



# X

## The **Xiris Glossary** of Weld Imaging Terminology



# Introduction

Automated welding, camera technology, and digital image processing are all complex subjects. When you combine them in a Weld Camera system—and factor in the rapid pace of technological change—the terminology used to discuss Weld Cameras is necessarily somewhat complicated and diverse. To help avoid any confusion, we offer the following glossary of terms.

**AC (Alternating Current)**

An electric current that reverses its direction at regularly recurring intervals. It is produced by all transformer-type welding machines.

**Arc Length**

The distance between the tip of the electrode and the weld puddle.

**Arc On Time**

The amount of time that a welding arc is fed power; usually made in reference to the total amount of time available.

**Arc Voltage**

The voltage across the welding arc.

**Back Gouging**

Carbon-air arc process that utilizes a carbon electrode to melt and blow out weld beads. The process is used to correct defective welds.

**Batch**

Any number of items containing the same coded information that is tested sequentially.

**Bead**

See Weld Bead.

**Bead Area**

The sum of the positional deviations from the ideal profile of the parent material being welded.

**Bead Height**

The peak deviation from the ideal profile of the parent material being welded.

**Bead Position (or Roll Angle)**

The angle, on a tube or pipe cross section, between the vertical and a line from the ideal circle's center to the peak point in the bead.

**Bead Width**

The linear distance between the left and right bead boundary, or bead edge points.

**Butt Joint**

A type of joint made between two workpieces in such a manner that the weld joining the parts is between the surface planes of both of the pieces joined. The edges of the material can be square or bevelled. When a butt joint needs to be made with sections too heavy to permit a square butt joint, the sections are beveled, or chamfered, to an angle of approximately 90°. The choice of a single or double bevel will depend upon the thickness of the metal and whether the sections can be welded from the sides. A double bevel uses approximately one-half the amount of weld metal required for a single bevel. The essential factor, in the preparation for welding, is that no part of the joint is left un-welded, whether single or double bevel.

**Chevrons**

A V-shaped pattern that occurs on the surface of a weld bead caused by inconsistent weld pool flow rate as the weld pool solidifies. This pattern most often occurs in thick-walled-pipe submerged arc welding, where it may be a result of water absorption on the flux used in a submerged arc welding process.

**Concavity**

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

**Convexity**

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

**Crater**

A depression at the termination of an arc weld.

**DC (Direct Current)**

An electric current that is continuously positive or negative. It is produced by most motor-driven arc welding machines and some rectifier sets.

**Deflection**

The overall deflection of the tube material from an ideal circle as a result of the forming process. Any deflection that occurs will move the starting point of all other defects up or down from the ideal circle.

**Direction of Travel**

The direction, relative to the workpiece, in which the weld head is traveling and making weld deposits.

**Dual Shield**

Open-arc process shielded by either granular flux or metal cored tubular wires, along with a secondary shield from external inert gas.

**Duty Cycle**

The arc on time measured in 10-minute cycles, when the welding power source can operate at rated output.

**Dynamic Range**

The range of brightness in which a camera can successfully capture the lightest and darkest areas of an image without losing detail. It is usually measured as a multiple, such as 1000:1 (i.e., the brightest feature in an image that can be captured is a thousand times brighter than the darkest feature in an image that can be captured), or in decibels, such as 48 dB. Standard cameras typically have a dynamic range of about 1000:1, but in welding the range of brightness can easily exceed 10,000,000:1, which is greater than 120 dB.

**Eddy Current**

The most current and predominant testing technology used in the testing of weld integrity. It uses electromagnetic induction to detect flaws in a conductive weld material.

The eddy current process can detect sudden changes in the weld seam, but it does a poor job at detecting gradual changes. The reliability of detection of weld-related flaws using eddy current depends on the relative alignment of the seam to the eddy current density. If the seam wanders, the probability of detection diminishes. Also, complex defects with multiple measurement points such as mismatch cannot be effectively detected by eddy current.

**Edge Joint**

A joint between the edges of two or more parallel or nearly parallel members.

**Edge Preparation**

The contour prepared on the edge of a joint member for welding.

**Effective Length of Weld**

The length of weld throughout which the correctly proportioned cross-section exists.

**Electrode**

An electrical conductor used to conduct current through a workpiece to fuse two pieces together. Depending upon the welding process used, the electrode is either consumable, as in the case of GMAW (MIG) processes, or non-consumable, such as in GTAW (TIG) processes. For a DC system, the weld rod or stick may be a cathode for a filling-type weld or an anode for other welding processes. For an AC arc weld, the welding electrode would not be considered an anode or cathode.

**EMI (Electromagnetic Interference)**

Unwanted signals or noise created by electromagnetic radiation emitted by external electrical circuits carrying rapidly changing signals, such as a welding power supply, as a by-product of their normal operation.

**ERW (Electric Resistance Welding)**

Low-frequency welding, accomplished through a rotating copper electrode. It is used most often for mild steel tube above 6mm (.250") in diameter. This process is most suitable for the smallest diameters, as the impeders needed for high-frequency (HF) welding cannot fit into the smaller tube diameters. Parent material is rolled from flat to round and welded using electrical resistance to forge the strip edges together. As the welding transformer rotates, the copper electrodes come into contact with the tube edges, heating them so that they can be welded together. The diameter typically ranges from 12mm to 600mm outside diameter. Line speeds range from 60-150m/min. The ERW process is similar to the HF process in that cooling is used, making the addition of an inspection system more challenging.

**ERW (Electric Resistance Welded) and HFI (High-Frequency Induction) Welded Pipe**

A type of pipe that contains a solid-phase butt weld, originally produced using an ERW welding process to make the longitudinal weld. Now, however, most pipe mills use HFI for better control and consistency. Nonetheless, the product is still often referred to as ERW pipe, even though the weld may have been produced by the HFI process.

**Face of Weld**

The exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done.

**FCAW (Flux Cored Arc Welding)**

A semi-automatic or fully automatic welding process in which a tubular electrode containing flux is fed into the welding arc. The flux provides protection of the weld from the atmosphere.

**Ferrous Alloys**

Metallic alloys that contain predominantly iron, such as cast iron, wrought iron, steel, and stainless steel.

**Fiducial**

A mark or target, defining a datum point or standard of positional reference, used as a basis for calculation or measurement.

**Field of View**

The amount of area that can be seen by a camera at one time. It is a result of the size of the image sensor, the lens of the system, and the working distance between object and camera.

**Filler Rod**

The metal that is added in making a weld in certain types of welding processes, such as GMAW.

**Fillet Weld**

A weld of approximately triangular cross-section, as used in a lap joint, joining two surfaces at approximately right angles to each other.



**Flux**

A material applied to metal to prevent oxidation during the joining operations, to reduce surface tension, to promote the flow of the alloy, and to facilitate the bonding action between the base metal and the deposited metal. The flux may be a paste, powder, granular, or liquid.

**Freeze Line**

A line or seam from the surface into the welded area in the shape of a sharp valley. Particularly in ERW and HF welding processes, incomplete heating of the faces of the parent material can sometime occur, resulting in a potentially cold welded joint, which manifests itself as the freeze line in the tube. Such a defect could indicate major problems with the weld, such as cold welding or improper forming. It can very often be a point of a major failure of a weld in high-stress applications because the freeze line acts as a crack initiator into the welded material.

**Full Well Capacity**

The maximum amount of charge that can be stored in each sensor element in a digital CCD or CMOS camera sensor, where incident photoelectrons are recorded as electric charge.

**Global Camera Shutter**

An image-acquisition process used in some types of digital image sensors whereby the entire image is exposed and read out at one time. This provides consistent image features across the entire image, minimizing localized artifacts that could result from variations in movement or brightness while the frame is being exposed. All portions of the image are affected equally.

**Globular Transfer GMAW**

Named for "globs" of weld metal transferring across the arc in a gravity feed. Droplets across the arc are usually larger than the electrode diameter, producing an unsmooth weld bead appearance, with the possibility of spatter. This process is usually limited to flat and horizontal welding positions and is not used on thin metals.

**GMAW (Gas Metal Arc Welding)**

A semi-automatic or automatic arc welding process in which metals are joined by heating them with an arc, also referred to by its subtypes: metal inert gas (MIG) welding or metal active gas (MAG) welding. The arc is between a continuously fed filler-metal electrode and the workpiece. GMAW is the most common and readily available metal joining process, preferred for its versatility and speed and the relative ease of adapting the process to automation. There are four basic modes of metal transfer: short-circuit transfer, globular transfer, spray transfer, and pulsed-spray transfer.

**Ground Finish**

A finish achieved by using a grinder to remove millscale from the surface of raw steel.

**GTAW (Gas Tungsten Arc Welding)**

Also known as TIG (tungsten inert gas) welding, an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas, and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. A constant-current welding power supply produces energy that is conducted across the arc through a column of highly ionized gas and metal vapours known as a plasma. GTAW is the slowest process in metal joining, but produces a very high-quality weld with little bead. GTAW is used for pressure-quality welds on 300 series stainless steel, carbon steel, copper, or nickel at slower welding speeds. Parent material is rolled from flat to round and welded using a welding torch with a tungsten tip, usually employing argon or an argon/oxygen mixture as the shielding gas. The torch heats the edges of the strip until the metal begins to melt or puddle, and the next pair of rolls squeezes the strip edges together. Here, edge registration is critical. The tube diameter ranges from 6mm to 150mm outside diameter. Line speeds range from 3-4 m/min.

**HAZ (Heat-Affected Zone)**

The area of base material that has had its microstructure and properties altered by welding or heat-intensive cutting operations.

**HF (High-Frequency) Welding**

Today, most mild steel (carbon steel or "carbon black") and aluminum tube is welded with HF welders, which are also suitable for 400 series stainless steel, and even 300 series for some applications. Nearly 95 percent of the HF welders sold are solid state, using transistors to generate the alternating-frequency current. Parent material is rolled and welded using electrical resistance to forge the strip edges together. The diameter ranges from 6mm to 600mm OD. Line speeds range from 60-150m/min. Compared to other welding techniques, HF welding is somewhat forgiving of less-than-perfect edge registration. The HF welding process makes implementing an inspection system rather difficult because copious amounts of cooling are used, generating steam, smoke, and liquid splashes, all of which can impede the optical path of the inspection unit. Special considerations must be made to modify the area of inspection to keep the inspection area clean.

**Ideal Tube Profile**

The ideal shape of a tube in cross section if the tube were perfectly round.

**Infrared Camera**

Camera that images the weld area after the weld box to determine the profile and penetration of heat in the HAZ. It offers some information but does not provide key quantitative parameter data, such as mismatch measurement.

**IR (Infrared) Light**

Electromagnetic radiation with wavelengths longer than those of visible light (i.e. > 750 nm) extending to about 1 mm. This range of wavelengths includes most of the thermal radiation emitted by objects near room temperature. Infrared light is emitted by welding processes as a result of the workpiece or weld arc getting hot.

**Keyholes**

A hole that develops when the sides of the seam undergoing welding burn away to create the weld pool.

**LBW (Laser Beam Welding)**

A welding process used to join multiple pieces of metal through the use of a laser beam that provides a concentrated heat source, allowing for narrow, deep welds and high welding rates. LBW has high power resulting in small heat-affected zones with good-quality welds and high heating and cooling rates. The depth of penetration is proportional to the amount of power supplied but is also dependent on the location of the focal point. A continuous or pulsed laser beam may be used depending upon the application. Due to the high cooling rates, cracking is a concern when welding high-carbon steels. The speed of welding is proportional to the amount of power supplied but also depends on the type and thickness of the workpieces. The cost of LBW is high relative to that of GTAW, although it is faster. LBW is used primarily for exotic metals (nickel, titanium) and 300 series stainless steel, though some manufacturers use it on 400 series stainless steel as well. Parent material is rolled from flat to round and welded by either a CO<sub>2</sub> or Nd:YAG laser in which a molten puddle is generated between two edges of steel and allowed to solidify to form a weldment. LBW produces the smallest heat-affected zone (HAZ) and a bead even smaller than that produced by GTAW. The focus laser beam creates a keyhole where material is made molten and solidifies. Since there is almost no change in the grain structure of the parent metal, the finished piece has greater flexibility than a GTAW part. However, with this technique, edge registration is more critical than with the others. The tube diameters range from 2mm to 200mm in size. Line speeds range from 8-12m/min.

**Longitudinally Welded SAW Pipe (also known as UOE)**

Welded pipe with a longitudinal seam weld, which is the most popular welding process for large diameter pipe. Double submerged arc welded (DSAW) pipe is welded pipe whose longitudinal butt joint is welded in at least two passes, one of which is on the inside of the pipe. The welds are made by heating with an electric arc between the bare metal electrode. Pressure is not used. Filler metal for the welds is obtained from the electrodes. For diameters above 36", double-seam welded pipe is specified as an alternative in API 5L. Double-seam welded pipe has two longitudinal seams 180° apart, formed by the SAW process. Finished pipes are normally 40 feet (12 m) and occasionally 60 feet (18 m) long, depending on the capacity of the pipe mill and the ease of transport to the pipeline.

**MCAW (Metal Cored Arc Welding)**

A semi-automatic or automatic arc welding process where a continuously fed tubular electrode with a metal core using an external shielding gas is required as filler material. The flux is used to protect against the atmospheric contaminants.

**Remote Focus Module**

A device integrated into a Weld Camera to allow for the focusing of the elements of the camera lens remotely through software.

**MIG (Metal Inert Gas) Welding**

See GMAW.

**Millscale Finish**

A layer of iron oxide that forms on steel as it leaves the steel mill.

**Mismatch**

The relative offset from the ideal tube profile between the two bead boundary points on either side of the weld bead area. This phenomenon occurs when the two sides of the parent material are joined unevenly during the welding process. It is of particular concern during tube manufacturing because many tube mills employ a grinder or scarf tool to remove any excess bead that is out of round. If there is mismatch prior to welding, once the tube has been ground down, part of the wall on the high side of the mismatch may get ground down as well, causing significant thinning of the tube wall after grinding the weld area.

**Modulated Welding**

A method of controlling the power delivered to an electric arc welding head by varying the amplitude, phase, or frequency of a high-frequency periodic waveform, called the carrier signal, with a modulating signal, which typically contains information to be transmitted. Any of these properties can be modified in accordance with a low-frequency signal to obtain the modulated signal. Typically, a high-frequency square wave pulse train is used as carrier signal.

**Non-Ferrous Alloys**

Alloys that contain little or no iron, such as copper, brass, bronze, nickel, titanium, magnesium, or aluminum.

**Open Arc Welding**

A group of welding processes in which fusion is obtained by heating with an uncovered or open electric arc, or arcs, with or without the use of filler metal.

**Orbital Welding**

A specialized area of welding in which the arc is mechanically rotated 360° around a static workpiece, such as a pipe or tube, in a continuous process.

**PAW (Plasma Arc Welding)**

An arc welding process similar to GTAW that can be used to join all metals that can be welded with GTAW (i.e., most commercial metals and alloys) but is an advance over GTAW. The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten) and the workpiece. The key difference from GTAW is that in PAW, by positioning a non-combustible tungsten electrode within the body of the torch, the plasma arc can be separated from the shielding gas envelope. The plasma is then forced through a fine-bore copper nozzle that constricts the arc, and the plasma exits the orifice at high velocities (approaching the speed of sound) and a temperature approaching 20,000°C. PAW has a greater energy concentration than GTAW and therefore allows for deeper penetration and deposition rates.

**Pinhole**

A portion of the weld bead where material is missing, visible as a small hole through the weld line.

**Pipe/Vessel Cladding (or Overlay)**

Cladding or weld overlay is a welding procedure that adds weld metal to the surface of the workpieces, as opposed to joining two pieces of material together. Generally, this process is used to provide enhanced corrosion resistance or wear resistance to a pipe or vessel, with a different material used for the cladding layer than for the base metal.

**Porosity**

Defect in weld structure and appearance caused by trapped gases or impurities.

**Pressure Testing**

Taking the tube off line, plugging both ends, and filling the tube with liquid under pressure. This is a very slow post-manufacturing process, and defects are found well after all the value-added manufacturing processes. Pressure testing is also a very labor-intensive process.

**Pulsed Welding**

A form of modulated welding in which the modulation of the power source is done by varying the timing of the waveform.

**Pulsed-Spray Transfer GMAW**

A variation of spray transfer in which the welding machine “pulses” the output between high peak currents and low background currents. The weld pool gets to cool slightly during the background cycle, making it slightly different than spray transfer. This can allow for welding in all positions on either thin or thick metals.

**Raised or Sunken Welds**

The material in the bead area that may rise on top of the tube surface (raised weld) or drop below it (sunken weld), depending on the compression force applied on the parent material to make the seam and the weld arc size. A raised weld defect could be indicative of quality problems in the welding process. Conversely, the sunken weld defect is a much more visibly significant defect that could create weakness in the tube along the bead.

**Roll Angle**

See Bead Position

**Root**

The base of a weld joint, typically found between two beveled edges.

**Root Pass**

The initial pass in a welding process where the weld bead fuses to the root gap at the base of the weld joint.

**SAW (Submerged Arc Welding)**

An arc welding process in which metals are fused together by heating with an electric arc (or arcs) between a bare metal electrode( or electrodes) and the workpiece. Shielding against oxidation is provided by a blanket of granular, fusible material (much like a sand), usually brought to the work from an external feeder. Filler metal is obtained from the electrode, and sometimes from a supplementary welding rod.

**Seam Guidance**

A process used to ensure that an arc welding head is properly tracking the seam weld so that the head is in the center of the seam.



**Shielding Gas**

Inert or semi-inert gases commonly used in GMAW and GTAW welding processes. Their purpose is to protect the weld area from atmospheric gases (e.g., oxygen, nitrogen, and water vapor) that could contaminate the weld and reduce its metallurgical integrity.

**Short-Circuit Transfer GMAW**

A welding process that gets its name from the welding wire actually “short circuiting” (touching) the base metal many times per second. Some spatter is produced, but the transfer can be used in all welding positions and on all thicknesses of metal.

**Skelp**

Flat plates that are formed, bent, and prepared for welding.

**Spiral Welded Pipe**

Pipe created from a process that allows large-diameter pipe to be produced from narrower plates (i.e., skelp), with the welds occurring in a spiral pattern. The defects that usually occur in creating spiral welded pipe are mainly those associated with the SAW process and are similar in nature to those for longitudinally welded pipe. An additional problem with early efforts to produce spiral welded pipe was poor dimensional accuracy, particularly “out of roundness” at the pipe ends.

**Spray Transfer GMAW**

Welding process named for a “spray” of tiny molten droplets across the arc, usually smaller than the wire diameter. This process uses relatively high voltage and amperage values, and the arc is “on” at all times after the arc is established. Very little if any spatter is produced. This process is usually used on thicker metals in flat or horizontal welding positions.

**Straight Beads**

The weld bead that is deposited when the width of the weld deposit is approximately the same as the diameter of the welding electrode.

**Sunken Weld**

A Weld phenomenon where molten material sinks below the ideal tube profile as the weld is cooling.

**Tandem GMAW**

When two or more welding guns are configured to work in sequence, leading into the same welding puddle. Typically, this process is used to increase welding productivity as more weld material can be deposited faster, with greater welding penetration.

**TIG (Tungsten Inert Gas) Welding**

See GTAW.

**Tube Mill**

A manufacturing line that takes flat strips of steel, aluminum, copper, or exotic material and rolls it into a cylindrical shape for a longitudinal welding process. The tube is produced continuously and then cut to length after the weld has been ground flat, cooled, and shaped.

**Ultrasonic Testing**

A testing process that uses high-frequency sound vibrations, which are transmitted into material by an ultrasonic transducer. The test instrument then analyzes the ultrasonic signals, which are received using either a pulse-echo or through-transmission method. These ultrasonic non-destructive testing methods will indicate material defects such as longitudinal and transverse cracks, inclusions, and others, as well as interior and outside diameters and significant dimensional changes such as thickness and ovality. The weakness of this testing method is that the sensor has to be perfectly aligned with the seam. Also, it cannot detect small defects or changes, including minor dimensional changes.

**Undercut**

Weld phenomenon where the laser beam hits the seam between the two sides of the tube in an oblique manner, melting either side of the seam unevenly. This defect may form if the laser beam is too far off center of the ideal welding zone of the tube material. Undercut is actually a non-welded area of the bead on one or both sides of the seam, appearing and behaving like a crack along the bead, creating a very weak point on the weld cross-section.

**Uni-Shield**

Open-arc process shielded by granular flux and no secondary gas shield.

**UV (Ultraviolet) Light**

Electromagnetic radiation with a wavelength shorter than that of visible light (i.e. less than about 750 nm), but longer than X-rays (i.e., greater than 10 nm).

**Weaving**

A welding method employed when wider weld beads are required where the electrode is moved from side to side in a weaving motion. The greatest efficiency results from a weave of not more than 2½ times the diameter of the electrode.

**Weld Bead**

The strip of welded material left after the welding process, usually rising higher than the base material. The feature is usually a combination of melted parent material and filler material used in the welding process.

**Weld Crater**

A depression at the termination of an arc weld.

**Weld Crater Kerfs**

The volume between where the original metal existed and the depression at the termination of an arc weld.

**Weld Monitor**

A device used to collect data on a welding process. It could be a data collection device that records important welding data such as voltage, speed, current, pulse duration, and frequency. Or it could be a Weld Camera monitoring system

that could acquire images of the welding in process for an operator to monitor remotely.

**Weld Puddle**

The small area of molten metal that forms during welding, immediately after the welding arc. The cooled weld puddle forms the permanent joint. Also known as the weld pool, molten pool, or molten puddle.

**Weld Seam**

The weld seam is where the two workpieces touch in preparation for welding to occur. Ideally, the weld pool should be centered over the weld seam.

**Weld Toe**

The point at which the weld face and base metal meet.

**Weld Camera**

A camera equipped with the ability to image a High Dynamic Range of brightness to be able to see the brightest features of a weld arc and its dark surrounding environment simultaneously and display the image on a remote monitor so that the operator can view and record the process

**Welding Codes**

Welding procedures and standards governing the welding process, as well as consumables.

**Weldment**

An assembly whose component parts are formed by welding.

**Wetting**

The behavior of molten parent or filler material when it makes contacts with the solid parent material surface. Molten weld material with poor wetting ability tends to form droplets or spheres, while molten weld material with good wetting ability tends to spread out evenly over the weld bead surface area

**Workpiece**

Two or more pieces of material that are placed together in preparation for fusing together using a welding process.

# Would you like more information?

[sales@xiris.com](mailto:sales@xiris.com)

+1 866 GO XIRIS

+1 905 331 6660

[www.xiris.com](http://www.xiris.com)

