

AI-Based Laser Welding In-Line Quality Monitoring

Why inspect samples when you can inspect every weld?

High-volume automated welding leaves little room for error: thousands of welds per part, where a single undetected defect can cause failure downstream, and sample-based inspection can't keep pace with automated production. Fraunhofer USA's in-line inspection approach addresses that directly, validated on battery busbar welding and hairpin welding for electric motor stators. It builds on a production track record: an AI system Fraunhofer USA deployed for resistance spot welding at a major automotive manufacturer reduced manual quality verification effort by more than 50%, with ROI in under a year.

50%

Reduced Manual
Quality Verification
Effort for Resistance
Spot Welding

Subsurface Defect Detection

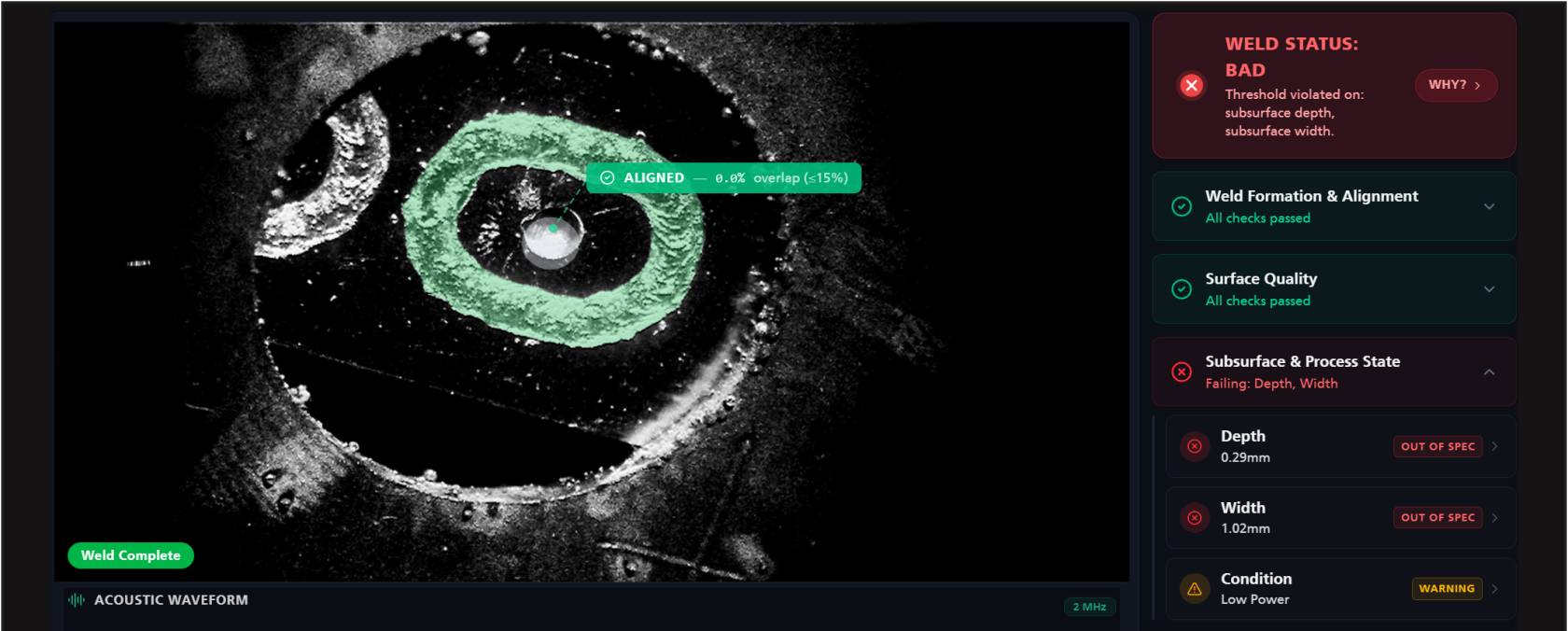
Defects like incomplete penetration or lack of fusion form beneath the weld surface, where visual inspection cannot detect them. Destructive sampling checks only a fraction of production, leaving defects hidden until parts fail downstream. Fraunhofer USA combines visual, acoustic, and process data to catch these conditions in every weld, validated against metallography and X-ray inspection.

Real-Time Detection

A defect caught close to the weld event is usually much less costly than one found downstream. Every weld is evaluated the moment it is finished, at line rate, so a problem surfaces while the part is still in front of the operator.

Listening for Defects

Welding produces sound and vibration that change with what's happening inside the weld. A contact-free laser microphone picks up that acoustic signature without touching the part or interfering with the weld itself, giving the AI model a data source no camera can provide: information from inside the weld that a camera can't see.



Line Integration

Fraunhofer USA builds each deployment around your existing equipment, adding only the sensors a given process calls for: up to four acoustic channels, plus cameras and process signal inputs as required. Integration uses the industrial protocols (MQTT, OPC UA) your systems already run. Inference runs locally, so production data never leaves the building.

Adaptability

The same monitoring approach carries over to other weld types. In a prior AI in Manufacturing validation, one calibration experiment was sufficient to adapt the model to a new setup, reducing future setup-specific data collection.

How It Works

This approach captures synchronized visual, acoustic, and process data throughout the weld and processes it through AI models built for the specific application. Two layers of analysis run in parallel: one evaluates specific weld conditions (formation and alignment, surface quality, subsurface depth and width), and a second produces an overall quality call (good, bad, or repairable) in real time. A weld outside spec is flagged immediately with the measurement that caused the failure, so an operator knows exactly what to check rather than just that something went wrong.

Capabilities

Sensing:	High-speed camera, 3D laser scanner, contact-free acoustic sensing, selected to match the process
Detection speed:	Real-time, in-line, milliseconds per weld
Coverage:	100% of welds
Classification accuracy:	90%+, validated on busbar and hairpin welding
Integration:	Built around your existing equipment and line
Data handling:	Local inference, no cloud dependency
Communication:	Compatible with MQTT, OPC UA, and other standard industrial protocols
Adaptation:	Recalibrates to a new setup with a single calibration run

Partner With Fraunhofer USA

Fraunhofer USA is a 501(c)(3) nonprofit research and development organization with more than 30 years of experience applying advanced manufacturing, artificial intelligence, software systems, and materials science to industry and government challenges.

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