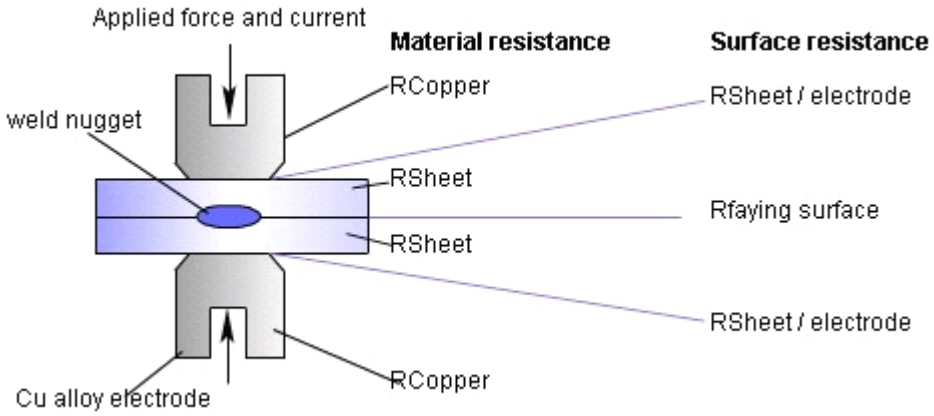
Resistance Spot Welding Feature and Electrodes

Principles

The relationship between heat, current, resistance and time is given by the relationship:

Heat $Q = I^2 \times R \times t$

Modern equipment can accurately control the current and time. Any uncertainty in the process comes from variability in the resistance term. Furthermore, with aluminium metal being such a good electrical conductor (~ three times better than steel), heat generated during welding is primarily obtained from the contact resistances at the faying surfaces, and not from the bulk material resistance.



Reproducible and stable sheet surfaces are essential for successful RSW of aluminium. Resistance spot welding of aluminium is therefore a surface-critical process. (Do and Don't)

There are many different materials-related factors that combine to determine the value of contact resistance at the sheet surfaces:

- Surface texture (e.g. EDT or none)
- Composition of oxide film (function of alloy type and processing route)
- Degree of any surface cleaning
- Type & amount of any chemical pre-treatments
- Type & amount of any residual lubricants, weld-through sealers or adhesives.

RSW in the Automotive Industry

Resistance Spot Welding (RSW) is widely used in the high-volume manufacture of sheet metal products. The automotive industry has relied on

RSW as a principal joining method for many decades. A typical car contains between 2000 and 3000 spot welds.

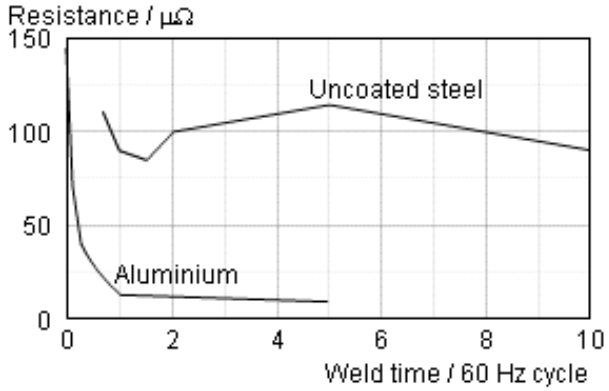
Advantages of RSW in high-volume automotive manufacturing

- Inexpensive (per-weld cost ~€ 0.05)
- Rapid process (< 1 second per weld)
- Ease of automation (flexible process)
- No per-weld consumables (i.e. no issues of piece-cost, inventory, additional weight or recycling difficulties)
- Low training costs (in manual operations).

General Motors Yukon (SUV), with lightweight spot welded all-aluminium rear door (tailgate). Manufactured at 500,000 units per year.

Robotic welding on aluminium body assembly line

Typical Parameters for RSW of Aluminium



The chart shows how the electrical resistance of aluminium falls rapidly at the commencement of welding.

Because aluminium has such a low electrical resistance and is a good conductor of heat, it is necessary to deliver high welding currents over a very short time interval.

0.9 mm guage	Bare aluminium**	Bare steel	Zn coated steel
Weld time / 50 Hz cycle	3	7 − 10	9 − 12
Current range / kA	18.0 − 23.0	7.0 − 10.0	8.5 − 11.0
Force / kN	4.1 − 5.0	1.9 − 2.6	2.2 − 2.9

** EN AW-6111 mill finish + lubricant

The table (for a relatively thin closure-sheet gauge) illustrates the need for more powerful equipment when spot welding aluminium. Thicker gauges (e.g. for structural applications)

Aluminium when compared to steels needs:

- ★ Higher currents,
- ★ Higher electrode forces,
- ★ Shorter weld times.

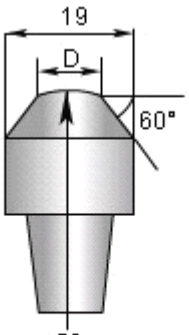
Electrodes and their Maintenance

Reasons for electrode maintenance

★ Improved consistency of RSW process (quality assurance)

★ Increased productivity (less down-time for electrode changes)

Electrode maintenance equipment for aluminium RSW should be designed primarily to remove accumulated oxide deposits from the electrode contact surface. Retention / restoration of the original electrode geometry is less necessary than for steels because there is little mechanical deformation during wear. Frequent "light" operations (e.g. buffing / polishing after every ~20 welds) are preferable to the "heavy" in-situ re-machining (dressing) approach. By adopting the "little and often" approach, the electrodes remain "as-new", and there is no practical limit to the number of times an individual electrode can be re-buffed.



All dimensions in mm. Not to scale.

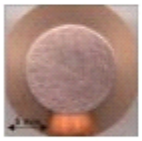
D = 10 for gauges < 2.3 mm

D = 12 for gauges >= 2.3 mm

Zirconium RWMMA Class 2

Copper

Too worn to buff at ~ 50 welds



At start (buffed once)

Handheld buffing wheel (every 14 welds)

Anode at 4000 welds

no further buffing

Typical anode at 2000 welds