Weldable hot rolled steel sheet piles

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Introduction

This Standard was established in 2000 and has gone through the revision in 2006 to this day. In the previous revision, the shape of the hat type was added. The revision at this time is to correspond to the increase of necessity of addition of the high strength steel, etc, afterwards. This Standard specifies the hot rolled steel sheet piles which are especially excellent in weldability, and also specifies carbon equivalent, free nitrogen and Charpy absorbed energy thereof which are not specified in MMS A 5528.

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

1 Scope

This Standard specifies the hot rolled steel sheet piles (hereafter referred to as "steel sheet piles") which are used for sheathing, coffering, structural foundations and other similar applications, and especially excellent in weldability.

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 applies.

MMS G 0320 Standard test method for heat analysis of steel products

MMS G 0321 Product analysis and its tolerance for wrought steel

MMS G 0404 Steel and steel products __ General technical delivery requirements

MMS G 0415 Steel and steel products __ Inspection documents

MMS G 1201 Iron and steel - General rules for analytical methods

MMS G 1228 Iron and steel - Methods for determination of nitrogen content

MMS G 3192 Dimensions, mass and permissible variations of hot rolled steel sections

MMS Z 2241 Metallic materials __ Tensile testing __ Method of test at room temperature

MMS Z 2242 Method for Charpy pendulum impact test of metallic materials

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3 Term and definition

For the purposes of this Standard, the following term and definition apply.

3.1 Free nitrogen

nitrogen solid dissolved in steel excepting nitrogen (nitride type nitrogen) contained in nitride which precipitates in the steel by combining with the alloy elements of high affinity with nitrogen (aluminum, titanium, vanadium and the like)

4 Classification and symbols

Steel sheet piles shall be classified into three types, and symbols thereof shall be as given in table 1.

Table 1 Classification symbol

Classification symbol
MM 295
MM 390
MM 430

5 Chemical composition

Steel sheet piles shall be tested in accordance with 10.1, and the heat analysis values thereof shall be as given in table 2.

Table 2 Chemical composition

Classification symbol	C	Si	Mn	P	S	Free nitrogen [a)]
MM 295	0.18 max.	0.55 max.	1.50 max.	0.040 max.	0.040 max.	0.0060 max. [b)]
MM 390						
MM 430						

If necessary, alloying elements other than those in this table may be added. For compositions contained in the calculation formula for carbon equivalent specified in clause 6 but not given in this table, the test of 10.1 shall be carried out,

Notes [a)] The free nitrogen shall be determined from the total quantitative value of nitrogen in the steel subtracted by the quantitative value of nitride type nitrogen. The determination method of total quantitative value of nitrogen shall be in accordance with MMS G 1228. The determination method of quantitative value of nitride type nitrogen shall be according to steel - nitride type nitrogen determination method shown in Annex A.

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The determination of nitride type nitrogen shall be carried out on the sample taken from the product. Total nitrogen content may be replaced by the value of free nitrogen content.

b) For the steel products whose free nitrogen content is over 0.006 0% to and including 0.010 0%, Charpy impact test shall be carried out on the test pieces subjected to the strain ageing (subjected to 3% strain, then kept 1 h at 250 ºC); and when the result thereof satisfies table 5, the specified value of free nitrogen may be determined as 0.010 0% or under.

6 Carbon equivalent

Carbon equivalent of steel sheet piles shall be calculated according to formula (1) by using the heat analysis values of 10.1 and the result shall be as given in table 3.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Si}{24} + \frac{Ni}{40} + \frac{Cr}{5} + \frac{Mo}{4} + \frac{V}{14} \quad \text{.....(1)}$$

where, C_{eq} : carbon equivalent (%)

Table 3 Carbon equivalent

Classification symbol	Carbon equivalent
MM 295	0.44 max.
MM 390	0.45 max.
MM 430	0.46 max.

According to the agreement between the purchaser and the manufacturer, the carbon equivalent may be determined according to formula (2) in place of table 3. However, in this case, the carbon equivalent according to formula (1) shall satisfy table 3.

$$C_{eq}(IIW) = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad \text{.....(2)}$$

where, C_{eq} (IIW) : carbon equivalent according to formula of IIW [1)] (%)

Note 1) International Institute of Welding

7 Mechanical properties

7.1 Yield point or proof stress, tensile strength and elongation

The tensile test shall be carried out on steel sheet piles in accordance with 10.2, and the yield point or proof stress, tensile strength and elongation thereof shall be as given in table 4.

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Table 4 Yield point or proof stress, tensile strength and elongation

Classification symbol	Yield point or proof stress N/mm^2	Tensile strength N/mm^2	Test specimen	Elongation %
MM SY295	295 min.	450 min.	No. 1A	18 min.
			No. 14B	24 min.
MM SY390	390 min.	490 min.	No. 1A	16 min.
			No. 14B	20 min.
MM SY390	430 min.	510 min.	No. 1A	14 min.
			No. 14B	19 min.
NOTE : 1 N/mm^2 = 1 MPa				

7.2 Coupling tensile strength of straight line shape steel sheet piles

Straight line shape steel sheet piles shall be tested in accordance with 10.3, and the coupling tensile strength [2)] shall be 3.92 MN/m or over for those of under 10 mm in thickness and 5.88 MN/m or over for those of 10 mm or over to and excluding 16 mm in thickness.

Note [2)] Maximum load converted to the value of 1 m in width where the test piece has been withstand during the coupling tensile strength test of straight line shape steel sheet piles.

7.3 Charpy absorbed energy

When steel sheet piles are subjected to the impact test of 10.2 under the conditions of table 5, Charpy absorbed energy thereof shall be as given in table 5. In this case, the Charpy absorbed energy shall be the mean value of the three test pieces, and shall be evaluated in accordance with 9.6 of MMS G 0404.

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Table 5 Charpy absorbed energy

Classification symbol	Test temperature [a]	Charpy absorbed energy J			Type and sampling direction of test piece [b]
		Height × width of test piece			
		Standard size test piece	Sub-size test piece		
	°C	10 mm × 10 mm	10 mm × 7.5 mm	10 mm × 5 mm	
MM 295	0	43 min.	32 min.	22 min.	V notch in rolling direction
MM 390					
MM 430					

Notes [a] When testing at the temperature lower than this temperature upon the agreement between the purchaser and the manufacturer, the test temperature may be replaced by that temperature.

[b] In the case of testing with the test piece sampled perpendicularly to the rolling direction, the test in the rolling direction may be omitted if the purchaser approves.

8 Shapes, dimensional tolerances and unit mass

Shapes, dimensional and tolerances thereof, and the unit mass shall be as follows.

a) The sectional shapes of steel sheet piles shall be U shape, straight line shape, Z shape, H shape and hat shape, and the designation of each part shall be as given in figure 1.

b) The coupling of steel sheet piles shall have a shape that allows adequate interlocking at the time of piling and easy disengagement at the time of extracting, and should be of a structure that secures water tightness as much as possible.

c) The shape and dimensional tolerance of steel sheet piles shall be as given in table 6.

d) The unit mass shall be upon the agreement between the purchaser and the manufacturer.

e) According to the designation by the purchaser, boring or mounting of accessories for suspension at construction may be carried out. The inspection, marking, etc. in this case shall be upon the agreement between the purchaser and the manufacturer.

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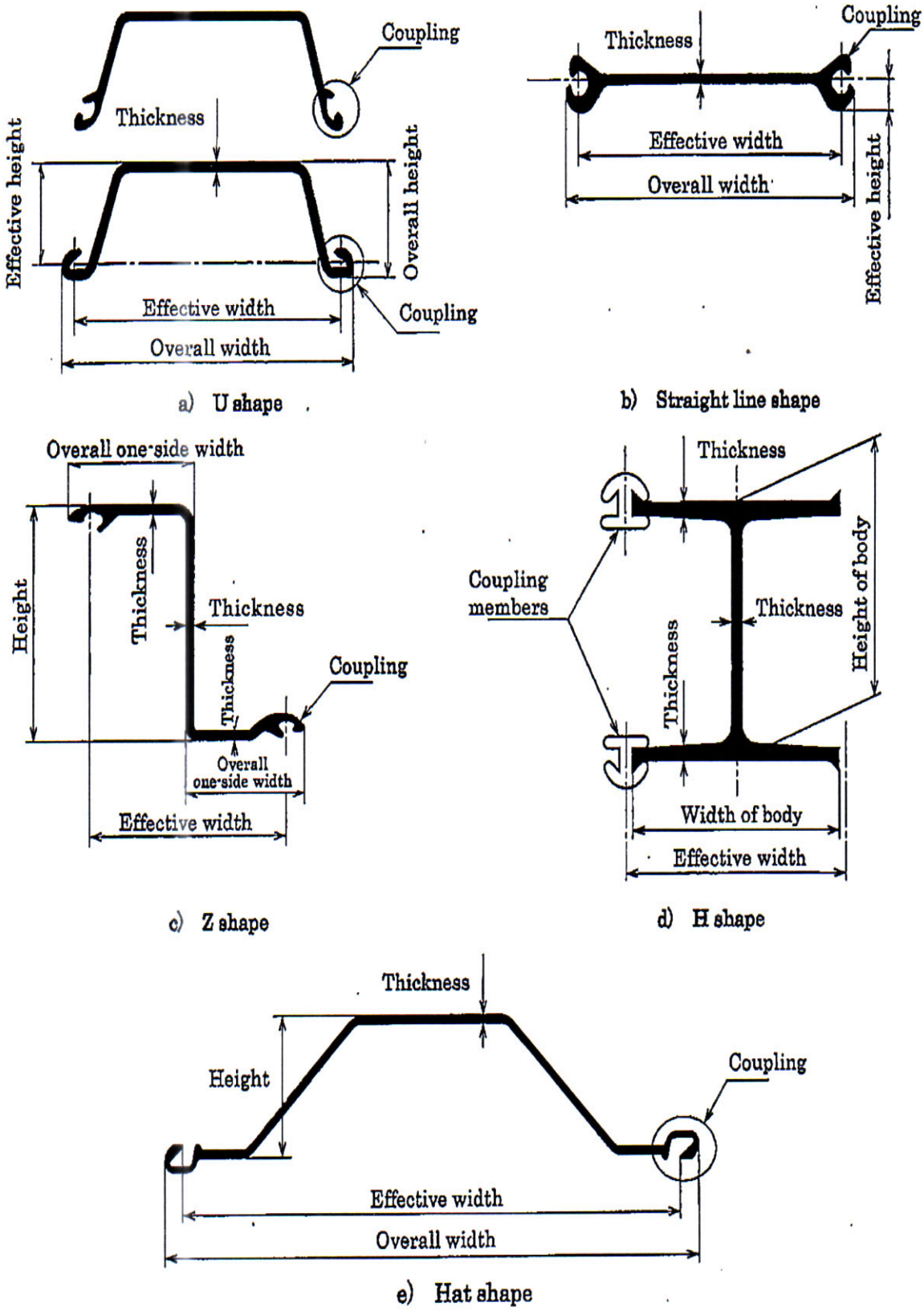

Figure 1 Designation of each part of section

Table 6 Shapes and dimensional tolerances

Items		Sectional shape				
		Straight line shape	Straight line shape	Hat Shape	Z shape	H Shape
Width		± 4mm	Effective width ≤ 400 ± 4 mm 400<Effective width ≤500 ± 4 mm 500<Effective width ≤600 + 6 mm -5 MM	+ 10 mm - 5 mm	+ 8mm -4 mm	± 4mm
Height		-	±4 %		±5 mm	±1.0 %
Thick-ness	Under 10 mm	+ 1.5 mm - 0.7 mm	+1.0mm -0.8mm	±1.0 mm		
	10 mm or over to and excl.6 mm	+ 1.5 mm - 0.7 mm	+1.2mm -0.8mm	±1.2 mm		
	16 mm or over	-	+1.5mm -0.3mm	±1.5 mm		
Length		+ Not specified 0				
Deflec- tion [a)]	10 m or un-der in length	Overall length (m) x 0.15 % max.	Overall length (m) x 0.10 % However, 20 mm max.	Overall length (m) x 0.12 % max.	Overall length (m) x 0.15 % max.	
	Over 10 m in length	[(Overall length – 10m) x 0.10%+15 mm]max.		[(Overall length - 10m) x0.10%+ 12 mm]max.	[(Overall length - 10m) x0.10% + 15 mm]max.	
Cam-ber [a)]	10 m or under in length	Overall length (m) x 0.20% max.	Overall length (m) x 0.20 % However, 20 mm max.	Overall length (m) x 0.25% max.	Overall length (m) x 0.15% max.	
	Over 10 m in length	[(Overall length - 10m) x0.10%+20 mm]max.		[(Overall length - 10m) x0.20% + 25 mm] max.	[(Overall length - 10m) x0.15% + 15 mm]max.	
Difference in vertically cut sections		4%of width max.			4 % of height and width max	
Overall width differ-ence		-	Within 1 m of end part in direction of length, the difference between maximum and minimum of overall width is 4 mm or under	-	-	-
End deflection		-	Within 1 m of end part in direction of length, the end deflection is 1.5 mm or under	-	-	-
Coupling mating angle		-	≥ 6°	≥4°	-	-

The applicable places of tolerance on width, height and thickness shall be as show in figure 1. The tolerances on width shall be applied to overall width for a straight time shape, a U Shape and a hat shape, to overall on side width for a Z shape, and to the width of body for an H shape. Tolerances on height shall be applied to overall height for a U shape and to the height of body for an H shape.

Notes a) Deflection shall be in the parallel direction to a sheet pile wall and camber shall be in the vertical direction To a sheet pile wall.

b) End deflection shall be ½ chord side measured value or tangent side measured value.

c) As for coupling mating angles, see figure 2.

9 Appearance

Steel sheet piles shall be free from defects detrimental to use. However, such defects may be removed or repaired in accordance with clause 9 of MMS G 3192.

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10. Tests

10.1 Chemical analysis test

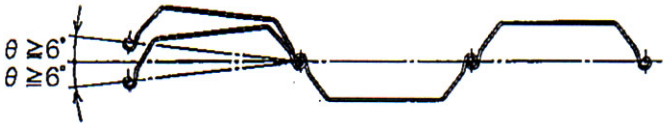
The chemical analysis test shall be as follows.

a) General requirements for chemical analysis test and the sampling method shall be as specified in clause 8 of MMS G 0404.

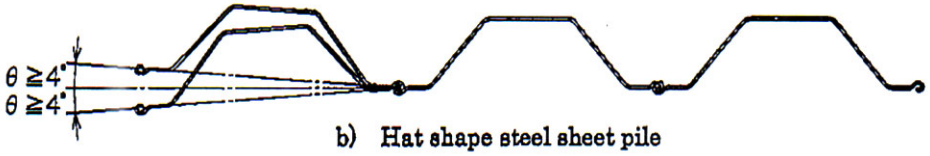
b) The heat analysis method shall be as specified in MMS G 0320.

c) The determination method of free nitrogen shall be as specified in the steel - nitride type nitrogen determination method shown in Annex A.

d) The determination of nitride type nitrogen in measurement of free nitrogen shall be carried out on the sample taken from from the product of every heat. The sampling method in this case shall be as specified in clause 4 of MMS 0321. The tensile test piece after fracture may be used as the specimen.



a) U shape steel sheet pile



b) Hat shape steel sheet pile

Figure 2 Coupling mating angle of U shape and hat shape steel sheet pile

10.2 Mechanical test

10.2.1 General

General requirements for mechanical test shall be in accordance with clause 7 and clause 9 of MMS G 0404. The sampling method of the specimen shall be in accordance with Class A in 7.6 of MMS G 0404, and the number of test pieces and the sampling position shall be as follows.

a) Number of tensile test pieces, The steel sheet piles of the same heat, same sectional shape and same sectional dimensions constitute one lot, from which one tensile test piece shall be taken. When the lot exceeds 50 t in mass, two test pieces shall be taken.

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b) Number of impact test pieces, The steel sheet piles of the same heat, same sectional shape and same dimensions constitute one lot, form which one specimen for impact test shall be taken, and three test pieces shall be taken from the specimen.

c) Sampling position and sampling direction of tensile test piece The tensile test piece shall be taken parallel to the rolling direction from the position as given in figure 3. When sampling according to figure 3 is impracticable, the test piece shall be taken as close to the specified position as possible.

d) Sampling position of impact test piece The specimen for sampling of impact test pieces shall be taken from the position as given in figure 3. The sampling position in the thickness direction of impact test pieces shall be as given in figure 4.

10.2.2 Test piece

The tensile test piece and the impact test piece shall be as follows.

a) The tensile test piece shall be No. 1A or No. 14B in MMS Z 2541.

b) The impact test piece shall be the V-notch test pieces in MMS Z 2242. When the sampling of the standard size test piece is impracticable, the sub - size test piece of 7.5 mm or 5 mm in width may be used.

10.2.3 Test method

a) The tensile test method shall be in accordance with MMS Z 2241.

b) The impact test method shall be in accordance with MMS Z 2242.

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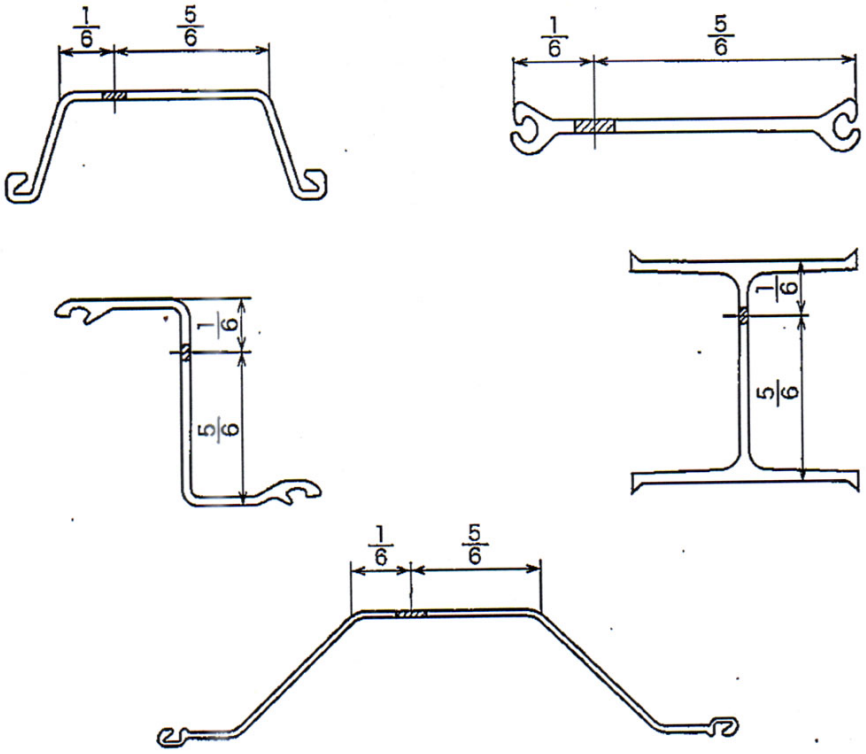

Figure 3 Sampling position of specimen for sampling tensile and impact test piece

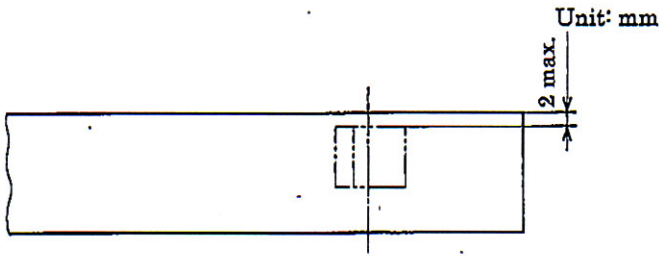

Figure 4 Sampling position of impact test piece in thickness direction

10.3 Coupling tensile test on straight line shape steel sheet piles

The coupling tensile test on a straight line shape steel sheet piles shall be as follows.

a) Two coupling tensile test pieces shall be taken at right angles to the rolling direction from each lot of the same heat and the same sectional dimensions. In this case, the dimensions of one test piece shall be about 100 mm in width and about 300 mm in length, and each one of the pair shall have a coupling on one side and thus representing the couplings on both sides of the steel sheet pile.

b) The coupling tensile test shall be carried out by measuring the disengagement strength of coupling (the breaking strength if the test piece breaks before the disengagement of the coupling) in accordance with MMS Z 2241. In this case, the test piece shall be set in such a manner that the two coupling engage each other with the tensile axis parallel to the axis of the test pieces, as given in figure 5. The distance between grips shall be 400 mm or over.

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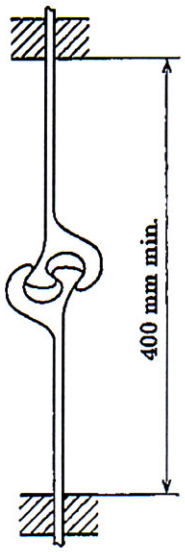

Figure 5 State of test pieces adequately set

11 Inspection

Inspection shall be as follows.

a) General requirements for inspection shall be in accordance with MMS G 0404.

b) Chemical composition shall comply with the requirements of clause 5.

c) Carbon equivalent shall comply with the requirements of clause 6.

d) Mechanical properties shall comply with the requirements of clause 7.

e) Shapes and dimensions shall comply with the requirements of clause 8.

f) Appearance shall comply with the requirements of clause 9.

12 Re-inspection

Re-inspection shall be as follows.

a) For steel sheet piles having failed to meet the requirements of tensile test or coupling tensile test, retest may be carried out for acceptance in accordance with 9.8 of MMS G 0404.

b) For steel sheet piles having failed to meet the requirements of impact test specified in 9.6 of MMS G 0404, retest may be carried out for acceptance in accordance with 9.8 of MMS G 0404.

13 Marking

For each steel sheet pile that has passed the inspection, the following items shall be marked by suitable means so as to ensure that those markings remain until the time of pile driving. However, part of the items may be omitted in the case where approval is given by the purchaser.

a) Classification symbol

b) Heat number or inspection number

c) Symbol (agreed between the purchaser and the manufacturer) indicating shape and dimensions (or sectional performance)

d) Length (in meter)

e) Manufacturer's name or its abbreviation

14 Report

The report shall be in accordance with clause 13 of MMS G 0404, and the manufacturer shall submit the standard designation 3.1B in table 1 of MMS G 0415 to the purchaser. When inspection documents other than this are required, the purchaser shall make a request to the manufacturer at the time of ordering. For reporting the free nitrogen content, the fact that the values in table 2 are satisfied or the fact that the result of strain aging Charpy impact

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test carried out according to Note [1)] in table 2 satisfies the values specified in table 5 shall be noted in the report. The total nitrogen content may be reported instead of free nitrogen content if the total nitrogen content meets the requirements of nitrogen in table 2.

Further, alloying elements listed in table 2 and contained in the formula of carbon equivalent, and other chemical compositions than those in table 2 according to the footnote in table 2 are added, the contents thereof shall be appended.

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Annex A (normative)

Steel - nitride type nitrogen determination method

A.1 Scope

This Annex specifies the determination method of the nitride type nitrogen in steel products in order to obtain the free nitrogen content ratio specified in the text. However, silicon nitride cannot not be determined as nitride type nitrogen by this method.

A.2 General requirements

General requirements common to the determination method shall be in accordance with MMS G 1201.

A.3 Summary

After decomposing iron being the matrix of a sample by a suitable method, insoluble residue is filtered by a polycarbonate membrane filter. The captured insoluble residue is decomposed by sulfuric acid and potassium sulfate. After making the solution alkaline by sodium hydroxide, steam distillation is carried out, the distillated ammonia is absorbed in boric acid, water or dilute sulfuric acid. And the absorbed ammonia in the solution is determined by an amid sulfuric acid titration method, a bis (1-pheny1-3 methyl-5 pyrazolone) absorptiometry or indophenol blue absorptiometry.

A.4 Reagents

The reagents shall be as follows.

A.4.1 Sulfuric acid

A.4.2 Potassium sulfate

A.4.3 Methanol

A.4.4 Methyl acetate

A.4.5 Bromine - methanol solution 10% (volume fraction)

Measure out 135 ml of methanol by using a measuring cylinder and transfer it into an Erlenmeyer flask (300 ml). Add 15 ml of bromine to this by using a measuring cylinder or a conical liquid meter, and stir the solution. This solution shall be prepared immediately before the test.

A.4.6 Bromine methyl acetate solution 10% (volume fraction)

Measure out 135 ml of methyl acetate by using a measuring cylinder and transfer it into an Erlenmeyer flask (300 ml). Add 15 ml of bromine to this by using a measuring cylinder or a conical liquid meter, and stir the solution. This solution shall be prepared immediately before the test.

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A.4.7 Iodine - methanol solution 0.14 g/ml

Measure out 42 g [1)] of iodine and transfer it into a beaker (300 ml). Add methanol and stir to make the total quantity 300 ml 1). This solution shall be prepared immediately before the test.

Note [1)] According to the quantity to be used, the measuring quantity and the total q uantity may be changed as long as this ratio is observed.

A.4.8 Tetramethylammonium chloride (TMAC) acetylacetone - methanol electrolyte

Measure out 5 g of TMAC by a scale, 50 ml of acetylacetone by using a measuring cylinder or a conical liquidometer, and transfer them into a beaker (500 ml). Add methanol and stir to make the total quantity 500 ml. This solution shall be prepared immediately before the test.

A.5 Operation

A.5.1 Separation of nitride type nitrogen

Separation of nitride type nitrogen shall be in accordance with any of the following.

a) Iodine methanol method

1) Weigh out 1 g to 5 g of a sample to the nearest 1 mg, transfer it into a dry common ground Erlenmeyer flask (500 ml) and add 50 ml of iodine - methanol solution (A.4.7) per 1 g of the sample. Determine the amount of sample to be weighed out so that the nitrogen amount calculated from the estimated content of nitride type nitrogen comes within the applicable range of the determination method of nitrogen in MMS 1228 to be applied. Mount a dry common ground coiled condenser and warm to about 60 ºC in a water bath. During warming, stir the solution by ultrasonic equipment or magnetic stirrer. When precipitation occurs during decomposition, increase the amount of iodine - methanol solution. When decomposition of the basic material is complete, take out the flask from the water bath, and cool it.

2) Suction - filter the solution by using a polycarbonate membrane filter (47 mm Ø, 0.2 µm in pore diameter) and collect the insoluble residue on the filter. Wash it with methanol until coloration of the filter is no longer observed.

3) Detach the filter from the suction filter and dry filter at room temperature.

b) Bromine methyl acetate method

1) Weigh out 1 g to 5 g of a sample to the nearest 1 mg, transfer it into a dry common ground Erlenmeyer flask (300 ml) and add 150 ml of bromine methyl acetate solution (A.4.6). Determine the amount of sample to be weighed out so that the nitrogen

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amount calculated from the estimated content of nitride type nitrogen comes within the applicable range of the determination method of nitrogen in MMS G 1228 to be applied. Mount a dry common ground coiled condenser and decompose it at room temperature. During decomposition, stir the solution by ultrasonic equipment or magnetic stirrer.

2) Suction - filter the solution by using a polycarbonate membrane filter. (47 mm Ø, 0.2 μm in pore diameter) and collect the insoluble residue on the filter. Wash it with methyl acetate until coloration of the filter is no longer observed.
3) Detach the filter from the suction filter and dry to filter at room temperature.

c) **Bromine - methanol method**

1) Weigh out 1 g to 5 g of a sample to the nearest 1 mg, transfer it into a dry common ground Erlenmeyer flask (300 ml) and add 150 ml of bromine methanol solution (A.4.5). Determine the amount of sample to be weighed out so that the nitrogen amount calculated from the estimated content of nitride type nitrogen comes within the applicable range of the determination method of nitrogen in MMS G 1228 to be applied. Mount a dry common ground coiled condenser and decompose it at room temperature. During decomposition, stir the solution by ultrasonic equipment or magnetic stirrer.
2) Suction - filter the solution by using a polycarbonate membrane filter. (47 mm Ø, 0.2 μm in pore diameter) and collect the insoluble residue on the filter. Wash it with methyl acetate until coloration of the filter is no longer observed.
3) Detach the filter from the suction filter and dry to filter at room temperature.

d) **Controlled potential electrolysis method**

1) Polish the surface of a sample cut out into an appropriate sized block with an abrasive paper (P120 to P400 in grain size of abrasive grain) and ultrasonically wash it in methanol. After drying, weigh the mass.
2) In an electrolytic bath wherein 500 ml of TMAC acetyl acetone methanol electrolyte (A.4.8) is contained, make the sample an anode either by hanging with a platinum wire or by fixing with a magnet, make platinum or copper a cathode, electrolyze under a specific electric potential by using a controlled potential electrolytic equipment, and dissolve the basic material. Make the dissolved amount of the basic material about 1g [2)].

Not 2) When electrolyzed at 100 m A for 1 h, about 0.1 g is dissolved

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3) After the electrolysis ends, take out the sample from the electrolytic bath, put it into a dry beaker (200 ml), add methanol until the sample is completely immersed, wash ultrasonically and shake off the attached insoluble residue. Filter by sucking the cleaning liquid and the electrolyte of the sample by using a polycarbonate membrane filter (47 mm Ø, 0.2 μm in pore diameter), and collect the insoluble residue on the filter. Wash it by methanol until coloration of the filter is no longer observed.
4) Detach the filter from the suction filter and dry the filter at room temperature.
5) Sufficiently wash the sample with methanol. After drying weigh the mass, subtract it from the mass obtained in [1)] and make it the dissolved amount of the sample.

A.5.2 Decomposition of insoluble residue

Transfer the insoluble residue obtained in A.5.1 a), A.5.1 b), A.5.1 c) or A.5.1 d) into an Erlenmeyer flask (300 ml) with polycarbonate membrane filter, and add 10 g of potassium sulfate and 20 ml of sulfuric acid. After vaporizing the moisture by moderate heating, mount a funnel on the mouth of the flask, let it generate the white fumes of sulfuric acid by heating for about 1 h and decompose the insoluble residue, etc. After allowing to cool down to room temperature, add 10 ml of water little by little and eliminate sulfur dioxide by boiling for a while. Cool it to room temperature.

A.5.3 Determination of nitrogen

The determination of nitrogen in the solution obtained in A.5.2 shall be according to any of the following.

a) Ammonia distillation separation amidosulfuric acid titration method According to Annex 1 of MMS G 128.
b) Ammonia distillation separation bis (1-phenyl-3methyl-5pyrazolone) absorptiometry According to Annex 2 of MMS G 1228.
c) Ammonia distillation separation indophenol blue absorptiometry According to Annex 3 of MMS G 1228.

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