

## 4.2.3. For resistance spot welding

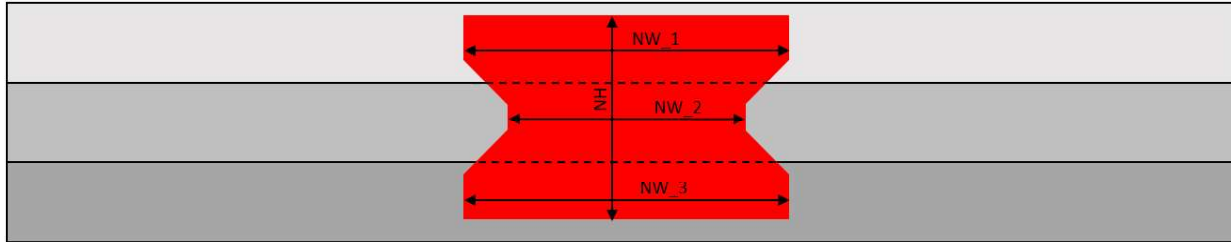
When performing the measurement for resistance spot welding, the current temperature is used to determine the measured values. At the point when the electrical current is turned off, the temperature field is fixed for measurement. If switching of measuring method is enabled, the peak temperature is used to determine the final measured values.

The figures will only show one measurement if it depends on liquidus and solidus temperature. Therefore the figures will only show symbols like "NH" instead of "NHL" or "NHS". Weld nugget is symbolized with red area.

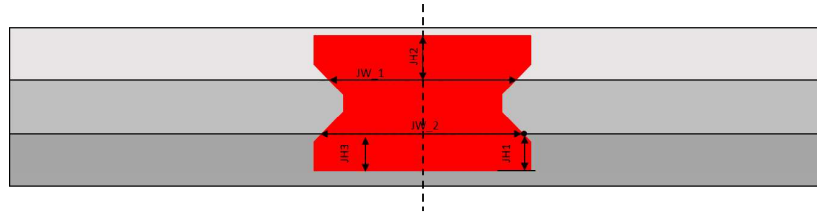
- NuggetHeightLiquidus: Nugget height measured based on liquidus temperature (NHL)
- NuggetWidthLiquidus\_1: Nugget width in upper sheet measured based on liquidus temperature (NWL\_1)
- NuggetWidthLiquidus\_2: Nugget width in lower sheet (center sheet for 3 join partners) measured based on liquidus temperature (NWL\_2)
- NuggetWidthLiquidus\_3: Nugget width in lower sheet (only for 3 join partners) measured based on liquidus temperature (NWL\_3)
- JointHeightLiquidus1\_1: Joint height in upper sheet measured based on liquidus temperature and method 1 (JHL1\_1)
- JointHeightLiquidus1\_2: Joint height in lower sheet measured based on liquidus temperature and method 1 (JHL1\_2)
- JointHeightLiquidus2\_1: Joint height in upper sheet measured based on liquidus temperature and method 2 (JHL2\_1)
- JointHeightLiquidus2\_2: Joint height in lower sheet measured based on liquidus temperature and method 2 (JHL2\_2)
- JointHeightLiquidus3\_1: Joint height in upper sheet measured based on liquidus temperature and method 3 (JHL3\_1)
- JointHeightLiquidus3\_2: Joint height in lower sheet measured based on liquidus temperature and method 3 (JHL3\_2)
- JointWidthLiquidus\_1: Joint width between upper and lower sheet (center sheet for 3 join partners) measured based on liquidus temperature (JWL\_1)
- JointWidthLiquidus\_2: Joint width between center and lower sheet (only for 3 join partners) measured based on liquidus temperature (JWL\_2)
- NuggetHeightSolidus: Nugget height measured based on solidus temperature (NHS)
- NuggetWidthSolidus\_1: Nugget width in upper sheet measured based on solidus temperature (NWS\_1)
- NuggetWidthSolidus\_2: Nugget width in lower sheet (center sheet for 3 join partners) measured based on solidus temperature (NWS\_2)
- NuggetWidthSolidus\_3: Nugget width in lower sheet (only for 3 join partners) measured based on solidus temperature (NWS\_3)
- JointHeightSolidus1\_1: Joint height in upper sheet measured based on solidus temperature and method 1 (JHS1\_1)
- JointHeightSolidus1\_2: Joint height in lower sheet measured based on solidus temperature and method 1 (JHS1\_2)
- JointHeightSolidus2\_1: Joint height in upper sheet measured based on solidus temperature and method 2 (JHS2\_1)

- `JointHeightSolidus2_2`: Joint height in lower sheet measured based on solidus temperature and method 2 (JHS2\_2)
- `JointHeightSolidus3_1`: Joint height in upper sheet measured based on solidus temperature and method 3 (JHS3\_1)
- `JointHeightSolidus3_2`: Joint height in lower sheet measured based on solidus temperature and method 3 (JHS3\_2)
- `JointWidthSolidus_1`: Joint width between upper and lower sheet (center sheet for 3 join partners) measured based on solidus temperature (JWS\_1)
- `JointWidthSolidus_2`: Joint width between center and lower sheet (only for 3 join partners) measured based on solidus temperature (JWS\_2)
- `HeatAffectedZoneAC1_1`: Diameter of heat affected zone in upper sheet measured based on AC1 temperature (HAZAC1\_1)
- `HeatAffectedZoneAC1_2`: Diameter of heat affected zone in lower sheet (center sheet for 3 join partners) measured based on AC1 temperature (HAZAC1\_2)
- `HeatAffectedZoneAC1_3`: Diameter of heat affected zone in lower sheet (only for 3 join partners) measured based on AC1 temperature (HAZAC1\_3)
- `HeatAffectedZoneAC3_1`: Diameter of heat affected zone in upper sheet measured based on AC3 temperature (HAZAC3\_1)
- `HeatAffectedZoneAC3_2`: Diameter of heat affected zone in lower sheet (center sheet for 3 join partners) measured based on AC3 temperature (HAZAC3\_2)
- `HeatAffectedZoneAC3_3`: Diameter of heat affected zone in lower sheet (only for 3 join partners) measured based on AC3 temperature (HAZAC3\_3)
- `ContactWidthElectrode_1`: Contact diameter for contact between electrode and upper sheet (CWE1). In the Joining Optimizer GUI the contact diameter after the welding loadcase is shown as the diameter will be zero for cooling when the electrodes will be removed.
- `ContactWidthElectrode_2`: Contact diameter for contact between lower sheet and electrode (CWE2). In the Joining Optimizer GUI the contact diameter after the welding loadcase is shown as the diameter will be zero for cooling when the electrodes will be removed.
- `ContactWidth_1`: Contact diameter for contact between upper sheet and lower sheet (center sheet for 3 join partners) (CW1)
- `ContactWidth_2`: Contact diameter for contact between center sheet and lower sheet (only for 3 join partners) (CW2)
- `upperBound`: It is calculated based on the weld size to detect expulsion
- `lowerBound`: It is calculated based on minimum sheet thicknesses to detect expulsion
- `Expulsion`: Expulsion displays the joining plane expulsions(P,P1) and surface expulsions (S,ST,SB) detected during RSW process.
- `PrepulseCurrent`: Pre-pulse current displays the current value with applied fitting factor used in the prepulse loadcase
- `PrepulseTime`: Pre-pulse time displays the time value with applied fitting factor used in the prepulse loadcase
- `minMatThickness`: Minimum thickness of all sheets
- `minMatThicknessTC`: Minimum thickness of top and center sheets

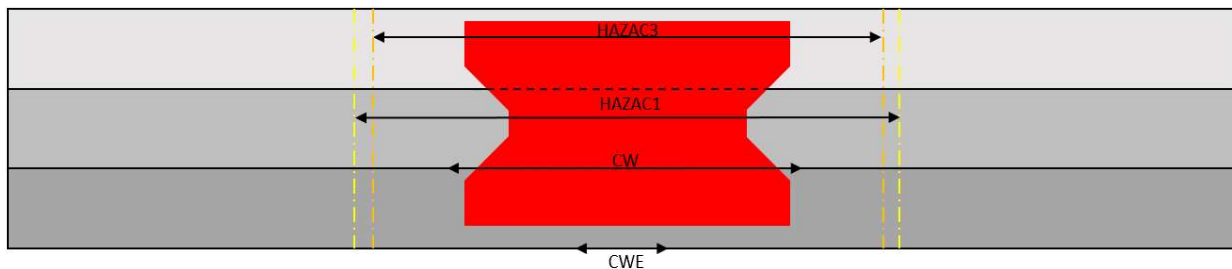
- `minMatThicknessCB`: Minimum thickness of center and bottom sheets
- `matThicknessT`: Thickness of the top sheet
- `matThicknessC`: Thickness of the center sheet
- `matThicknessB`: Thickness of the bottom sheet
- `nLayer`: Number of sheets in the stack



**Figure 4.3. Measurement of resistance spot welding processes part 1**



**Figure 4.4. Measurement of resistance spot welding processes part 2**



**Figure 4.5. Measurement of resistance spot welding processes part 3**

**Remarks to resistance spot welding measurement:**

- **Joint height method 1:** Vertical measurement from intersection point of join plane with solidus/liquidus boundary to highest point of solidus/liquidus of weld nugget.
- **Joint height method 2:** Vertical measurement on symmetry axis of highest point with solidus/liquidus temperature. The measuring according to method 2 will not show the same results as method 1. This is due to deformation of sheets and due to the shape of the weld nugget.
- **Joint height method 3:** Sheet thickness minus smallest distance from sheet surface to solidus/liquidus boundary.
- **Contact width:** The contact width is not necessarily equal to the joint width.
- **matThicknessT/C/B:** These variables can also be used for traffic light quantification to customise the color criteria in resultThresholdRSW.ini based on material thicknesses using math expressions.