

TRAILING SHIELD: A BRIGHT IDEA – A BRIGHT WELD

Why not try Trailing Shield (gas shield extension) for welding Stainless Steels and other metal alloys? Welding Titanium, there is no question.

This article is based on the welder's response and metallurgical and welding technological assessments of actual and possible advantages using trailing shield by welding both titanium and stainless steel.



☑ Titanium Grade 2 welded by Glenn Hovet with second generation Trailing Shield 2.0™ from TiTech PRO™.

HISTORICAL FLASHBACK

For decades Titanium welding is performed employing either gas shielded process with inert gas purge and auxiliary shielding to protect material behind weld torch or chamber welding. The purpose is to prevent air from reacting with the hot metal surface until the temperature is low to prevent unacceptable oxidation.

Titanium alloys are used in the aircraft and space industry in the USA since 1950's and spread to other industries as time passed. In Norway, Titanium was introduced with the oil industry in the 1970's. As welding of titanium required auxiliary shielding, creative souls made their own versions of trailing shields or fixed gas shielding. That was also the case in Norway, but we have only one commercial producer, TiTech Production AS (TiTech PRO™), distributes their product with the trademark TITECH PRO™ - TRAILING SHIELD®.

Trailing Shield may be defined as a device providing the zone behind the welding torch with shielding gas to protect the hot surface from oxidizing, and prevent embrittlement or poor corrosion resistance.

WHY TRAILING SHIELD?

The welding torch provides gas flow arc shielding and metal transfer. The gas is ionized and produces an arc-plasma energy transfer which in turn is melting the metal. Argon is the most common shielding gas for TIG-welding, but in case of lack of fusion, adding 30% Helium will increase energy transfer.

Torch shielding gas protects the weld pool and adjacent hot metal surface from the air. But by very reactive metals like titanium, the torch gas may not give sufficient protection. By welding, the torch is continuously moving away from the hot weldment, allowing the hot Titanium surface to combine with Oxygen and Nitrogen from the air. While at room temperature up to 200°C air combine with titanium forming a silver bright coloured protective oxide, high-temperature oxides may adversely affect properties.

The colour of the affected surface depends on oxide layer thickness (just like the refraction of light in oil contamination on water). From 300-400°C, the colour of the un-shielded surface becomes straw yellow which is normally acceptable. Some standards (ISO 15614-5 and Norsok M-601) may also allow a narrow band of intensive colours close to the limits of the gas shield. Temperatures from 400°C and above result in a thicker oxide layer starting with dark blue, then purple, brown or even light-blue and grey-blue colours, which indicates exposure to air at elevated temperatures for too long time. This is not acceptable because the properties of the Titanium surface are adversely affected as Oxygen and Nitrogen at elevated temperatures may dissolve directly into the

base material, potentially causing embrittlement. This is stated in a TWI report which concludes:

"It is conventional for trailing gas shields to extend coverage down to a metal temperature of 250°C, to prevent the formation of coloured oxide films".



According to Norsok M-601, coloured oxide shall not be removed before visual inspection because the colours are telling the welding history and will be an acceptance factor. The oxide may be removed after finished welding by brushing with a clean stainless steel brush, also between weld layers. Clean brush will not leave either iron contamination or oil/grease (i.e. carbon and hydrogen) affecting the properties. An angle grinder is not recommended as it might add iron contamination and leave grinding marks on the surface. Before welding starts: oxide brushing and degreasing will remove moisture and hydrogen, which may cause porosity and embrittlement of weld deposits. Even a fingerprint is said to lead to porosity in the weld deposit.

Its essential trailing shield gas flow is distributed without turbulence, producing uniform gas protection of the weld for the optimal shield, like Generation 2 Norwegian trailing shield, according to international welders' and welding engineers' response. We are proud of Norway being in front in trailing shield development.

We believe that you may even increase heat input to some extent within the existing WPQR range of approval or document by a new WPQR. Increased heat input implies increased welding productivity and still has a silver

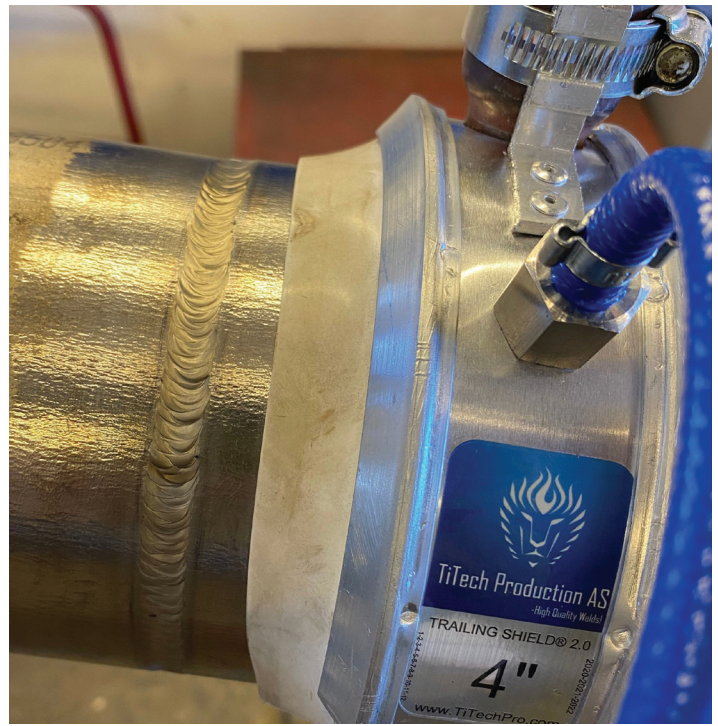
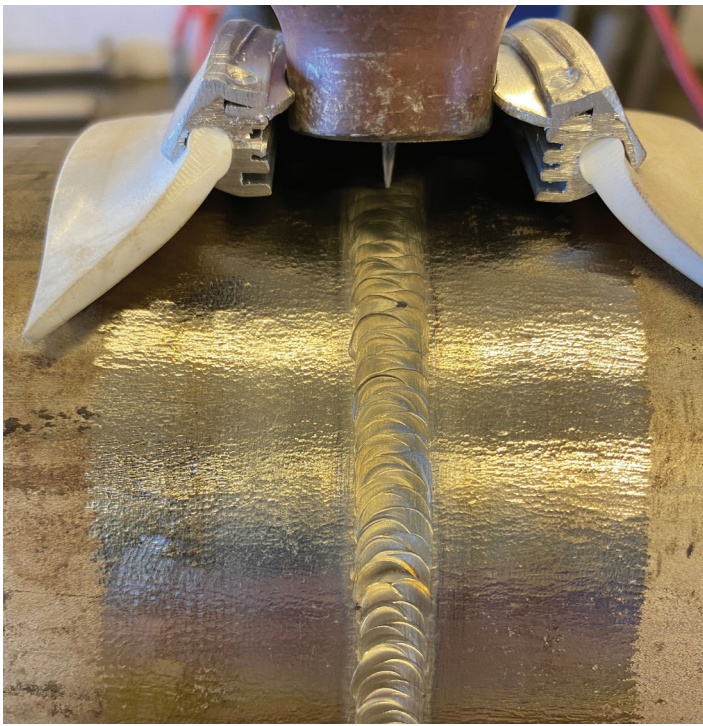
bright weldment surface due to uniform gas distribution and the cooling effect.

TRAILING SHIELDS ONLY FOR TITANIUM?

Trailing shields may have the same positive effect on welding other metal alloys, with the exception of carbon steel. Stainless steel alloys are like titanium getting oxidized in the air at ambient temperatures. 11-12% Chromium Steel alloys form a corrosion-resistant Chromium oxide layer at room temperature. The ability to protect the Chromium Steels from a more aggressive environment will improve by adding more Chromium and Molybdenum. But at elevated temperatures like obtained by welding, exposed in air, the Chromium oxide layer will grow thicker, extracting Chromium from the Steel surface affecting the corrosion-resistant properties of high Chromium alloys like super duplex and 6Mo Stainless steel, and even for 316 and duplex Stainless steel. Depending on requirements, the oxide and adjacent metal surface need to be removed.

Like titanium welding, welding of stainless steel will have similar oxide colour challenges (ref. Norsok M-601). Trailing shields may leave a bright silver weld after weld completion without the need for brushing or pickling.

In many cases, Stainless steel brushing may be sufficient to remove an oxide layer. But in cases like robotic and mechanized welding, the efficiency will be affected by the need to remove oxide between welding passes. Trailing shields will produce a bright weldment both during



316 Stainless steel welded by Glenn Hovet with second generation Trailing Shield 2.0™ from TiTech PRO™.

welding and after finished welding. No post-weld treatment is needed.

As with Stainless steel, other metal alloys may benefit by using trailing shields.

The first commandment, in general, is always to start with a clean weld joint and 99,996% pure gas. Humidity contains hydrogen, and grease consists of hydrogen and carbon, all having a detrimental effect, especially on titanium. Even Trailing shields cannot compensate for contaminated shielding gas. Welding produces heat that affects surface properties, heat affected zone (HAZ) in the weld deposit.

When welding steel, we usually wish for slow cooling; however, non-hardenable stainless steels, hardenable aluminum alloys and other metal alloys require rapid cooling to not disturb the metal structure and properties. Trailing shield may have a good influence on cooling the weldment, including HAZ, for better mechanical and corrosion properties.

TRAILING SHIELDS FOR OTHER REASONS THAN OXIDATION OR COOLING WELDMENTS?

On-site welding and in large buildings, the gas shielded may be affected by air movements. The shielding gas may be blown away or disturbed by turbulence causing various weld defects. Trailing shield creates a protected localized environment around the welding process that keeps the shielding gas in place, including the zone behind the welding torch.

Trailing shield might also have a good influence on welders' work environment, like air pollution and ergonomic aspects. Less need for brushing, grinding or pickling after welding is good for welders' health.

TRAILING SHIELD FOR OTHER WELDING PROCESSES THAN TIG?

Automated and mechanized welding processes are most commonly performed by MIG/

MAG or plasma welding. Trailing shields are perfectly tailor-made for these welding processes and may raise productivity as there is less need for interrupting welding sequence because of oxide cleaning. MIG/MAG and plasma are effective welding processes that may produce higher heat input than TIG, and thus meet a more significant challenge to make acceptable weldments due to oxide colours. Trailing Shield may tackle the challenge by providing prolonged gas protection and cooling of weldments.

Applying Trailing shields for metals other than titanium may be beneficial and cost-effective. **W**



► **Tor Marlow Barka, Sr. Welding engineer (IWE), Sr. Metallurgist (MSC)**