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**Rolling stock — Body frame —
Design methods for welded joints**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Land, Infrastructure and Transport, through deliberations at the Japanese Industrial Standards Committee as the result of proposal of revision of Japanese Industries Standard submitted by Japan Association of Rolling Stock Industries (JARI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS E 4047** : 1988 is replaced with this Standard.

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Rolling stock — Body frame — Design methods for welded joints

Introduction

This Japanese Industrial Standard was established in 1974 and, through two revisions, comes down to this time. The last revision was made in 1988, and after that, **JIS E 4049** (Welded joints of stainless steel for railway rolling stock — Design methods) and **JIS E 4050** (Welded joints of aluminium alloy for railway rolling stock — Design methods) were established in 1990 and in 1992, respectively. The revision at this time has been made in order to respond to a request that common specifications of these three standards be unified for the sake of convenience.

Further, no International Standard corresponding to this Standard has been established at this point.

1 Scope

This Standard specifies the design methods for welded joints used for the body frame of rolling stock (hereafter referred to as “joints”). However, joints related to the spot weld, seam weld, laser weld and friction stir weld are not included.

Further, this Standard can be applied to the following parts, if necessary:

- structure of locomotive;
- framework for underfloor apparatus;
- hanging part for apparatus of fitting.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

- JIS E 4001 *Railway rolling stock — Vocabulary*
- JIS E 7106 *Rolling stock — General requirements of carbody structures for passenger car*
- JIS G 3101 *Rolled steels for general structure*
- JIS G 3106 *Rolled steels for welded structure*
- JIS G 3114 *Hot-rolled atmospheric corrosion resisting steels for welded structure*
- JIS G 3125 *Superior atmospheric corrosion resisting rolled steels*
- JIS G 3131 *Hot-rolled mild steel plates, sheets and strips*
- JIS G 3141 *Cold-reduced carbon steel sheets and strips*
- JIS G 3350 *Light gauge sections for general structure*

JIS G 3444	<i>Carbon steel tubes for general structural purposes</i>
JIS G 3452	<i>Carbon steel pipes for ordinary piping</i>
JIS G 3454	<i>Carbon steel pipes for pressure service</i>
JIS G 4051	<i>Carbon steels for machine structural use</i>
JIS G 4305	<i>Cold-rolled stainless steel plate, sheet and strip</i>
JIS G 5101	<i>Carbon steel castings</i>
JIS H 4000	<i>Aluminium and aluminium alloy sheets, strips and plates</i>
JIS H 4100	<i>Aluminium and aluminium alloy extruded shape</i>
JIS H 4140	<i>Aluminium and aluminium alloy forgings</i>
JIS K 1101	<i>Oxygen</i>
JIS K 1105	<i>Argon</i>
JIS K 1106	<i>Liquid carbon dioxide</i>
JIS Z 3001	<i>Welding terms</i>
JIS Z 3021	<i>Symbolic representation of welds</i>
JIS Z 3211	<i>Covered electrodes for mild steel</i>
JIS Z 3212	<i>Covered electrodes for high tensile strength steel</i>
JIS Z 3221	<i>Stainless steel covered electrodes</i>
JIS Z 3232	<i>Aluminium and aluminium alloy welding rods and wires</i>
JIS Z 3233	<i>Tungsten electrodes for inert gas shielded arc welding, and for plasma cutting and welding</i>
JIS Z 3312	<i>MAG welding solid wires for mild steel and high strength steel</i>
JIS Z 3315	<i>Solid wires for CO₂ gas shielded arc welding for atmospheric corrosion resisting steel</i>
JIS Z 3321	<i>Stainless steel, welding rods and solid wires</i>
JIS Z 3351	<i>Submerged arc welding solid wires for carbon steel and low alloy steel</i>
JIS Z 3410	<i>Welding coordination — Tasks and responsibilities</i>

3 Terms and definitions

For the purpose of this Standard, the definitions given in **JIS E 4001** and **JIS Z 3001** and the following definitions apply.

3.1 ordinary steel

steel material of base metal to be used for body frame except for stainless steel material and aluminium alloy material

3.2 boxing

welding, in single fillet weld, which goes further to the back face at the end of the material

The abbreviated code is “TW”, which is combined with L , the length of going around, to be expressed as “TW- L ” and attached to the end of the welding symbol. Practical relational dimensions shall be as shown in figure 2 a).

4 Design instruction

The design instruction in a drawing shall be as follows.

- The design instruction of joints shall be entered in drawings using the symbolic representation of weld of **JIS Z 3021**. However, if it cannot be expressed suitably by only the symbolic representation of weld, it is preferable to use it together with rough sketch, detailed drawing and so on jointly.
- The instructions for welding method, the treatment method before and after weld, testing method and so on shall be given when necessary.
- The grade of welding concerning the body frame shall be classified as Class A, Class B and Class C in the order of importance (see table D.1). If there are parts required to be of classes other than the above (i.e. upper class) based on the strength evaluation, it should be noted as such in the drawing.
- When air tightness is necessary for the joint, the mark of (㊟) shall be given at the end of the symbolic representation of weld.

NOTE : (㊟) is a symbol to express “air tight”.

5 Base metal and welding consumables

5.1 Base metal

The base metal to be used for body frame shall be in accordance with table 1. However, base metals other than below may be used under the agreement between the manufacturer and the purchaser.

Table 1 Base metal

Material classification of body frame	Standard number	Classification symbol
Ordinary steel material	JIS G 3101	SS330 or SS400
	JIS G 3106	SM400A, SM400B, SM490A, SM490B, SM490YA, SM490YB or SM520B
	JIS G 3114	SMA400AW, SMA400BW, SMA490AW or SMA490BW
	JIS G 3125	SPA-H or SPA-C
	JIS G 3131	SPHC, SPHD or SPHE
	JIS G 3141	SPCC, SPCD or SPCE
	JIS G 3350	SSC400
	JIS G 3444	STK400
	JIS G 3452	SGP
	JIS G 3454	STPG370 or STPG410

Table 1 (concluded)

Material classification of body frame	Standard number	Classification symbol
Ordinary steel material	JIS G 4051	S10C, S12C, S15C, S17C, S20C, S22C, S25C, S28C or S30C
	JIS G 5101	SC410 or SC450
Stainless steel material	JIS G 4305	SUS301L, SUS304
Aluminium alloy material	JIS H 4000	A5005P, A5052P, A5083P or A7N01P
	JIS H 4100	A5052S, A5083S, A6063S, A6N01S, A7003S or A7N01S
	JIS H 4140	A5083FD or A7N01FD

5.2 Welding consumables

Classification of welding consumables to be used shall be in accordance with table 2. These materials are not necessarily marked on the drawings unless especially required by the manufacturer.

Table 2 Welding consumables

Classification of body frame material	Name of welding consumables	Standard number and classification
Ordinary steel material	Coated arc electrode	JIS Z 3211 D4301, D4303, D4313, D4316 or D4327
		JIS Z 3212 D5001, D5016 or D5816
	Welding wire	JIS Z 3312 YGW11, YGW12, YGW13, YGW14, YGW15, YGW16 or YGW17
		JIS Z 3315 YGA-50W or YGA-50P
		JIS Z 3351 YS-S1, YS-S2 or YS-S3
	Welding flux	Shall be selected according to welding wire, base metal and so on.
	Welding gas	JIS K 1101 JIS K 1105 JIS K 1106
Stainless steel material	Coated electrode	JIS Z 3221 D308 or D308L
	Welding bar and solid wire	JIS Z 3321 Welding wire shall be Y308 or Y308L
	Shielding gas for welding	JIS K 1101 JIS K 1105
Aluminium alloy material	Welding bar and welding wire	JIS Z 3232 Bar and wire shall be selected according to base metal.
	Shielding gas for welding	JIS K 1105
Common	Electrode for TIG welding	JIS Z 3233 Electrode shall be selected according to base metal.

6 Load acting on joints

The object of static and dynamic load acting on joint shall be the load acting on the joint of body work by the load specified by **JIS E 7106**.

Further, plural loads acting on the joints of body frame by the plural loads shall be composed by **JIS E 7106** considering their simultaneity.

7 Stress calculation

The stress calculation of joints shall be performed according to the stress calculation formula in table 3.

Table 3 Stress calculation formula of joint

No.	Loading condition	Groove welded joint	Fillet welded joint	Toe base metal
1	In the case where the joint is subjected to tensile force or compression force (P)	$\sigma = \frac{P}{A}$	$\tau = \frac{P}{\Sigma(al)}$	$\sigma = \frac{P}{A''}$
2	In the case where the joint is subjected to shear force (Q)	$\tau = \frac{Q}{A}$	$\tau = \frac{Q}{\Sigma(al)}$	$\tau = \frac{Q}{A''}$
3	In the case where the joint is subjected to bending moment (M)	$\sigma = \frac{M}{Z}$ or $\sigma = \frac{My}{I}$	$\tau = \frac{M}{Z'}$	$\sigma = \frac{M}{Z''}$
4	In the case where the joint is subjected to bending moment (M) and shear force (Q) simultaneously, and the combination is taken into consideration.	$\sigma = \sqrt{\left(\frac{M}{Z}\right)^2 + 3\left(\frac{Q}{A}\right)^2}$	$\tau = \sqrt{\left(\frac{M}{Z'}\right)^2 + \left(\frac{Q}{A'}\right)^2}$	$\sigma = \sqrt{\left(\frac{M}{Z''}\right)^2 + 3\left(\frac{Q}{A''}\right)^2}$

Where, σ : tensile stress or compression stress produced on the joint (MPa)

τ : shearing stress produced in the joint (MPa)

A : throat cross-sectional area (mm²)

a : throat depth of each fillet = $0.7 \times$ fillet size (mm²)

l : effective length of weld of each fillet weld (mm)

I : geometrical moment of inertia of a throat cross section (mm⁴)

y : distance from a neutral axis (mm)

Z : modulus of section of a throat cross section (mm³)

Z' : modulus of section of the figure obtained by transferring the throat cross section of each fillet to a plane parallel to a base-metal cross section (see figure 1) (mm³)