Application Note

Trace Moisture Measurement in Welding

Welding integrity depends on a controlled environment. Even trace amounts of moisture in shielding gases, carrier gases or on base metals can lead to weld defects that compromise strength, appearance and durability. Trace moisture measurement pin points water vapour at parts per million (ppm) levels, enabling engineers to maintain ideal parameters for gas metal arc welding, tungsten inert gas welding, laser welding and other fusion processes. By integrating reliable sensors into welding gas lines or storage vessels, manufacturers can detect moisture excursions before defects manifest, ensuring consistent, high quality welds and reducing costly rework.

What is welding?

Welding is a fabrication process that joins two or more materials, typically metals or thermoplastics, by applying heat, pressure or both to fuse them into a single, solid piece.

Key characteristics:

- Fusion based - most welding involves melting the base materials and often adding a filler metal.
- Permanent - unlike bolting or riveting, welding creates a permanent joint.
- Shielding - many processes use shielding gases or flux to protect the molten weld pool from atmospheric contamination.

Welding is essential across nearly every industrial sector, including aerospace, automotive, energy, construction and manufacturing. It's also used in maintenance and repair, especially where strength and durability are critical.

What are welding gases, where are they used and why are they important?

Welding gases refer to various industrial gases such as argon, carbon dioxide, helium, oxygen, acetylene, propane, natural gas and specialised blends used in welding processes such as MIG, MAG, TIG, plasma, laser and oxy-fuel welding, to achieve strong, defect free joints between metals. These gases have several essential roles, most notably as shielding gases that protect the molten weld pool from atmospheric contamination and as fuel gases that generate the high temperatures needed for certain welding methods.

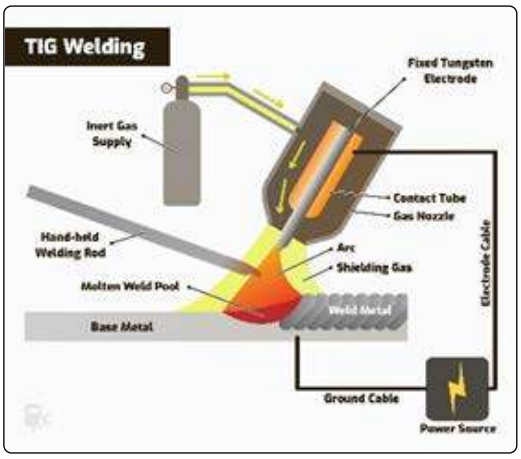

Fig.1

Where are welding gases used?

Welding gases are integral to a wide range of welding processes:

- MIG (Metal Inert Gas) and MAG (Metal Active Gas) welding are semi-automatic processes using gas to shield the arc and weld pool with inert gases (such as argon) for non-reactive protection and active gases (such as carbon dioxide) to enhance deeper weld fusion and arc stability.
- TIG (Tungsten Inert Gas) welding uses inert gases (primarily argon or helium) to protect the weld area, especially for high-quality welds on aluminium, stainless steel and titanium (*Fig.1*).
- Plasma and laser welding require precise gas control for arc stability and weld quality.
- Oxy-fuel welding and cutting involves fuel gases (such as acetylene, propane or natural gas) mixed with oxygen to create a high temperature flame for melting and joining metals.

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Moisture problems encountered in welding applications

Introduction of hydrogen from trace moisture contamination

Moisture, whether from atmospheric humidity, contaminated gas lines or improperly stored consumables, introduces hydrogen into the welding environment. At the high temperatures present during welding, water vapour decomposes, releasing hydrogen atoms, which are absorbed by the molten weld pool, leading to increased hydrogen content in the weld metal. Even trace amounts of moisture in the shielding gas can substantially raise the diffusible hydrogen level.

Weld defects - porosity, cracking and embrittlement

The presence of hydrogen from moisture contamination is a primary cause of several weld defects:

- Porosity - as the weld pool solidifies, trapped gases, including hydrogen, form cavities or pores within the weld metal. This porosity can appear as scattered pinholes or “Swiss cheese” patterns, severely weakening the weld.
- Cracking - hydrogen induced cracking (commonly called hydrogen embrittlement) is a critical concern, especially in high strength steels and sensitive alloys. Hydrogen trapped in the weld can cause delayed cracking, often hours or days after welding, compromising structural integrity.
- Brittleness - excess hydrogen can make the weld metal brittle, causing loss of ductility and ability to withstand mechanical stresses, increasing the risk of sudden failure.

Degradation of weld appearance and mechanical properties

Moisture contamination not only causes internal defects but also affects the surface quality and appearance of the weld. Porosity and inclusions lead to unsightly weld beads and reduce the weld’s load bearing capacity. These imperfections are not merely cosmetic; they represent weak points that can lead to premature failure under service conditions.

Alteration of shielding gas properties and arc stability

Moisture changes the composition of the shielding gas, potentially forming unwanted compounds in TIG welding, such as argon-hydrogen or argon-oxygen mixtures, that alter arc characteristics. This can result in: unstable arcs, inconsistent weld penetration and increased risk of oxidation or nitration of the weld pool, further degrading weld quality.

Ensuring Weld Quality Through Standards Compliance

Moisture in welding applications presents several problems that directly impact weld quality, mechanical properties and overall process reliability. Adherence to industry standards, such as ISO 14175 (which governs shielding gases), is essential for ensuring both quality and safety in welding operations. These standards set stringent requirements for gas purity, including moisture content limits.

Additionally, NADCAP (National Aerospace and Defense Contractors Accreditation Program) certification is recognised globally for ensuring that special processes in aerospace and defence meet the highest standards of quality and reliability. Compliance with these standards guarantees welding process integrity and demonstrates a commitment to best practice, which is crucial in industries with stringent quality requirements.

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Sources of moisture

Moisture originates from several sources throughout the welding process, each contributing to the risk of hydrogen contamination and weld defects.

- Shielding gases
  Shielding gas supply systems are a primary source of moisture contamination. Moisture can be present as an impurity in gas cylinders, especially if the gas is not of high purity or if the cylinders are neglected. Leaks in gas lines or during cylinder changes can allow atmospheric moisture to enter the system, contaminating the shielding gas. Furthermore, the materials used in gas delivery components, such as hoses and regulators, can allow atmospheric moisture to permeate into the gas stream, for example, rubber hoses have high moisture permeability, which can result in a substantial increase in moisture content by the time the gas reaches the weld torch, even if the gas leaving the purifier is extremely dry.
- Gas supply
  Cylinder valves and fittings can leak ambient air, introducing humidity. Gas delivered from suppliers may already contain ppm level moisture.
- Piping and tubing
  Condensation inside long or uninsulated pipelines forms water films that vaporise under gas flow.
- Regulators and filters
  Poor filter maintenance leads to water accumulation in the coalescing elements. Regulators venting to the atmosphere draw humid air back into the system.
- Cylinder surface adsorption
  Metal surfaces adsorb moisture when stored in humid environments. Rapid depressurisation chills gas, causing moisture.

Solutions to minimise and prevent moisture contamination

To prevent and measure moisture in welding applications, implement targeted solutions and best practices such as:

- Gas purging with dry shielding gases such as argon or nitrogen to ensure gas delivery systems are leak free and moisture free.
- Directly measure moisture content in the shielding gas or purged area using trace moisture analysers, ensuring it is within acceptable limits.
- Install desiccant dryers or gas purifiers in the shielding gas supply line, removing residual moisture before the gas reaches the weld pool.
- Set the shielding gas flow rate correctly, too high can create turbulence and draw in moist air, whilst too low may not adequately shield the weld.
- Perform regular equipment maintenance, inspect hoses, regulators and gas delivery systems for leaks or damage that could allow the entry of humid air. Use hoses with low moisture permeability and replace worn components.

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Measurement solutions

Trace moisture analysers should be strategically placed in welding setups to ensure shielding gas and environmental conditions remain dry enough to prevent weld defects.

Recommended installation points

Shielding gas supply line

Use portable trace moisture analysers at the welding torch head. This ensures the gas is dry at the point of use, preventing hydrogen induced cracking and porosity (*Fig.2*).

Fig.2

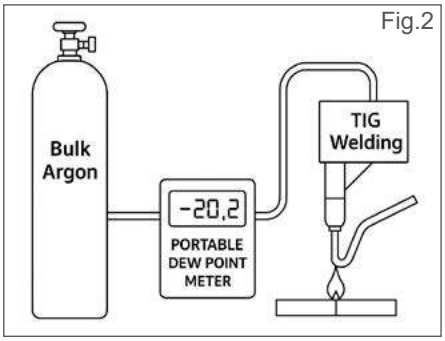
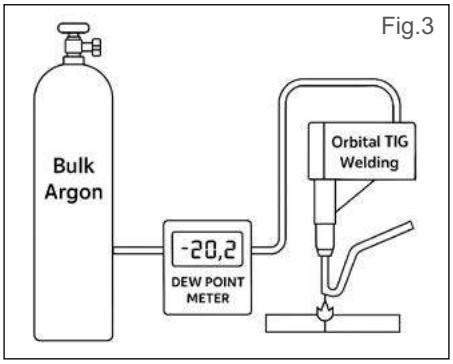


Fig.3



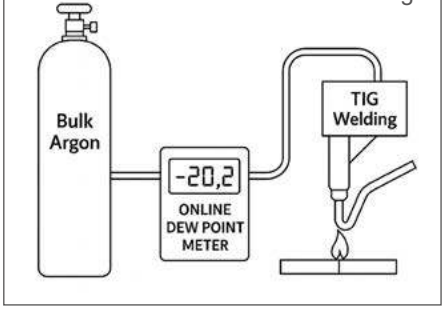
Gas cylinder or manifold outlet

For centralised systems, install an inline trace moisture analyser for continuous measurement at the outlet of the gas manifold or regulator to monitor bulk gas dryness before distribution (*Fig.3*).

Purge gas lines

For pipe or vessel welding, when purging with argon or nitrogen, install moisture sensors in the purge line or exhaust to verify the moisture content during setup and welding (*Fig.4*).

Fig.4



Trace moisture measurement is critical for maintaining welding quality, reliability and safety. By detecting water vapour at the ppm level, engineers can mitigate porosity, hydrogen cracking and strength loss. Selecting the right sensor technology, integrating it effectively into the welding gas supply and following rigorous calibration and maintenance practices, ensures best performance. Incorporating real time moisture data into quality control systems not only safeguards weld integrity but also streamlines troubleshooting, reduces scrap and enables compliance with industry standards.

Suitable Products

Portable Hygrometers

Online Hygrometers

Online Hygrometers

Trace Moisture Analysers

If you would like more details of trace moisture measurement in welding gases, please contact: +44 (0) 1274 733100 or contact@amsystems.co.uk

alpha moisture systems