

## Background

Titanium filler wire used in aerospace welding applications is often stored in inert environments prior to welding to minimize exposure to atmospheric moisture, oxygen, and foreign contaminants that can degrade weld quality. Although Ti-6Al-4V is considered readily weldable, titanium's high chemical reactivity makes the surface condition of the filler wire critically important, as ambient exposure allows moisture adsorption, oxide film growth, and particulate contamination to accumulate on the consumable. Retained moisture within surface microcracks can dissociate under arc heat and introduce hydrogen directly into the molten weld pool, promoting porosity formation and hydride-induced embrittlement, while excessive oxide development or metallic contaminants may contribute to oxygen pickup and contamination cracking. By limiting this environmental interaction, inert storage seeks to preserve a cleaner filler wire surface and reduce the likelihood of weld defects originating from consumable contamination. Therefore, it is necessary to evaluate whether maintaining titanium filler wire in an inert environment prior to welding provides a measurable improvement in weld integrity compared to conventional ambient storage practices.

## Motivation

While not explicitly required by code, GE Aerospace stores their Ti filler in baths of argon to prevent oxidation prior to welding. To move toward more sustainable practices, GE Aerospace requested that the necessity of storing their filler wire in argon be investigated to potentially remove the requirement from their internal standards and to save costs on argon expenditures.

## Objectives & Approach

### Objectives:

- Evaluate the effect of Ti-6Al-4V filler metal contamination on weld quality.
- Produce consistent weld beads suitable for microstructural evaluation.
- Compare welds made with controlled oxidation states of filler wire.

### Approach:

- Perform manual GTAW to create samples
- Ship samples to GE Aerospace for metallographic preparation (polishing and etching)
- Analyze microstructure and look for defects and other metallographic issues in the welds.

## Conclusions

From visual microscopy, no significant difference was found between welds made with unoxidized filler compared to pre-oxidized filler metal.

Welds from all three types of filler were found to be similar in grain structure and contained no significant defects.

## Future Work

Mechanical testing and hardness data collection should be done to evaluate the physical effects of pre-oxidized filler metal.

Further testing should be done with filler that has been oxidized in a more controlled manner, such as an oven, to allow for even oxidation and a more extreme of oxidation over the entire piece of filler.

## Results & Discussion

- A repeatable GTAW bead-on-plate procedure was successfully developed after revising the initial approach to increase weld metal volume by stacking filler wire, enabling effective metallographic analysis.
- Optical microscopy revealed that **all three filler conditions (argon-stored, torched, and water-exposed)** produced welds that were **acceptable with similar grain structures and no consistent defect trends**.
  - Control samples established a sound baseline, though minor preparation artifacts (e.g., over-etching) highlighted limitations in interpretation.
  - Torched samples exhibited the greatest variability, including **isolated defects such as toe cracking, lack of fusion, and reinforcement**, but these were not consistently observed across all samples. One torched sample showed **possible  $\alpha'$  (alpha-prime) formation along  $\beta$  grain boundaries**, indicating localized microstructural transformation without catastrophic degradation.
  - Water-exposed samples also produced **acceptable welds**, though some showed **reduced dilution and increased reinforcement**, similar to torched samples. Importantly, strong-performing samples within this group suggest that **water exposure alone does not directly correlate with poor weld quality**.
- Overall, the **largest source of variation was weld consistency (penetration and dilution)** rather than filler wire condition. No clear, repeatable reduction in weld quality was observed due to contamination under the conditions tested.



Figure 1 - Control Sample Cross Section



Figure 2 - Torched Sample 1



Figure 3 - Torched Sample 2



Figure 4 - Torched Sample 3



Figure 5 - Water Sample 1



Figure 6 - Water Sample 2

