Automation of Resistance Spot Weld Inspection

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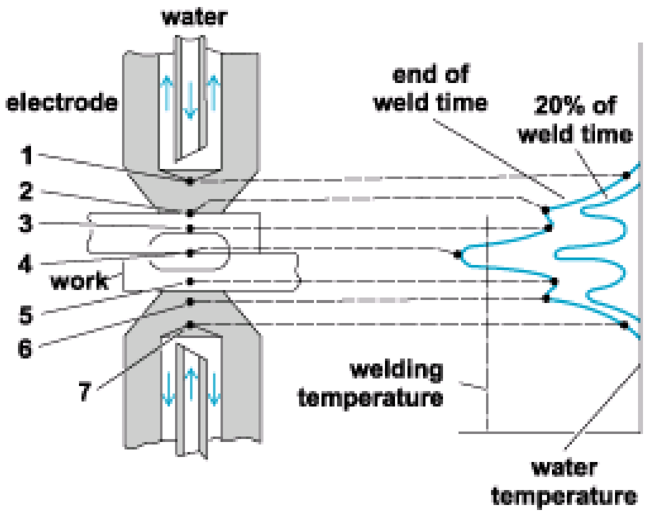
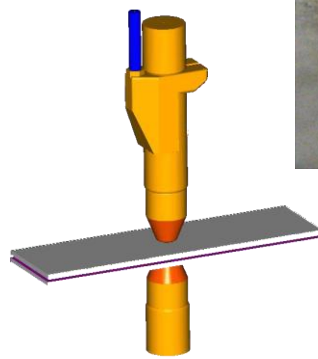
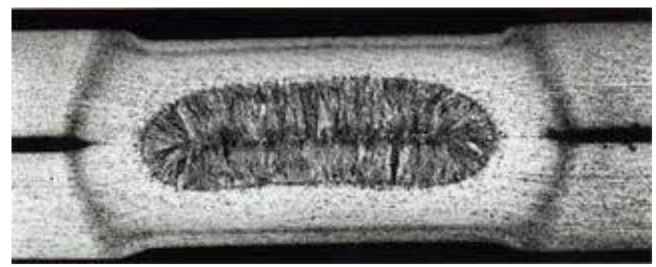
2 – Tessonics Inc.

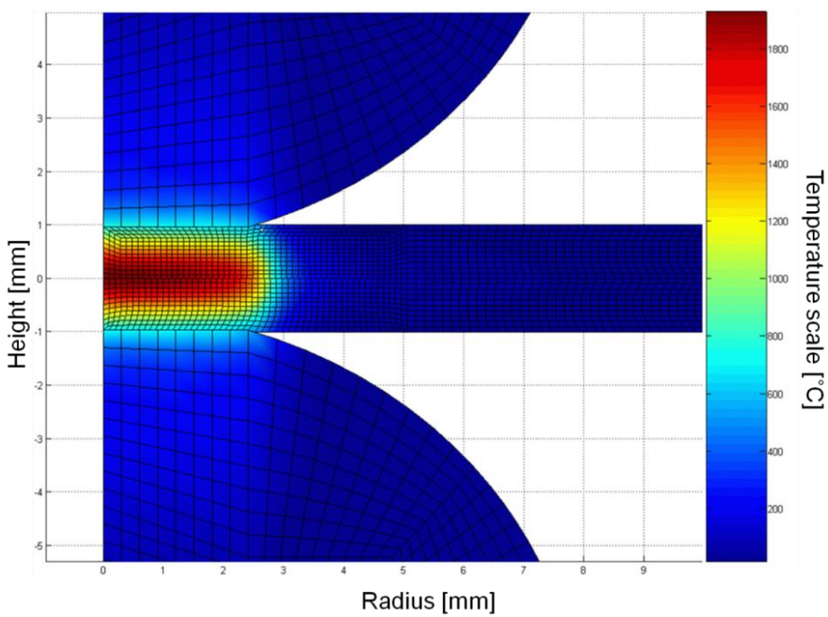
Spot Welding





Outside (top) and inside (bottom) look of spot weld



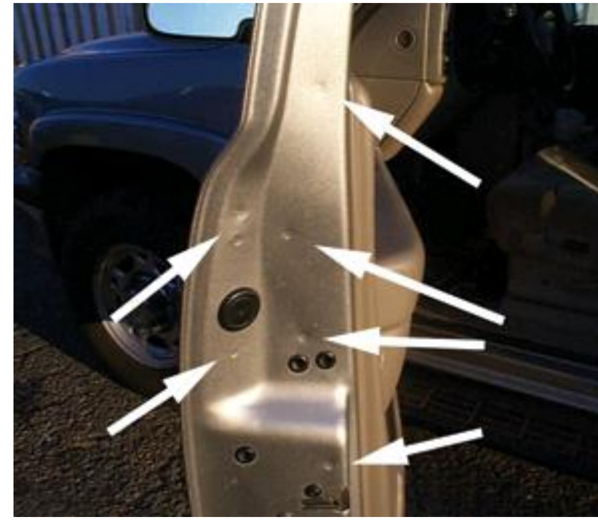


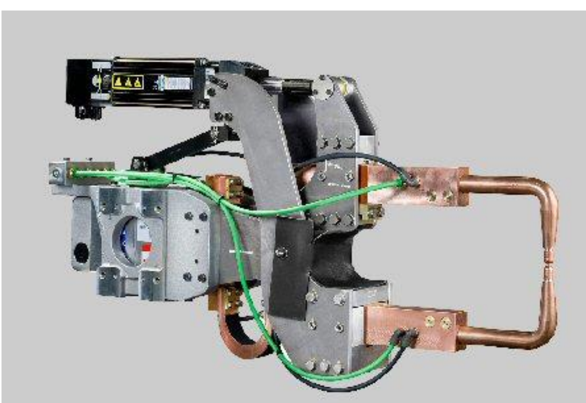
Spot welding involves
- electrode forces: 500..2200 lb
- electric currents: 5000..13000 A
- temperatures: 70..3000 F

Some means of quality control are required to ensure uninterrupted automatic production.

Resistance Spot Welding in Industry

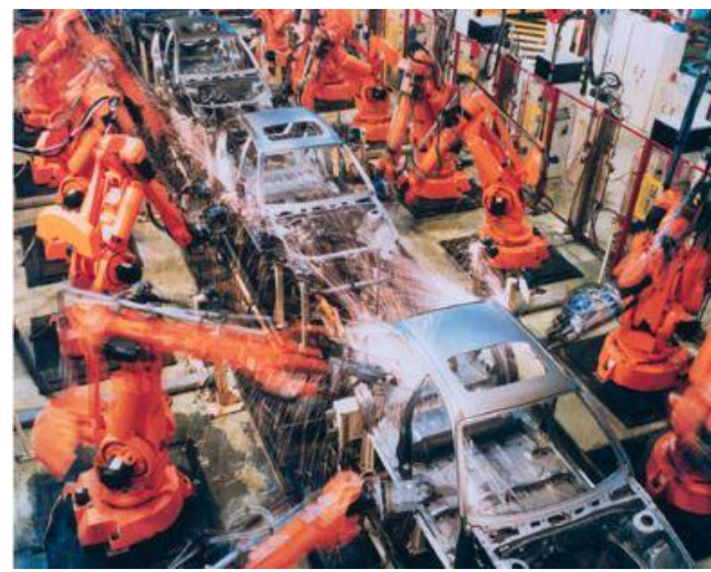
Regular vehicle contains 4000-6000 spot welds





Spot welding is highly automated today.

So has to be inspection.



Testing Spot Weld Using 2D Ultrasonic Matrix

2D Matrix Array Technology

Resistance Spot Weld Analyzer (RSWA)

- A portable, easy in operation ultrasonic device for assessing the quality of resistance spot welds
- Ultrasonic sensor is the latest generation of matrix transducer technology
- Provides internal image of the weld
- Automatically estimates the nugget diameter and surface indentation
- Features automatic setup and calibration

The RSWA's sensor is a unique matrix transducer designed specifically for spot weld testing

Unlike phased arrays, commonly used in medical ultrasonic devices, this probe has 52 channels that work independent from each other

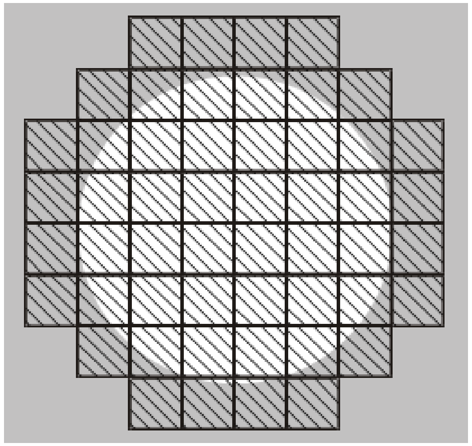
Parameters:

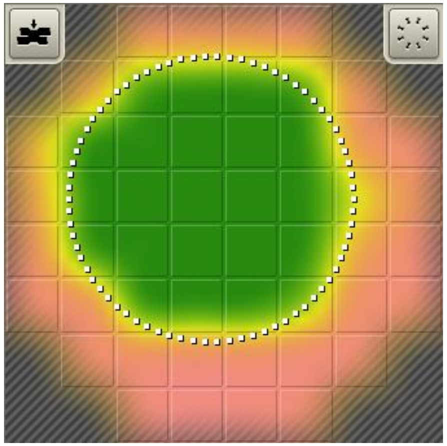
- 8×8 matrix
- 52 independent elements
- 1.25 mm element size
- 15 MHz central frequency
- 2 m cable with 52 coaxes
- Replaceable delay line

Matrix transducer

uses electronic scanning to obtain the 3D image

- *Pros:* No moving parts, real-time imaging and nugget size estimation, hand-held, simple in operation
- *Cons:* Low resolution, probe is larger than that in single-transducer devices

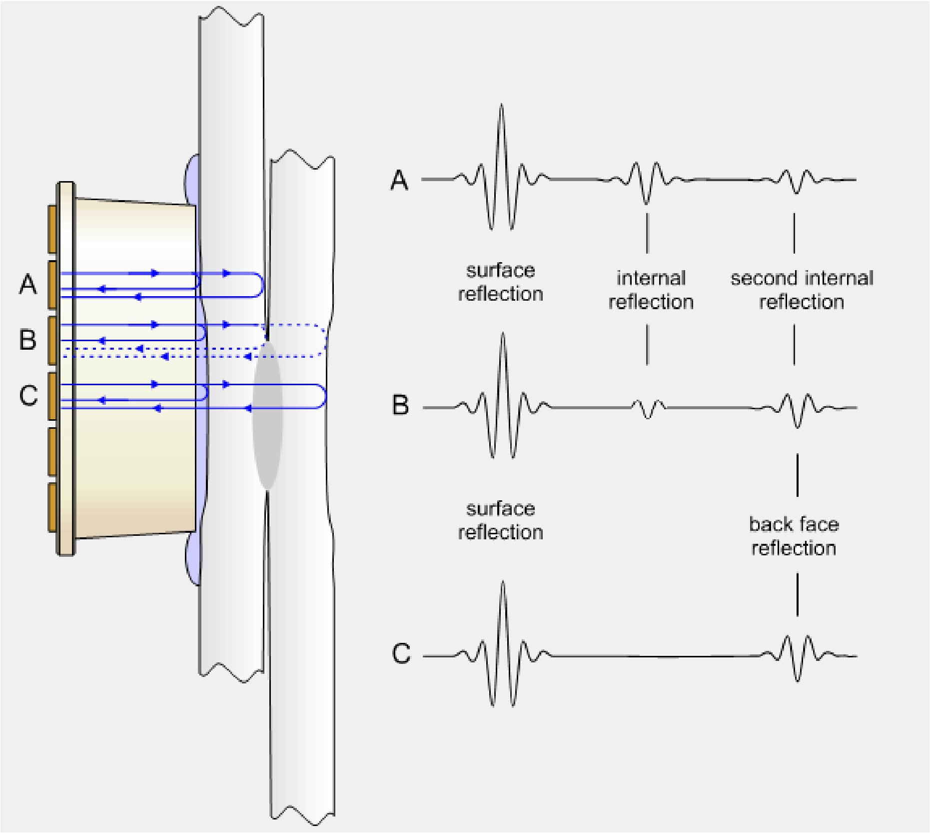




From Single-Element Probes to 2D Matrix Transducers

Matrix transducer

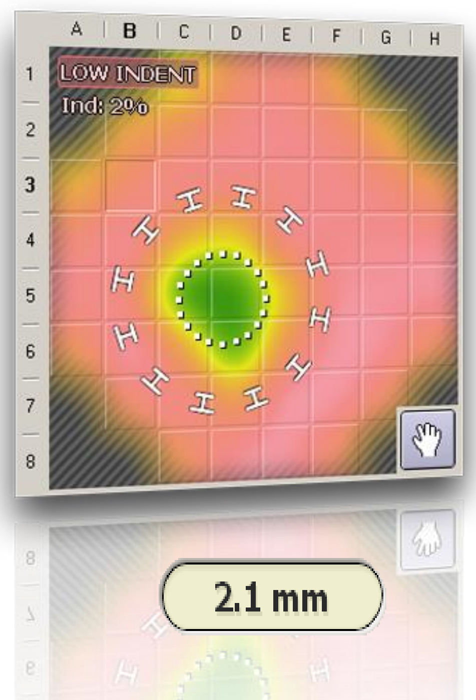
unique design provides five measurements for every weld



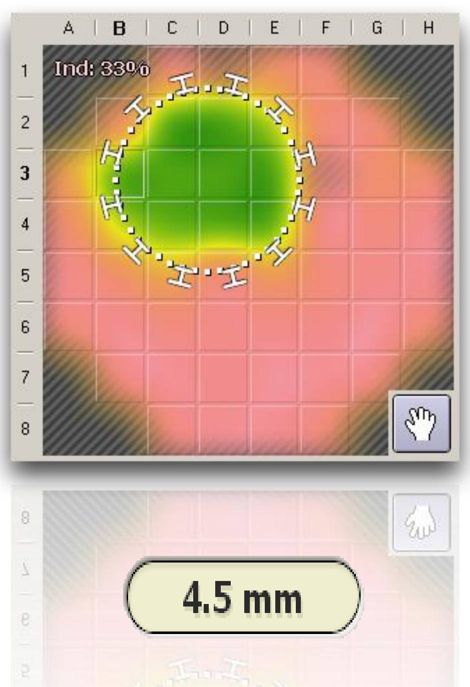
1. *Image*
2. *Diameter*
3. *Indentation*
4. *Front Plate Thickness*
5. *Stack Thickness*

- **Instant visual feedback greatly simplifies the interpretation of measurement data**

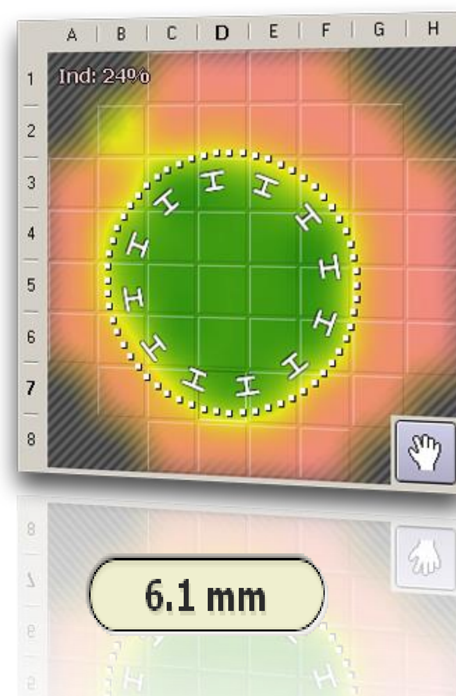
smaller than minimum size



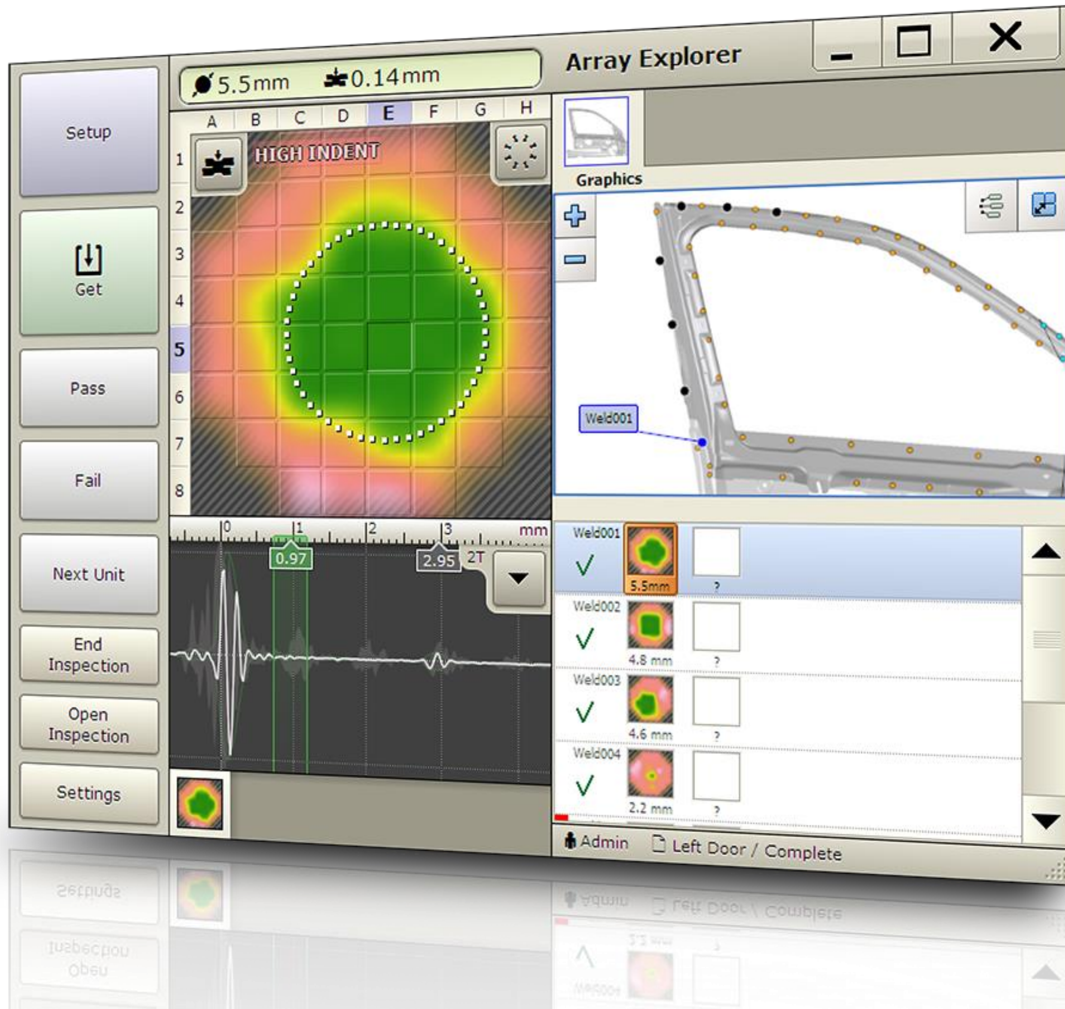
minimum size



larger than nominal size



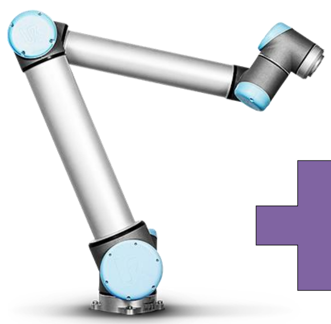
- The ultrasonic representation of a weld’s internal structure is conveniently displayed on the screen as a color coded image
- The software displays the estimation for nugget diameter, surface indentation, and other parameters
- The automatic setup procedure simplifies RSWA operation



Motivation for further automation

- Eliminate human error factor
- Improve repeatability and consistency
- Speed up inspection process
- Automate reporting and decision making

handling of components



[1]

Universal Robots: UR 10

- handling of optical measurement system and ultrasonic probe

camera and image processing

[2]

IDS Imaging: Camera
VMT IS: software

- detection of spot welds
- automated visual inspection
- determination of coordinates

automatic nugget size estimation

[3]

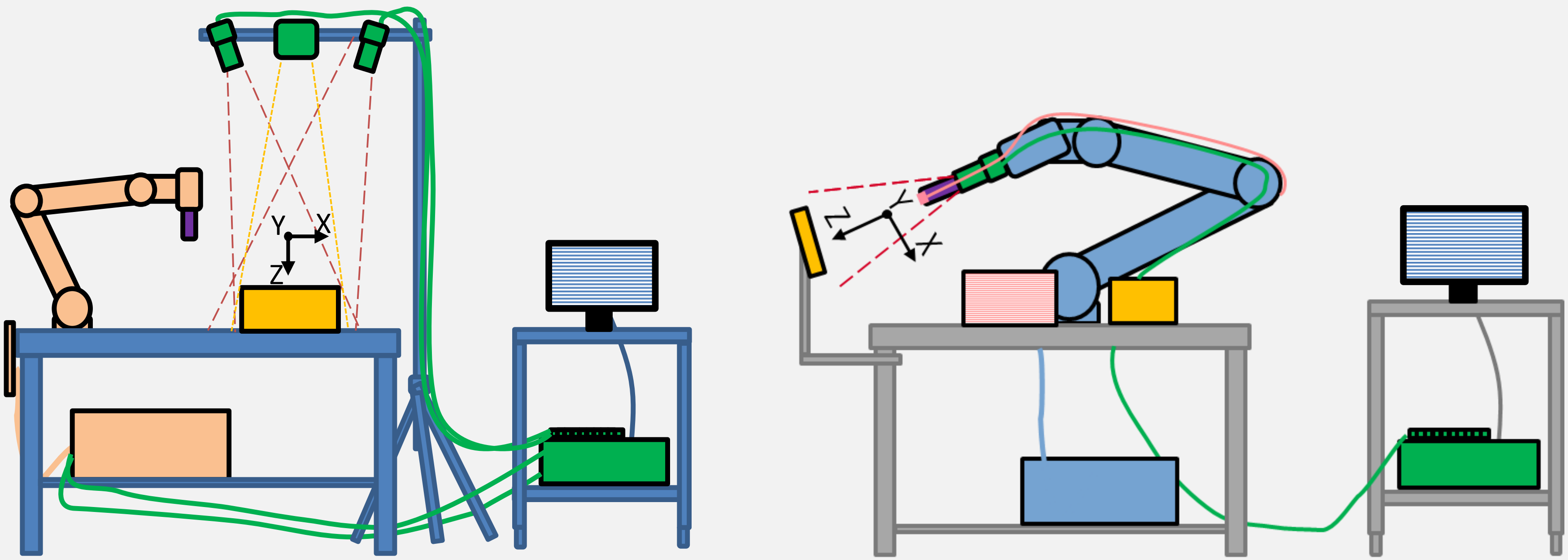
Tessonics: RSWA

- non-destructive testing of spot welds

fully automated non-destructive inspection system

schematic representation

first step | **second step**

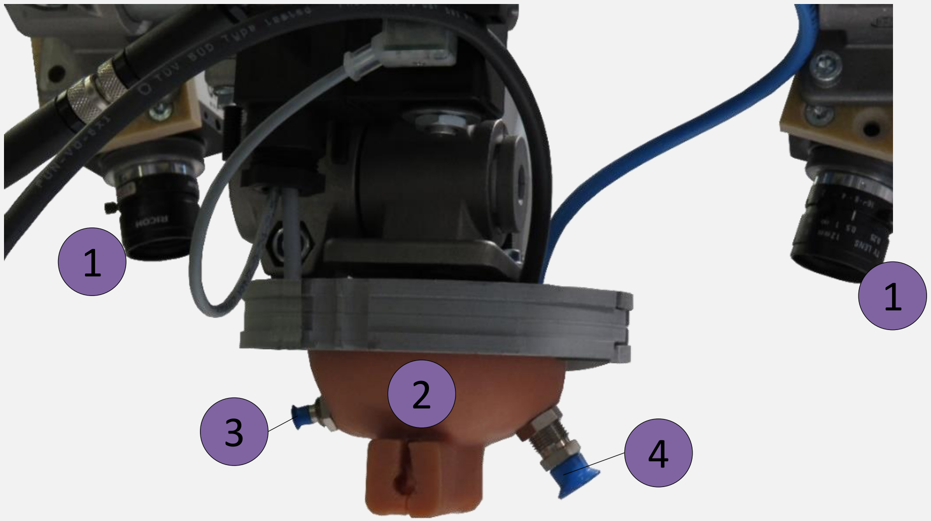


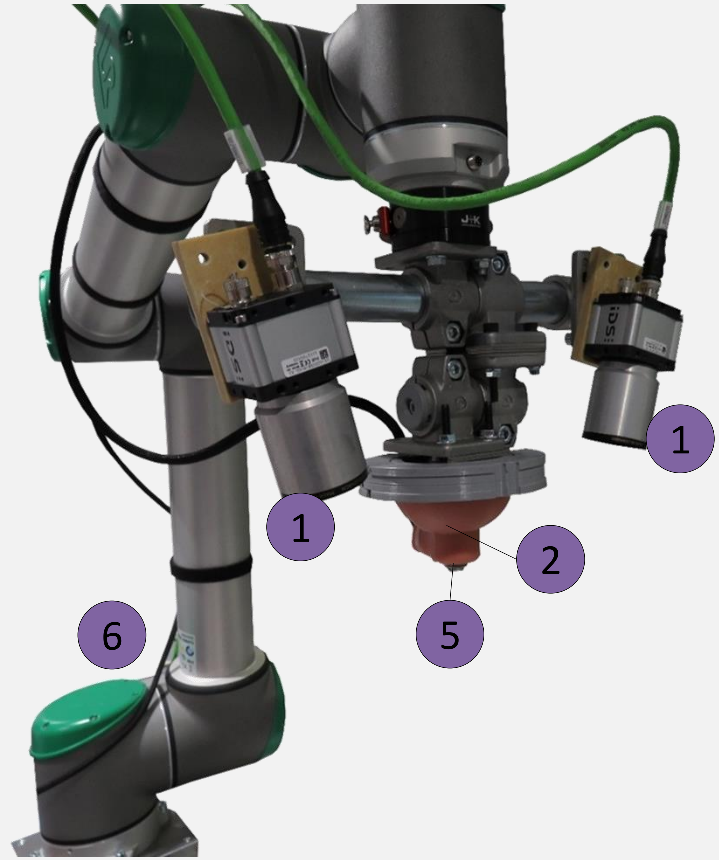
development process

- optical camera system
- robot and ultrasonic probe
- RSWA (Resistance Spot Weld Analyzer)
- test specimen

essential components

third step

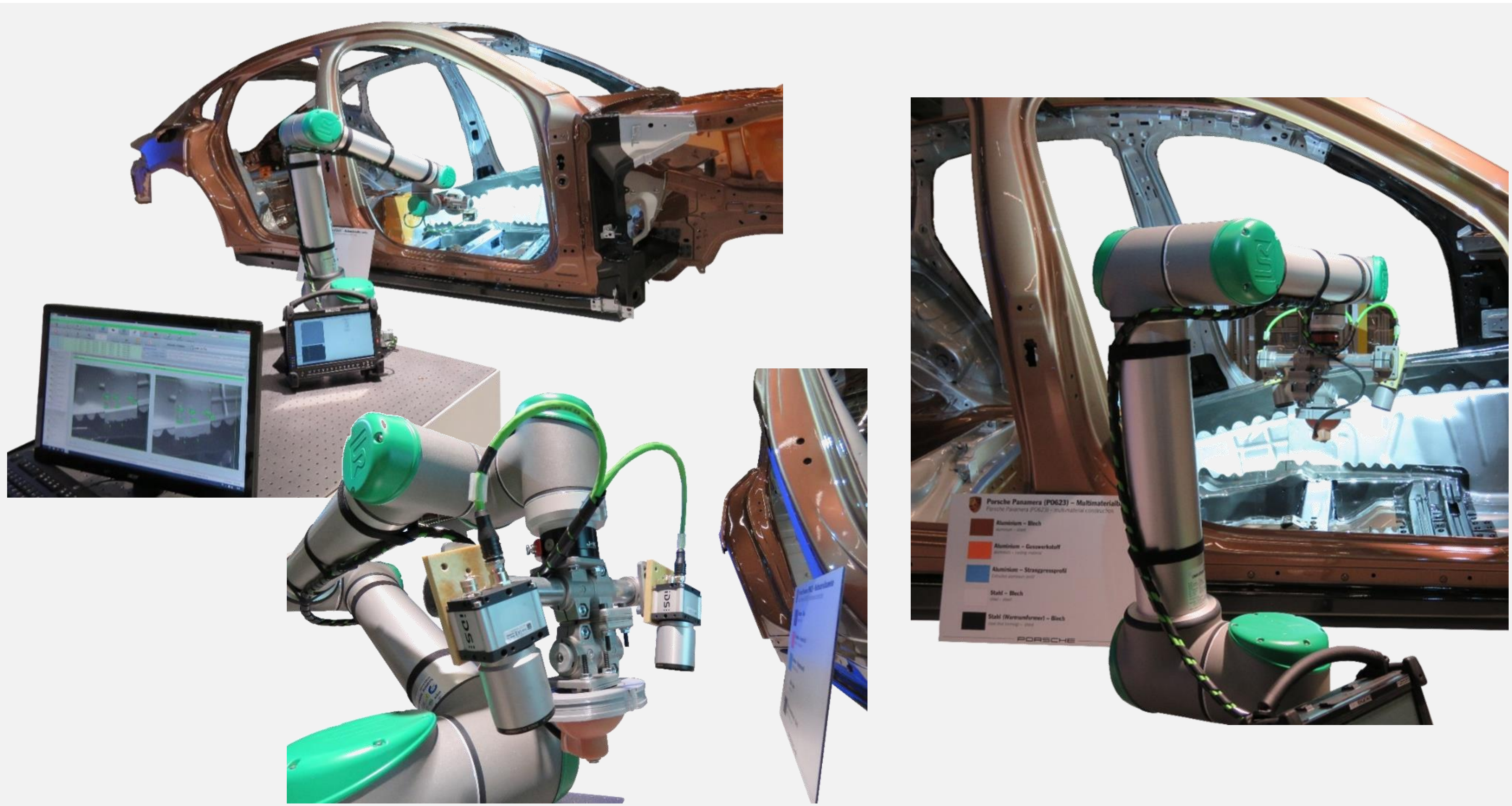




1…optical camera system
2…flexible probe holder
3…couplant application
4…couplant extraction
5…RSWA probe
6…robot

- Porsche Leipzig GmbH

example of the new Porsche Panamera

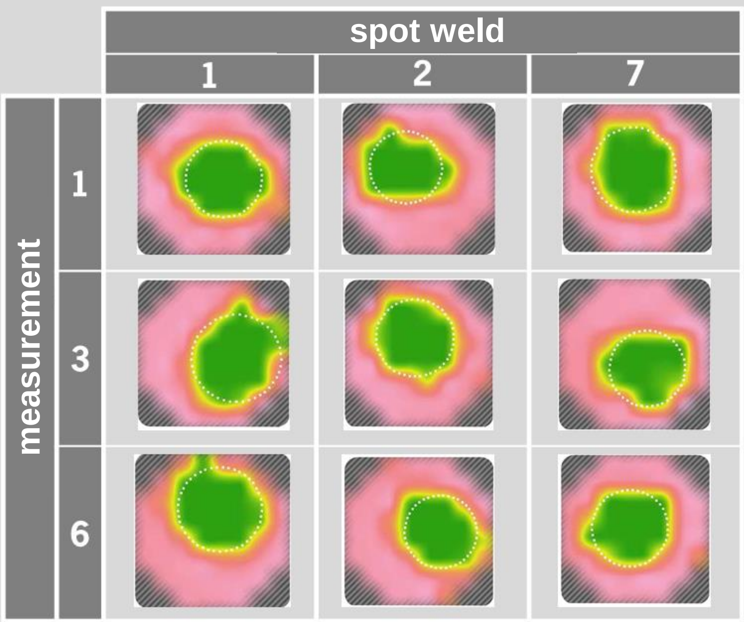


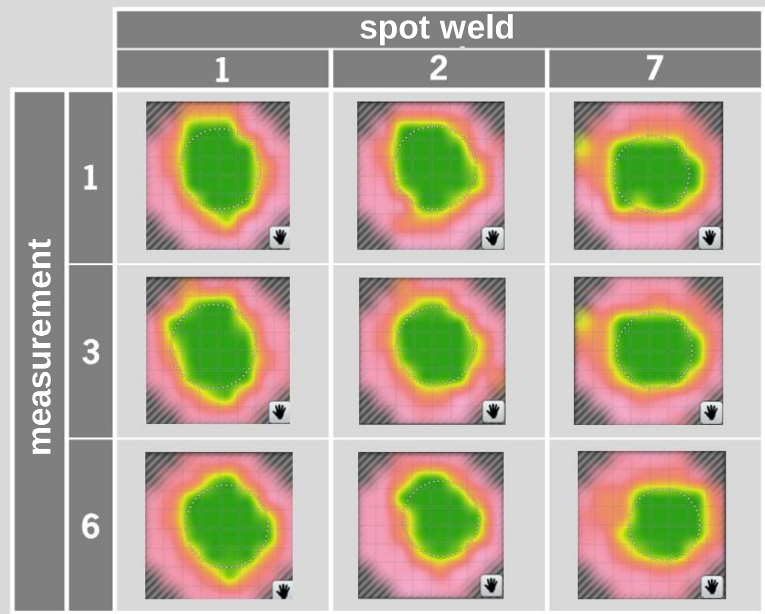
- Porsche Leipzig GmbH

concept realization

- **correlation of test results**

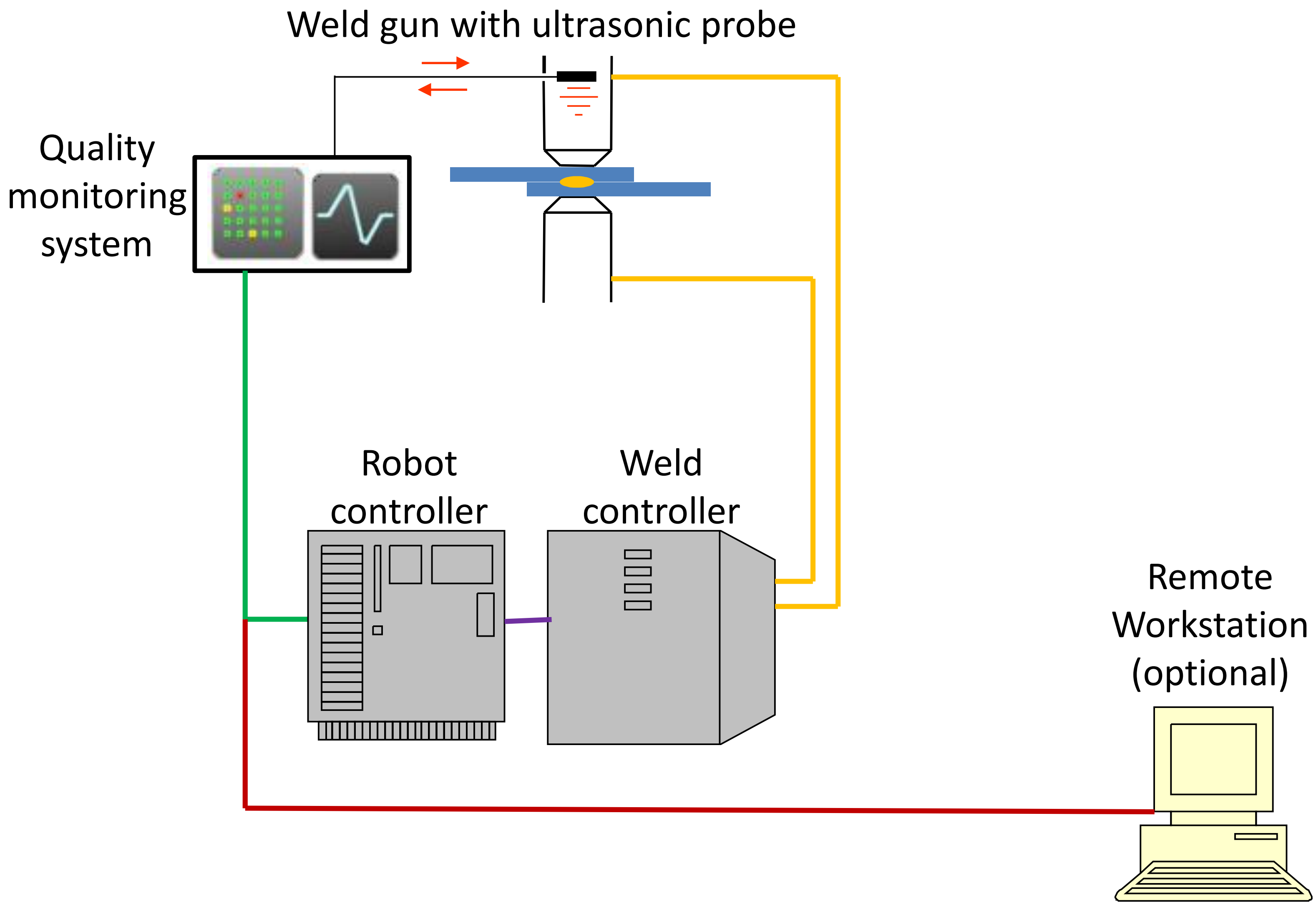
manual examination	automated testing
uneven point orientation	consistent point orientation
deviated point contours	comparable point contours
multiple measurements of the spot weld	single measurement of the spot weld
different weld diameters (± 0.5mm)	high repeatability of measurements (± 0.2mm)





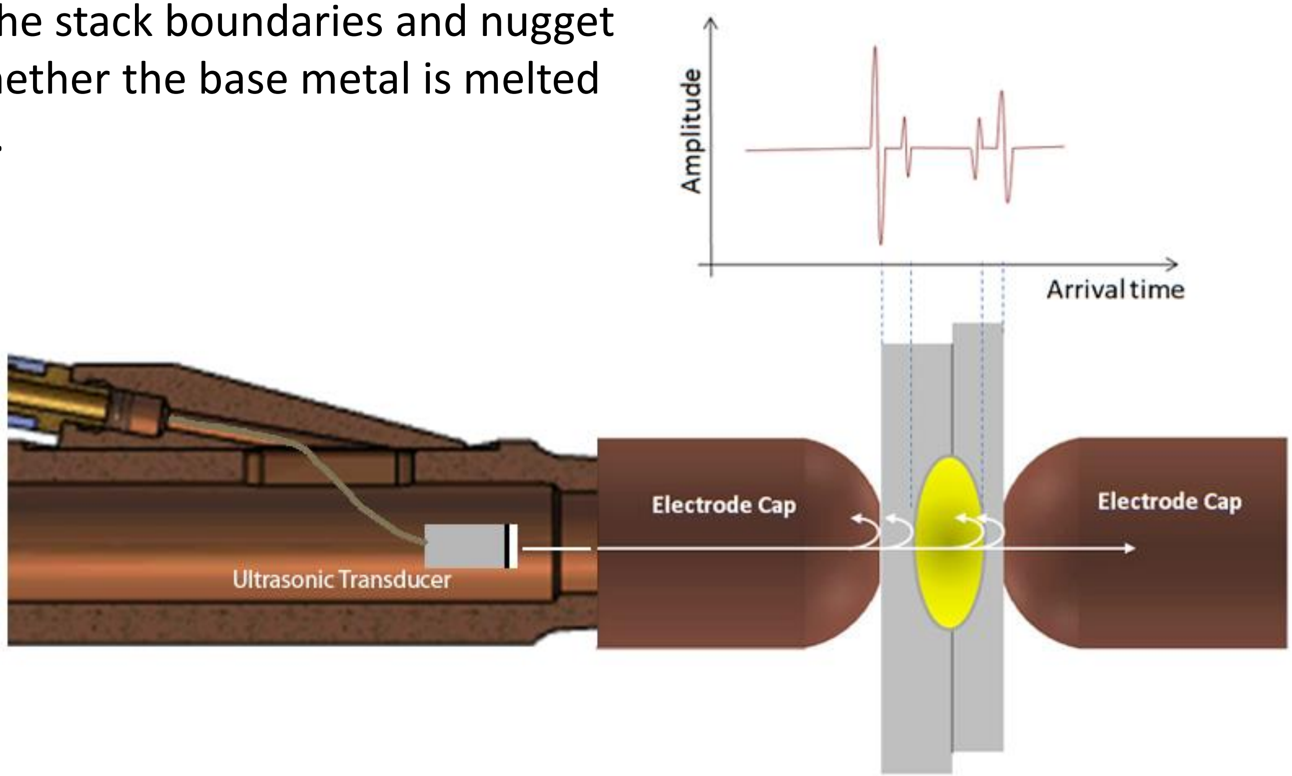
Testing Spot Welds at the Moment of Their Production

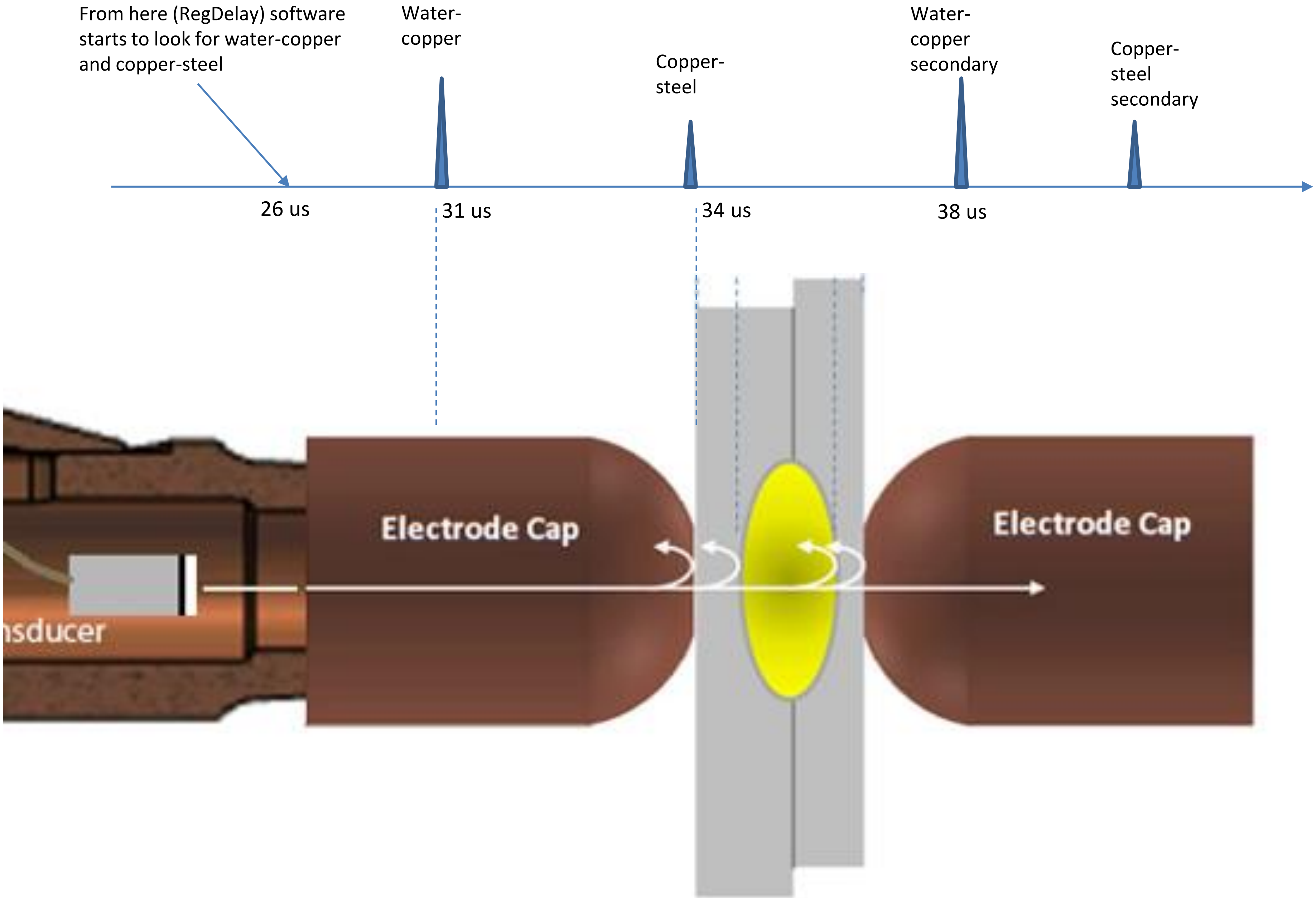
Welding Application with Ultrasonic Monitoring Station



Testing Configuration

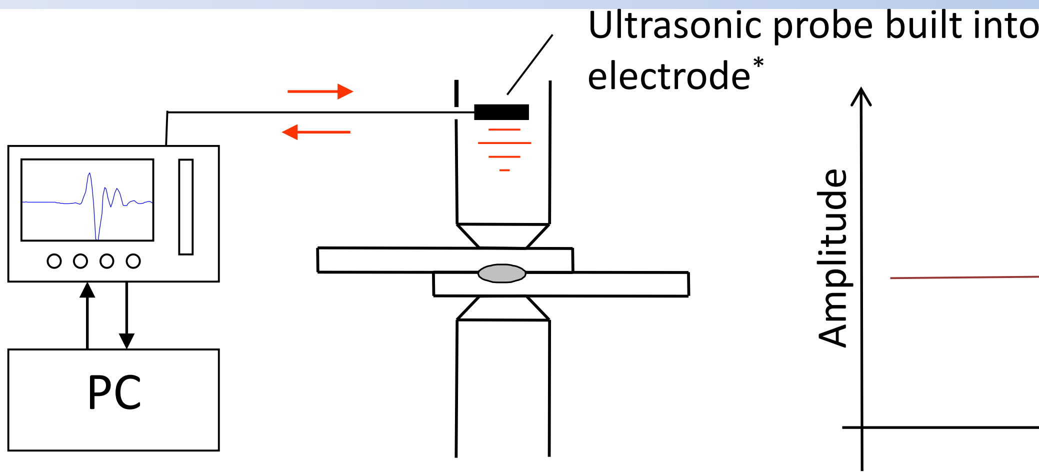
Ultrasonic wave is sent by the ultrasonic transducer submerged into the cooling water stream. Reflections from the stack boundaries and nugget tell whether the base metal is melted or not.

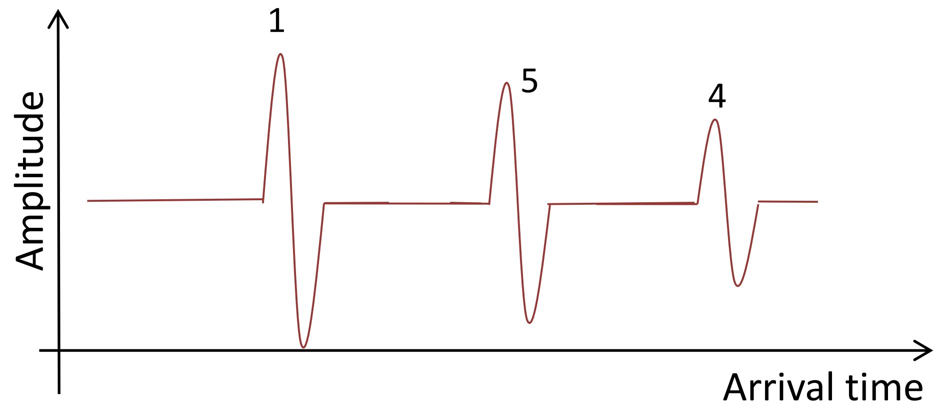


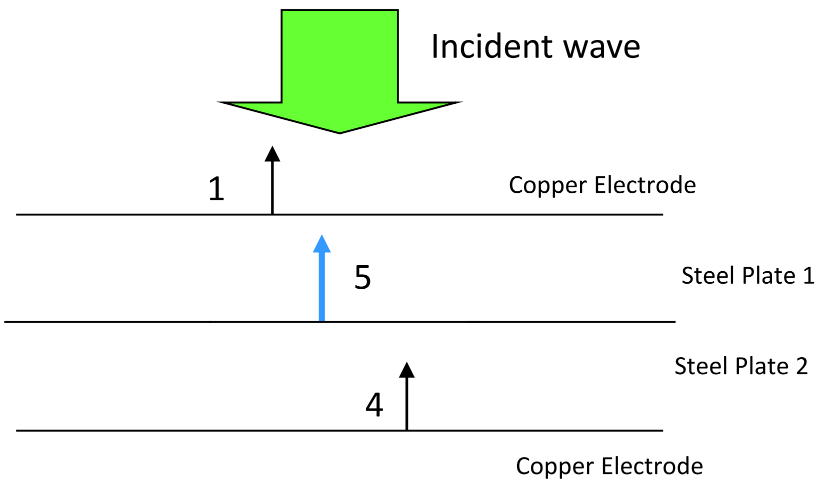


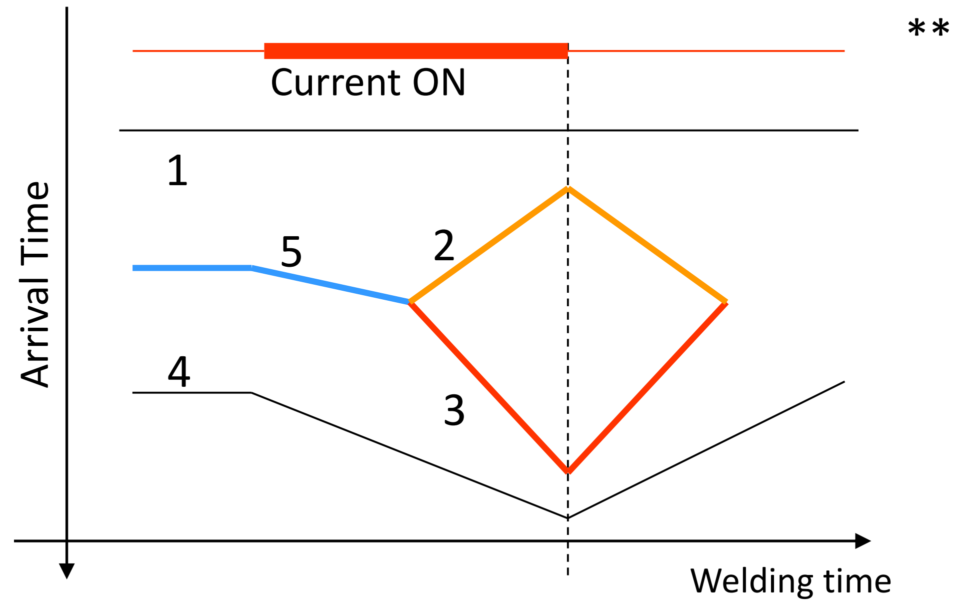
From here (RegDelay) software starts to look for water-copper and copper-steel
Water-copper
Copper-steel
Water-copper secondary
Copper-steel secondary
26 us
31 us
34 us
38 us
Electrode Cap
nsducer
Electrode Cap

Physical Principles of Real-time Ultrasonic Testing of Spot Welds





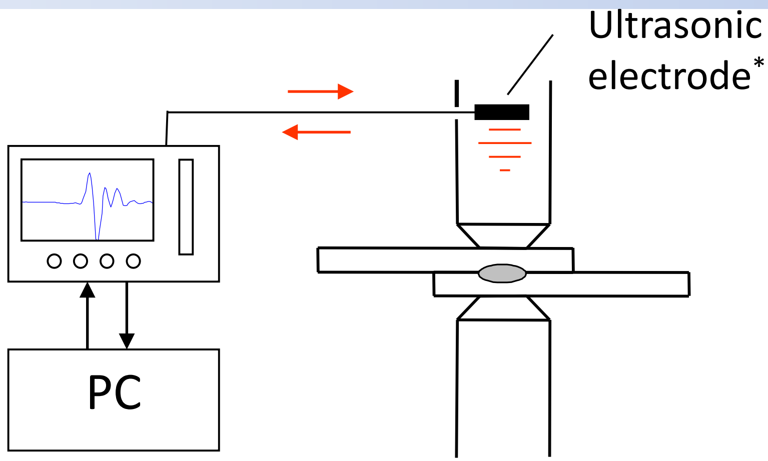


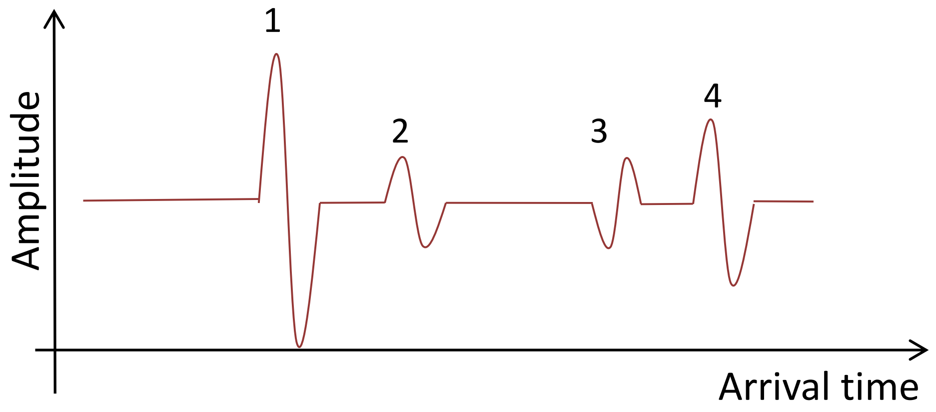


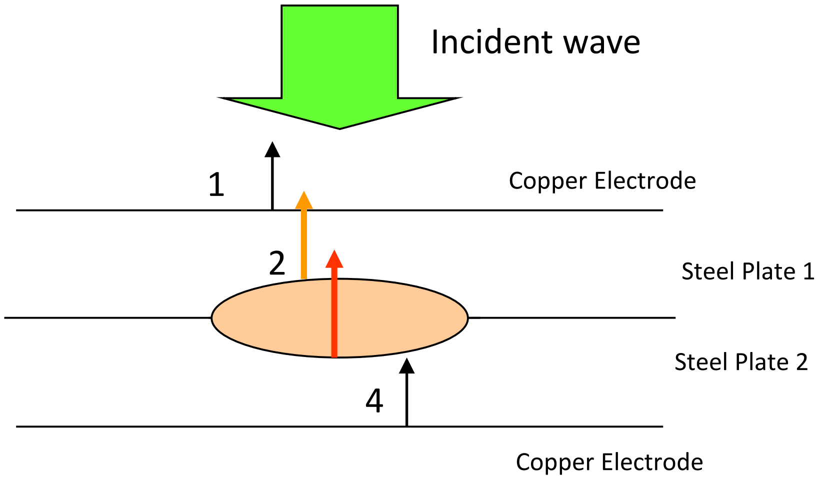
***Transducer built into an electrode by Maev et al. US Patent 6297467**

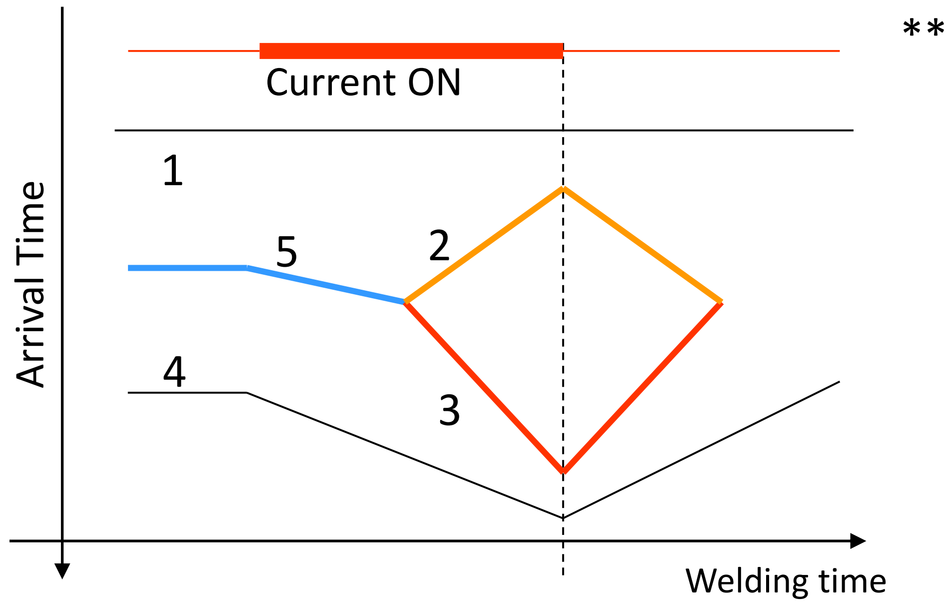
** Ultrasonic In-Process Monitoring And Feedback Of Resistance Spot Weld Quality. Patent application by R.Gr. Maev and A.M. Chertov. Attorney Docket No. 706940US1

Physical Principles of Real-time Ultrasonic Testing of Spot Welds









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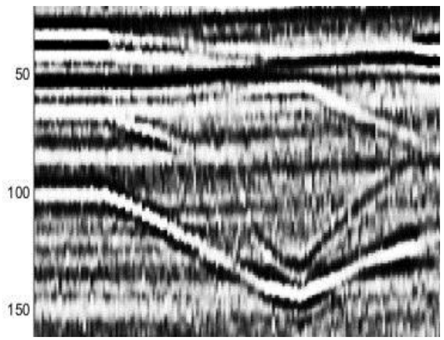
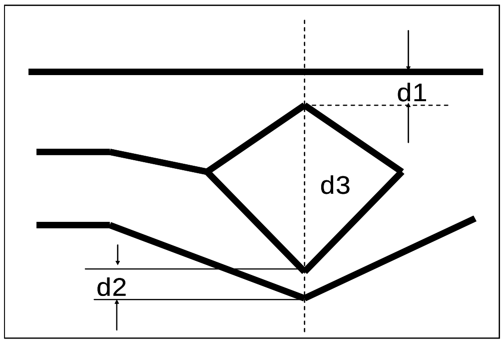
Geometry Matching

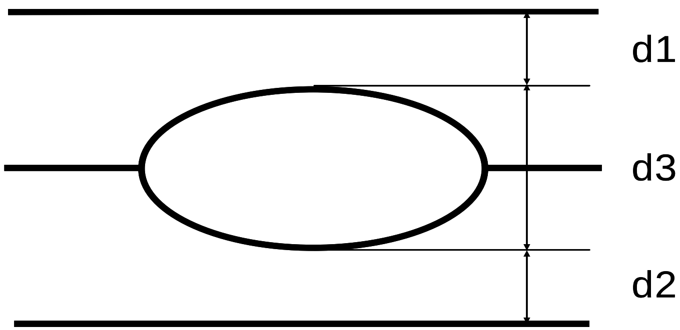
Real Acoustic Image

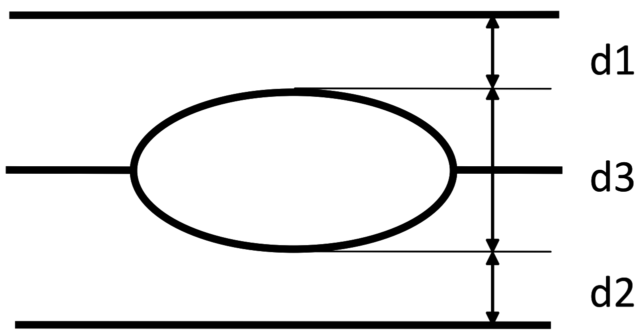


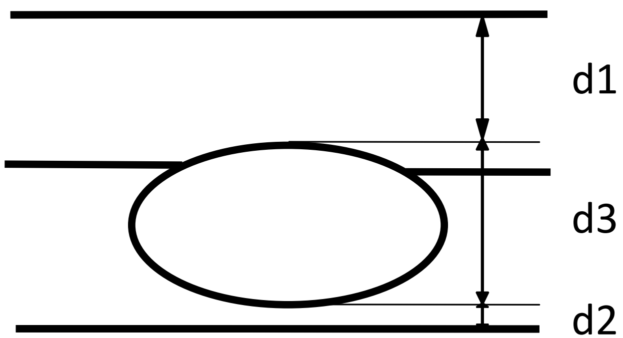
Pattern



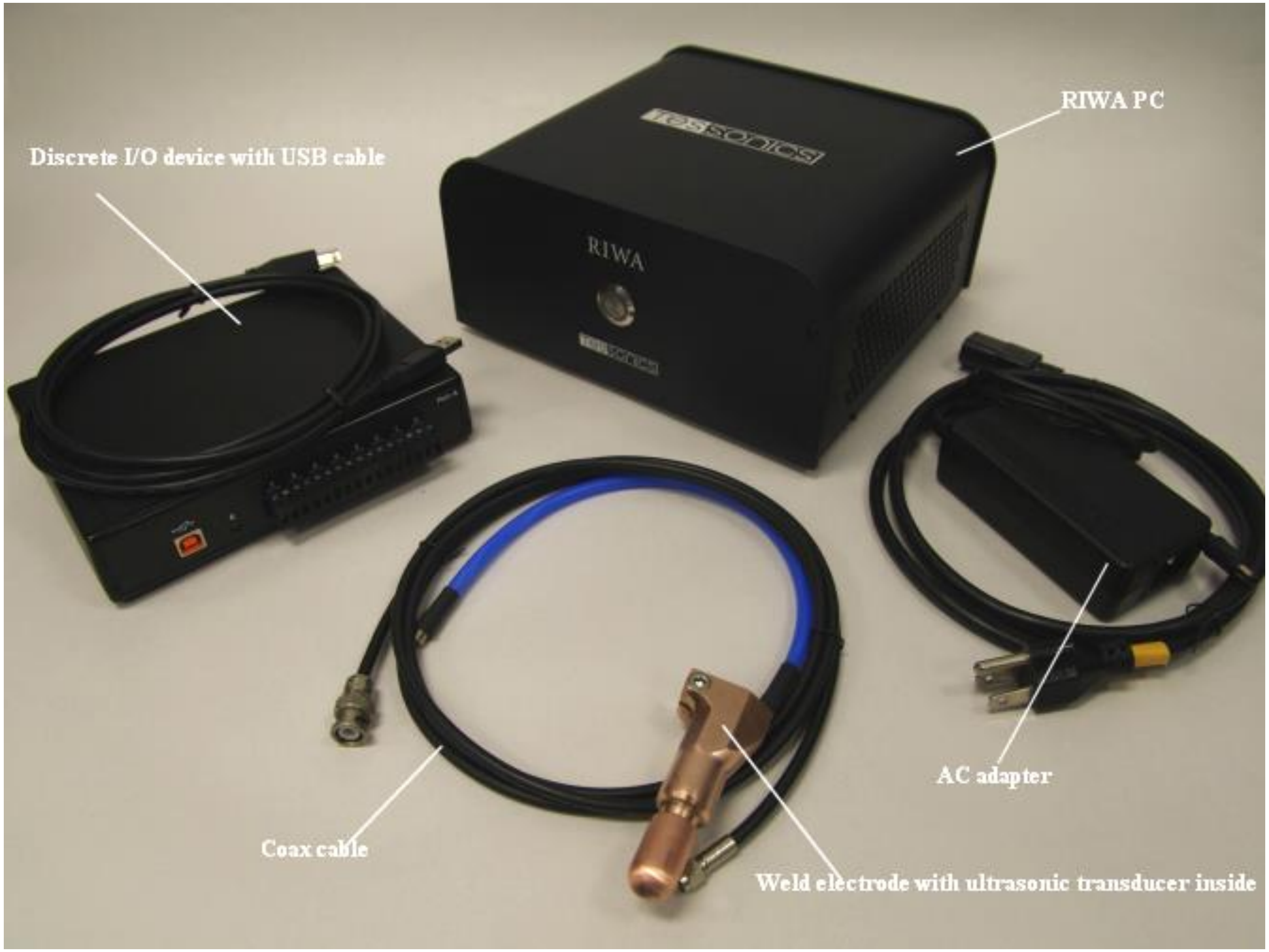
Weld geometry







RIWA System


RIWA PC
Discrete I/O device with USB cable
RIWA
AC adapter
Coax cable
Weld electrode with ultrasonic transducer inside

Transducer Built into Customer’s Electrode

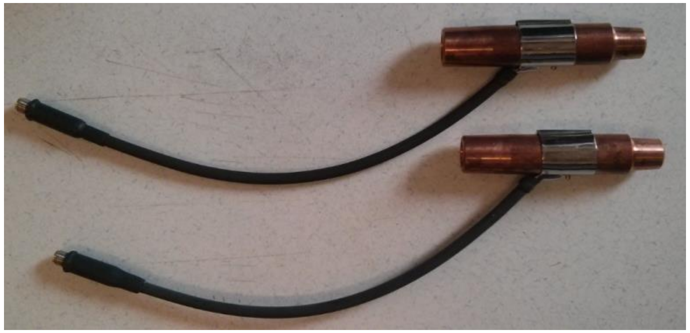
Flex coaxial cable is installed outside

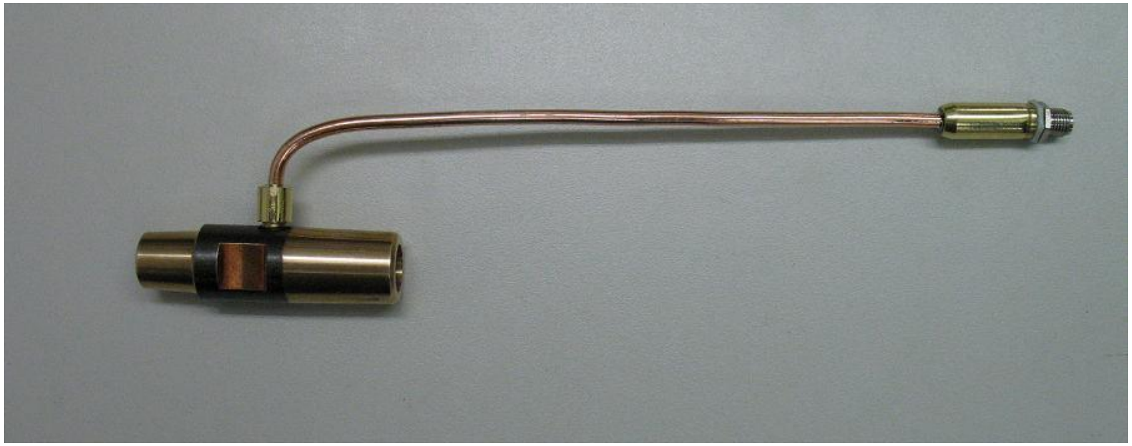
Water enters center channel and returns on the outer

Cap can be replaced in the usual manner

Water flow is maintained in the proper way to cool electrode cap

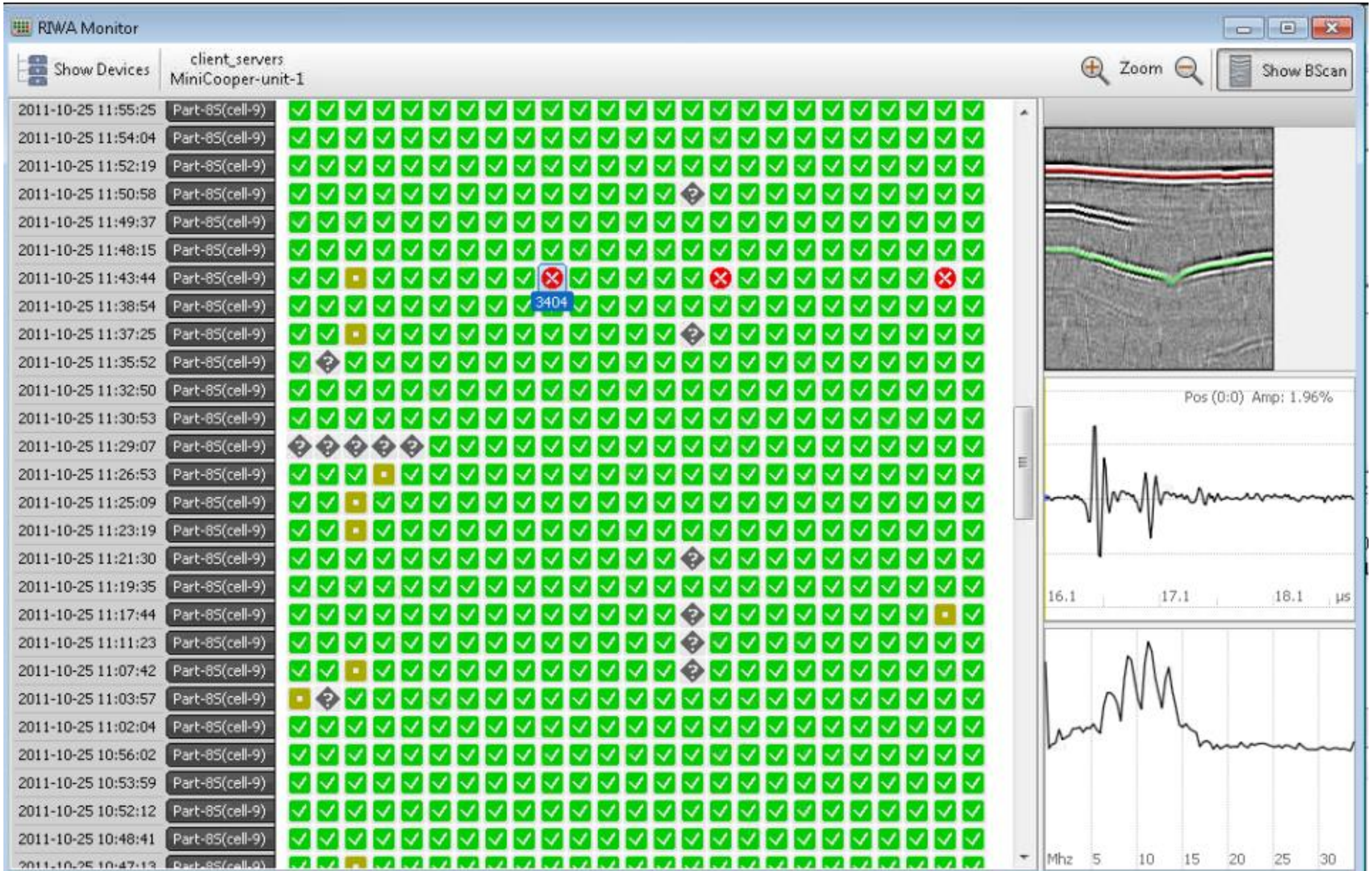
Probe Designs



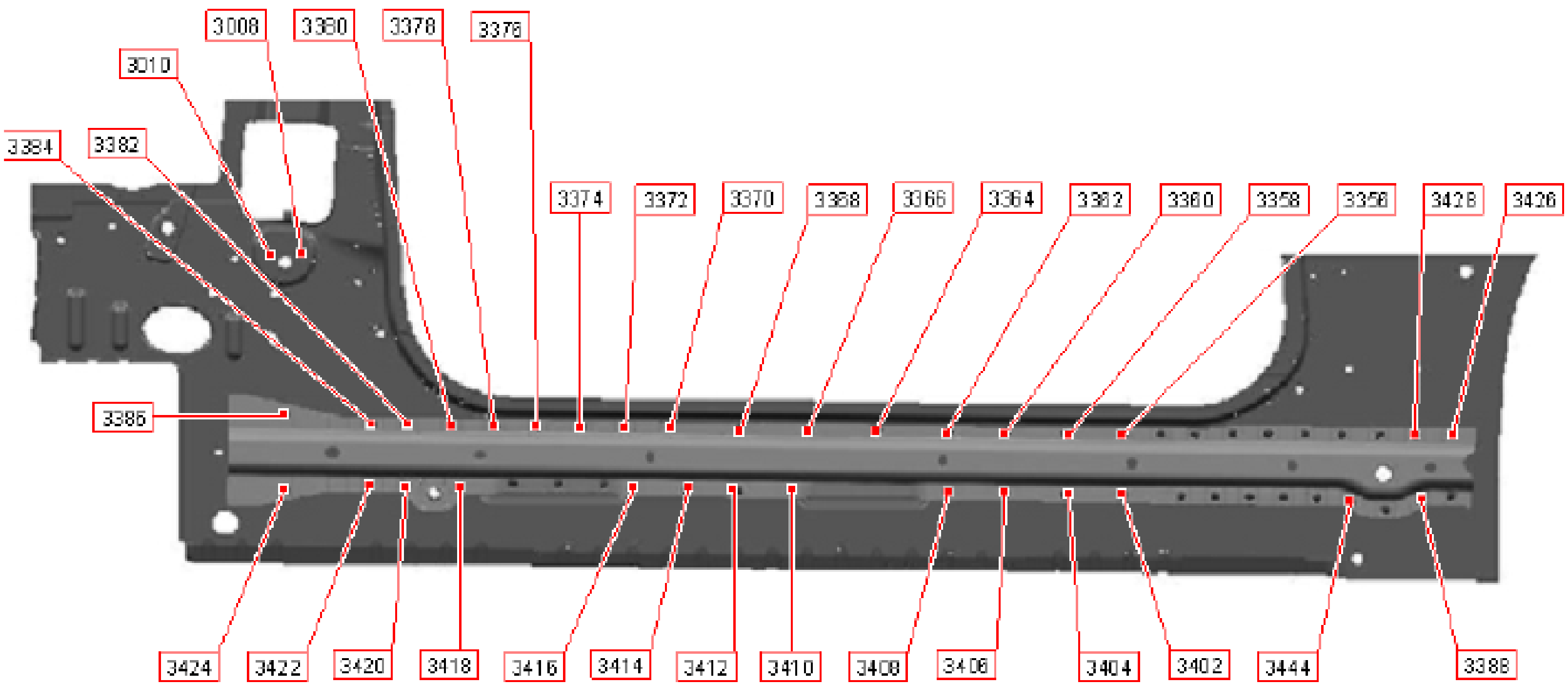


Data representation

Each weld is ultrasonically scanned during formation. Special software analyzes the image (signature). Based on calibration data, it makes a decision about weld quality.
At 11:43:44 part was intentionally built with three undersize welds.



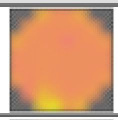
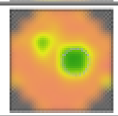
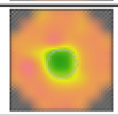
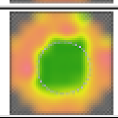
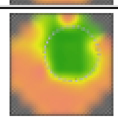
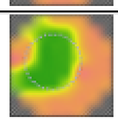
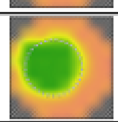
Inspected Part



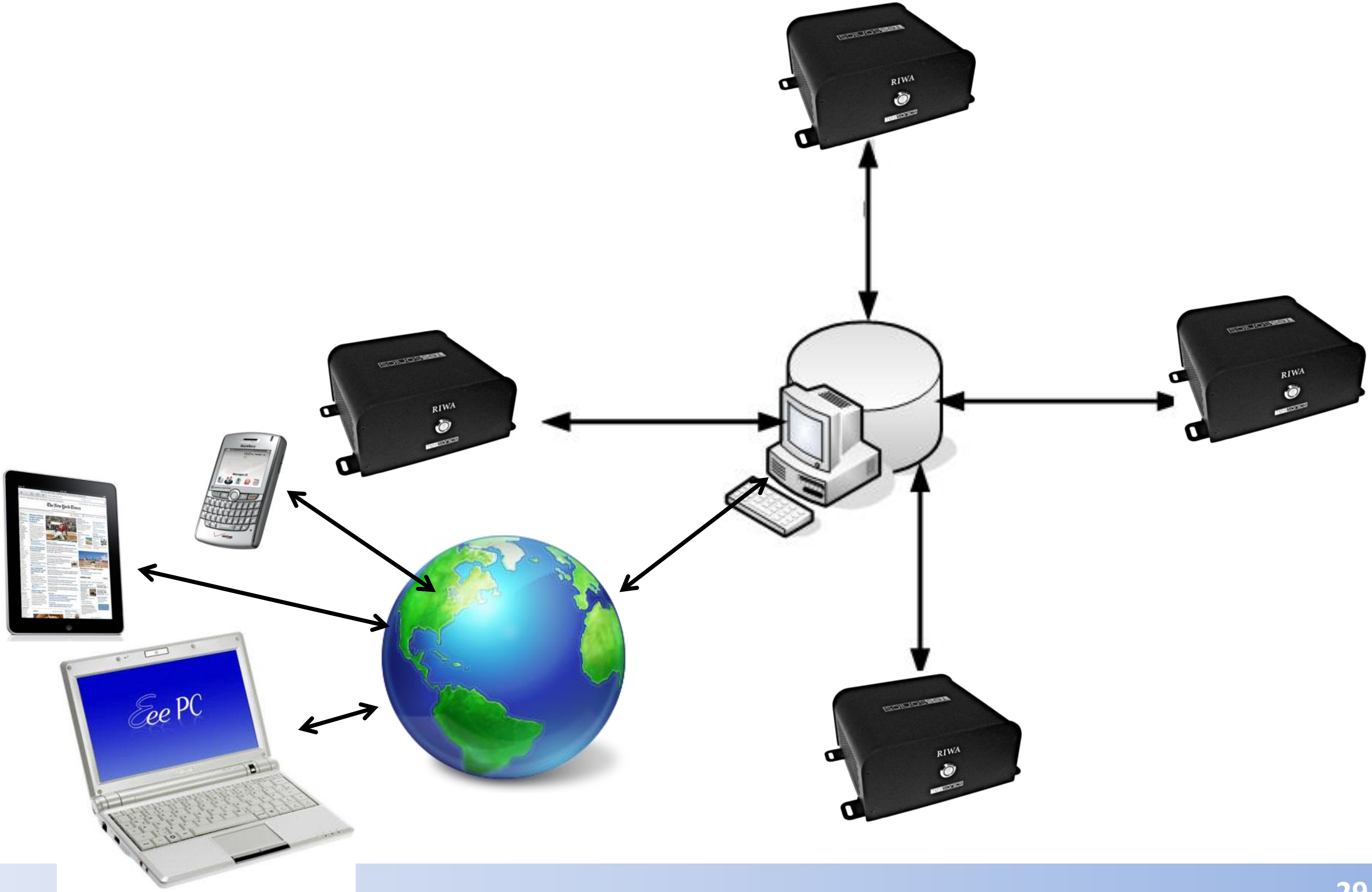
TesSonics

RSWA Measurements Validated the RIWA readings

Performance example

Decision		Weld				Diameter		Indentation	Time	Route	Inspection Description
Decision	Reason	Id	C-Scan	Sfty	3T	Measured	Min.	Measured			
Fail		3364		No	Yes	-	4.7	-	31/10/2011 20:07:39		CW Purpose Failures
Fail		3428		No	Yes	2.6	4.7	0.02	31/10/2011 20:18:29		CW Purpose Failures
Fail		3404		No	Yes	2.7	4.7	0.04	31/10/2011 20:13:55		CW Purpose Failures
Pass		3382		No	Yes	5.1	4.7	0.02	31/10/2011 20:10:54		CW Purpose Failures
Pass		3418		No	Yes	5.2	4.7	0.05	31/10/2011 20:16:24		CW Purpose Failures
Pass		3360		No	Yes	5.4	4.7	0.05	31/10/2011 20:07:11		CW Purpose Failures
Pass		3010		No	Yes	5.5	4.7	0.05	31/10/2011 20:05:16		CW Purpose Failures

Communication Between Units



Summary

Both systems provide quality evaluation to most of the welds being produced by the robot.

Since the quality of the weld is determined at the spot, feedback provided by the system can be used to prevent producing more bad welds (send alerts, send notifications to maintenance personnel, stop the production line, etc.).

Communication between systems and a main server makes the remote monitoring of the whole production floor accessible from a single PC. Special software performs analysis and creates customized reports from the collected data.

Conclusions

Automation of inspection in body-in-white is a:
- Necessity
- Cost saver
- Time saver
- Ambassador of reliability and repeatability