

JIS

JAPANESE INDUSTRIAL STANDARD

Construction of Welded Aluminium Alloy Liquefied Natural Gas Storage Tanks

JIS B 8251—1981

Translated and Published

by

Japanese Standards Association

Printed in Japan

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

JAPANESE INDUSTRIAL STANDARD

J I S

Construction of Welded
Aluminium Alloy Liquefied
Natural Gas Storage Tanks

B 8251-1981
(Reaffirmed: 1986)

1. Scope

This Japanese Industrial Standard specifies the general rules of construction of cylindrical vertical storage tanks with double shell, flat bottom, spherical roof, hereinafter referred to as the "storage tanks", having welded aluminium alloy inner tank out of on-ground storage tanks to store liquefied natural gas.

Remark: The units and numerical values given in { } in this Standard are in accordance with the International System of Units (SI), and are appended for reference.

2. Materials

2.1 General For the materials used for parts of storage tank to contact the liquefied natural gas, materials having sufficient mechanical property relating to the liquefied natural gas of -162°C shall be selected.

2.2 Inner Tank Materials Structural materials used for inner tank shall comply with the following Standards or be equal or superior thereto.

A 5083 P-0 of JIS H 4000

A 5083 BE-0, A 5083 BD-0 of JIS H 4040

A 5083 TE-0, A 5083 TD-0 of JIS H 4080

A 5083 S-0 of JIS H 4100

A 5083 FD-0, A 5083 FH-0 of JIS H 4140

2.3 Outer Tank and Attachment Materials The materials used for outer tank and attachment shall comply with the following Standards or be those equal or superior thereto in quality.

SS 41 of JIS G 3101

JIS G 3106

JIS G 3115

SF 40 A, SF 45 A of JIS G 3201

STK 41 of JIS G 3444

JIS G 3452

STPG 38 of JIS G 3454

Applicable Standards: See pages 37 & 38.

JIS G 3457

STPL 39 of JIS G 3460

S 20 C, S 25 C, S 45 C of JIS G 4051

SNB 7 of JIS G 4107

JIS G 4303

SUS 304 of JIS G 4304

SUS 304 of JIS G 4305

JIS H 4000, JIS H 4040, JIS H 4080, JIS H 4100, JIS H 4140

AC 4 C-T 6, AC 7 A-F of JIS H 5202

2.4 Filler Materials The filler materials used for welding of aluminium and aluminium alloy shall, as a rule, comply with the specifications of JIS Z 3232. However, for A 5083, those of A 5183-BY, A 5183-WY or those equivalent or superior thereto in quality.

3. Allowable Stress of Material

3.1 Allowable Tensile Stress The allowable tensile stress of material to be used for calculation shall be in accordance with JIS B 8243.

3.2 Allowable Shearing Stress The allowable shearing stress shall be 60 % of allowable tensile stress.

3.3 Allowable Compressive Stress The allowable compressive stress shall be obtained according to the following:

(1) In the case of $\lambda \leq 20$

$$\sigma_c = \sigma_a$$

(2) In the case of $20 < \lambda \leq 1$

$$\sigma_c = \frac{1 - 0.4 \left(\frac{\lambda}{1} \right)^2}{\nu} \sigma_{0.2}$$

(3) In the case of $\lambda > 1$

$$\sigma_c = \frac{\sigma_{0.2}}{3.75 \left(\frac{\lambda}{1} \right)^2}$$

where σ_c : allowable compressive stress (kgf/mm²) {N/mm²}

σ_a : allowable tensile stress (kgf/mm²) {N/mm²}

$\sigma_{0.2}$: proof stress (kgf/mm²) {N/mm²}

λ : slenderness ratio of compressive material (compressive material $\lambda \leq 160$, post material $\lambda \leq 120$)

$$\lambda = \frac{l_k}{r}$$

l_k : buckling length (cm), according to the following.

Concerning moving	Constraint			Free	
Concerning rotation	Both ends free	Both ends constraint	One end free, other end constraint	Both ends constraint	One end free, other end constraint
l_k	l	$0.5 l$	$0.7 l$	l	$2 l$

Remark: l : length of compressive material or post material (cm)

γ : modulus of longitudinal elasticity concerning the buckling axis (cm)

$$\nu = 1.5 \left(0.9 + 0.6 \frac{\lambda}{A} \right)$$

provided $\nu \geq 1.5$

$$A = \sqrt{\frac{\pi^2 E}{0.6 \sigma_{0.2}}}$$

E : modulus of longitudinal elasticity (kgf/mm²) {N/mm²}.

3.4 Allowable Bending Stress The allowable bending stress shall be same as the allowable tensile stress.

3.5 Allowable Stress of a Fillet Weld The allowable shearing stress of a fillet weld of attachment to side plate shall be 60 % of allowable tensile stress, provided that for calculation the theoretical throat of a fillet weld shall be used.

4. Design

4.1 General The design general shall be as follows:

- (1) The storage tank shall be designed by taking into consideration using of course, assembly, pressure resistance test, cool-down, inspection, etc.
- (2) The storage tank is that to store liquefied natural gas in which inner tank, heat insulating material of bottom part, foundation and anchor strap are integral, and shall be designed by taking into consideration the correlation of each part of these.
- (3) For anchor strap of storage tank, the gas pressure, liquid pressure, earthquake power and effect of temperature shall be taken into consideration, and the connecting part with its interior shall be free from excess local stress.

- (4) The heat insulating material of storage tank shall have sufficient heat resistance required for design.
Further, the heat insulating material of bottom part shall have sufficient pressure bearing function relative to liquid pressure, gas pressure, etc., and the affect of earthquake and the like shall be taken into consideration.
- (5) The foundation of storage tank shall be sufficiently rigid against liquid pressure, gas pressure, etc. and the affect of earthquake and temperature change shall be taken into consideration.
- (6) The attaching part of nozzle of storage tank shall be free from excess stress due to estimated outer force.
- (7) The outer tank shall retain heat insulating material and seal gas and be airtight structure.
- (8) The outer tank shall be taken with sufficient countermeasures against corrosion.

4.2 Loads The storage tank shall be so designed that it is safe relative to the combination of load shown in the following and load considered to be required.

(1) Static Loads

- (a) The load due to self-weight (including attachments) of storage tank
- (b) The load due to heat insulating material
- (c) The load due to weight of storage liquid
- (d) The load due to gas pressure of storage liquid (including negative pressure)
- (e) The load due to fallen snow ⁽¹⁾
- (f) The load due to pressure of seal gas
- (g) Other load to be considered

(2) Dynamic Loads

- (a) The load due to wind pressure ⁽¹⁾
- (b) The load due to earthquake
- (c) Other load to be considered

Note ⁽¹⁾ The load due to fallen snow, the load due to wind pressure shall be received only by exterior.

- (3) Calculation of Loads The fallen snow load, wind load, earthquake load shall be as follows:

- (a) Fallen Snow Load The fallen snow load per horizontal projection area of storage tank shall be obtained by multiplying the unit weight of fallen snow by vertical deepest fallen snow in the district.
The unit weight of fallen snow shall be not less than 2 kgf {20 N} for horizontal projection area 1 m² per 1 cm of fallen snow.
- (b) Wind Load The wind load (Q) due to wind pressure shall be calculated according to the following formula. However, in the case where it is installed at a place having a fear of receiving strong wind such as seaside, river side, on mountain, etc. or where the height from the ground surface up to the crest of storage tank is not less than 25 m, the speed pressure shall be taken as 300 kgf/m² {3.1 kPa}.

$$Q = Aqk$$

where Q : wind load (kgf) {N}

A : pressure receiving area, being the maximum vertical cross section of storage tank (m²)

q : speed pressure (kgf/m²), $q = 60\sqrt{h}$ { $q = 0.6\sqrt{h}$ (kPa)}

k : wind force coefficient, being 0.4 for spherical roof, and 0.7 for cylindrical shell

h : height of storage tank from the ground (m)

- (c) Load due to Earthquake Moving For the load due to earthquake moving, apply the load 0.3 time the self weight in horizontal direction and the load 0.15 time the self weight in vertical direction at its center of gravity, and make the combination of loads in horizontal direction and vertical direction the severe conditions.
Furthermore, the local vibration characteristics, ground conditions, etc. shall, in some cases, be taken into consideration.

4.3 Joints

4.3.1 Dimensions of Welds The dimensions of welds shall be as follows:

- (1) In the case of butt welding, it shall be theoretical throat dimension.
- (2) In the case of fillet weld, it shall be size of a fillet weld.

4.3.2 Restriction on Use of Welding The restriction on use of welding shall be as follows:

- (1) The minimum dimension of fillet weld shall be as follows, except where specially specified.

- (a) In the case where the plate thickness is 6 mm, the size of the fillet weld shall be not less than 6 mm.
- (b) In the case where the plate thickness exceeds 6 mm, the size of fillet weld shall be not less than $1/3$ time the thinner plate thickness and the minimum value, be 6 mm.
- (2) For one side welding lap joint, it shall not be applied to those other than bottom plate, roof and attachments.
- (3) The lap allowance of lap joint shall be not less than 5 times the nominal thickness of thinner plate.

4.3.3 Joints of Storage Tank The joints of storage tank body shall, as a rule, be in accordance with Fig. 1 and Fig. 2.

Fig. 1. Joints of Storage Tank

(1) Longitudinal Joint of Side Plate and Knuckle Plate

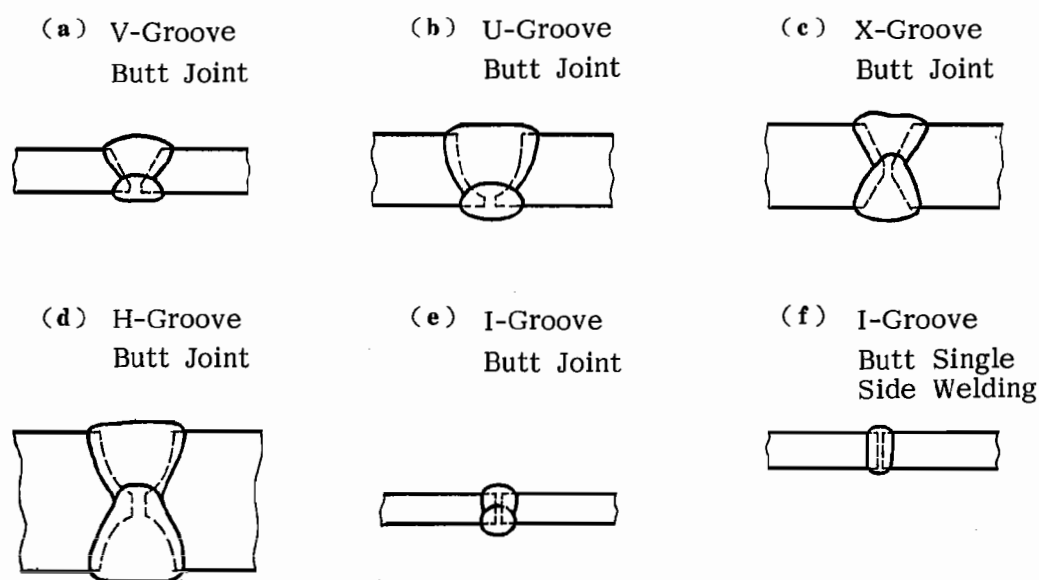
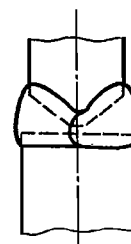
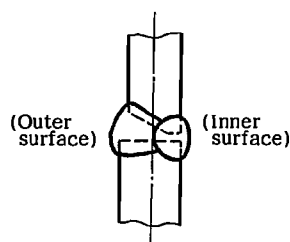


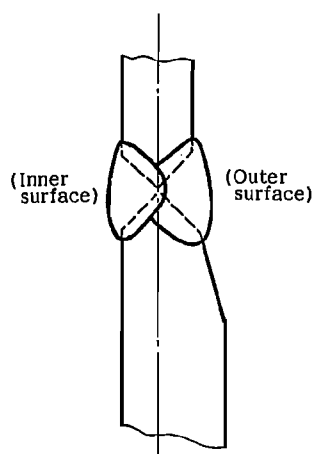
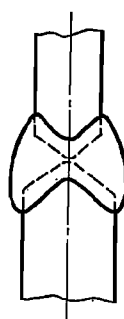
Fig. 1 (Continued)

(2) Horizontal Joint of Side Plate and Knuckle Plate

- (a) I-Groove Butt Joint (b) V-Groove Butt Joint (c) V-Groove Butt Joint (d) K-Groove Butt Joint

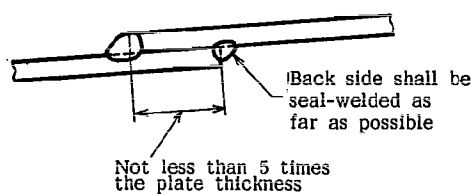


- (e) X-Groove Butt Joint (f) X-Groove Butt Joint

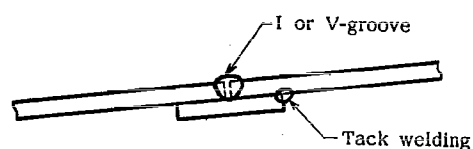


(3) Joints between Mutual Roof Plates

- (a) Lap Joint



- (b) Butt Joint (with Backing Metal)



- (c) Butt Joint (One Side or Both Side Welding)

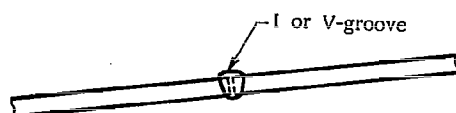
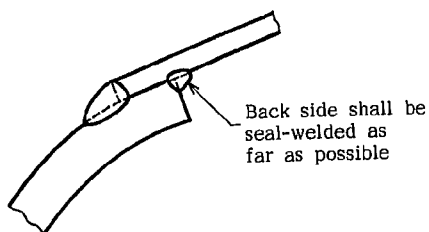


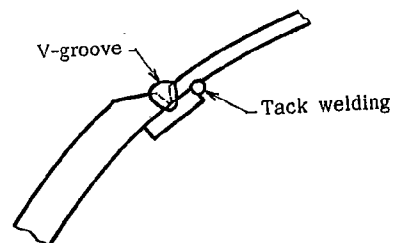
Fig. 1 (Continued)

(4) Joint of Roof Plate with Knuckle Plate

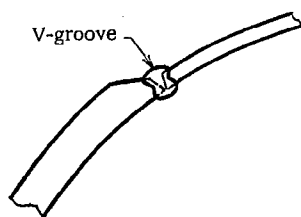
(a) Lap Joint



(b) Butt Joint (with Backing Metal)

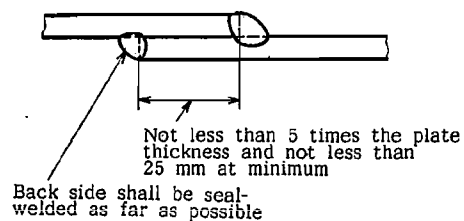


(c) Butt Joint

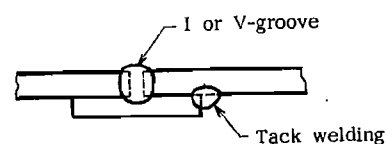


(5) Joint of Mutual Bottom Plates

(a) Lap Joint



(b) Butt Joint



(c) Butt One Side or Both Side Welding

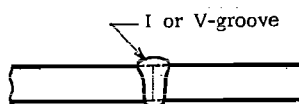
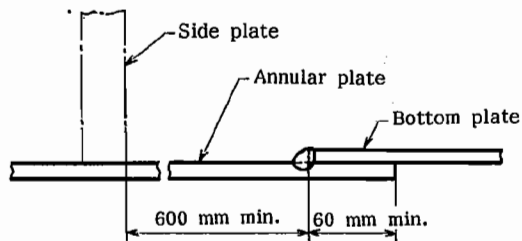


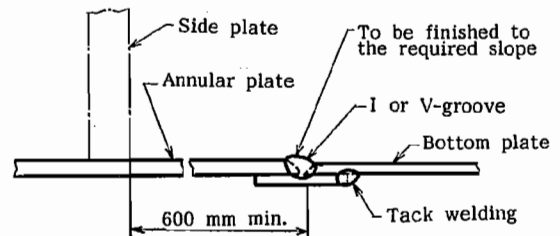
Fig. 1 (Continued)

(6) Joint of Bottom Plate with Annular Plate

(a) Lap Joint

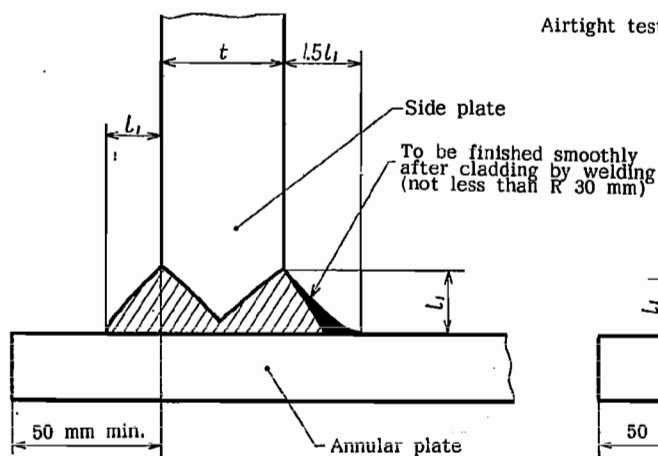


(b) Butt Joint

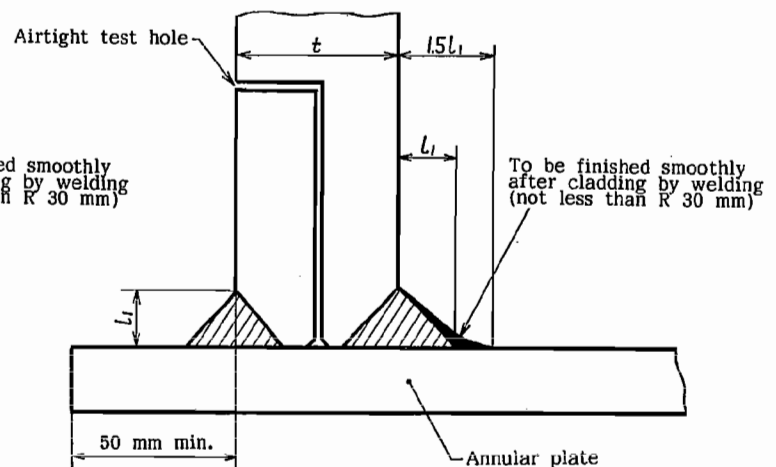


(7) T Joint of Annular Plate with Side Plate

(a) Example of Full Penetration Welding



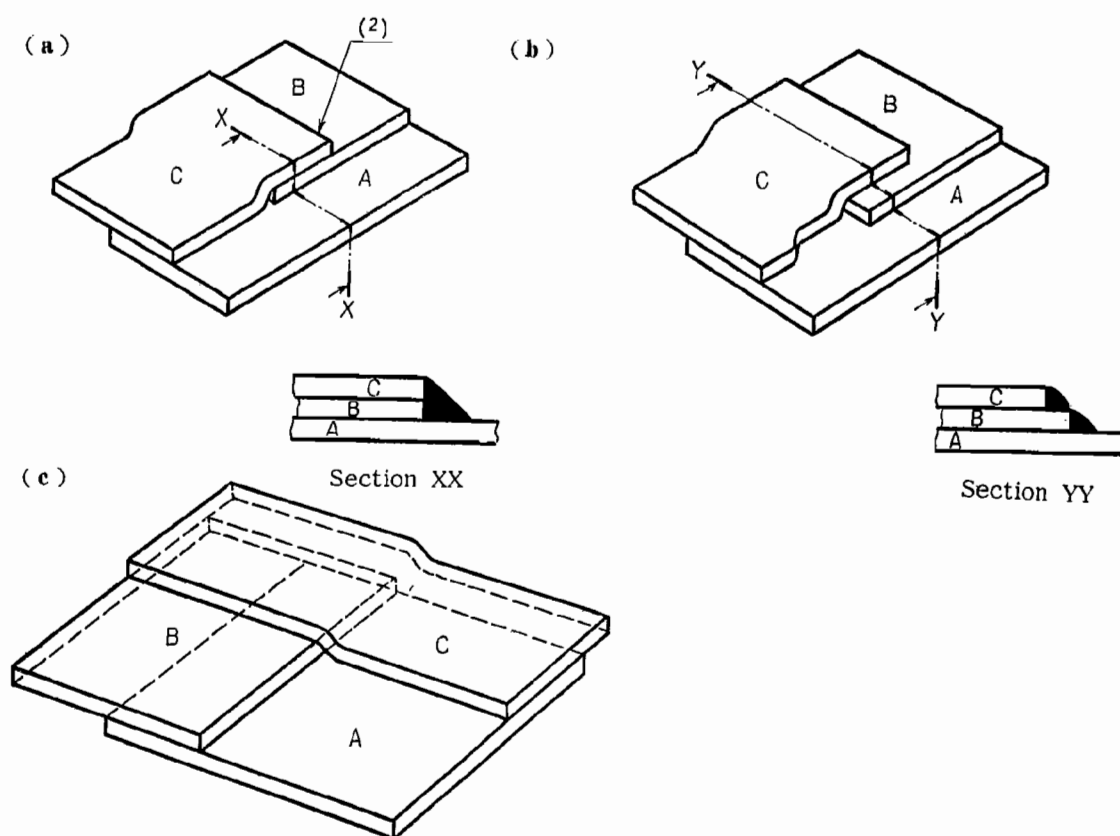
(b) Example of Joint with Airtight Test Hole



10
B 8251-1981

Fig. 2. Arrangement of Bottom Plates

(1) Assembly of Three Sheet Lap Part

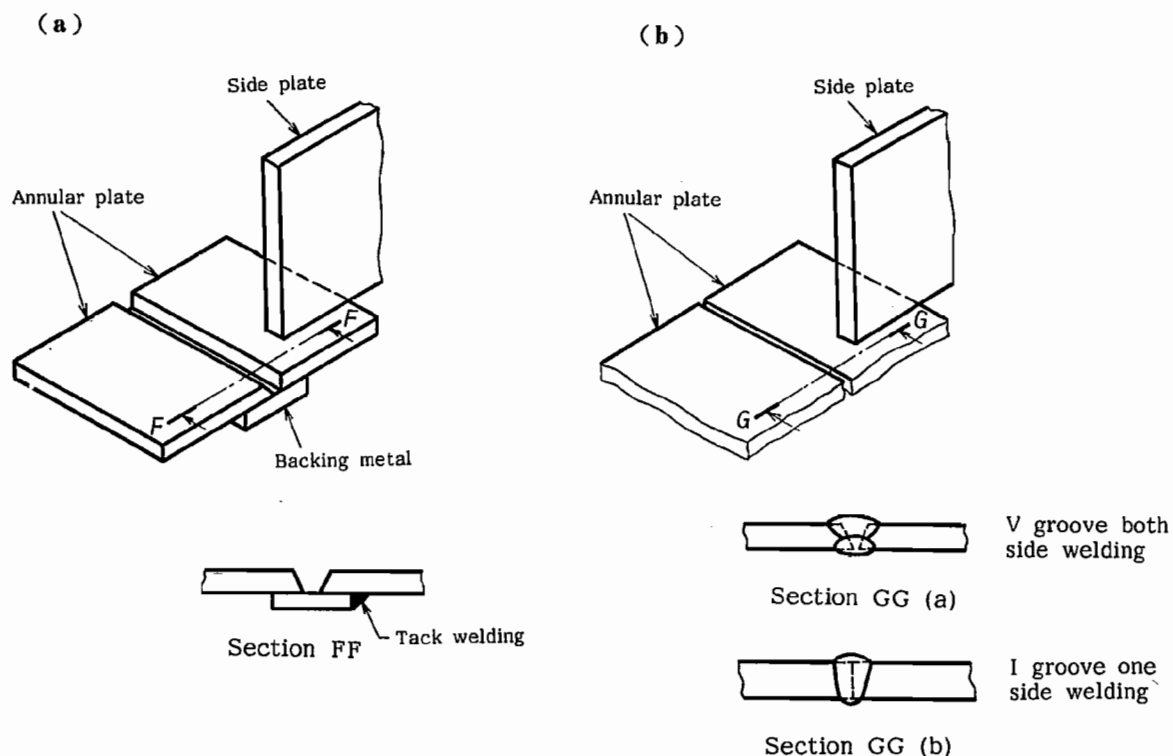


Note (2) This corner part shall be rounded or so notched that it is not interferent to welding.

Remark: A shows the lowest layer plate, B, the intermediate layer plate and C, the uppermost layer plate.

Fig. 2 (Continued)

(2) Assembly of Side Plate and Annular Plate



4.4 Inner Tank

4.4.1 Side Plate The structure of side plate shall be as follows:

(1) Thickness of Side Plate

- (a) The thickness of side plate shall be not less than the value calculated according to the following formula:

$$t = \frac{PD}{200 \sigma_a \eta - P} \quad \left\{ t = \frac{PD}{2 \sigma_a \eta - P} \right\}$$

where t : minimum plate thickness of side plate (mm)

P : pressure at lower weld line of each stage of side plate
(³) (kgf/cm²) {MPa}

D : inner diameter of inner tank (mm)

σ_a : allowable tensile stress of material (kgf/mm²)
{N/mm²}

η : welding efficiency, to be 1.00

Note (³) The pressure applied on the side plate shall be the sum of liquid head pressure when the liquid to be stored is filled up to the highest liquid level and the gas pressure corresponding to the design pressure.