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	TOYOTA ENGINEERING STANDARD	TS H5600G	CLASS C1
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SPOT WELDING

1. Scope

This standard specifies the qualities required of spot-welding (hereinafter referred to as "spot welding") portions of automotive parts.

Materials to be welded

Parts consisting of steel plates with thicknesses of 0.4 mm and over to 3.2 mm incl. specified in TSG3100G, 3101G, 3103G, 3104G, 3107G, 3108G, 3109G, 3110G, 3111G, 3580G, and 6602G, and equivalent materials(1)

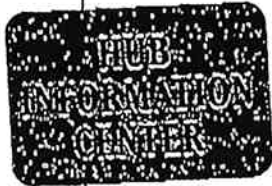
Note:(1) e.g., machine structural carbon steel pipe STKM11A

Remarks:1. This specification applies to the process and product design.

Resistance spot welds are considered satisfactory when they carry the intended or expected loads. The loads on welds in a vehicle in real world are varied in both type and magnitude. Therefore, they are not addressed by this specification. Any attempted application of this document to other uses, such as post-collision crash weld quality assessment, may lead to an erroneous result or conclusion.

Spot welds are considered discrepant when they do not meet the criteria of this specification. Discrepant spot welds by retaining a portion of their engineering properties may still contribute to the integrity of the assembly.

2. In this standard, units and numerical values given in { } are based on the customary units system and are given for reference.



2. Definitions

Major technical terms used herein are as defined below.

(1) Nugget

~~A resolidified portion that appears at a weld (Fig. 1)~~


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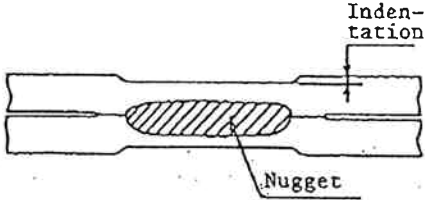
Prepared and Written by: Metallic Material Dept.	Engineering Administration Div. © TOYOTA MOTOR CORPORATION
Material Engineering Div. I	Established / 3 rd Revised: Feb. 1998

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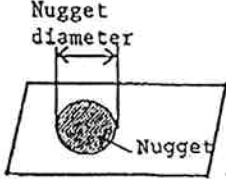
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Section vertical to the plate surface



Section parallel to the plate surface

Fig. 1 Nugget, Nugget Diameter, and Indentation

(2) **Nugget diameter**
 The diameter of a resolidified portion that appears at a weld as measured on the plane where two pieces connect (Fig. 1)

(3) **Weld button diameter**
 The diameter of a weld nugget left on the base metal in the form of a button after the weld is destructed at the nugget by applying twist or tensile shear, hitting with chisel, or peeling the weld (Fig. 2)

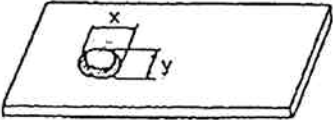


Fig. 2 Weld Button Diameter

(4) **Crack**
 A group of fissures caused to a weld

(5) **Indentation**
 A dent on the surface of the base metal caused by an electrode tip (Fig. 1)

(6) **Blowhole**
 Nearly globular cavity caused in a nugget

(7) **Pit**
 Small hollow holes caused on the surface of a weld

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(8) Penetration ratio

A rate expressed by equation (1) or (2) with the thickness of the thinner piece as reference and by Fig. 3

$$\text{Thinner piece penetration ratio (\%)} = \frac{t_1}{T_1} \times 100 \dots (1)$$

$$\text{Thicker piece penetration ratio (\%)} = \frac{t_2}{T_1} \times 100 \dots (2)$$

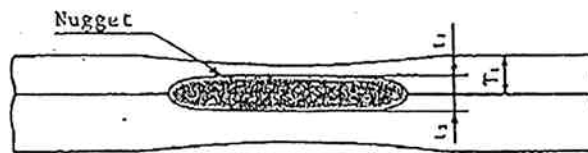


Fig. 3 Penetration Ratio

With a weld among three or more pieces, measure the penetration ratio for each pair of T₁ and T₂ and of T₂ and T₃, as shown in Fig. 4.

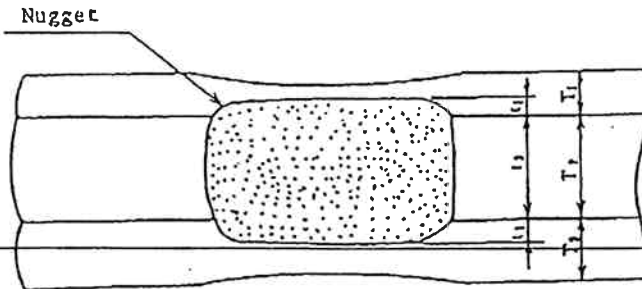


Fig. 4 Penetration Ratio of a Weld among Three or More Pieces

3. Welding Classification

The classes and applications of welding are as presented in Table 1.

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Table 1 Welding Classes and Applications

Class	Applications
Class A	Welds that require exceptional strength; welds that require full strength with a limited number of welded spots
Class B	Welds that require surplus strength
Class C	Welds other than classes A and B

4. Welding Quality

4.1 Exterior Quality

In classes A and B, neither crack that reaches the surface nor pit that exceeds 1.5 mm in diameter is unacceptable.

4.2 Interior Quality (Nugget Diameter and Penetration Ratio)

(1) The nugget diameter shall conform to Table 2. For the weld of different sheet thickness or of more than three sheets overlapped, the nugget diameter and penetration shall be based on the thickness of the thinnest of outer sheet. If no applicable thickness is found in Table 2, the nugget diameter shall be obtained from the relevant formula in Table 2. When needed, the measurement result of the nugget diameter can be substituted for that of the weld button diameter. In such case, a sufficient investigation shall be conducted in order to confirm a relationship between nugget diameter and the weld button diameter.

(2) Penetration ratio in classes A and B shall be 20% or greater.

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Table 2 Nugget Diameter (Minimum)

Unit: mm

Sheet thickness, T	Nugget diameter		
	Class A	Class B	Class C
0.4	3.2	2.5	1.9
0.5	3.5	2.8	2.1
0.6	3.9	3.1	2.3
0.7	4.2	3.3	2.5
0.8	4.5	3.6	2.7
0.9	4.7	3.8	2.8
1.0	5.0	4.0	3.0
1.2	5.5	4.4	3.3
1.4	5.9	4.7	3.5
1.6	6.3	5.1	3.8
1.8	6.7	5.4	4.0
2.0	7.1	5.7	4.2
2.3	7.6	6.1	4.5
2.5	7.9	6.3	4.7
2.6	8.1	6.4	4.8
2.8	8.4	6.7	5.0
2.9	8.5	6.8	5.1
3.2	8.9	7.2	5.4
Formula	$5\sqrt{T}$	$4\sqrt{T}$	$3\sqrt{T}$


4.3 Tensile Shear Load (Reference)

The tensile shear load shall be as given in Table 3. For the weld of different sheet thicknesses or of more than three sheets overlapped, the tensile shear load shall be based on the thickness of the thinnest sheet of those bearing the load.

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Table 3 Tensile Shear Load (Minimum) (For Materials of 270 MPa or Equivalent)					
Sheet thickness, T (mm)	Class A (kN) [kgf]	Class B (kN) [kgf]	Class C (kN) [kgf]	Class A (kN) [kgf]	Class B (kN) [kgf]
0.4	1.16 [120]	0.95 [97]	0.69 [70]		
0.5	1.61 [165]	1.32 [135]	0.98 [100]		
0.6	2.11 [215]	1.73 [175]	1.27 [130]		
0.7	2.65 [270]	2.16 [220]	1.62 [165]		
0.8	3.23 [330]	2.65 [270]	1.96 [200]		
0.9	3.82 [390]	3.14 [320]	2.35 [240]		
1.0	4.51 [460]	3.72 [380]	2.74 [280]		
1.2	5.88 [600]	4.90 [500]	3.63 [370]		
1.4	7.45 [760]	6.08 [620]	4.51 [460]		
1.6	9.11 [930]	7.15 [730]	5.29 [540]		
1.8	10.9 [1100]	8.33 [850]	6.08 [620]		
2.0	12.7 [1300]	9.41 [960]	6.96 [710]		
2.3	15.3 [1560]	10.9 [1100]	8.04 [820]		
2.5	16.6 [1690]	11.6 [1180]	8.53 [870]		
2.6	17.2 [1760]	12.0 [1220]	8.82 [900]		
2.8	17.9 [1820]	12.4 [1260]	9.11 [930]		
2.9	18.2 [1860]	12.6 [1290]	9.31 [950]		
3.2	20.0 [2040]	14.0 [1430]	10.3 [1050]		
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5. Test

5.1 Testing for Exterior and Interior Quality

(1) Test piece

Welds of the subject product shall be used as it is or after cutting them to an appropriate size. When there is no other choice, test pieces can be prepared separately. In such case, however, the test piece shall be prepared with the same material and welding machine as used for the subject product subject to the specifications indicated in Fig. 5 and 6 and Table 4. With regard to continuous weldings, the number of such weldings are 10 or more in principle. The test piece for the joint of plates different in thickness shall be based on the thickness of the thinner of the outer sheet.

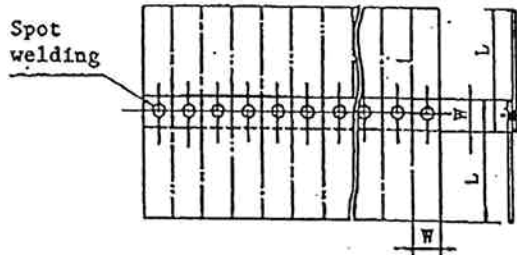


Fig. 5 Continuous Welding Test Piece

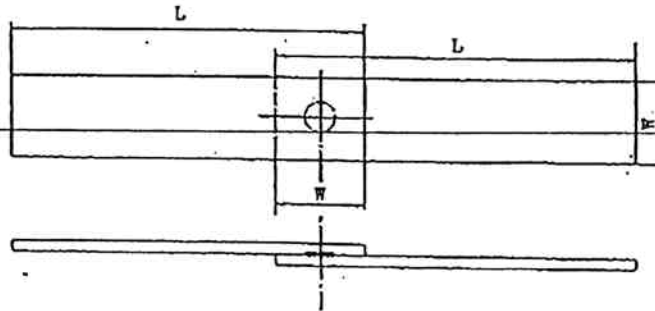



Fig. 6 Single Spot Welding Test Piece


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<p>Table 4 Dimensions</p> <p style="text-align: right;">Unit: mm</p> <table border="1" style="margin: auto; border-collapse: collapse;"> <thead> <tr> <th style="padding: 5px;">Plate thickness</th> <th style="padding: 5px;">W</th> <th style="padding: 5px;">L</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">To 0.8 excl.</td> <td style="padding: 5px;">20</td> <td style="padding: 5px;">75</td> </tr> <tr> <td style="padding: 5px;">0.8 to 1.3 excl.</td> <td style="padding: 5px;">30</td> <td style="padding: 5px;">100</td> </tr> <tr> <td style="padding: 5px;">1.3 to 2.5 excl.</td> <td style="padding: 5px;">40</td> <td rowspan="2" style="padding: 5px; vertical-align: middle;">125</td> </tr> <tr> <td style="padding: 5px;">2.5 to 3.2 excl.</td> <td colspan="2" style="padding: 5px; vertical-align: middle;">50</td> </tr> <tr> <td style="padding: 5px;">3.2 and over</td> <td style="padding: 5px;">150</td> </tr> </tbody> </table>			Plate thickness	W	L	To 0.8 excl.	20	75	0.8 to 1.3 excl.	30	100	1.3 to 2.5 excl.	40	125	2.5 to 3.2 excl.	50		3.2 and over	150
Plate thickness	W	L																	
To 0.8 excl.	20	75																	
0.8 to 1.3 excl.	30	100																	
1.3 to 2.5 excl.	40	125																	
2.5 to 3.2 excl.	50																		
3.2 and over	150																		
<p>(2) Exterior quality test method</p> <p>Check for the following properties.</p> <p>(a) Cracking and pitting</p> <p style="padding-left: 20px;">Visually check</p> <p>(b) Indentation</p> <p style="padding-left: 20px;">Where needed, height difference between the approximate center of the dent and a point on the sheet surface about the dent diameter apart from the center of the dent shall be measured. These measurements can be substituted for the longitudinal section passing through the center of the dent.</p> <p>(3) Interior quality test method</p> <p>(a) Test shall be conducted on a section perpendicular (Fig. 7) or parallel (Fig. 8) to the plate surface.</p> <p>(b) As for the test on the section vertical, cut off the section passing nearly the center of the welded spot by suitable means, polish and etch the sectional surface and examine for nugget diameter and penetration ratio. Measure the nugget diameter and percent welding depth at the resolidified portion. Heat-affected zone shall not be included in this measurement.</p> <p>(c) As for the test on the parallel section, destruct the nugget portion to make the weld button on the base metal by applying the twisting or tensile load, hitting with chisel or peeling the weld. Then, the diameter of the trace of the shear-fractured nugget or such weld button shall normally be measured in "X" and "Y" directions and the average diameter shall be calculated (Fig. 8).</p>																			
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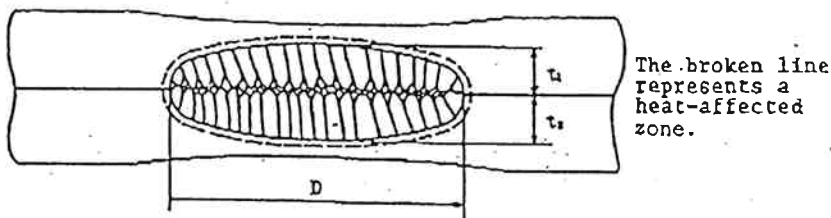


Fig. 7 Measuring Method for Nugget Diameter and Penetration Ratio (Perpendicular Section)

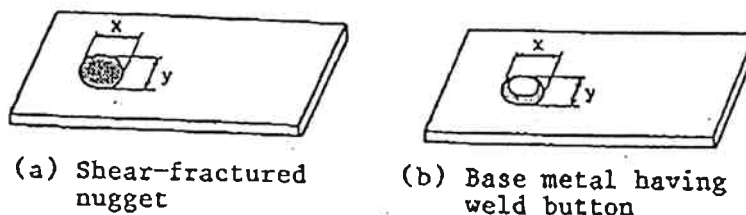


Fig. 8 Measuring Method for Nugget Diameter (Parallel Section)

5.2 Tensile Shear Test

(1) Test piece

Test piece shall be cut out from the welded portion of the subject product as shown in Fig. 6 in principle. The test piece for the joint of plates different in thickness shall be based on the thickness of the thinner of the outer sheet. In case that it is impossible to cut out such test piece from the subject product, a test piece with 10 or more continuous spot welds as shown in Fig. 5 or single spot weld as shown in Fig. 6 can be prepared for use instead.

(2) Test method

- (a) Tension load shall be applied to test pieces in accordance with TSG2203G, and the maximum load shall be measured.
- (b) Some appropriate splints may be applied to test pieces so as to reduce eccentric load.

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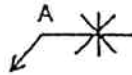
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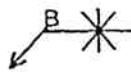
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6. Instructions to Be Entered in Drawings

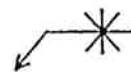
- (1) Write "Conform to TSH5600G for spot welding quality." in the "Note" box of the drawing.
- (2) To specify the welding class of the weld in question, conform to the diagrams below. For class C, omit the class indication symbol.



Portion to be class A



Portion to be class B



Portion to be class C

- (3) If the above do not apply, individually specify the required quality.
- (4) Conform to TSZ6200G for the indication of spot welding symbol.

Applicable Standards

TSG2203G	Tensile Test Method for Metallic Materials
(TSG3100G	Cold Rolled Steel Sheets
(TSG3101G	Hot-Rolled Steel Sheets
(TSG3103G	Electroalvanized Steel Sheets
(TSG3104G	Terne Steel Sheets
(TSG3107G	Hot Dip Aluminum Coated Steel Plates
(TSG3108G	Hot Dip Galvanized Steel Sheets
(TSG3109G	Galvanealed Steel Sheets
(TSG3110G	Double-Layered Zinc-Iron Alloy Coated Steel Sheets
(TSG3111G	Zinc-Iron Alloy Electroplated Steel Sheets
(TSG3580G	Stainless Steels
(TSG6602G	Laminated Damping Steel Sheets
TSZ6200G	Symbolic Representation of Welds

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