

## **Inline-Process and Quality Control of Spotwelds of Car Bodies - Ultrasonic Sensors integrated in Resistance Welding Electrodes**

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### **Abstract**

The inline ultrasonic testing system SPOTline is used for inspection and process control of resistant spot weldings. SPOTline provides with directly into the welding tongs integrated ultrasonic sensors a 100% inspection during the welding process. The through transmission signals will be collected, stored and evaluated by means of intelligent logical combinations of gated amplitude and time of flight information during the welding process. The results will be transmitted online from the SPOTline-client in the sql-data-base of the server for processing. SPOTline is an ultrasonic inspection system, which is working under real production conditions in a network of welding robots. Test with 2 and 3 plates, high strength steels and all coatings demonstrate the accurately identification of discrepant welds.

**Keywords:** SPOTline, automotive, spot weld testing, inline testing, quality control, spot weld diameter

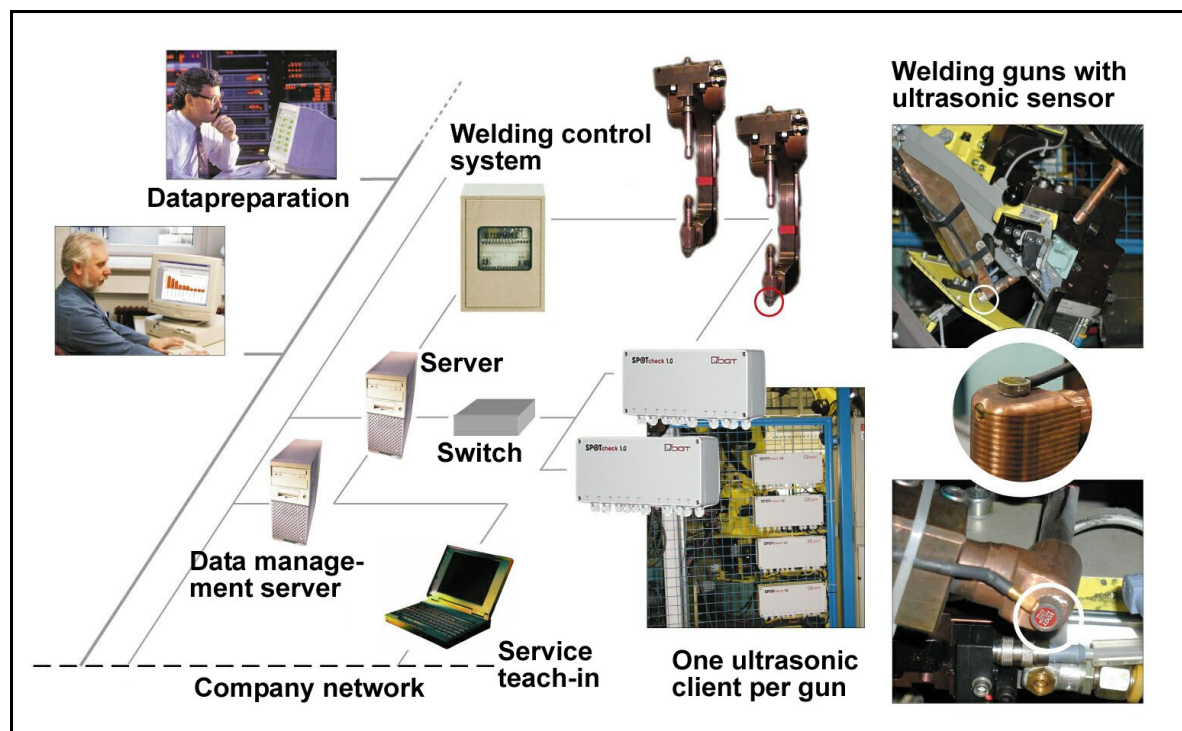
### ***SPOTline –***

#### ***Inline Process control of Resistance Spot welding of car body frames***

The inline ultrasonic testing system SPOTline is used for inspection and process control of resistant spot weldings. SPOTline provides a 100 % inspection during the welding process by ultrasonic sensors which are integrated directly into the welding tongs. During the welding process ultrasonic pulses are conducted with 500 Hz from the SPOTline-client through the weld nugget. The through-transmission signals are recorded, stored and evaluated. Pulse echo signals could be used too for the compensation of tip temperature changes were there is a high temperature gradient during the welding as well as for relative measurements and check of sensor functionality after or before welding. Immediately after completion of the spot weld a

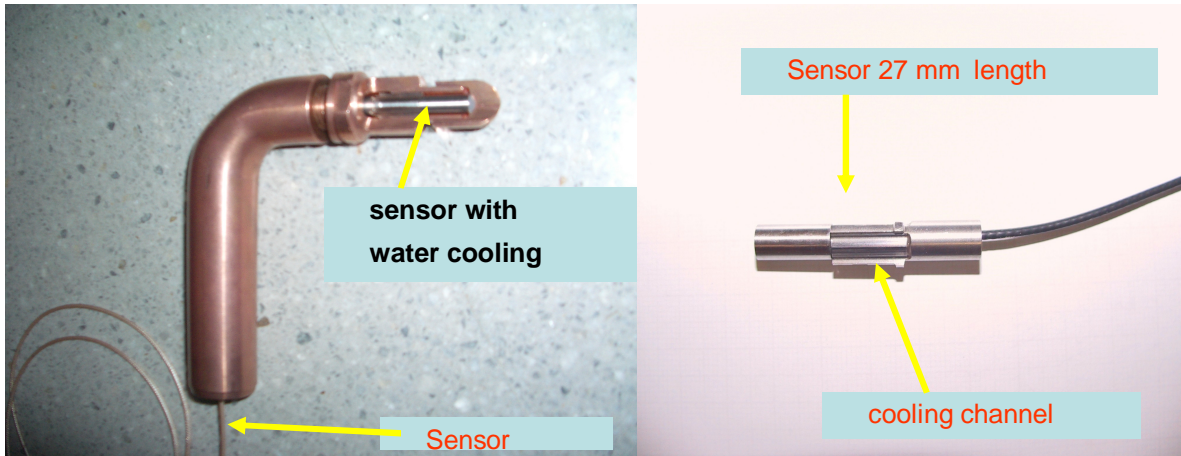
result value is available which correlates to the quality (diameter) of the spot weld. This value is assigned according to quality characteristics by two limit values into three classes: good spot, average spot or discrepant spot. Therefore the inspection result is not a diameter value but one of the classes mentioned correlated to the quality of the spot weld. In production stick welds, discrepant and small nuggets are recognized during welding. The basic testing system consists of four components (figure 1):

SPOTLINE clients , SPOTLINE communication unit, ultrasonic sensors and optional SPOTLINE information terminals.



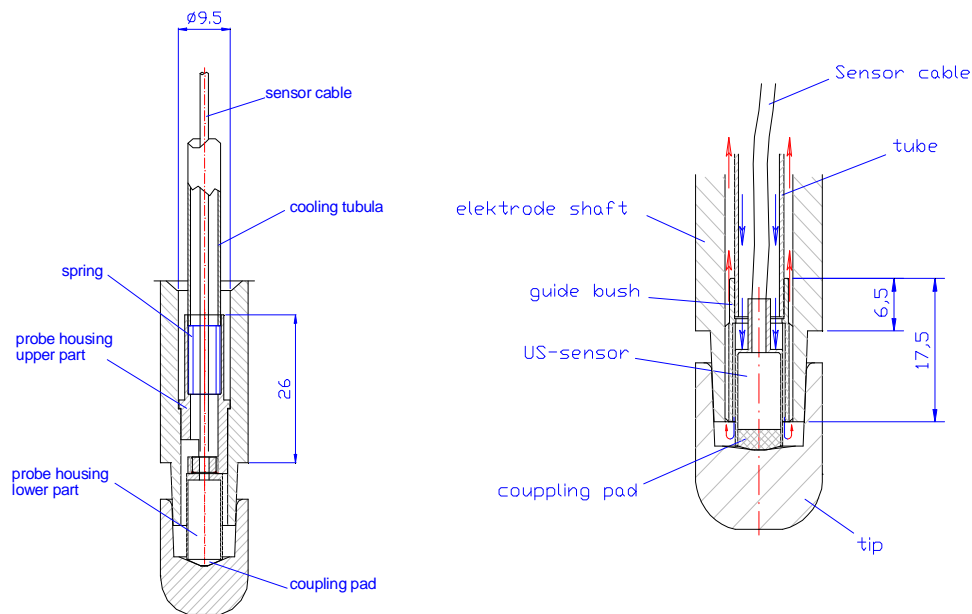
**Figure 1: System Configuration**

The ultrasonic sensors produce the required ultrasonic pulses for testing which run through the weld during the welding procedure. Therefore ultrasonic transducers are positioned at both sides of the welding tongs. The accurate classification of spot welds depends on reliable basic measurements which can be obtained by optimal positioning of the sensors in the tongs. Due to the big variety of tongs and electrode shaft geometries, different sensor types, and resulting from this, different sensor positions have been developed. The sensors are producing a longitudinal wave, which usually is located on the tip base and transmits directly and vertically through the electrode tip into the spot weld which is to be tested.

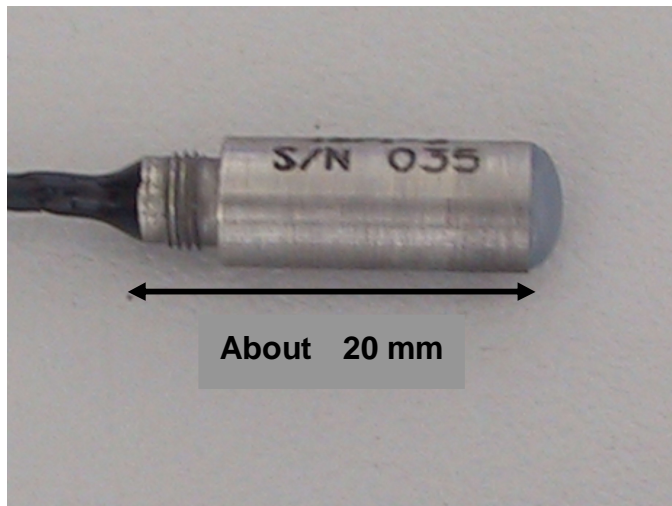


**Figure 2: Internal standard sensor**

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**Figure 3: Internal standard sensor (spring loaded) and new sensor concept (water pressure loaded)**

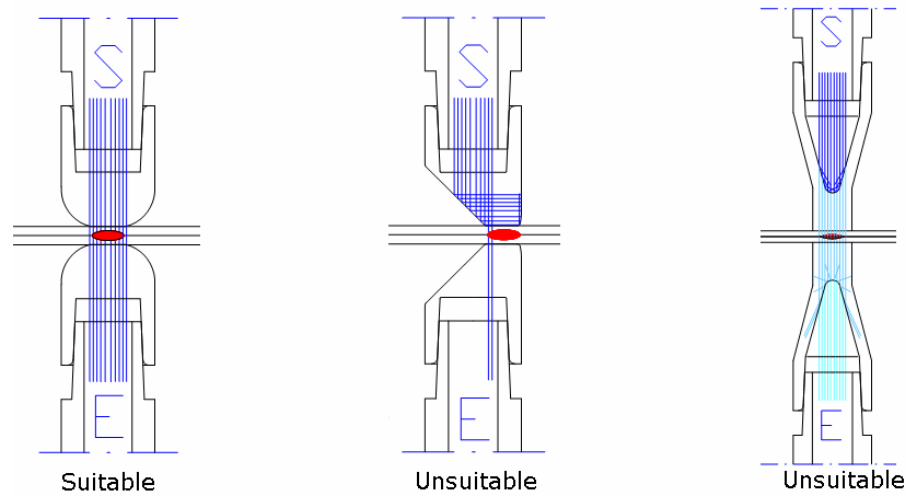


**Figure 4: smallest sensor coupled by the cooling water pressure ( patent by VOGT)**

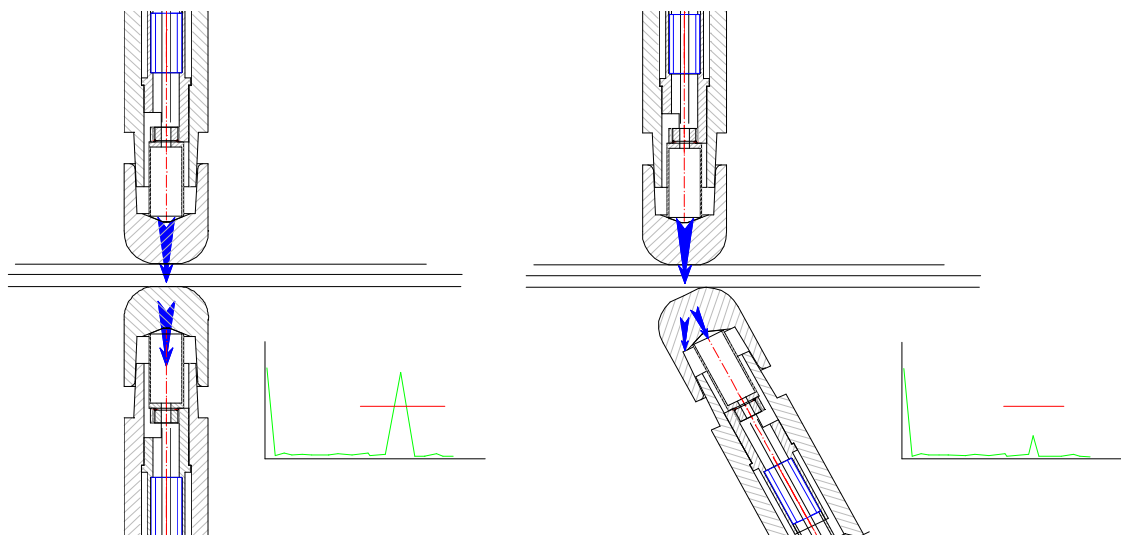
The ultrasonic sensor housing consists of two parts, the upper and lower part (which is the Ultrasonic sensor itself). The actual ultrasonic sensor is located in the bottom of the housing, which is coupled to the tip ground by means of a coupling pad (patent by VOGT). The new design even doesn't need the spring suspended sensor housing as the sensor itself is pressed to the electrode tip by the water pressure of the cooling water. By this the sensor length is about 20 mm long.

In case the water pressure is not high enough it can be used a sensor with a spring-suspended housing in order to catch up the displacement of the electrode tip at the clamping cone. The upper part of the sensor housing serves for the guidance of the cooling water up to the tip ground. The sensor cable outgoing from the lower part of the sensor can be led on arbitrary. At curved tong arms (guns) this should be laid completely through the cooling pipe in the tong arm. In case electrode holders are used, the cable will be led out at the face side of the holder.

Actual VOGT is designing a sensor type with a small connector so that replacement of the sensors is easier to do. Due to the design of the sensor housing, it is guaranteed that the cooling-water flows to the front of the tip ground around the lower part of the sensor housing. The principle allows a sufficient cooling of the tips and of the ultrasonic sensors. Only rotation symmetric electrode tips with face flatness inner tip ground are to be used. Excenter tips prevent a sufficient through-transmission, which is influencing the test result negatively. Roofing tips with tapering bottom hole drillings are also affecting the through-transmission as well as the coupling because of the not face flatness of the tip ground (figure 5). In principle X- as well as C-tongs can be equipped. The expenditure for installation resp. the modifications which have to be made are based on the design of the tong arms and the electrode holder and out of this reason have to be considered individually. For closed tongs the entering angle X of both electrode shafts to one another should be within  $180^\circ \pm 12^\circ$  (figure 6).



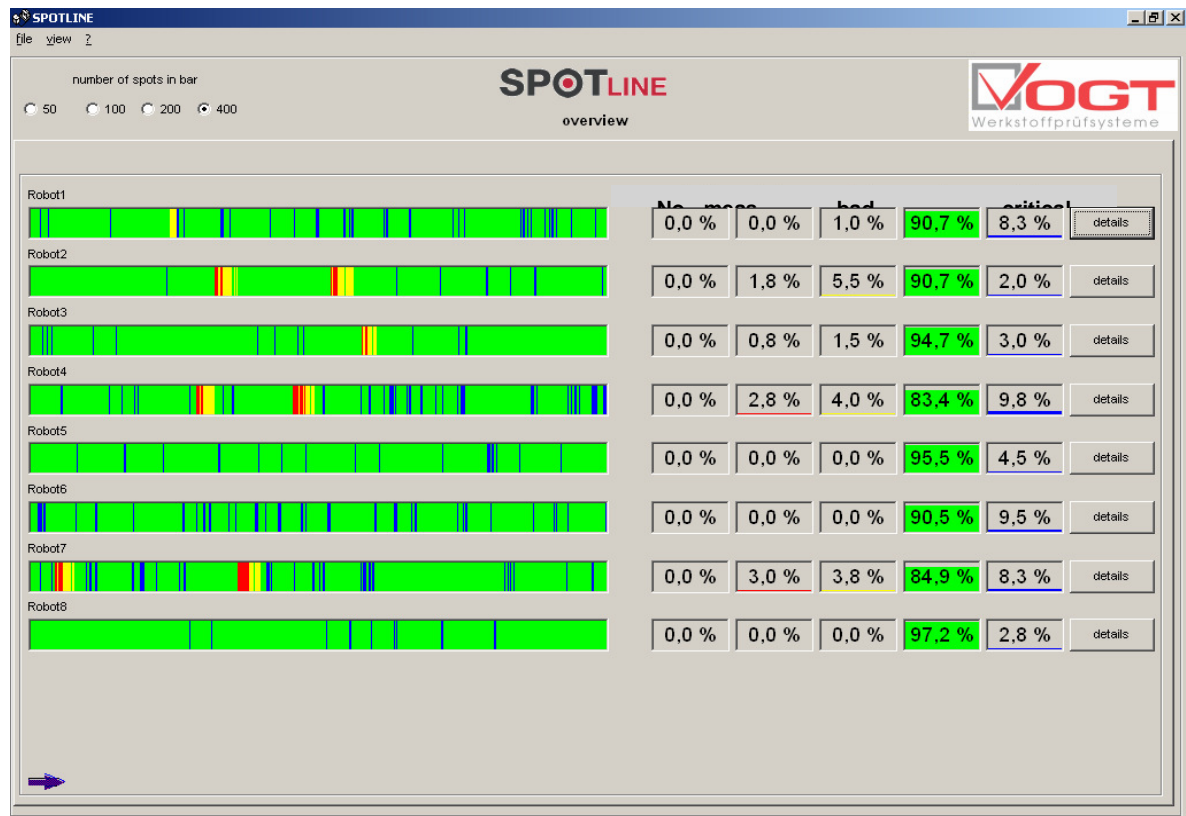
**Figure 5: Hardware requirement for the tips (caps)**



**Figure 6: Entering angle of the tongs**

The ultrasonic signals of both UT sensors are recorded in order to generate the raw data. The test range (spot weld) is right between the two sensors implemented in the shafts. Data acquisition starts with the end of the squeeze time and continues during the entire welding-time lasting into the hold time. During this period the sensors are operating in through transmission and optional in pulse echo mode with a pulse rate of 500 Hz each. (each 2 ms one measurement). The amplitude and time-of-flight data resulting from the through transmission mode are continuously recorded and analysed thereafter. Optional the Pulse Echo data are measured a few times during the welding and are used for temperature compensation and sensor checks only.

Each SPOTline Client sends the evaluated spot weld quality for all tested spots of a welding cycle to the SPOTline Server. In general Each 20 SPOTline Clients are connected to one SPOTline Server. On the terminals which can be connected to the SPOTline Server the quality data can be evaluated by means of statistical process control.



**Figure 7: Terminal software for online statistical process control**