5-Day Sanitary Orbital Fusion Welding Training Agenda

Pharmaceutical / Food / Beverage / Dairy Applications

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

PROCESS TRAINING	SANITARY QUALITY	REAL WELD DEVELOPMENT

Prepared by OWETEC Services

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

Program Overview

This agenda rebuilds the original pharmaceutical / food and beverage 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 sanitary welding capability.

The course is designed for welders, maintenance teams, fabrication personnel, QA/QC, inspectors, engineers, supervisors, and project teams working around pharmaceutical tubing, biopharmaceutical utilities, food-grade transfer lines, beverage systems, dairy process piping, clean steam, WFI, CIP/SIP, skids, process panels, and product-contact stainless systems.

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, tungsten geometry, purge pressure, gas quality, amperage, pulse timing, travel speed, heat input, weld head setup, material chemistry, and inspection criteria all affect the final sanitary weld.

Pharmaceutical	Food & Beverage	Dairy

Training area	What the class is built to accomplish
Process scope	Closed-head orbital fusion GTAW as the primary focus, with practical discussion of open-head orbital, manual GTAW support, and wire-feed applications when the customer's work requires it.
Sanitary focus	Internal weld profile, oxidation control, cleanability, drainability, ferrule and fitting welds, surface condition, contamination prevention, and documentation discipline.
Equipment focus	Weld head setup, collet selection, tungsten installation, arc gap, purge setup, program entry, schedule adjustment, machine printouts, and basic 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 numbers, machine data, inspection records, borescope records, repair tracking, WPS/PQR/WPQ/WOPQ concepts, and customer-specific turnover packages.

Course outcomes

- Understand why sanitary orbital welds are evaluated differently than general industrial welds.
- Prepare tube and fittings correctly through cutting, facing, deburring, cleaning, handling, and fit-up verification.
- Set up orbital welding equipment, weld heads, collets, tungsten, purge, and shielding gas correctly.
- Build and adjust weld schedules using process logic instead of relying only on auto-generated programs.
- Evaluate OD and ID weld conditions, recognize common sanitary defects, and identify root causes.
- Apply sanitary welding practices to ferrules, elbows, tees, reducers, valve bodies, skids, and realistic assemblies.
- Understand documentation, traceability, qualification concepts, and quality expectations for validated or hygienic systems.

5-Day Program Map

Day	Primary focus	Practical output
Day 1	Sanitary welding foundations, industry requirements, materials, tube system fundamentals, and prep standards.	Students understand what makes a sanitary weld acceptable and what can make it fail before the weld is even made.
Day 2	Equipment setup, weld head selection, tube preparation, purging, gas 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, and sanitary inspection.	Students can troubleshoot weld results and make intelligent changes to amperage, travel speed, pulse timing, arc gap, purge, and downslope.
Day 4	Advanced sanitary assemblies, fittings, ferrules, reducers, valves, sequence planning, documentation, and qualification concepts.	Students fabricate and inspect realistic sanitary assemblies while maintaining 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, tubing sizes, student skill level, quality expectations, and production pain points.

Day 1 Detailed Agenda

DAY 1

Sanitary Welding Foundations, Industry Requirements, Materials, and Tube System Fundamentals

Build the foundation before touching the machine.

Training purpose

Day 1 establishes why pharmaceutical, food, beverage, and dairy orbital welding requires tighter process discipline than normal industrial welding. The class focuses on sanitary quality, internal weld profile, cleanability, corrosion resistance, material behavior, tube system components, and the fundamentals that determine weld success before the arc starts.

Application and industry review

- How orbital welding is used in pharmaceutical, biopharmaceutical, food, beverage, and dairy systems.
- Typical applications: WFI, clean steam, CIP/SIP, product transfer, dairy process lines, beverage piping, clean utilities, skids, panels, manifolds, and valve clusters.
- Difference between sanitary welding, high-purity welding, and general industrial tube or pipe welding.
- Why internal profile, oxidation control, drainability, and cleanability can be more important than OD appearance.
- How poor welds create contamination traps, corrosion points, cleaning problems, product risk, and inspection failures.

Sanitary and hygienic quality expectations

- ASME BPE awareness for pharmaceutical and bioprocessing systems.
- 3-A sanitary principles for food, beverage, and dairy equipment.
- EHEDG hygienic design concepts related to cleanability and crevice avoidance.
- FDA/cGMP awareness around controlled fabrication, equipment cleanliness, documentation, and validated processes.
- How project specifications, 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, and puddle control.
- Primary/high pulse amperage, background/low pulse amperage, pulse timing, travel speed, and heat input.
- Shielding gas versus internal purge gas.
- Pre-purge, post-purge, oxygen control, and oxidation prevention.
- Downslope, closure behavior, crater control, and tie-in quality.

Materials and metallurgy for sanitary service

- 304/304L and 316/316L stainless steel tubing.
- 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.
- Electropolished versus mechanically polished tubing.
- Surface finish, Ra awareness, passivation concepts, and contamination control.

- AL-6XN, Hastelloy, and other corrosion-resistant alloys as advanced application discussion where relevant.

Sanitary tube, fitting, and component fundamentals

- Tube-to-tube welds, tube-to-ferrule welds, and tube-to-fitting welds.
- Short ferrules, long ferrules, pulled tees, reducers, elbows, instrument tees, sample ports, and valve bodies.
- Tangent length, weld head clearance, fitting mass, and heat sink behavior.
- Tube ovality, wall mismatch, OD/ID surface condition, cut squareness, burr control, and fit-up.

Hands-on lab: tube preparation fundamentals

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

Day outcome

Students understand the sanitary 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 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, and the first controlled weld schedule. Students learn how orbital equipment is configured and how setup details directly affect weld quality.

Orbital welding system components

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

Weld head selection and setup

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

Tungsten electrode preparation

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

Tube prep and cleanliness workflow

- Squaring, facing, chip control, burr removal, and inspection after facing.
- Solvent wipe practices and clean handling for sanitary tubing.
- Protecting electropolished ID surfaces and avoiding embedded contamination.
- Good versus bad coupon preparation examples.

Purge and gas control

- Shielding gas flow and internal purge gas flow.
- Flow versus pressure and why excessive purge pressure can deform the internal bead.
- Purge dam and plug setup, venting strategy, pre-purge time, post-purge time, and oxygen displacement.

- Oxygen ppm monitoring when available.
- Diagnosing discoloration, sugaring, oxidation, and poor gas coverage.

Introduction to weld schedule development

- Starting with material, OD, wall thickness, weld head type, arc gap, tungsten, purge, and target profile.
- Primary amperage, background amperage, pulse timing, travel speed, level programming, and downslope.
- Why autogenerate programs are starting points, not final weld procedures.
- How to document starting programs and controlled adjustments.

Hands-on lab: setup and first welds

- Prepare coupons from start to finish.
- Install tungsten, set arc gap, verify collets, and set up purge.
- Enter or load a starting program and perform pre-weld checks.
- Make first sanitary orbital fusion welds on 316L tubing.
- Inspect OD and ID where possible, compare results, and identify first corrective actions.

Day outcome

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

Day 3 Detailed Agenda

DAY 3

Weld Schedule Development, Process Variables, Defect Prevention, and Sanitary 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 sanitary welds using practical inspection logic.

Amperage and heat input control

- Primary/high pulse amperage and how it drives penetration.
- Background/low pulse amperage and how it supports puddle control and cooling.
- Recognizing lack of penetration, excessive penetration, excessive bead width, and overheating.
- 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 tube response.
- How pulse balance can help stabilize penetration and reduce overheating.

Travel speed and level strategy

- Travel speed effect on heat input, bead width, penetration, and tie-in.
- Fast travel versus slow travel symptoms.
- 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.

Arc gap, tungsten position, and weld head mechanics

- Arc gap influence on arc voltage, bead width, penetration, and OD/ID consistency.
- Tube ovality and collet fit problems that create arc gap variation.
- Electrode misalignment, rotor drag, poor grounding, and weld head mechanical issues.
- Recognizing when a weld issue is equipment setup, not 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.

Sanitary defect recognition and root cause analysis

- Lack of penetration, excessive penetration, internal concavity, excessive convexity, mismatch, undercut, and poor fusion.

- Sugaring, oxidation, heat tint, porosity, arc strikes, tungsten inclusions, crater defects, and poor tie-in.
- Distinguishing preparation defects, purge defects, material behavior, and programming issues.
- Using weld results to decide the next controlled parameter change.

Inspection methods and acceptance thinking

- OD visual inspection, ID visual inspection, borescope review, bead width measurement, profile evaluation, and discoloration assessment.
- Internal profile expectations for drainability, cleanability, and product-contact surfaces.
- Communication between welders, inspectors, QA, and engineering when a weld is questionable.
- Why a no-call or good-looking OD does not automatically mean sanitary acceptability.

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 sanitary 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 sanitary quality expectations.

Day 4 Detailed Agenda

DAY 4

Advanced Sanitary Assemblies, Fittings, Documentation, Traceability, and Qualification Concepts

Apply the process to real-world assemblies and quality-system expectations.

Training purpose

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

Advanced sanitary weld applications

- Tube-to-ferrule, tube-to-elbow, tube-to-tee, tube-to-reducer, tube-to-valve, and tube-to-instrument fitting 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 ferrules, valves, reducers, or fittings.
- How fitting mass, geometry, and heat sink behavior change weld response.

Fitting-specific challenges

- Ferrule geometry and clamp connection expectations.
- Pulled tee and reducer transition behavior.
- Valve body heat sink and access limitations.
- Collet engagement problems around short tangents.
- Purge challenges through fittings and assemblies.
- When to adjust program levels or build joint-specific schedules.

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, and distortion control.
- Maintaining accessibility for the weld head and borescope.
- Protecting finished welds, open tube ends, and clean surfaces during fabrication.

Mock skid or sanitary spool assembly

- Build a realistic assembly using tube, elbows, tees, reducers, ferrules, and valve-simulated components.
- 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 numbers, tubing/fitting traceability, welder/operator ID, machine ID, and procedure/program ID.
- Machine printouts, parameter records, borescope images, inspection reports, and repair logs.
- How documentation supports audits, turnover packages, validation records, and customer review.

- What information welders should capture before, during, and after welding.

WPS/PQR/WPQ/WOPQ and qualification concepts

- Practical explanation of WPS, PQR, WPQ, and WOPQ.
- Difference between procedure qualification, welder qualification, and welding operator qualification.
- How ASME Section IX concepts can support sanitary fabrication when required by contract or quality plan.
- How company-specific and customer-specific qualification testing may differ from code minimums.
- How to build ranges that support production without losing control of the process.

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 sanitary 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-ferrule, 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 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 assessment.
- Capturing images and linking them to weld numbers.
- How internal weld records support QA, validation, and customer turnover packages.

Advanced troubleshooting scenarios

- Good OD with bad ID oxidation.
- Proper flow but poor purge because of bad venting or trapped volume.
- Internal suck-back caused by excessive heat or purge pressure issues.
- Ferrule weld overheating.
- Valve body 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.
- Weld head rotation, collet, arc gap, or tungsten issues creating false parameter problems.

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.

SOP and best-practice closeout

- Recommended controls for tube receipt, storage, cutting, facing, cleaning, fit-up, purge, welding, inspection, documentation, repair, and equipment maintenance.
- How to structure internal orbital welding procedures so operators have clear, repeatable expectations.
- How to maintain continuity, consistency, and accountability across shifts or project teams.

Completion review

- Final knowledge review covering sanitary fundamentals, prep, purge, parameters, inspection, defects, documentation, and troubleshooting.
- Review of student performance and recommended next training or qualification steps.
- Issuance of course completion documentation as applicable to the training engagement.

Day outcome

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

Pharmaceutical / Biopharmaceutical Emphasis

- ASME BPE-focused weld quality expectations.
- WFI, clean steam, CIP/SIP, high-purity utilities, and validated process piping.
- Electropolished tubing handling, passivation awareness, and surface finish protection.
- Borescope documentation, weld maps, traceability packages, and QA review expectations.
- Cleanroom behavior and gowning awareness where applicable.

Food / Beverage / Dairy Emphasis

- 3-A sanitary design awareness and product-contact weld expectations.
- Drainability, clean-in-place behavior, microbial harborage prevention, and ferrule weld quality.
- Dairy tubing, beverage process piping, clamp connections, pulled tees, and maintenance repair concerns.
- Practical sanitation, cleanability, and production reliability discussions.

Advanced Welding Emphasis

- Open-head orbital welding and open-head wire-feed orbital welding.
- Larger diameter sanitary tubing, heavier wall components, and difficult access welds.
- AL-6XN, Hastelloy, and corrosion-resistant alloys.
- Dissimilar thickness welds, valve body heat sink control, and customer-specific coupon development.

Quality / Documentation Emphasis

- WPS development, PQR support, WPQ/WOPQ qualification support, and controlled variable ranges.
- Weld log, weld map, borescope report, inspection report, and repair report templates.
- SOP development for cutting, facing, cleaning, purge, welding, inspection, and maintenance.
- Production audit readiness and customer turnover package structure.

OWETEC differentiator

The goal is not to create machine operators. The goal is to develop welders and technical personnel who understand the process well enough to make sanitary 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, code requirements, project requirements, and quality-plan expectations.

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 sanitary orbital welding workflow.
- 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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