OBJECTIVES: This specification covers the plate steels of various chemical compositions and mechanical properties that are used in the frames of industrial fork lift trucks and similar applications. These materials are divided into five classes as follows:

Class

1 Low Carbon Steels – No mechanical property requirements.

2 Low Carbon Steels – 230 N/mm² (33 ksi*) Minimum Yield Strength

3 Low Carbon Steels – 250 N/mm² (36 ksi*) Minimum Yield Strength

4 High Strength, Low Alloy (HSLA) Steels – 290 to N/mm² (42 to 65 ksi) Yield Strength

5 Quenched and Tempered High Strength, Low Alloy (HSLA) Steels – 690 N/mm² (100 ksi) Minimum Yield Strength

These materials are normally available in sheets, plates, bars, and shapes, although not all Classes are available in all forms. These materials can normally be formed, bent, and welded, although different bend radii and welding procedures may be required for different Classes.

* ksi = psi x 1000. For example, 30 ksi = 30,000 psi.

SCOPE: This specification replaces these existing HC-specifications for **new design drawings**:

HC-115 Class	Previous HC-Specification that is replaced	Chinese Equivalent Grade
Class 1	HC-16	Grade Q195 per GB/T 700-2006
Class 2	None	Grade Q235 per GB/T 700-2006
Class 3	HC-7	Grade 345B per GB/T 1591-2008
Class 4	HC-112	Grade Q345 to Q460 per GB/T 1591-2008
Class 5	HC-17	Grade Q690 per GB/T 16270-2009

Class 1 materials are intended for non-load carrying applications, or where the applied loads are extremely small. This material typically has good machinability, formability, and weldability. It typically exhibits relatively low wear resistance. These materials are normally available in sheets, strips, plates and bars. Not all thicknesses are available. Check thickness availability before specifying.

Class 2 materials are intended for low stressed [230 N/mm² (33 ksi) minimum yield strength] applications. This material is only available in sheets up to 6 mm (0.236 inch) thick in the United States. If thicker materials are required in the United States, **Class 3** materials should be specified. This material, however, is available in sheets and plates in thicknesses up to 40 mm (1-1/2 inches) in other countries. This material is easily machined, formed, and welded. Not all thicknesses are available. Check thickness availability before specifying.

Class 3 materials are intended for low stressed [250 N/mm² (36 ksi) minimum yield strength] applications. This material is available in plates to over 200 mm (7.9 inches) thick. This material is easily machined, formed, and welded. Not all thicknesses are available. Check thickness availability before specifying.

Class 4 materials are as-rolled high strength, low alloy (HSLA) steels intended for higher stressed applications than **Class 2 and 3** materials. The yield strengths of this material range from 290 to 450 N/mm² (42 to 65 ksi). This material is available in sheets up to 15 mm (0.6 inches) in thickness and plate up to 100 mm (3.9 inches thick for higher yield strength materials and up to 250 mm (9.8 inches) thick lower strength levels. This material is also available in various shapes, although not all shapes are available in all grades. This material can be easily machined and formed, although larger radii are required in comparison to **Class 1, 2 and 3** materials. This material can be welded, although specific procedures are required. Not all thicknesses are available. Check thickness availability before specifying.

Class 5 materials are quenched and tempered high strength, low alloy (HSLA) steels having minimum yield strength of 690 N/mm² (100 ksi). This material is normally produced under various brand names by different steel suppliers, which vary in chemical composition and the maximum thickness available. This material is normally only available in plate. This material can be machined, but at lower feeds and speeds than **Class 1, 2 or 3** materials. This material can be formed, however, large radii are required This material can be welded, although special welding procedures are required. Certain grades of this class should not be stress-relieved after welding.

SUGGESTED USE OF THIS SPECIFICATION

When specifying materials per this specification, the Designer is encouraged to specify all the materials classes that are appropriate for the design. This is done to allow maximum sourcing flexibility.

For example: If **Class 1, 2 and 3** materials are all suitable for a design, the Designer should specify all three as optional materials on the drawing.

Design must reference HCE-151, Fit and Finish Zones, in order to confirm if the individual component is surface critical, Zone A or B. If the component is surface critical, Zone A or B, secondary processing will be required to eliminate the mill scale inherently present on the surface. To achieve maximum effectiveness of secondary process such as, but not limited to, Temper Pass, the material thickness in Zones A and B should be targeted at or below 12.7mm (0.5”) as mill scale presence will increase with the thickness of material.

CITED: See Master Index or attached Appendix for a complete list of Citing & Cited Documents.

REQUIREMENTS: Quality and Condition

Accuracy & Material: Refer to associated ASTM specifications and items documented in this standard.

Surface Quality: ASTM and European specifications make note that mill scale is inherent to the hot rolling process and the material should be avoided or secondary processes used to ensure required surface conditions are achieved. This standard, along with the Zones specified in HCE-151, will help guide Design to define the appropriate drawing specification and User Plants or Suppliers to establish the appropriate secondary process or boundary to manage items such as mill scale, pitting and laminations.

Secondary processing can be, but is not limited to, temper pass, pickled, grit blasted or surface grinding. Grinding to remove surface imperfections is permitted so long as the material thickness is not decreased below the minimum specified value, including permitted thickness tolerance. When surface grinding is used the final process should use a grit / process that will not read thru the finish painted part and must smoothly transition into areas with no rework. No welding is permitted to conditioned surfaces or edges.

Surface Requirements for Temper Pass Steel up to 12.7mm (0.5"):
Material must be free of scale (Primary or Secondary)
Surface defects are not to exceed the following criteria:

1. Can be perceptible to the touch and depth may not exceed 0.127mm (0.005")
2. Up to 6 imperfections maximum in a 254mm x 254mm (10" x 10") area
3. Distance between areas must be at least 914mm (36")
4. Maximum of 5% of total area with defects

Surface Requirements for Steel exceeding 12.7mm (0.5"):

Primary and secondary scale cannot be eliminated by the Temper Pass process when the material thickness exceeds 12.7mm (0.5"). When material exceeding this thickness is required in A and B Zones of the truck, secondary processing will be required if scale (Primary or Secondary) is present on the material. Design is to consider the appropriate drawing requirements (Descale, Deburr, etc.…) to ensure requirements are clearly communicated.

Scale is permitted in truck Zones C and D as these areas are not visible to the customer in their normal line of sight. However, if the level of scale is severe enough, responsible parties may need to establish a maximum condition boundary to guide the component part suppliers or HYG's manufacturing process if raw material is received. Boundaries should be documented with clear pictures that can be maintained and used by all required inspection groups. If a Boundary cannot be achieved, secondary processing may be required.

Definitions and images of possible imperfections can be found at the end of this document.

CLASS 1 MATERIALS

Chemical Composition

The chemical analysis of this material is shown in Table 1. Standard product analysis tolerances included in SAE specifications, ASTM A29/A29M, or ASTM A6/A6M68 shall apply.

Table 1
Chemical Analysis of **Class 1** Material

Element	Weight Percent
Carbon	0.12 max.
Manganese	0.60 max.
Sulfur	0.050 max.
Phosphorous	0.040 max.

Alternate Specifications

Chinese: Grade Q195 per GB/T 700-2006

Table 2
Mechanical Properties of **Class 1** Material
(Typical values; not a part of the specification)

Property	Typical Value
Yield Strength, N/mm² (ksi)	138 – 276 [20 – 40]
Elongation in a 50 mm (2” Gage Length, %	25 min.
Hardness, Rockwell B	60 max.

Processing

This material can be produced from rimmed, capped, or killed steels, although capped or killed steels are preferred due to their more uniform properties throughout the thickness.

Dimensional Tolerances

Dimensional tolerances shall be as included in ASTM A29/A29M for bars, and to ASTM A568/A568M for sheet.

Hot-wrought (rolled) steel bars shall conform to special Bar quality as included in ASTM A576. Cold-finished bars produced in accordance with ASTM A108 are specified to be made from hot-wrought bars in accordance with ASTM A576. Bars shall be supplied in the as-rolled condition.

Steel sheet shall conform to commercial quality, cold-rolled as included in ASTM A1008 or commercial quality, hot-rolled as included in ASTM A1011.

Method of Specifying

HC-115, CLASS 1
HC-115, CLASS 1, 2 OR 3
HC-115, CLASS 1, 2, 3 OR 4
Etc.

Note: HC-115 CLASS 2 and 3 can often be substituted for CLASS 1. When appropriate, CLASS 2 and CLASS 3 should also be specified on the drawing when CLASS 1 is specified.

General Information (NOT A PART OF THE SPECIFICATION)

This material is commonly stocked by steel service centers in plate and bar forms. The material can also be drawn in complex shapes. The material is easily welded by all common welding methods using low carbon steel filler metals. No special precautions, except for use of low hydrogen practices, are normally required, although the steel should be above approximately 4° C (40° F).

Recommended bend radii are:

Material Thickness, mm (in)	Minimum Bend Radius (T = material thickness)
20 (3/4) and under	1T
over 20 to 25 (3/4 to 1)	2T
over 25 to 40 (1 to 1-1/2)	3T
over 40 to 50 (1-1/2 to 2)	5T
over 50 (2)	6T

CLASS 2 MATERIALS

Similar HYG Standards

There are no HYG material standards that are similar to this Class of material.

Chemical Composition

The chemical analysis of this material is shown in Table 2A. Standard product analysis tolerances included in ASTM A568/A568M shall apply.

Table 2A
Chemical Analysis of **Class 2** Material

Element	Weight Percent
Carbon	
Thicknesses up to 16 mm (5/8 inch)	0.17 max.
Thicknesses of 16 to 40 mm (5/8 to 1-1/2 inch)	0.20 max.
Manganese	1.40 max.
Silicon	Optional
Phosphorous	0.045 max.
Sulfur	0.045 max.
Nitrogen	0.009 max. (1)

(1) The maximum value for nitrogen does not apply if the chemical analysis exhibits an aluminum content of 0.020% minimum, or if sufficient other nitrogen binding elements are present. These nitrogen-binding elements shall be reported in the test report.

Alternate Specifications

Chinese: Grade Q235 per GB/T 700-2006

European: Grade S235J per EN

Mechanical Properties

Mechanical properties of this material are shown in Table 2B

Table 2B
Mechanical Properties of **Class 2** Material

Yield Strength	
Thicknesses of less than 16 mm (5/8 inch)	235 N/mm² (34 ksi) minimum
Thicknesses of 16 to 40 mm (5/8 to 1-1/2 inch)	225 N/mm² (33 ksi) minimum

Dimensional Tolerances

The dimensional tolerances for sheets shall be as specified in ASTM A568/A568M. The dimensional tolerances for plates shall be per the appropriate national or EN standard corresponding to the country of purchase.

Method of Specifying

HC-115, CLASS 2
HC-115, CLASS 2 OR 3
HC-115, CLASS 2, 3 OR 4
Etc.

Note: HC-115 Class 3 can often be substituted for Class 2. When appropriate, Class 3 should also be specified on the drawing when Class 2 is specified.

Certification

The supplier shall include with each material or subcontracted parts lot a statement certifying compliance to this material specification, signed by an authorized representative of the supplier. The certification for each heat of steel shall include the results of chemical analysis and mechanical testing.

General Information (NOT A PART OF THE SPECIFICATION)

This material is primarily intended for use in countries other than the United States, where 230 N/mm² (33 ksi) yield strength material is more commonly available. This material is only available in the United States as sheet or strip material in thicknesses up to 6 mm (0.236 inch). **Class 3** material having a yield strength of 250 N/mm² (36 ksi) yield strength is more commonly available in the United States, and should normally be specified.

This material can be welded by all common welding methods using low carbon steel filler materials. Use of low hydrogen practices are normally required, and the steel should be above approximately 4° C (40° F).

Recommended bend radii are:

Material Thickness, mm (inch)	Minimum Bend Radius (T = material thickness
20 (3/4) and under	1T
over 20 to 25 (3/4 to 1)	2T
over 25 to 40 (1 to 1-1/2)	3T

CLASS 3 MATERIALS

Chemical Composition

The chemical analysis of this material is shown in Table 3. Standard product tolerances included in ASTM A6/A6M/A6M or ASTM A568/A568M shall apply.

Table 3
Chemical Analysis of **Class 3** Material

Product	Sheet	Shapes *(A)*	Plates *(B)*				
Thickness, mm (inches)	To 6mm (1/4 include	All	To 20 [3/4 to 1-1/2], incl	Over 20 to 40 [3/4 to 1-1/2], incl.	Over 40 to 65 [1-1/2 to 2-1/2], incl.	Over 65 to 100 [2-1/2 to 4], incl.	Over 100 [4]
Carbon, max %	0.25	0.26	0.25	0.25	0.26	0.27	0.29
Manganese, %	0.90 max.	---	---	0.80-1.20	0.80-1.20	0.85-1.20	0.85-1.20
Phosphorous, max %	0.035	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max %	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Silicon, %	---	0.40 max.	0.40 max.	0.40 max.	0.15-0.40	0.15-0.40	0.15-0.40
Copper, min., % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Product	Bars			
Thickness, mm (inches)	To 20 (3/4 incl.	Over 20 to 40 [3/4 to 1-1/2] Incl.	Over 40 to 100 1-1/2 to 2-1/2 Incl.	Over 100 [4]
Carbon, max %	0.26	0.27	0.28	0.29
Manganese, %	---	0.60-0.90	0.60-0.90	0.60-0.90
Phosphorous, max %	0.04	0.04	0.04	0.04
Sulfur, max %	0.05	0.05	0.05	0.05
Silicon, %	0.40 max.	0.40 max.	040 max.	0.40 max.
Copper, min., % when copper steel is specified	0.20	0.20	0.20	0.20

(A) – Manganese content of 0.85 – 1.35% and silicon content of 0.15 – 0.40% is required for shapes over 634 kg/m [426 lb./ft].

(B) – For each reduction of 0.01% below the specified carbon maximum, an increase of 0.06% manganese above the specified maximum will be permitted up to the maximum of 1.35%.

Alternate Specifications

Chinese: Grade 345B per GB/T 1591-2008 or GB/T 700-2006 Q275

European: Grade S275J per EN 10025-2:2004

Tensile Properties

The tensile properties are shown in Table 4. These are the specified values.

Table 4
Tensile Requirements *(A)* of **Class 3** Materials

Sheet	
Tensile Strength, N/mm² [ksi]	365 [53] min.
Yield Strength, N/mm² [ksi]	250 [36] min.
Elongation 50 mm [2 inch] gage Length % Thickness under 6.0 to 2.5 mm [0.230" to 0.097"] Thickness under 2.5 to 1.6 mm [0.097" to 0.064"] Thickness under 1.6 to 0.65 mm [0.064" to 0.025"]	 22 min. 21 min. 17 min.
Plates, Shapes, *(B)* and Bars:	
Tensile Strength, N/mm² [ksi]	400-550 [58-80]
Yield Strength, N/mm² [ksi]	250 *(C)* [36]
Plates and Bars *(D), (E):*	
Elongation in 50 mm [2in.] min., %	23
Shapes:	
Elongation in 50 mm [2in.] min., %	21 *(B)*

(A) – See Specimen Orientation under the tension tests section of ASTM A6/A6M/A6M.

(B) – For wide flange shapes over 634 kg/m [426 lb./ft], the 550 N/mm² [80 ksi] maximum tensile strength does not apply and a minimum elongation in 50 mm [2 in.] of 19% applies.

(C) – Yield point 220 N/mm² [32 ksi] for plates over 200 mm [8 in.] in thickness.

(D) – Elongation not required to be determined for floor plate.

(E) – For plates wider than 600 mm [24 in.], the elongation requirement is reduced two percentage points.b See elongation requirement adjustments under the Tension Tests section of ASTM A6/A6M/A6M.

Processing

Plate and sheet shall be structural quality. Plates and sheets 40 mm (1-1/2 inches) thick and under are semi-killed. Plates over 40 mm (1-1/2 inches thick) are fully killed.

Bars under 60.7 kg/m (40.8 lbs./ft) are merchant quality. Larger bars are special quality, fully killed.

Shapes are structural quality, semi-killed.

Dimensional Tolerances

Dimensional tolerances shall be as included in ASTM A6/A6M/A6M and ASTM A568/A568M

Method of Specifying

HC-115, CLASS 3
HC-115, CLASS 2 OR 3
HC-115, CLASS 2, 3 OR 4
Etc.

Note: HC-115 Class 2 can often be substituted for Class 3. When appropriate, Class 2 should also be specified on the drawing when Class 3 is specified.

Certification

The supplier shall include with each material or subcontracted parts lot a statement certifying compliance to this material specification, signed by an authorized representative of the supplier. The certification for each heat of steel shall include the results of chemical analysis and mechanical testing.

General Information (NOT A PART OF THE SPECIFICATION)

This material is commonly stocked by steel service centers in plate, bar and structural shape forms. The material is easily welded by all common welding methods using low carbon steel filler metals. No special precautions, except for use of low hydrogen practices, are normally required, although the steel should be above approximately 4° C (40° F).

Recommended bend radii are:

Material Thickness, mm (inch)	Minimum Bend Radius (T = material thickness
20 (3/4) and under	1T
over 20 to 25 (3/4 to 1)	2T
over 25 to 40 (1 to 1-1/2)	3T
over 40 to 50 (1-1/2 to 2)	5T
over 50 (2)	6T

CLASS 4 MATERIALS

Chemical Composition

The chemical composition of this material is shown in Table 5. Standard product analysis tolerances included in ASTM A6/A6M/A6M shall apply.

Table 5
Chemical Analysis of **Class 4** Materials

Grade N/mm² [ksi]	Diameter Thickness, or Distance Between Parallel Faces, mm [in.] Plates & Bars	Structural Shapes Classes *(B)*	Carbon, max. %	Manganese, (C) max. %	Phosphorous, max. %	Sulfur, max. %	Silicon	
							Plates to 40 mm [1-1/2] Thick, shapes to 634 kg/m, [426lb./ft] Sheet, Piling, Bars, Zee and Rolled Tees	Over 40 mm [1-1/2 in.] Thick & Shapes Over 634 kg/m [426lb.ft]
290 [42]	150 [6]	All	0.21	1.35 *(G)*	0.04	0.05	0.40 max.	0.15-0.40
345 [50]	100 [4]	All	0.23	1.35 *(G)*	0.04	0.05	0.40 max.	0.15-0.40
415 [60]	32 [1-1/4]	1, 2, 3	0.26	1.35 *(G)*	0.04	0.05	0.40 max.	*(H)*
450 [65]	>13 to 32 [1-1/4 to ½]	2, 3	0.23	1.65	0.04	0.05	0.40 max.	*(H)*
450 [65]	≤13 [1/2] *(F)*	1 *(F)*	0.26	1.35	0.04	0.05	0.40 max.	*(H)*

Note: The chemical analyses of sheet materials are slightly different.

(A) – Copper when specified shall have a minimum content of 0.20% by heat analysis (0.18% product analysis).

(B) – See Specification A6/A6M.

(C) – Manganese, minimum by heat analysis of 0.80% (0.75% product analysis) shall be required for all plates over 10 mm [3/8 in.] in thickness; a minimum of 0.50% (0.45% product analysis) shall be required for plates 10 mm [3/8 in.] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1.

(D) – Silicon content in excess of 0.40% by heat analysis must be negotiated.

(E) – Bars over 40 mm [1-1/2 in.] in diameter, thickness, or distance between parallel faces shall be made by a killed steel practice.

(F) – An alternative chemical requirement with a maximum carbon of 0.21% and a maximum manganese of 1.65% is permissible with the balance of the elements as shown in Table 5.

(G) – A maximum manganese of 1.50% is permissible, with an associated reduction of the carbon maximum of 0.03%.

(H) – The size and grade is not described in this specification.

Alternate Specifications

Chinese: Grades Q345, Q420, Q460 per GB/T 1591-2008

European: Grades S355N, S420N, S460N per EN 10025-3:2004

Table 5 (Continued)
Alloy Content

Type *(A)*	Elements	Heat Analysis, %
1	Columbium *(B)*	0.005 – 0.05 *(B)*
2	Vanadium	0.01 – 0.15
3	Columbium *(A)*	0.005 – 0.05 *(C)*
	Vanadium	0.01 – 0.15
	Columbium plus Vanadium	0.02 – 0.15 *(D)*
4	Vanadium	0.01 – 0.15 *(E)*
	Nitrogen	0.015 max. *(E)*

(A) – Alloy content shall be in accordance with Type 1, 2, 3, or 4 and the contents of the applicable elements shall be reported on the test report

(B) – Columbium shall be restricted to the following thicknesses and sizes unless killed steel is furnished. Killed steel shall be confirmed by a statement of *killed steel* on the test report, or by a report on the presence of a sufficient quantity of a strong deoxidizing element, such as silicon at 0.10% or higher, or aluminum at 0.015% or higher.

Grade N/mm² [ksi]	Maximum Plate, Bar, Sheet Piling, Zees, & Rolled Tee Thicknesses, mm [in.]	Structural Shape Size Groupings (ASTM A6/A6M/A6M, Table 3
290 and 345 [42 and 50]	20 [3/4]	**Classes 1 and 3**
415 and 450 [60 and 65]	13 [1/2]	**Class 1**

(C) – Product analysis limits = 0.004 to 0.06%.

(D) – Product analysis limits = 0.01 to 0.16%.

(E) – The vanadium to nitrogen ratio shall be 4 to 1 or greater.

Tensile Properties

The specified tensile properties are shown in Table 6.

Table 6
Tensile Requirements of **Class 4** Material *(A)*

Grade N/mm² [ksi]	Yield Point, min.		Tensile Strength, min.		Minimum Elongation, % *(B) (C) (D)*	
	N/mm²	[ksi]	N/mm²	[ksi]	In 200 mm [8 in.]	In 50 mm [2 in.]
290 [42]	290	[42]	415	60	20	24
345 [50]	345	[50]	450	65	18	21
415 [60]	415	[60]	520	75	16	18
450 [65]	450	[65]	550	80	15	17

Note: The lowest grade for sheet and strip has a 310 N/mm² (45 ksi) yield point. Sheet materials also include additional grades having minimum yield points of 380 N/mm² (55 ksi) and 480 N/mm² (70 ksi).

(A) – See Specimen Orientation under the Tension Tests section of ASTM A6/A6M/A6M.

(B) – Elongation not required to be determined for floor plate.

(C) – For wide flange shapes over 634 kg/m [426 lb./ft] elongation in 50 mm [2 in.] of 19% minimum applies.

(D) – For plates wider than 600 mm [24 in.], the elongation requirement is reduced two percentage points for Grades 290 and 345 [42 and 50] and three percentage points for Grades 415 and 450 [60 and 65]. See elongation requirement adjustments in the Tension Tests section of ASTM A6/A6M/A6M.

Processing

This material can be produced from capped, or killed steels. Rimmed steels are not permitted.

Sheet, plate, structural shapes, and bars greater than 60.7 kg/m (40.8 lbs./ft.) shall be semi-killed, structural quality.

Steel bars less than 60.7 kg/m (40.8 lbs./ft.) shall be semi-killed, merchant quality.

Dimensional Tolerances

Dimensional tolerances shall be as included in ASTM A6/A6M/A6M for bars and plates.

Method of Specifying

HC-115, CLASS 4, GRADE 290
HC-115, CLASS 4, GRADE 415
Etc.

Note: When appropriate, additional HC-115 classes should be specified on the drawing as optional.

Certification

The supplier shall include with each material or subcontracted parts lot a statement certifying compliance to this material specification, signed by an authorized representative of the supplier. The certification for each heat of steel shall include the results of chemical analysis and mechanical testing.

General Information (NOT A PART OF THE SPECIFICATION)

This material is commonly stocked by steel service centers in sheet, plate, bar, and limited structural shape forms. The material can be welded by all commons welding methods, although special filler metals and procedures are required. Grades 42 and 50 are normally welded using a filled metal having a specified minimum tensile strength of 480 N/mm² (70 ksi), such as E70XX or ER70S-X. Grades 60 and 65 are normally welded using a filler metal having a minimum tensile strength of 550 N/mm² (80 ksi), such as E80XX or ER80S-X. Preheating may be required depending upon the joint geometry and constraint.

Recommended bend radii are:

	Minimum Bend Radius (T = material thickness)			
Material Thickness, mm (in.)	Grade 42	Grade 50	Grade 60	Grade 65
20 (3/4) and under	2T	2T	4T	5T
over 20 to 25 (3/4 to 1)	3T	3T	5T	6T
over 25 to 40 (1 to 1-1/2)	4T	5T	6T	7T
over 40 to 50 (1-1/2 to 2)	5T	6T		
over 50 (2)	6T	7T		

CLASS 5 MATERIALS

Chemical Composition

The chemical analysis of this material is shown in Table 7. Standard product analysis tolerances included in ASTM A6/A6M/A6M shall apply.

Table 7
Chemical Analysis of **Class 5** Material

Maximum Thickness mm [in.]	Grade A, 32 [1-1/4]	Grade B, 32 [1-1/4]	Grade C, 32 [1-1/4]	Grade E, 150 [6]	Grade F, 65 [2-1/2]	Grade H, 50 [2]	Grade J, 32 [1-1/4]
Carbon	0.15-0.21	0.12-0.21	0.10-0.20	0.12-0.20	0.10-0.20	0.12-0.21	0.12-0.21
Manganese	0.80-1.10	0.70-1.00	1.10-1.50	0.40-0.70	0.60-1.00	0.95-1.30	0.45-0.70
Phosphorous, max.	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur, max.	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Silicon	0.40-0.80	0.20-0.35	0.15-0.30	0.20-0.40	0.15-0.35	0.20-0.35	0.20-0.35
Nickel	. . .	. . .	. . .	. . .	0.70-1.00	0.30-0.70	. . .
Chromium	0.50-0.80	0.40-0.65	. . .	1.40-2.00	0.40-0.65	0.40-0.65	. . .
Molybdenum	0.18-0.28	0.15-0.25	0.15-0.30	0.40-0.60	0.40-0.60	0.20-0.30	0.50-0.65
Vanadium	. . .	0.03-0.08	. . .	*(A)*	0.03-0.08	. . .	. . .
Titanium	. . .	0.01-0.03	. . .	0.01-0.10	. . .	. . .	. . .
Zirconium	0.05-0.15 *(B)*	. . .	. . .	. . .	. . .	. . .	. . .
Copper	. . .	. . .	. . .	. . .	0.15-0.50	. . .	. . .
Boron	0.0025 max.	0.0005-0.005	0.001-0.005	0.001-0.005	0.0005-0.006	0.0005-0.005	0.001-0.005
Columbium, max.	. . .	. . .	. . .	. . .	. . .	. . .	. . .

Maximum Thickness mm [in.]	Grade K, 50 [2]	Grade M, 50 [2]	Grade P, 150 [6]	Grade Q, 150 [6]	Grade R, 65 [2-1/2]	Grade S, 65 [2-1/2]	Grade T, 50 [2]
Carbon	0.10-0.20	0.12-0.21	0.12-0.21	0.14-0.21	0.15-0.20	0.11-0.21	0.08-0.14
Manganese	1.10-1.50	0.45-0.70	0.45-0.70	0.95-1.30	0.85-1.15	0.10-1.50	1.20-1.50
Phosphorous, max.	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur, max.	0.035	0.035	0.035	0.035	0.035	0.20	0.010
Silicon	0.15-0.30	0.20-0.35	0.20-0.35	0.15-0.35	0.20-0.35	0.15-0.45	0.40-0.60
Nickel	. . .	1.20-1.50	1.20-1.50	1.20-1.50	0.90-1.10	. . .	. . .
Chromium	. . .	. . .	0.85-1.20	1.00-1.50	0.35-0.65	. . .	. . .
Molybdenum	0.45-0.55	0.45-	0.45-0.60	0.40-0.60	0.15-0.25	0.10-0.60	0.45-0.60
Vanadium	. . .	. . .	. . .	0.03-0.08	0.03-0.08	0.06	0.03-0.08
Titanium	. . .	. . .	. . .	. . .	. . .	*(C)*	. . .
Zirconium	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Copper	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Boron	0.001-0.005	0.001-0.005	0.001-0.005	. . .	. . .	0.001-0.005	0.001-0.005
Columbium, max.	. . .	. . .	. . .	. . .	. . .	0.06	. . .

(A) – May be substituted for part of all of titanium content on a one for one basis.

(B) – Zirconium may be replaced by cerium. When cerium is added, the cerium/sulfur ratio should be approximately 1.5 to 1, based upon heat analysis.

(C) Titanium may be present in levels up to 0.06% to protect the boron additions.

Alternate Specifications

Chinese: Grade Q690 per GB/T 16270-2009

European: Grade S690Q per EN 10025-6:2004

Tensile Properties

The tensile properties are shown in Table 8. These are specified minimum values.

Table 8
Tensile and Hardness Requirements of **Class 5** Materials

Note 1 – See Specimen Orientation under the Tension Tests section of ASTM A6/A6M/A6m.

Note 2 – Either the full thickness rectangular specimen shown in Figure 3 of Test Methods and Definitions ASTM A370, or the 12.5-mm [1/2-in.] diameter specimen shown in Figure 4 of Test Methods and Definitions ASTM A370 may be used for plates over 20 to 40 mm [3/4 to 1-1/2 in.] in thickness.

Note 3 – Where ". . ." appears in this table there is no requirement.

Thickness, mm [in.]	Ultimate Tensile Strength, N/mm² [ksi]	Yield Strength *(A)*, min. N/mm² [ksi]	Elongation in 40 mm [2 in.], *(B), (C), (D)* min., %	Reduction of Area, *(B), (C)* min., %	Brinell Hardness *(E)* Number
To 20 [3/4], incl.	760 to 895 [110 to 130]	690 [100]	18	40 *(F)*	235 to 293
Over 20 to 65 [3/4 to 2-1/2], incl.	760 to 895 [110 to 130]	690 [100]	18	40 *(F)*, 50 *(G)*	. . .
Over 65 to 150 [2-1/2 to 6], incl.	690 to 895 [100 to 130]	620 [90]	18	50 *(G)*	. . .

(A) – Measured at 0.2% offset or 0.5% extension under load as described in the Determination of Tensile Properties section of Test Methods and Definitions ASTM A370.

(B) - Elongation and reduction of area not required to be determined for floor plates.

(C) – For plates tested in the transverse direction, the elongation minimum percent is reduced by 2% and the reduction of area minimum requirement is reduced by 5%. See elongation requirement adjustments under the Tension Tests section of ASTM A6/A6M/A6M.

(D) – When measured on the Figure 3 (Test Methods and Definitions ASTM A370) 40-mm [1-1/2 in.] wide specimen (see Note 2 of this table), the elongation is determined in a 50-mm [2 in.] gage length, which includes the fracture and shows the greatest elongation.

(E) – See Section 8 of this specification.

(F) – When measured on the Figure 3 (Test methods and Definitions ASTM A370) 40-mm [1-1/2 in.] wide specimen (see Note 2 of this table).

(G) – When measured on the Figure 4 (Test methods and Definitions ASTM A370) 12.5-mm [1/2 in.] round specimen (see Note 2 of this table).

Processing

This material is to be supplied in the liquid quenched and tempered condition. The material shall be austenitized at a minimum temperature of 900° C (1650° F) and tempered at a minimum temperature of 620° C (1150° F).

Material shall be fine-grained (ASTM 5 or finer per ASTM E112), fully-killed structural quality. Additional refining by vacuum-arc remelting (VAR) or electroslag remelting (ESR) is permitted.

Dimensional Tolerances

Dimensional tolerances shall be as included in ASTM A6/A6M.

Method of Specifying

HC-115, CLASS 5
Etc.

Note: When appropriate, additional HC-115 classes should be specified as optional.

Certification

The supplier shall include with each material or subcontracted parts lot a statement certifying compliance to this material specification, signed by an authorized representative of the supplier. The certification for each heat of steel shall include the results of chemical analysis and mechanical testing, as well as the actual austenitizing and tempering temperatures shall also be included in the material test report.

General Information (NOT A PART OF THE SPECIFICATION)

This material is commonly stocked by steel service centers in plate form, although not all grades may be available from any one source. The material can be welded by all common welding methods, although special filer metals and procedures are required. Alloy steel filler metals are required for matching weld metal strength. Preheating is normally required for welding of material thicknesses over 25 mm (1 inch) depending upon the joint geometry and constraint.

Recommended bend radii are:

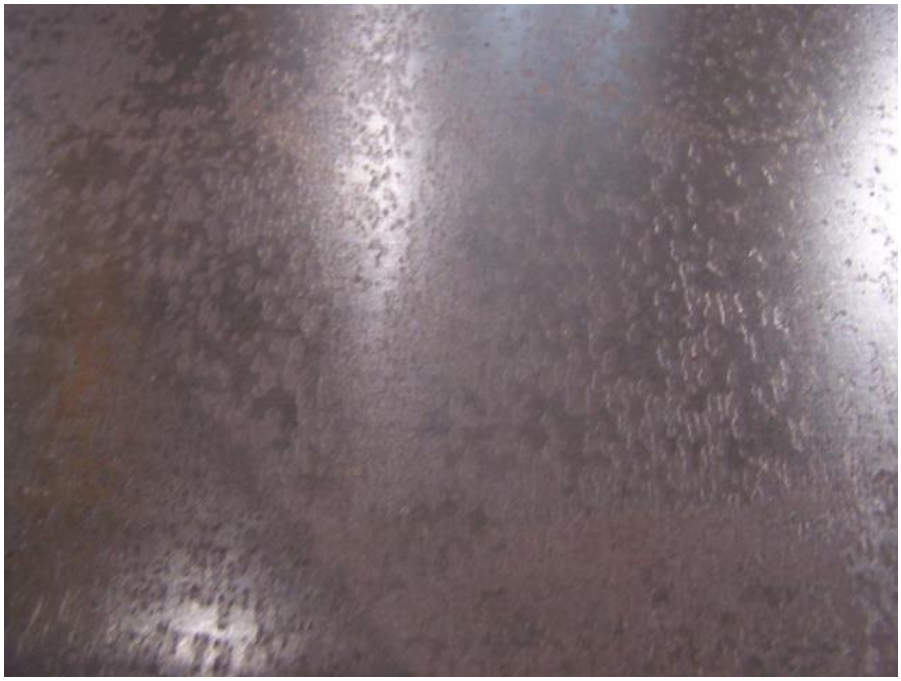
Material Thickness, mm (in.)	Minimum Bend Radius (T = material thickness)
20 (3/4) and under	4T
over 20 to 25 (3/4 to 1)	4T
over 25 to 40 (1 to 1-1/2)	6T
over 40 to 50 (1-1/2 to 2)	6T
over 50 (2)	8T

Definitions and Possible Imperfections:

Scratches or Streaks: Scratch on the surface. Its appearance varies from so small it is barely visible to large and sharp scratches with detachment of material.

Rolled in Primary Scale: Furnace scale not eliminated during the process of scale removal and was rolled in over the surface of the plate or sheet.

Rolled in Secondary Scale: Net pattern on the surface of the plate or sheet with little depth. Created when steel is exposed to oxygen during the Hot Rolling process.

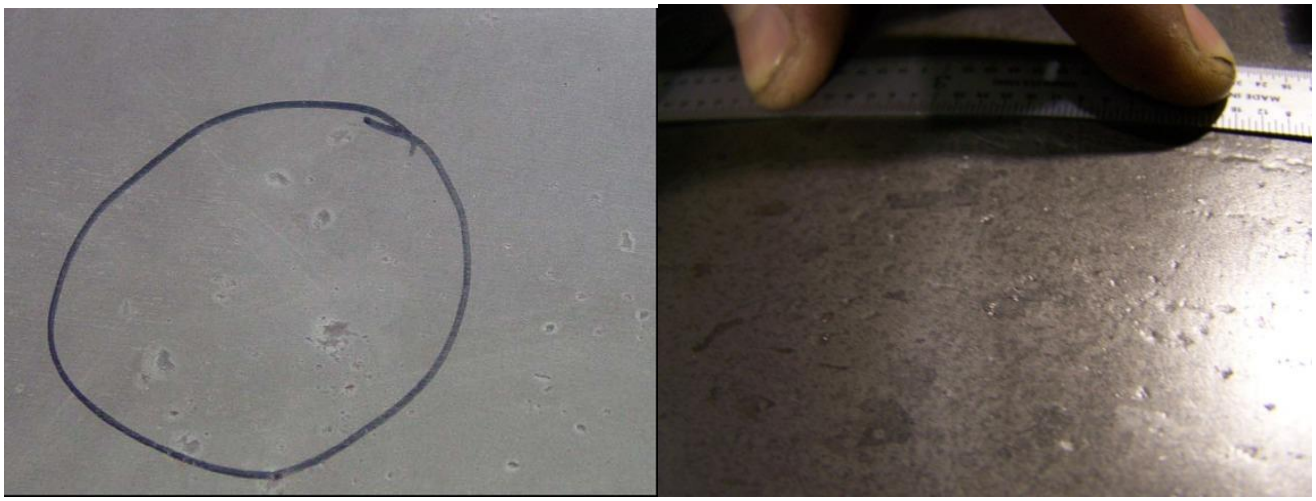


Scabs: Irregular shaped metal rolled on the surface of the plate. A foreign object that can be removed from the surface leaving a dent.

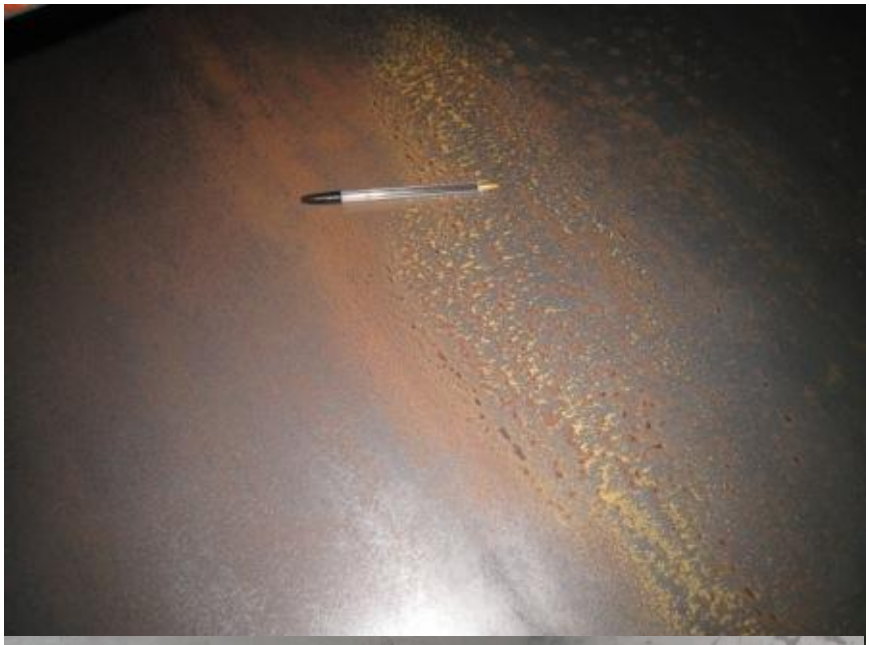
Slivers (Laminations): Ruptures on the surface running parallel to the rolling direction.

Rolled-in Foreign Objects: Foreign objects stamped on the surface during the rolling operations.

Pits: Shallow holes on the surface caused by dirty rolls, extreme rusting or rolled-in and removed scale.



Rust Pits: Shallow holes on the surface caused by extreme rusting.



Annex

Cited Documents

ASTM A6/A6M/A6M-01b, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A29/A29M/A29M-99e1, Standard Specification for Steel Bars, Carbon and Alloy, Hot- Wrought and Cold Finished General Requirements for…

ASTM A108, Standard Specifications for Steel Bars, Carbon, Cold-Finished, Standard Quality

ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A568, Standard Specification for Steel Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for…

ASTM A1008, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength, Low-Alloy and High-Strength Low-Alloy with Improved Formability

ASTM A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

ASTM A576-90b(2000), Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM A6/A6M68/A668M-96(2001), Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use

ASTM E112-96e1, Standard Test Methods for Determining Average Grain Size

HC-7, Structural Steel Shapes, Plate and Bar

HC-16, Commercial Quality Steel and Strip

HC-17, Quenched and Tempered Alloy Structural Steel

HC-112, High Strength Low Alloy Steel (HSLA) 50,000PSI Minimum Yield Strength

HCE-151, Fit and Finish Zones