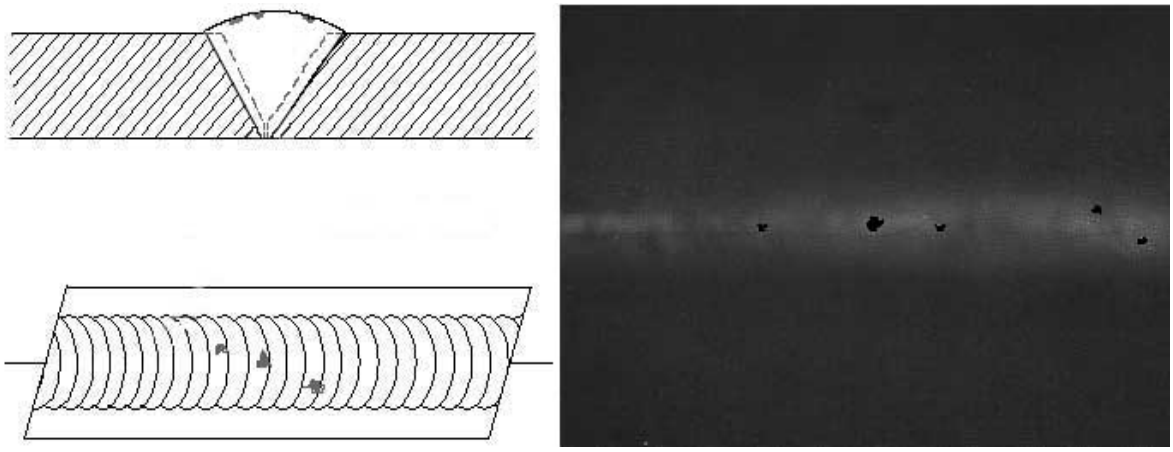
Discontinuities in TIG welds

The following discontinuities are unique to the TIG welding process. These discontinuities occur in most metals welded by the process, including aluminum and stainless steels. The TIG method of welding produces a clean homogeneous weld which when radiographed is easily interpreted.

Tungsten inclusions. Tungsten is a brittle and inherently dense material used in the electrode in tungsten inert gas welding. If improper welding procedures are used, tungsten may be entrapped in the weld. Radiographically, tungsten is more dense than aluminum or steel, therefore it shows up as a lighter area with a distinct outline on the radiograph.



Oxide inclusions are usually visible on the surface of material being welded (especially aluminum). Oxide inclusions are less dense than the surrounding material and, therefore, appear as dark irregularly shaped discontinuities in the radiograph.



Discontinuities in Gas Metal Arc Welds (GMAW)

The following discontinuities are most commonly found in GMAW welds.

Whiskers are short lengths of weld electrode wire, visible on the top or bottom surface of the weld or contained within the weld. On a radiograph they appear as light, "wire like" indications.

Burn-Through results when too much heat causes excessive weld metal to penetrate the weld zone. Often lumps of metal sag through the weld, creating a thick globular condition on the back of the weld. These globs of metal are referred to as icicles. On a radiograph, burn-through appears as dark spots, which are often surrounded by light globular areas (icicles).