

TOYOTA ENGINEERING STANDARD

NO. : TSH5603G

TITLE : ARC WELDING

CLASS : C1

Established/Revised : Rev.2 (Feb.2005)

This standard has been revised in consequence of the addition of leg measurement position to Note (2) in Section 4, "Quality of Welded Portion."

Engineering Information
Planning Dept.
Engineering Administration Div.
TOYOTA MOTOR CORPORATION

<p>TOYOTA ENGINEERING STANDARD</p>	<p>TSH5603G</p>	<p>CLASS</p>		
		<p>C1</p>		
<p><u>ARC WELDING</u></p>				
<table border="1" style="width: 100%;"> <tr> <td> <p>Prepared and Written by: Metallic Material Dept. Material Engineering Div. 2</p> </td> <td> <p>Engineering Administration Div. © TOYOTA MOTOR CORPORATION Established/ 2 Revised: Feb.2005</p> </td> </tr> </table>			<p>Prepared and Written by: Metallic Material Dept. Material Engineering Div. 2</p>	<p>Engineering Administration Div. © TOYOTA MOTOR CORPORATION Established/ 2 Revised: Feb.2005</p>
<p>Prepared and Written by: Metallic Material Dept. Material Engineering Div. 2</p>	<p>Engineering Administration Div. © TOYOTA MOTOR CORPORATION Established/ 2 Revised: Feb.2005</p>			

1. Scope

This standard covers arc welding (hereinafter referred to as "welding") of automobile parts. If design drawings or equivalent documents (e.g. Technical Instruction Sheets) contain special instructions on welding, these instructions supersede this standard. This standard does not cover portions welded for convenience of production (e.g. temporary welded portions).

Remark 1:

If parts made of high-carbon steel⁽¹⁾, alloy steel⁽¹⁾, or carburized steel are to be welded, the design, production engineering, and other departments concerned shall discuss the issues related to material properties (such as hardness at heat-affected zone), before applying this standard.

Remark 2:

This standard covers welding to be performed during production processes and product manufacturing. It shall not apply to various loads applied to welded sections in vehicles when they are used on the market. It is acceptable that individual cross sections of welded portions do not meet this standard, as long as the portions can bear design loads as a whole.

Note:(1)

Materials with a carbon content of 0.3 mass% min.

1.1 Welded Materials

Materials specified in TSG3100G, TSG3101G, TSG3103G, TSG3107G, TSG3108G, TSG3109G, TSG3111G, TSG3113G, TSG3150G, TSG3153G, TSG3154G, TSG3155G, TSG3200G, TSG3211G, TSG3220G, TSG3242G, TSG3290G, TSG3580G, TSG7200G, TSG7202G, TSG7203G, TSG7207G, and equivalent materials

1.2 Welding Method

Object welding methods comprise CO₂ arc welding, MIG welding, MAG welding, TIG welding, plasma welding, and shielded metal arc welding. However, arc spot welding via these methods is not covered by this standard.

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.

- The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
- This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

2. Definition of Properties

(1) Leg

Distance between the root of joint and the toe of fillet weld, and a portion with a penetration (distance, in vertical direction, between the base material surface [prior to melting] and melting boundary) of 0.1 mm or longer

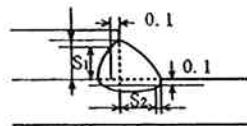


Fig. 1-(a)

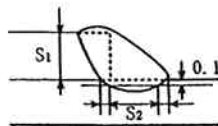


Fig. 1-(b)

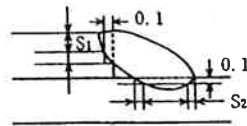


Fig. 1-(c)

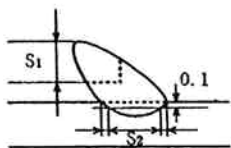


Fig. 1-(d)

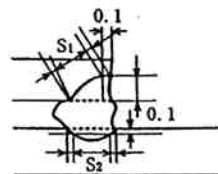


Fig. 1-(e)

Fig. 1 Lap Fillet Weld (Unit: mm)

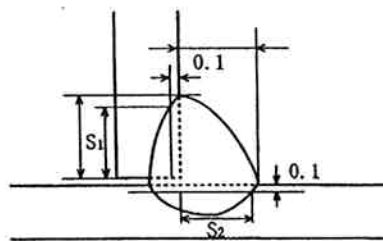


Fig. 2-(a)

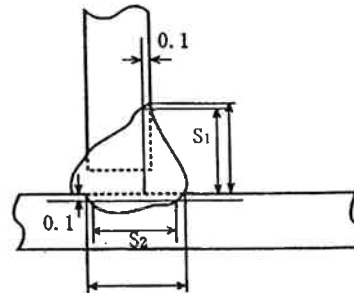


Fig. 2-(b)

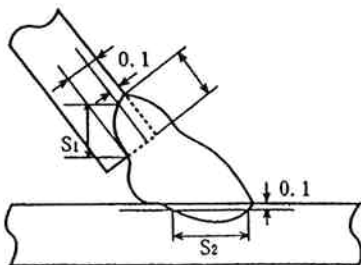


Fig. 2-(c)

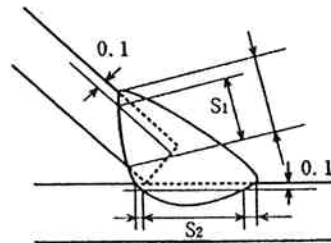


Fig. 2-(d)

Fig. 2 Fillet Weld (Unit: mm)

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 •The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 •This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:

Feb.2005

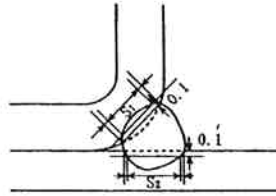


Fig. 3 Flare Weld (Unit: mm)

(2) Throat

Throat of actually welded portion; the shortest distance between the root and surface of weld bead

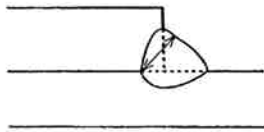


Fig. 4-(a)

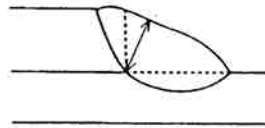


Fig. 4-(b)

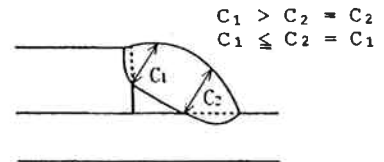


Fig. 4-(c)

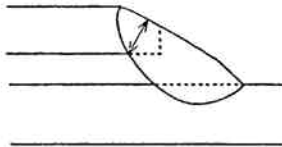


Fig. 4-(d)

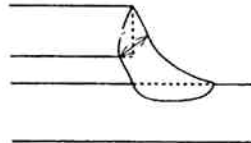


Fig. 4-(e)

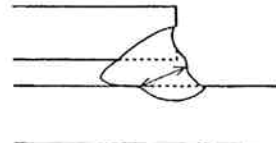


Fig. 4-(f)

Fig. 4 Lap Fillet Weld

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD

TSH5603G

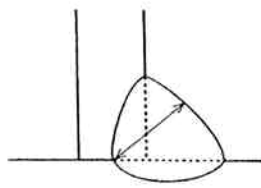


Fig. 5-(a)

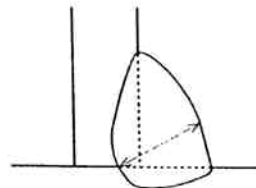


Fig. 5-(b)

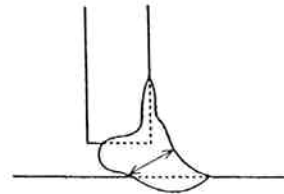


Fig. 5-(c)

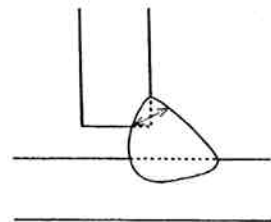


Fig. 5-(d)

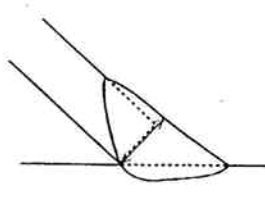


Fig. 5-(e)

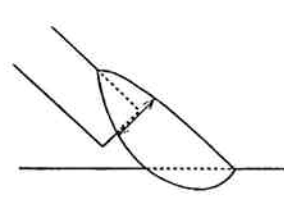


Fig. 5-(f)

Fig. 5 Fillet Weld

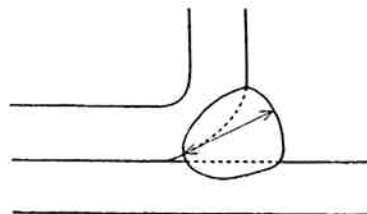


Fig. 6 Flare Weld

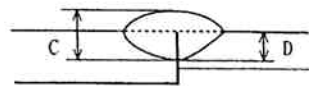


Fig. 7-(a) When Base Metal Surfaces on the Weld Side Are on the Same Plane

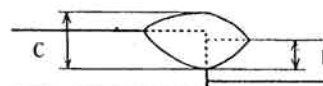


Fig. 7-(b) When Base Metal Surfaces on the Weld Side Are Not on the Same Plane

Fig. 7 Butt Weld

Remark:

$C \geq 0.8 t$ and Penetration depth: $D \geq 0.6 t$

"t" is thickness of thinner plate. In the case of a bar, plate thickness (t) shall be 1/2 of outer diameter.

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:

Feb.2005

(3) Length of weld

Bead length on the weld line of the welded object

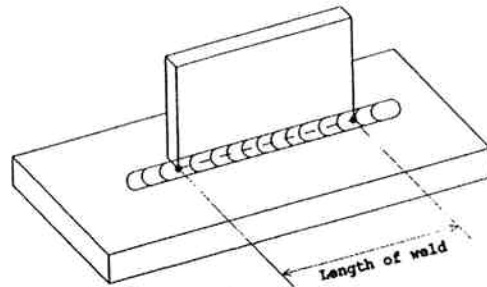


Fig. 8-(a) When Weld Bead Extends along Weld Line

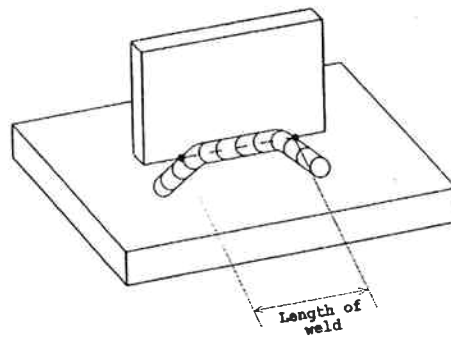


Fig. 8-(b) When Weld Bead Deviates from Extension of Weld Line

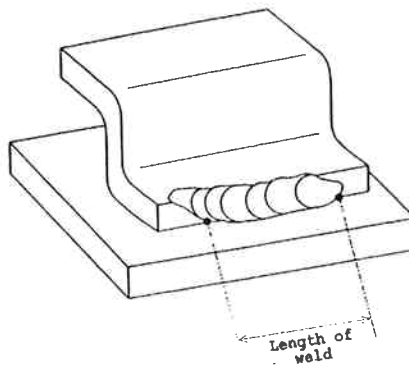


Fig. 8-(c) When Toes of Weld Are Dislocated

Fig. 8 Length of Weld

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 •The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 •This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

(4) Undercut

A groove-like portion at the toe of weld of base metal, where weld metal is not filled

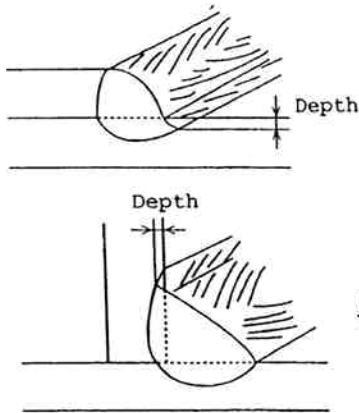


Fig. 9-(a) Depth

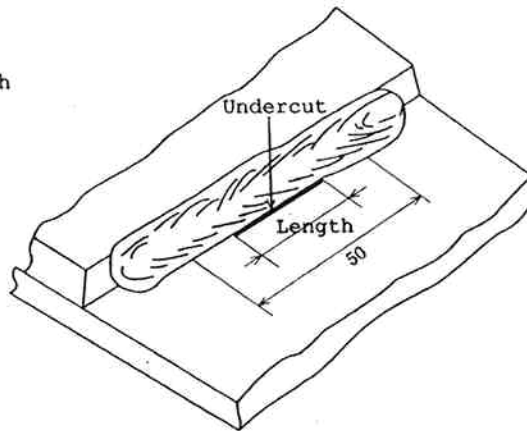


Fig. 9-(b) Length

Fig. 9 Undercut (Unit: mm)

(5) Overlap

A portion at the end of base metal, where deposited metal does not fuse, but overlaps, base metal

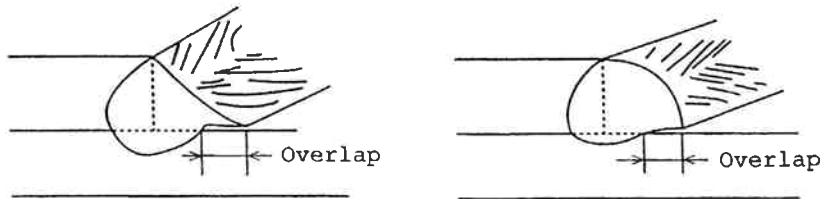


Fig. 10 Overlap

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

(6) Blowhole

An open hole in bead surface

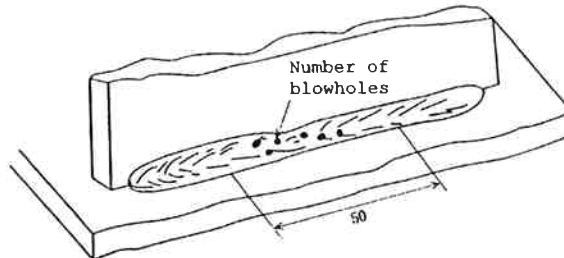


Fig. 11-(a) When Blowholes Are Dispersed

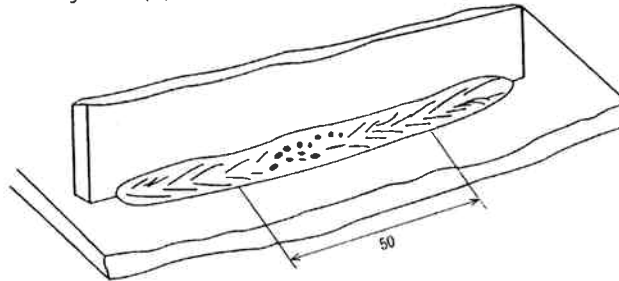


Fig. 11-(b) When Blowholes Are Clustered

Fig. 11 Blowholes (Unit: mm)

(7) Hole

Through hole penetrating to the other side of base metal

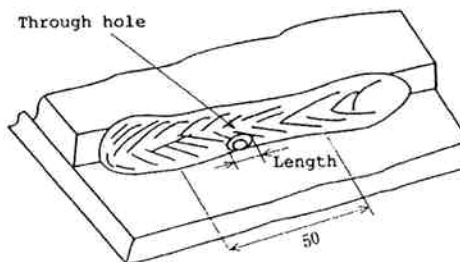


Fig. 12 Hole (Unit: mm)

$$\text{Hole diameter} = \frac{\text{Major axis} + \text{Minor axis}}{2}$$

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

(8) Burn-through

A portion in which part of base metal is fused and missing

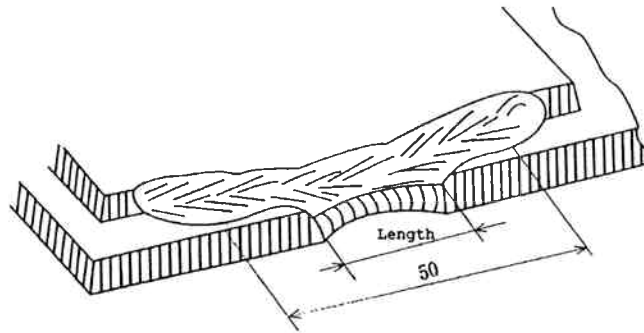


Fig. 13 Burn-Through (Unit: mm)

(9) Bead width

Distance between both ends, at a weld metal portion without deviation

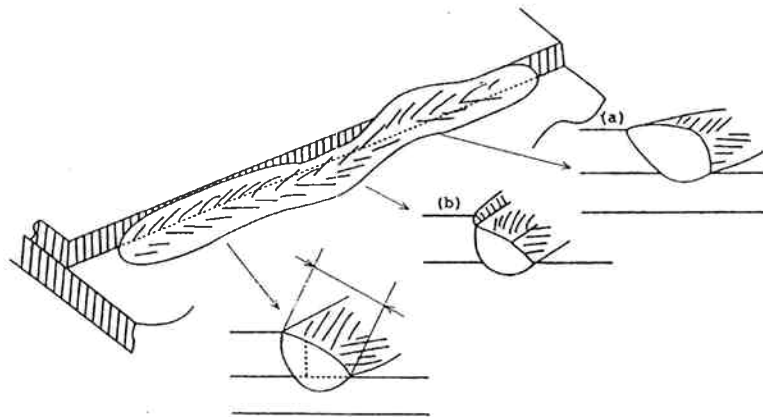


Fig. 14 Bead Width

Remark:

Do not measure bead width where bead deviates as indicated by points (a) and (b).

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 •The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 •This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD

TSH5603G

(10) Discontinuation in bead
 Discontinuation in the same weld line

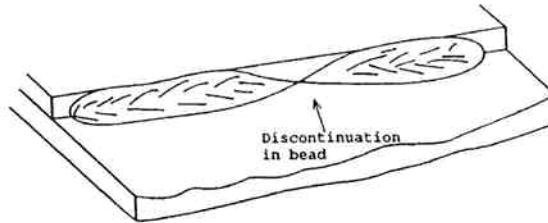


Fig. 15 Discontinuation in Bead

3. Classification of Welded Portion

For the quality of arc welding, 3 classes, A, B and C, are specified. Table 1 shows their applications. Determine class by referring to Table 2 in Section 4 "Quality of Welded Portion."

Table 1 Classification of Welding Quality and Application

Classification	Application
Class A	Welded portion that requires particularly high strength
Class B	Welded portion that requires high strength
Class C	Welded portion not classified as Class A or B

4. Quality of Welded Portion

The allowable range of the quality characteristics of welded portions shall conform to Table 2.

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD

TSH5603G

Table 2 Allowable Range for Quality Characteristics

Property	Characteristics			Measured portion
	Class A	Class B	Class C	
(1) Leg ⁽²⁾	80% min. of thickness of thinner plate			Section 2, (1)
(2) Throat ⁽³⁾	70% min. of thickness of thinner plate; or 80% min. in the case of butt welding			Section 2, (2)
(3) Length of weld	Within ⁽²⁾ % of length of weld specified on design drawing; or within ⁽²⁾ mm if length of weld is 125 mm or shorter			Section 2, (3)
(4) Undercut	Depth: Not larger than whichever is smaller, 0.5 mm or 20% of thickness of thinner plate (over the entire length)	Depth: The increment from whichever is smaller, 0.5 mm or 20% of thickness of thinner plate, shall be 10% max. of an interval of 50 mm.	Depth: The increment from whichever is smaller, 0.5 mm or 20% of thickness of thinner plate, shall be 30% max. of an interval of 50 mm.	Section 2, (4)
(5) Overlap ⁽³⁾	Overlap: Not larger than whichever is smaller, 0.5 mm or 20% of thickness of thinner plate (over the entire length)	Overlap: The increment from whichever is smaller, 0.5 mm or 20% of thickness of thinner plate, shall be 10% max. of an interval of 50 mm.	Overlap: The increment from whichever is smaller, 0.5 mm or 20% of thickness of thinner plate, shall be 30% max. of an interval of 50 mm.	Section 2, (5)
(6) Blowhole	Blowhole or group of blowholes shall be dispersed with intervals of 50 mm min. Regardless of the number of blowholes, the total open area shall be 1 mm ² max.	The number of open blowholes or groups of clustered blowholes occurring in an interval of 50 mm shall be 5 max., or the open area of the groups shall be 10% max. of the interval.	The number of open blowholes or groups of clustered blowholes classified as B occurring in an interval of 50 mm shall be 10 max., or the open area of the groups shall be 30% max. of the interval.	Section 2, (6)
(7) Hole	No hole in weld due to burn-through is permissible.	Holes 2 mm or larger and less than 5 mm in diameter shall occur only once, or not at all, in an interval of 50 mm.	Holes 5 mm or larger in diameter shall occur only once, or not at all, in an interval of 50 mm.	Section 2, (7)
(8) Burn-through	No detrimental burn-through causing reduction in joint cross section or concentration of stress is permissible.	Burn-through shall be 10% max. in an interval of 50 mm.	Burn-through shall be 30% max. in an interval of 50 mm.	Section 2, (8)
(9) Bead width	At least 1.5 times the thickness of thinner plate		At least 1.2 times the thickness of thinner plate	Section 2, (9)
(10) Discontinuation in bead	Bead shall be continuous in weld.			Section 2, (10)

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD

TSH5603G

Note: (2)

Leg shall be determined for the portion with a penetration (distance, in vertical direction, between the base material surface [prior to melting] and melting boundary) of 0.1 mm or longer. (Fig. 16)

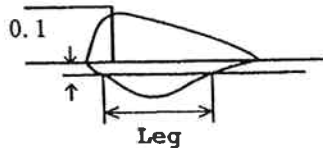


Fig. 16 Leg in Lap Fillet Weld (Unit: mm)

Note: (3)

Shell body parts shall be excepted.

Remark 1:

Where a specific portion is designated in a drawing or the like as "No detrimental phenomenon at beginning and terminating ends of weld is permissible," the portion shall be visually of Class A quality, regarding quality characteristics (4) to (10).

Remark 2:

Determine required product quality regarding crack, if necessary, through discussion by Design, Production Technology, Quality Assurance and other departments concerned.

5. Test Method

The test method shall be in accordance with Table 3.

Table 3 Classification of Test Methods

Quality	Test method
(1) Leg	Section test
(2) Throat	
(3) Length of weld	Appearance test
(4) Undercut	Appearance test, section test
(5) Overlap	Section test
(6) Blowhole	Appearance test, section test
(7) Hole	Appearance test
(8) Burn-through	
(9) Bead width	Appearance test, section test
(10) Discontinuation in bead	Appearance test

5.1 Appearance Test

Using slide calipers, scales, and other measuring instruments, inspect the welded portion visually without breaking or cutting it and in accordance with the required quality characteristics.

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD**TSH5603G****5.2 Section Test**

Cut the welded portion vertically to the weld line by using a suitable means (that does not give undesirable effects, such as heating and cracking), and examine the portion in accordance with TSG2100G.

6. Indication in Drawing

The method of indication in drawings and other documents shall be as follows:

- (1) The method for indicating welding symbols shall conform to TSZ6200G.
- (2) If necessary, indicate the class of each welded portion according to the following method. However, do not indicate the class when the welded portion falls under Class C.

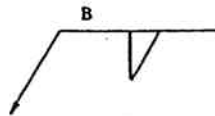


Fig. 17 Example of Class Indication

- (3) When applying this standard to drawings, describe clearly "Quality of arc welding shall conform to TSH5603G." in the note columns of the drawings. When applying characteristics different from those specified in Section 4, indicate the specific characteristic requirements in each drawing.
- (4) If it is necessary to indicate the toe of weld, indicate it together with its tolerance.

Applicable Standards

TSG2100G	Microscopic Structure Detecting Method for Metal
TSG3100G	Cold Rolled Steel Sheets
TSG3101G	Hot-Rolled Steel Sheets
TSG3103G	Electrogalvanized Steel Sheets
TSG3107G	Hot Dip Aluminum Coated Steel Plates
TSG3108G	Hot Dip Galvanized Steel Sheets
TSG3109G	Galvannealed Steel Sheets
TSG3111G	Zinc-Iron Alloy Electroplated Steel Sheets
TSG3113G	Hot Dip Aluminum Coated Chromium Alloy Steel Sheets
TSG3150G	Carbon Steel Tubes for Machine Structural Purposes
TSG3153G	Cold-Drawn Carbon Structural Tubes
TSG3154G	Steel Tubes for Heat Treatment
TSG3155G	Coated Steel Pipes Exhaust Piping
TSG3200G	Carbon Steels for Machine Structural Use
TSG3211G	Low Manganese Steels
TSG3220G	Chromium Steels
TSG3242G	Vanadium Steels
TSG3290G	General Carbon Steels
TSG3580G	Stainless Steels

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
 *The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
 *This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
 Feb.2005

TOYOTA ENGINEERING STANDARD

TSH5603G

TSG7200G	Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
TSG7202G	Aluminum and Aluminum Alloy Seamless Pipes and Tubes
TSG7203G	Aluminum and Aluminum Alloy Rods, Bars, and Wires
TSG7207G	Aluminum and Aluminum Alloy Extruded Shapes
TSZ6200G	Symbolic Representation of Welds

NOTES: The recipient of this standard shall undertake the following confidentiality obligations upon the receipt of this standard.
•The recipient shall discard by shredding or fire, or return to Toyota Motor Corporation if appropriate, the documents contained in this standard when they are no longer necessary due to the termination of the work concerned or the revision of current version of this standard.
•This standard and the technical information related thereto are owned by and under sole control of Toyota Motor Corporation. They shall not be disclosed in whole nor in part to any third party without prior written consent of Toyota Motor Corporation.

Established/ 2 Revised:
Feb.2005