# Spacecraft depend on orbital welding

By Dick Herzfeld, Polysoude

**Producing welds for satellites and launch vehicle propulsion systems that are able to withstand the rigors of deep space is a task accorded to orbital welding. With every component manufactured for the NASA Space Program, the weld joints must meet the highest quality certification standards. This means that every weld must pass the stringent purity and integrity tests.**

For many years, automated welding has been the tool of choice for aerospace companies manufacturing launch vehicles - e.g., Atlas, Titan, and other rockets - or which fabricate spacecraft for NASA and Jet Propulsion Labs (JPL) that are designed for critical, deep-space missions, like the Cassini mission to Saturn and the Genesis mission to collect particles of solar wind.

### How orbital welding is used

For a typical spacecraft, the propulsion system's tubing alone requires several hundred welds. Altogether, spacecraft and launch vehicles use a variety of stainless steel and titanium tubing, having wall thicknesses varying from 0.0016 to 0.090 inch and with diameters from 1/8 to 1 1/2 inches. Having multiple weld heads available for different tube sizes saves setup time, but changing weld head inserts can be just as effective.


*Propulsion tubing system*

The products must be defect-free, so the welds must have full penetration and meet Class-A X-ray quality standards. Much time and effort are expended on process control to ensure that every weld meets the rigid quality standards. Due to tube thinness, these welds are difficult to weld consistently by hand, and automatic orbital welding is the only method that can achieve consistently uniform welds.

Using closed chamber weld heads avoids tube contamination, plus, automated welding maintains part alignment, while providing complete inert gas coverage of the weld zone. That prevents discoloration and embrittlement caused by exposure to oxygen, nitrogen or hydrogen. Critical welding parameters, such as amperes, volts, and travel speed that are necessary for successful welds, are controlled by the orbital welding power supply. In addition, to prevent burn-through on the thin materials being welded, the power supply delivers no welding current until an arc is established.

When subassemblies are mounted onto the vehicles, the tubing interconnects to the fuel tanks and then to the rocket engines. Orbital welding is the preferred tool here, too. Welders bring the equipment to the vehicle and weld in position, often using square butt welds or socket butt welds. Not uncommon, however, are instances of close weld head access, when two elbow fittings are welded together or a tube is connected to a component inside the spacecraft structure.

### Welding Preparations

Cleanliness is critical to aerospace applications. Material must be certified for chemistry, strength, and other criteria before acceptance. For example: titanium and stainless steel tubing can have no contamination and must be totally clean. Prior to welding, facilities will usually bend the tubes to shape with NC bending equipment, maintaining tube ends square to 0.002 inch and lightly deburred to ensure tight fit-up for welding. Tubes then go through a sequence of cleaning steps to bring them up to the facility's requirements. Often this is a high-level cleaning process in which they are checked for particulate contamination and non-volatile residue. Maintaining this cleanliness level during welding requires a controlled-access room with special air filtration. Aerospace orbital welding is done in clean rooms. Welding technicians will wear full clean-room suits, including latex gloves. Depending on program requirements, welding may be done in a Class 10,000 or Class 100,000 clean room. Welding procedures are designed to ensure that no contamination is introduced during the welding process.

*A rocket launches a communications satellite*

*Portable Power Source with integrated welding controller and real time monitoring*

### Certification

Companies that provide NASA with components like propulsion systems are responsible for delivering certified products. They must deliver all company generated test data to NASA, for its internal acceptance of weld quality and system functionality. These results may include proof that weld procedures are fully qualified before welding is performed. Once the vehicle is welded, the welds are inspected visually, X-rayed, proof-tested, and helium leak-tested at least once. Sometimes a propulsion system will go through several cycles or different cycles of inspection to ensure system integrity.

During certification, X-ray may occasionally find a lack of penetration indication. This defect can occur if the tungsten electrode isn't aligned perfectly over the weld joint. A small portion of the weld might not have been fully penetrated. A repair reweld cycle is made over that weld. Argon gas is used to ensure that the welder has a good purge before any welding or rewelding is done.

*Clean room working conditions*

### Conclusion

Welding applications in the aerospace industries demand high precision, a quality that can be entirely reproduced, and a reject rate that is as low as possible. Automatic orbital welding is being used to help to meet these requirements.

Welds on space-bound products are critical. Once a vehicle is launched and in orbit, there is no way to fix it. If just one weld fails, a mission can be lost, with catastrophic consequences.