5-Day Aerospace Orbital Welding Training Agenda

Precision Tube / Propulsion / Flight Hardware Support Applications

A detailed, application-based training program built around aerospace tube preparation, purge control, weld schedule development, orbital GTAW process variables, exotic-material awareness, inspection, documentation, troubleshooting, and qualification-style weld performance.

PROCESS TRAINING | AEROSPACE QUALITY | REAL WELD DEVELOPMENT

Prepared by OWETEC Services

Welding education, training, consulting, documentation, inspection, and qualification support.

Program Overview

This agenda rebuilds the aerospace orbital welding outline into a true OWETEC-level training plan. It removes the hour-by-hour structure and replaces it with a detailed day-by-day progression focused on real precision tube welding capability for aerospace, launch, propulsion, ground support, test systems, and flight-hardware-adjacent fabrication.

The course is designed for welders, fabrication personnel, QA/QC, inspectors, engineers, supervisors, and project teams working around precision tube systems, propulsion support hardware, clean fluid systems, oxygen/fuel service awareness, ground support equipment, orbital tube welds, and customer-specific aerospace quality requirements.

Training philosophy

This is not an equipment demonstration. The purpose is to train people to understand the welding process - not just load a program and press cycle start. Students learn how fit-up, facing, fixturing, tungsten geometry, purge quality, gas coverage, amperage, pulse timing, travel speed, heat input, material chemistry, weld head setup, discoloration, inspection criteria, and documentation discipline all affect the final aerospace-quality weld.

Aerospace	Precision Quality	Flight Hardware Support

Training area	What the class is built to accomplish
Process scope	Closed-head orbital fusion GTAW for precision tube work, with practical discussion of open-head orbital, manual GTAW support, wire-feed applications, and customer-specific flight/ground support needs.
Aerospace focus	Internal/root profile, oxidation control, thin-wall consistency, fixture discipline, FOD awareness, material sensitivity, inspection readiness, and documentation discipline.
Equipment focus	Weld head setup, collet/fixture selection, tungsten installation, arc gap, purge setup, trailing/shielding strategy where applicable, program entry, schedule adjustment, machine records, and weld head maintenance.
Hands-on focus	Tube cutting, facing, cleaning, fit-up, purge setup, coupon welding, schedule development, fitting welds, mock assembly work, inspection, and troubleshooting.
Documentation focus	Weld logs, weld maps, heat/lot traceability, machine data, inspection records, borescope records, repair tracking, WPS/PQR/WPQ/WOPQ concepts, and customer-specific quality packages.

Course outcomes

- Understand why aerospace orbital welds are evaluated differently than general industrial welds.
- Prepare tube and fittings correctly through cutting, facing, deburring, cleaning, handling, FOD awareness, and fit-up verification.
- Set up orbital welding equipment, weld heads, collets/fixtures, tungsten, purge, shielding gas, and documentation controls correctly.
- Build and adjust weld schedules using process logic instead of relying only on auto-generated programs.
- Evaluate OD and ID/root weld conditions, recognize common aerospace weld defects, and identify root causes.
- Apply precision welding practices to tube-to-tube welds, fittings, elbows, reducers, valve bodies, thin-wall assemblies, and realistic aerospace-style spools.
- Understand documentation, traceability, qualification concepts, inspection expectations, and quality requirements for aerospace and critical hardware support.

5-Day Program Map

Day	Primary focus	Practical output
Day 1	Aerospace welding foundations, precision quality expectations, materials, tube system fundamentals, and FOD/cleanliness awareness.	Students understand what makes an aerospace-quality weld acceptable and what can make it fail before the weld is even made.
Day 2	Equipment setup, weld head/fixture selection, tube preparation, purge control, tungsten setup, and first weld programs.	Students can set up equipment, prepare coupons, establish purge, and make controlled basic orbital fusion welds.
Day 3	Process variable control, weld schedule development, parameter adjustment, defect prevention, thin-wall control, and inspection.	Students can troubleshoot weld results and make intelligent changes to amperage, travel speed, pulse timing, arc gap, purge, and downslope.
Day 4	Aerospace-style assemblies, fittings, valves, sequence planning, documentation, traceability, and qualification concepts.	Students fabricate and inspect realistic assemblies while maintaining cleanliness, traceability, and weld documentation.
Day 5	Final application project, qualification-style welds, borescope/internal review, troubleshooting, SOP review, and closeout.	Students demonstrate the complete workflow from preparation through inspection, documentation, and corrective action.

No hourly schedule

This agenda intentionally avoids times. The instructor can control pace based on the customer's equipment platform, tube sizes, student skill level, quality expectations, cleanroom requirements, and production pain points.

Day 1 Detailed Agenda

DAY 1

Aerospace Welding Foundations, Precision Quality Expectations, Materials, and Tube System Fundamentals

Build the foundation before touching the machine.

Training purpose

Day 1 establishes why aerospace orbital welding requires tighter process discipline than normal industrial welding. The class focuses on precision quality, internal/root profile, clean handling, oxidation prevention, material behavior, tube system components, FOD awareness, and the fundamentals that determine weld success before the arc starts.

Application and industry review

- How orbital welding is used in aerospace, launch, propulsion support, ground support equipment, clean fluid systems, test stands, and precision tube assemblies.
- Typical applications: thin-wall stainless tubing, fuel/oxidizer support systems, pneumatic/hydraulic lines, valve manifolds, test panels, precision spools, and flight-hardware-adjacent assemblies.
- Difference between sanitary/high-purity tube welding, general industrial tube work, and aerospace precision welding.
- Why internal/root profile, oxidation control, thin-wall consistency, cleanliness, and documentation can be more important than OD appearance.
- How poor welds create contamination risk, leak risk, fatigue concerns, inspection failures, repair cycles, and schedule delays.

Aerospace quality expectations

- AWS D17.1 awareness where applicable and how customer specifications shape weld profile, discontinuity evaluation, inspection, and documentation expectations.
- Drawing requirements, weld symbols, traveler controls, inspection gates, and customer-specific acceptance criteria.
- FOD awareness, material handling, tube-end protection, part protection, and avoiding cross contamination.
- How project specifications, engineering requirements, customer standards, and quality plans drive final acceptance criteria.

GTAW and orbital fusion process fundamentals

- GTAW electrical theory and electrode negative welding behavior.
- Arc length, arc gap, arc cone shape, heat transfer, puddle control, and how thin-wall tube responds to heat input.
- Primary/high pulse amperage, background/low pulse amperage, pulse timing, travel speed, and heat input.
- Shielding gas versus internal purge gas, including purity, flow, pressure, and venting.
- Downslope, closure behavior, crater control, tie-in quality, and end-of-weld risk.

Materials and metallurgy for aerospace service

- 300-series stainless steels as common precision tube training materials.
- Nickel alloy, titanium, aluminum, and customer-specific exotic material awareness.
- Low-sulfur versus high-sulfur stainless behavior and puddle flow differences.
- Heat-to-heat variation and why the same program may not weld every heat of tubing the same way.
- Surface condition, contamination control, discoloration, oxidation, and corrosion/fatigue awareness.

Hands-on lab: precision tube preparation fundamentals

- Cutting, facing, deburring, cleaning, and handling precision tube.

- Checking cut squareness, facing quality, wall mismatch, joint alignment, and fixture engagement.
- Identifying damaged tube ends, scratches, clamp marks, embedded contamination, and poor handling practice.
- Preparing initial coupons for Day 2 weld setup and welding.

Day outcome

Students understand the aerospace welding environment, what defects matter, why material and fit-up control weld results, and how to evaluate whether a joint is ready to weld.

Day 2 Detailed Agenda

DAY 2

Equipment Setup, Weld Head/Fixture Selection, Tube Preparation, Purge Control, and First Welds

Turn fundamentals into controlled setup and repeatable first welds.

Training purpose

Day 2 focuses on equipment, tooling, purge, tungsten, fit-up, fixturing, and the first controlled weld schedule. Students learn how orbital equipment is configured and how setup details directly affect aerospace-quality welds.

Orbital welding system components

- Power supply, weld head, rotor, motor drive, collets, fixture blocks, gas lines, grounds, pendant, printer, and data output.
- Closed-head orbital fusion equipment used for precision tube-to-tube and tube-to-fitting work.
- When open-head orbital or open-head wire-feed equipment becomes necessary for size, wall, access, or fitting geometry.
- How equipment platform differences affect setup, programming, documentation, and troubleshooting.

Weld head, fixture, and access setup

- Selecting the correct weld head size for tube diameter, fitting configuration, tangent length, and access restrictions.
- Collet selection, fixture fit, tube support, rotor clearance, head alignment, cable management, and part protection.
- Arc gap gauge use and why consistent arc gap matters around the entire tube.
- Weld head access near valves, elbows, reducers, manifolds, and short tangent fittings.
- Common setup mistakes that create inconsistent ID/root profile, discoloration, lack of penetration, or tie-in problems.

Tungsten electrode preparation

- Tungsten type and diameter selection for small-diameter precision tube.
- Grinding direction, taper angle, tip flat, contamination control, and replacement intervals.
- How tungsten geometry affects arc focus, bead width, penetration, arc stability, and discoloration.
- Setting tungsten position in the head and confirming arc gap before welding.

Purge and gas control

- Shielding gas flow and internal purge gas flow.
- Flow versus pressure and why excessive purge pressure or poor venting can deform or contaminate the internal bead.
- Purge dam and plug setup, venting strategy, pre-purge time, post-purge time, and oxygen displacement.
- Diagnosing discoloration, sugaring, oxidation, trapped volumes, and poor gas coverage.

Hands-on lab: setup and first aerospace-quality welds

- Prepare coupons from start to finish using clean handling controls.
- Install tungsten, set arc gap, verify collets/fixtures, and set up purge.
- Enter or load a starting program and perform pre-weld checks.
- Make first precision orbital fusion welds and inspect OD/ID/root results.

Day outcome

Students can prepare tubing, set up orbital equipment, establish purge, install tungsten, verify arc gap, and make basic controlled aerospace-quality orbital fusion welds.

Day 3 Detailed Agenda

DAY 3

Weld Schedule Development, Process Variables, Thin-Wall Control, Defect Prevention, and Inspection

Teach students how to think through the weld, not just run the machine.

Training purpose

Day 3 is the core process-development day. Students learn how to adjust weld variables based on actual weld results, identify root causes, and evaluate precision tube welds using practical inspection logic.

Amperage and heat input control

- Primary/high pulse amperage and how it drives penetration, bead shape, and root/ID response.
- Background/low pulse amperage and how it supports puddle control, cooling, and consistency.
- Recognizing lack of penetration, excessive penetration, excessive bead width, overheating, and color changes.
- How heat builds through the weld cycle and why later levels may require adjustment.

Pulse timing and pulse frequency

- Pulse frequency, high pulse time, low pulse time, and puddle freeze behavior.
- Ripple pattern, bead consistency, internal bead shape, and thin-wall or heavy-wall response.
- How pulse balance can stabilize penetration and reduce overheating without losing fusion.

Travel speed and level strategy

- Travel speed effect on heat input, bead width, penetration, reinforcement, and tie-in.
- Fast travel versus slow travel symptoms and how to read the weld result.
- Level 1 start behavior, Level 2 stabilization, Level 3 side/gravity behavior, and Level 4 closure behavior.
- Why programs are divided by segments/quadrants and why parameters may change around the tube or pipe.

Arc gap, tungsten position, and weld head mechanics

- Arc gap influence on arc voltage, bead width, penetration, and OD/ID consistency.
- Tube ovality, collet fit, track alignment, rotor drag, poor grounding, and cable strain problems.
- Recognizing when a weld issue is equipment setup or fixturing, not just program settings.

Downslope, tie-in, and closure control

- Crater fill, tie-in appearance, final penetration, oxidation at closure, and end-of-weld concavity.
- Correcting poor closure, overlap, undercut, crater issues, and excessive heat at the stop point.
- How downslope settings must match tube size, wall thickness, heat input, and final weld behavior.

Aerospace defect recognition and root cause analysis

- Lack of penetration, excessive penetration, internal concavity, excessive convexity, mismatch, undercut, and poor fusion.
- Oxidation, discoloration beyond customer limits, porosity, arc strikes, tungsten inclusions, crater defects, and poor tie-in.
- Distinguishing preparation defects, purge defects, fixture issues, material behavior, and programming issues.
- Using weld results to decide the next controlled parameter change.

Hands-on lab: controlled weld development

- Make welds with controlled changes to amperage, travel speed, pulse timing, arc gap, purge pressure, and downslope.
- Compare weld results side by side and document what changed.
- Build a refined precision weld program from initial welds.
- Inspect, score, critique, and troubleshoot student welds.

Day outcome

Students can diagnose weld results, understand cause and effect, make controlled process changes, and evaluate welds against aerospace-quality expectations.

Day 4 Detailed Agenda

DAY 4

Aerospace Assemblies, Fittings, Documentation, Traceability, and Qualification Concepts

Apply the process to real-world precision assemblies.

Training purpose

Day 4 moves students from coupons into realistic fabrication. The focus is fitting-specific weld behavior, fixture planning, weld sequence planning, mock assemblies, documentation, traceability, and how qualification concepts support production welding.

Advanced aerospace weld applications

- Tube-to-tube, tube-to-fitting, tube-to-elbow, tube-to-reducer, tube-to-valve, and tube-to-manifold welds.
- Short tangent fittings, limited-access welds, small diameter tubing, thin-wall tubing, and dissimilar wall/mass conditions.
- Why a tube-to-tube program may not be right for fittings, valves, reducers, or manifolds.
- How fitting mass, geometry, and heat sink behavior change weld response.

Assembly planning and weld sequencing

- Reading a layout, identifying weld numbers, planning weld order, and preventing trapped welds.
- Purge routing, venting strategy, fit-up sequence, tube support, fixture strategy, and distortion control.
- Maintaining accessibility for the weld head and inspection.
- Protecting finished welds, open tube ends, and clean surfaces during fabrication.

Mock aerospace-style spool assembly

- Build a realistic assembly using tube, elbows, reducers, valve-simulated components, and precision fittings.
- Identify weld numbers and plan the sequence before welding.
- Prepare, fit, purge, weld, inspect, and record each weld.
- Discuss what would be accepted, repaired, reworked, or escalated in production.

Weld documentation and traceability

- Weld logs, weld maps, heat/lot numbers, tubing/fitting traceability, welder/operator ID, machine ID, and procedure/program ID.
- Machine printouts, parameter records, inspection reports, borescope images where applicable, and repair logs.
- How documentation supports audits, traveler closeout, engineering review, and customer acceptance.

Weld head maintenance and reliability

- Cleaning the weld head, rotor, collets, tungsten holder, cables, gas passages, and clamps.
- Rotor drag, poor grounding, cable strain, cooling issues, gas leaks, and electrode alignment problems.
- Preventive maintenance habits that protect weld quality and reduce downtime.

Day outcome

Students can apply orbital welding to realistic aerospace-style assemblies, plan weld sequence and purge, document work, and understand how qualification and quality systems control production welding.

Day 5 Detailed Agenda

DAY 5

Final Application Project, Qualification-Style Welds, Inspection Review, Troubleshooting, and Closeout

Demonstrate the complete workflow from prep to documentation.

Training purpose

Day 5 brings the training together through final welds, inspection review, troubleshooting, customer-specific discussion, SOP recommendations, and closeout. Students demonstrate the full workflow from preparation through weld evaluation.

Final practical welding evaluation

- Complete tube-to-tube, tube-to-fitting, or customer-specific qualification-style welds.
- Demonstrate cutting, facing, cleaning, fit-up, weld head setup, tungsten setup, purge, program selection, and weld execution.
- Make controlled adjustments when weld results require correction.
- Record relevant information for weld traceability and quality review.

Final weld inspection and critique

- Review OD appearance, ID/root profile where accessible, bead width, tie-in, color, penetration, and consistency.
- Evaluate concavity, convexity, mismatch, undercut, oxidation, porosity, and surface contamination.
- Discuss whether welds are acceptable, questionable, repairable, or rejectable.
- Focus on why the weld result happened and how to prevent recurrence.

Borescope and internal inspection review

- Borescope setup, image orientation, lighting, and common interpretation mistakes.
- Internal bead profile review and oxidation/discoloration assessment.
- Capturing images and linking them to weld numbers.
- How internal weld records support QA, engineering review, and customer turnover packages.

Advanced troubleshooting scenarios

- Good OD with bad ID/root oxidation.
- Proper flow but poor purge because of bad venting or trapped volume.
- Internal suck-back caused by excessive heat or purge pressure issues.
- Valve body or fitting lack of penetration.
- Program works on one heat of tubing but not another.
- Tie-in fails even though the rest of the weld is acceptable.

Customer-specific application review

- Review the customer's actual tubing sizes, fittings, equipment platform, materials, quality expectations, and production challenges.
- Discuss current pain points, inspection failures, documentation gaps, or operator skill needs.
- Recommend internal next steps for SOPs, qualification testing, weld maps, inspection process, and production control.

Day outcome

Students complete a full aerospace orbital welding progression and leave with a clear understanding of how to prepare, weld, inspect, troubleshoot, document, and support precision fabrication work.

Optional Customer-Specific Add-On Modules

These modules can be emphasized or added depending on the customer's systems, materials, equipment platform, codes, internal quality plan, and production needs.

Aerospace Quality Emphasis

- AWS D17.1 awareness where applicable to aerospace welding acceptance and inspection expectations.
- Customer-specific acceptance criteria, drawing notes, weld symbols, traveler controls, and inspection gates.
- FOD awareness, clean handling, part protection, and traceability discipline.

Precision Tube / Propulsion Emphasis

- Thin-wall tube welding, heat input control, ID/root profile, discoloration control, and tube-end preparation.
- Propulsion support, ground support, clean fluid, pneumatic, hydraulic, and test-system application discussion.
- Fixture planning, weld head access, sequence planning, and risk reduction for precision assemblies.

Materials / Exotic Alloy Emphasis

- 300-series stainless, nickel alloys, titanium awareness, aluminum awareness, and customer-specific material response.
- Material chemistry, sulfur behavior in stainless, heat-to-heat variation, purge quality, and oxidation sensitivity.
- Weld development strategy for sensitive materials, unusual wall thicknesses, and flight-hardware-adjacent applications.

Inspection / Documentation Emphasis

- Visual inspection, borescope/internal review, PT/RT/other NDE awareness, and customer-specific quality records.
- Weld logs, weld maps, traveler entries, machine records, repair logs, and turnover packages.
- SOP development for cutting, facing, cleaning, purge, welding, inspection, documentation, and maintenance.

OWETEC differentiator

The goal is not to create machine operators. The goal is to develop welders and technical personnel who understand precision orbital welding well enough to make aerospace-quality welds, recognize problems, correct defects, support documentation, and improve the customer's internal welding capability.

Training Deliverables and Closeout

At the conclusion of the training, OWETEC can support the customer with additional deliverables depending on the scope of work, customer specification, drawing requirements, inspection expectations, materials, and quality-plan requirements.

Potential deliverables

- Completed training agenda and attendance record.
- Course completion certificates.
- Student performance review or skill observations.
- Recommended weld procedure or schedule notes.
- Customer-specific weld schedule development support.
- WPS/PQR/WPQ/WOPQ support where required.
- SOP recommendations for orbital welding workflow, inspection, documentation, repair, and equipment maintenance.
- Inspection and documentation recommendations.
- Follow-up consulting support for production weld problems, qualification planning, or internal process development.

Important note

Final qualification requirements, acceptance criteria, documentation requirements, and inspection methods must be controlled by the customer's governing code, project specification, contract documents, quality plan, and internal procedures. This agenda is a training plan and can be tailored to the customer's specific applications.

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