Designation: A 36/A 36M – 01

Standard Specification for Carbon Structural Steel[1]

This standard is issued under the fixed designation A 36/A 36M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] covers carbon steel shapes, plates, and bars of structural quality for use in riveted, bolted, or welded construction of bridges and buildings, and for general structural purposes.

1.2 Supplementary requirements are provided for use where additional testing or additional restrictions are required by the purchaser. Such requirements apply only when specified in the purchase order.

1.3 When the steel is to be welded, a welding procedure suitable for the grade of steel and intended use or service is to be utilized. See Appendix X3 of Specification A 6/A 6M for information on weldability.

1.4 For Group 4 and 5 wide flange shapes for use in tension, it is recommended that the purchaser consider specifying supplementary requirements, such as fine austenitic grain size and Charpy V-notch impact testing.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system is to be used independently of the other, without combining values in any way.

1.6 The text of this specification contains notes or footnotes, or both, that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

1.7 For structural products cut from coiled product, the additional requirements, including additional testing requirements and the reporting of additional test results, of A 6/A 6M apply.

2. Referenced Documents

2.1 *ASTM Standards:*

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling[3]

A 27/A 27M Specification for Steel Castings, Carbon, for General Application[4]

A 307 Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength[5]

A 325 Specification for High-Strength Bolts for Structural Steel Joints[5]

A 325M Specification for High-Strength Bolts for Structural Steel Joints [Metric][5]

A 500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes[6]

A 501 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing[6]

A 502 Specification for Steel Structural Rivets[5]

A 563 Specification for Carbon and Alloy Steel Nuts[5]

A 563M Specification for Carbon and Alloy Steel Nuts [Metric][5]

A 570/A 570M Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality[7]

A 668/A 668M Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use[8]

F 568M Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners[5]

3. Appurtenant Materials

3.1 When components of a steel structure are identified with this ASTM designation but the product form is not listed in the scope of this specification, the material shall conform to one of the standards listed in Table 1 unless otherwise specified by the purchaser.

4. General Requirements for Delivery

4.1 Material furnished under this specification shall conform to the requirements of the current edition of Specification A 6/A 6M, for the ordered material, unless a conflict exists in which case this specification shall prevail.

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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[2] For ASME Boiler and Pressure Vessel Code Applications, see related Specifications SA-36 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.04.

[4] *Annual Book of ASTM Standards*, Vol 01.02.

[5] *Annual Book of ASTM Standards*, Vol 15.08.

[6] *Annual Book of ASTM Standards*, Vol 01.01.

[7] *Annual Book of ASTM Standards*, Vol 01.03.

[8] *Annual Book of ASTM Standards*, Vol 01.05.

TABLE 1 Appurtenant Material Specifications

NOTE 1—The specifier should be satisfied of the suitability of these materials for the intended application. Chemical composition and/or mechanical properties may be different than specified in A 36/A 36M.

Material	ASTM Designation
Steel rivets	A 502, Grade 1
Bolts	A 307, Grade A or F 568M, Class 4.6
High-strength bolts	A 325 or A 325M
Steel nuts	A 563 or A 563M
Cast steel	A 27/A 27M, Grade 65–35 [450–240]
Forgings (carbon steel)	A 668, Class D
Hot-rolled sheets and strip	A 570/A 570M, Grade 36
Cold-formed tubing	A 500, Grade B
Hot-formed tubing	A 501
Anchor bolts	F 1554

4.1.1 Coiled product is excluded from qualification to this specification until decoiled, leveled, and cut to length. Structural products produced from coil means structural products that have been cut to individual lengths from a coiled product and are furnished without heat treatment. The processor decoils, levels, cuts to length, and marks the product. The processor is responsible for performing and certifying all tests, examinations, repairs, inspections, or operations not intended to affect the properties of the material. For structural products produced from coils, two test results shall be reported for each qualifying coil. See Note 1.

NOTE 1—Additional requirements regarding structural products from coil are described in Specification A 6/A 6M.

5. Bearing Plates

5.1 Unless otherwise specified, plates used as bearing plates for bridges shall be subjected to mechanical tests and shall conform to the tensile requirements of Section 8.

5.2 Unless otherwise specified, mechanical tests shall not be required for plates over 1½ in. [40 mm] in thickness used as bearing plates in structures other than bridges, subject to the requirement that they shall contain 0.20 to 0.33 % carbon by heat analysis, that the chemical composition shall conform to the requirements of Table 2 in phosphorus and sulfur content, and that a sufficient discard shall be made to secure sound plates.

6. Materials and Manufacture

6.1 The steel for plates and bars over ½ in. [12.5 mm] in thickness and shapes other than Group 1 shall be semi-killed or killed.

7. Chemical Composition

7.1 The heat analysis shall conform to the requirements prescribed in Table 2, except as specified in 5.2.

7.2 The steel shall conform on product analysis to the requirements prescribed in Table 2, subject to the product analysis tolerances in Specification A 6/A 6M.

8. Tension Test

8.1 The material as represented by the test specimen, except as specified in 5.2 and 8.2, shall conform to the requirements as to the tensile properties prescribed in Table 3.

8.2 Shapes less than 1 in.^{2}[645 mm ^{2}] in cross section and bars, other than flats, less than ½ in. [12.5 mm] in thickness or diameter need not be subjected to tension tests by the manufacturer, provided that the chemical composition used is appropriate for obtaining the tensile properties in Table 3.

TABLE 2 Chemical Requirements

NOTE 1— Where ". . ." appears in this table, there is no requirement. The heat analysis for manganese shall be determined and reported as described in the heat analysis section of Specification A 6/A 6M.

Product	Shapes[A]	Plates[B]					Bars			
Thickness, in. [mm]	All	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 2½ [40 to 65], incl	Over 2½ to 4 [65 to 100], incl	Over 4 [100]	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 4 [100], incl	Over 4 [100]
Carbon, max, %	0.26	0.25	0.25	0.26	0.27	0.29	0.26	0.27	0.28	0.29
Manganese, %	...	...	0.80–1.20	0.80–1.20	0.85–1.20	0.85–1.20	...	0.60–0.90	0.60–0.90	0.60–0.90
Phosphorus, max, %	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max, %	0.05	0.05	0.05	0.05	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	0.40 max	0.40 max	0.40 max	0.40 max
Copper, min, % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	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 426 lb/ft [634 kg/m].

[B] For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum will be permitted, up to the maximum of 1.35 %.

TABLE 3 Tensile Requirements[A]

Plates, Shapes,[B] and Bars:	
Tensile strength, ksi [MPa]	58–80 [400–550]
Yield point, min, ksi [MPa]	36 [250][C]
Plates and Bars[D,E]:	
Elongation in 8 in. [200 mm], min, %	20
Elongation in 2 in. [50 mm], min, %	23
Shapes:	
Elongation in 8 in. [200 mm], min, %	20
Elongation in 2 in. [50 mm], min, %	21[B]

[A] See the Orientation subsection inthe Tension Tests section of Specification A 6/A 6M.

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

[C] Yield point 32 ksi [220 MPa] for plates over 8 in. [200 mm] in thickness.

[D] Elongation not required to be determined for floor plate.

[E] For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points. See the Elongation Requirement Adjustments subsection under the Tension Tests section of Specification A 6/A 6M.

9. Keywords

9.1 bars; bolted construction; bridges; buildings; carbon; plates; riveted construction; shapes; steel; structural steel; welded construction

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order.

Standardized supplementary requirements for use at the option of the purchaser are listed in Specification A 6/A 6M. Those that are considered suitable for use with this specification are listed by title:

S5. Charpy V-Notch Impact Test.

S30. Charpy V-Notch Impact Test for Structural Shapes: Alternate Core Location

In addition, the following optional supplementary requirement is also suitable for use with this specification:

S97. Limitation on Rimmed or Capped Steel

S97.1 The steel shall be other than rimmed or capped.

Designation: A 572/A 572M – 01

American Association State
Highway and Transportation
Officals Standard
AASHTO No.: M223

Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel[1]

This standard is issued under the fixed designation A 572/A 572M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers five grades of high-strength low-alloy structural steel shapes, plates, sheet piling, and bars. Grades 42 [290], 50 [345], and 55 [380] are intended for riveted, bolted, or welded structures. Grades 60 [415] and 65 [450] are intended for riveted or bolted construction of bridges, or for riveted, bolted, or welded construction in other applications.

1.2 For applications, such as welded bridge construction, where notch toughness is important, notch toughness requirements are to be negotiated between the purchaser and the producer.

1.3 The use of columbium, vanadium, titanium, nitrogen, or combinations thereof, within the limitations noted in Section 5, is required; the selection of type (1, 2, 3, 4, or 5) is at the option of the producer, unless otherwise specified by the purchaser. (See Supplementary Requirement S90.)

1.4 The maximum thicknesses available in the grades and products covered by this specification are shown in Table 1.

1.5 When the steel is to be welded, a welding procedure suitable for the grade of steel and intended use or service is to be utilized. See Appendix X3 of Specification A 6/A 6M for information on weldability.

1.6 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system is to be used independently of the other, without combining values in any way.

1.7 The text of this specification contains notes or footnotes, or both, that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

1.8 For structural products cut from coiled product, the additional requirements, including additional testing requirements and the reporting of additional tests, of A 6/A 6M apply.

2. Referenced Documents

2.1 *ASTM Standards:*

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling[2]

A 36/A 36M Specification for Carbon Structural Steel[2]

A 514/A 514M Specification for High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding[2]

3. General Requirements for Delivery

3.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 6/A 6M, for the ordered material, unless a conflict exists in which case this specification shall prevail.

3.1.1 Coiled product is excluded from qualification to this specification until leveled and cut to length. Structural products produced from coil means structural products that have been cut to individual lengths from a coiled product and are furnished without heat treatment. The processor decoils, levels, cuts to length, and marks the product. The processor is responsible for performing and certifying all tests, examinations, repairs, inspections, or operations not intended to affect the properties of the material. For structural products produced from coils, two test results shall be reported for each qualifying coil (Note 1).

NOTE 1—Additional requirements regarding structural products from coil are described in A 6/A 6M.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys, and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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[2] *Annual Book of ASTM Standards,* Vol 01.04.

TABLE 1 Maximum Product Thickness or Size

Grade	Yield Point, min		Maximum Thickness or Size				
	ksi	[MPa]	Plates and Bars		Structural Shapes Groups[A]	Sheet Piling	Zees and Rolled Tees
			in.	[mm]			
42 [290][B]	42	[290]	6	[150]	all	all	all
50 [345][B]	50	[345]	4[C]	[100][C]	all	all	all
55 [380]	55	[380]	2	[50]	all	all	all
60 [415][B]	60	[415]	1¼[D]	[32][D]	1, 2, and 3	all	all
65 [450]	65	[450]	1¼	[32]	1, 2, and 3	not available	all

[A] See Specification A 6/A 6M.

[B] In the above tabulation, Grades 42, 50, and 60 [290, 345, and 415], are the yield point levels most closely approximating a geometric progression pattern between 36 ksi [250 MPa], min, yield point steels covered by Specification A 36/A 36M and 100 ksi [690 MPa], min, yield strength steels covered by Specification A 514/A 514M.

[C] Round bars up to and including 9 in. [225 mm] in diameter are permitted.

[D] Round bars up to and including 3½ in. [90 mm] in diameter are permitted.

TABLE 2 Chemical Requirements[A] (Heat Analysis)

Diameter, Thickness, or Distance Between Parallel Faces, in. [mm] Plates and Bars	Structural Shapes Groups[B]	Grade	Carbon, max, %	Manganese,[C] max, %	Phosphorus, max, %	Sulfur, max, %	Silicon	
							Plates to 1½ in. [40 mm] in Thickness, Shapes to 426 lb/ft [634 kg/m], Sheet Piling, Bars, Zees, and Rolled Tees[D]	Plates Over 1½ in. [40 mm] in Thickness and Shapes Over 426 lb/ft [634 kg/m]
							max, %	range, %
6 [150]	all	42 [290]	0.21	1.35[E]	0.04	0.05	0.40	0.15–0.40
4 [100][F]	all	50 [345]	0.23	1.35[E]	0.04	0.05	0.40	0.15–0.40
2 [50]	all	55 [380]	0.25	1.35[E]	0.04	0.05	0.40	0.15-0.40
1¼ [32][G]	1,2,3	60 [415]	0.26	1.35[E]	0.04	0.05	0.40	[H]
>½ – 1¼ [13–32]	2,3	65 [450]	0.23	1.65	0.04	0.05	0.40	[H]
≤½ [13][I]	1[I]	65 [450]	0.26	1.35	0.04	0.05	0.40	[H]

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

[B] See Specification A 6/A 6M.

[C] Manganese, minimum, by heat analysis of 0.80 % (0.75 % by product analysis) shall be required for all plates over ⅜in. [10 mm] in thickness; a minimum of 0.50 % (0.45 % by product analysis) shall be required for plates ⅜ in. [10 mm] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1.

[D] Bars over 1½ in. [40 mm] in diameter, thickness, or distance between parallel faces shall be made by a killed steel practice.

[E] For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum is permitted, up to a maximum of 1.50 %.

[F] Round bars up to and including 9 in. [225 mm] in diameter are permitted.

[G] Round bars up to and including 3½ in. [90 mm] in diameter are permitted.

[H] The size and grade is not described in this specification.

[I] An alternative chemical requirement with a maximum carbon of 0.21 % and a maximum manganese of 1.65 % is permitted, with the balance of the elements as shown in Table 2.

4. Materials and Manufacture

4.1 The steel shall be semi-killed or killed

5. Chemical Composition

5.1 The heat analysis shall conform to the requirements prescribed in Table 2 and Table 3.

5.2 The steel shall conform on product analysis to the requirements prescribed in Table 2 and Table 3, subject to the product analysis tolerances in Specification A 6/A 6M.

6. Mechanical Properties

6.1 *Tensile Properties*:

6.1.1 The material as represented by the test specimens shall conform to the tensile properties given in Table 4.

7. Keywords

7.1 bars; bolted construction; bridges; buildings; columbium-vanadium; high-strength; low-alloy; plates; riveted construction; shapes; sheet piling; steel; structural steel; welded construction

TABLE 3 Alloy Content

Type[A]	Elements	Heat Analysis, %
1	Columbium[B]	0.005–0.05[C]
2	Vanadium	0.01–0.15
3	Columbium[B]	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]
5	Titanium	0.006-0.04
	Nitrogen	0.003–0.015
	Vanadium	0.06 max

[A]Alloy content shall be in accordance with Type 1, 2, 3, 4, or 5 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. See table below.

[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.

Grades	Maximum Plate, Bar, Sheet Piling, Zees, and Rolled Tee Thicknesses, in. [mm]	Structural Shape Size Groupings (Specification A 6/A 6M, Table A)
42, 50, and 55	¾	Groups 1 and 2
[290, 345, and 380]	[20]	Groups 1 and 2
60 and 65	½	Group 1
[415 and 450]	[13]	Group 1

TABLE 4 Tensile Requirements[A]

Grade	Yield Point, min		Tensile Strength, min		Minimum Elongation, %[B,C,D]	
	ksi	[MPa]	ksi	[MPa]	in 8 in. [200 mm]	in 2 in. [50 mm]
42 [290]	42	[290]	60	[415]	20	24
50 [345]	50	[345]	65	[450]	18	21
55 [380]	55	[380]	70	[485]	17	20
60 [415]	60	[415]	75	[520]	16	18
65 [450]	65	[450]	80	[550]	15	17

[A] See specimen Orientation under the Tension Tests section of Specification A 6/A 6M.

[B]Elongation not required to be determined for floor plate.

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

[D]For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points for Grades 42, 50, and 55 [290, 345, and 380], and three percentage points for Grades 60 and 65 [415 and 450]. See elongation requirement adjustments in the Tension Tests section of Specification A 6/A 6M.

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the order or contract. Standardized supplementary requirements for use at the option of the purchaser are listed in Specification A 6/A 6M. Those that are considered suitable for use with this specification are listed by title:

S5. Charpy V-Notch Impact Test.

S18. Maximum Tensile Strength

S30. Charpy V-Notch Impact Test for Structural Shapes: Alternate Core Location

In addition, the following supplementary requirements are suitable for use:

S81. Tensile Strength

S81.1 For Grade 50 [345] steel of thicknesses ¾in. [20 mm] and less, the tensile strength shall be a minimum of 70 ksi [485 MPa].

S90. Type

S90.1 The specific type of steel shall be as specified by the purchaser in the order or contract.

Designation: A 514/A514M – 00a

American Association State Highway and Transportation Officials Standard AASHTO No.: M 244

Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding[1]

This standard is issued under the fixed designation A 514/A514M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers quenched and tempered alloy steel plates of structural quality in thicknesses of 6 in. [150 mm] and under intended primarily for use in welded bridges and other structures.

NOTE 1—All grades are not available in a maximum thickness of 6 in. [150 mm]. See Table 1 for thicknesses available in each grade.

1.2 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X 3 of Specification A 6/A 6M for information on weldability.

1.3 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling[2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3]

E 112 Test Methods for Determining the Average Grain Size[4]

3. General Requirements for Delivery

3.1 Material furnished under this specification shall conform to the requirements of the current edition of Specification A 6/A 6M, for the ordered material, unless a conflict exists in which case this specification shall prevail.

4. Materials and Manufacture

4.1 The requirements for fine austenitic grain size in Specification A 6/A 6M shall be met.

5. Heat Treatment

5.1 The material shall be heat treated by the manufacturer to conform to the tensile and hardness requirements of Table 2 by heating to not less than 1650°F [900°C], quenching in water or oil and tempering at not less than 1150°F [620°C]. The heat-treating temperatures shall be reported on the test certificates.

6. Chemical Composition

6.1 The heat analysis shall conform to the requirements prescribed in Table 1.

6.2 The steel shall conform on product analysis to the requirements as prescribed in Table 1, subject to the product analysis tolerances in Specification A 6/A 6M.

7. Mechanical Properties

7.1 *Tension Test*—The material as represented by the tension test specimens shall conform to the tensile properties prescribed in Table 2.

7.2 *Hardness Test*—For plates ⅜ in. [10 mm] and under in thickness, a Brinell hardness test may be used instead of tension testing each plate, in which case a tension test shall be made from a corner of each of two plates per lot. A lot shall consist of plates from the same heat and thickness, same prior condition and scheduled heat treatment and shall not exceed 15 tons [15 Mg] in weight [mass]. A Brinell hardness test shall be made on each plate not tension tested and shall meet the requirements shown in Table 2.

8. Number of Tests

8.1 Except as described in 7.2, one tension test shall be taken from a corner of each plate as heat treated. Plates wider than 24 in. [600 mm] shall be tested in the transverse direction and are subject to the modifications for elongation and reduction of area contained in Footnote C of Table 2.

9. Retest

9.1 Plates subjected to Brinell hardness tests and which fail

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 01.03.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

TABLE 1 Chemical Requirements (Heat Analysis)

NOTE 1—Where "..." appears in this table, there is no requirement.

	Grade A, %	Grade B, %	Grade C, %	Grade E, %	Grade F, %	Grade H, %	Grade J, %
Maximum Thickness, in. [mm]	1¼[32]	1¼[32]	1¼[32]	6 [150]	2½[65]	2 [50]	1¼[32]
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
Phosphorus, 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	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	...	...	...	...	...	...	...

[A] May be substituted for part or 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.

	Grade K, %	Grade M, %	Grade P, %	Grade Q, %	Grade R, %	Grade S, %	Grade T, %
Maximum Thickness, in. [mm]	2 [50]	2 [50]	6 [150]	6 [150]	2½ [65]	2½ [65]	2 [50]
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	1.10–1.50	1.20–1.50
Phosphorus, 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	0.020	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	0.45–0.60	0.45–0.60	0.40–0.60	0.15–0.25	0.10–0.60	0.45–0.60
Vanadium, max	. . .	...	...	0.03–0.08	0.03–0.08	0.06	0.03–0.08
Titanium	. . .	...	...	...	...	[A]	...
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] Titanium may be present in levels up to 0.06 % to protect the boron additions.

TABLE 2 Tensile and Hardness Requirements

NOTE 1— See the Orientation and Preparation subsections in the Tension Tests section of Specification A 6/A 6M.
NOTE 2—Where "..'' appears in this table there is no requirement.

Thickness, in. [mm]	Ultimate Tensile Strength, ksi [MPa]	Yield Strength[A] min, ksi [MPa]	Elongation in 2 in. [50 mm],[BCD] min, %	Reduction of Area[BC], min, %	Brinell Hardness[E] Number
To ¾ [20], incl	110 to 130 [760 to 895]	100 [690]	18	40[F]	235 to 293
Over ¾ to 2½ [20 to 65], incl	110 to 130 [760 to 895]	100 [690]	18	40[F], 50[G]	...
Over 2½ to 6 [65 to 150], incl	100 to 130 [690 to 895]	90 [620]	16	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 A 370.
[B] Elongation and reduction of area not required to be determined for floor plates.
[C] For plates tested in the transverse direction, the elongation requirement is reduced by two percentage points and the reduction of area minimum requirement is reduced by five percentage points. See elongation requirement adjustments in the Tension Tests section of Specification A 6/A 6M.
[D] When measured on the Fig. 3 (Test Methods and Definitions A 370) 1½-in. [40-mm] wide specimen, the elongation is determined in a 2-in. [50-mm] gage length that includes the fracture and shows the greatest elongation.
[E] See Section 8 of this specification.
[F] When measured on the Fig. 3 (Test Methods and Definitions A 370) 1½-in. [40-mm] wide specimen.
[G] When measured on the Fig. 4 (Test Methods and Definitions A 370) ½-in. [12.5-mm] round specimen.

to meet the hardness requirements, at the manufacturer's option, may be subjected to tension testing and shall be accepted if the results conform to the requirements of Table 2.

9.2 The manufacturer may reheat-treat plates that fail to meet the mechanical property requirements of this specification. All mechanical property tests shall be repeated when material is resubmitted for inspection.

10. Test Specimens

10.1 When possible, all test specimens shall be cut from the plate in its heat-treated condition as shipped. If it is necessary to prepare test specimens from separate pieces, these pieces shall be full thickness, and all pieces shall be similarly and simultaneously heat treated with the material. All such separate

pieces shall be of such size that the prepared test specimens are free of any variation in properties due to edge effects.

10.2 The purchaser shall specify on the purchase order any additional thermal treatments which shall be given to the test specimens in addition to the heat treatment specified in Section 5. (This is intended to simulate thermal treatments which subsequently may be done by the fabricator.)

11. Keywords

11.1 alloy; bridges; high-yield-strength; plates; quenched; steel; structural steel; tempered; welded construction

Designation: A 53/A 53M – 01

An American National Standard

Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless[1]

This standard is issued under the fixed designation A 53/A 53M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] covers seamless and welded black and hot-dipped galvanized steel pipe in NPS ⅛ to NPS 26 [DN 6 to DN 650] (Note 1), inclusive, with nominal wall thickness (Note 2) as given in Table X2.2 and Table X2.3. It shall be permissible to furnish pipe having other dimensions (Note 2) provided such pipe complies with all other requirements of this specification.

NOTE 1—The dimensionless designators NPS (nominal pipe size) [DN (diameter nominal)] have been substituted in this specification for such traditional terms as "nominal diameter," "size," and "nominal size."

NOTE 2—The term nominal wall thickness has been assigned for the purpose of convenient designation, existing in name only, and is used to distinguish it from the actual wall thickness, which may vary over or under the nominal wall thickness.

1.2 This specification covers the following types and grades:

1.2.1 *Type F*—Furnace-butt welded, continuous welded Grade A,

1.2.2 *Type E*—Electric-resistance welded, Grades A and B, and

1.2.3 *Type S*—Seamless, Grades A and B.

NOTE 3—See Appendix X1 for definitions of types of pipe.

1.3 Pipe ordered under this specification is intended for mechanical and pressure applications and is also acceptable for ordinary uses in steam, water, gas, and air lines. It is suitable for welding, and suitable for forming operations involving coiling, bending, and flanging, subject to the following qualifications:

1.3.1 Type F is not intended for flanging.

1.3.2 When Types S and E are required for close coiling or cold bending, Grade A is the preferred grade. This provision is not intended to prohibit the cold bending of Grade B pipe.

1.3.3 Type E is furnished either nonexpanded or cold expanded at the option of the manufacturer.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 The following precautionary caveat pertains only to the test method portion, Sections 9, 10, 11, 15, 16, and 17 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 The text of this specification contains notes or footnotes, or both, that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

2. Referenced Documents

2.1 *ASTM Standards:*

A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[4]

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[5]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[6]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[4]

A 865 Specification for Threaded Couplings, Steel, Black or Zinc-Coated (Galvanized) Welded or Seamless, for Use in Steel Pipe Joints[5]

B 6 Specification for Zinc[7]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[8]

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[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

Current edition approved Mar. 10, 2001. Published May 2001. Originally published as A 53 – 15. Last previous edition A 53 – 00.

[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-53 in Section II of that code.

[3] *Annual Book of ASTM Standards*, Vol 01.06.

[4] *Annual Book of ASTM Standards*, Vol 01.03.

[5] *Annual Book of ASTM Standards*, Vol 01.01.

[6] *Annual Book of ASTM Standards*, Vol 01.05.

[7] *Annual Book of ASTM Standards*, Vol 02.04.

[8] *Annual Book of ASTM Standards*, Vol 14.02.

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[9]
E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[9]
E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products[9]
E 1806 Practice for Sampling Steel and Iron for Determination of Chemical Composition[10]
2.2 *ANSI Standards:*
ASC X12[11]
B1.20.1 Pipe Threads, General Purpose[11]
2.3 *ASME Standard:*
B36.10 Welded and Seamless Wrought Steel Pipe[12]
2.4 *Military Standards:*
MIL-STD-129 Marking for Shipment and Storage[13]
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[13]
2.5 *Federal Standards:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[14]
Fed. Std. No 183 Continuous Identification Marking of Iron and Steel Products[14]
2.6 *API Standard:*
5L Specification for Line Pipe[15]

3. Ordering Information

3.1 Information items to be considered, if appropriate, for inclusion in the purchase order are as follows:
3.1.1 Specification designation (A 53 or A 53M, including year of issue),
3.1.2 Quantity (feet, metres, or number of lengths),
3.1.3 Grade (see Table 1),
3.1.4 Type (see 1.2 and Table 2),
3.1.5 Finish (black or galvanized),
3.1.6 Size (either nominal (NPS) [DN] and weight class or schedule number, or both; or outside diameter and nominal wall thickness, Table X2.2 and Table X2.3),
3.1.7 Length (specific or random, Section 18),
3.1.8 End finish (plain end or threaded, Section 13),
3.1.8.1 Threaded and coupled, if desired,
3.1.8.2 Threads only (no couplings), if desired,
3.1.8.3 Plain end, if desired,
3.1.8.4 Couplings power tight, if desired,
3.1.8.5 Taper tapped couplings for NPS 2 [DN 50] and smaller, if desired,
3.1.9 Close coiling, if required (see 8.2),
3.1.10 Skelp for tension tests, if permitted (see 17.2),
3.1.11 Certification (see Section 22),
3.1.12 End use of material,
3.1.13 Special requirements, and
3.1.14 Selection of applicable level of preservation and packaging and level of packing required, if other than as specified or if MIL-STD-163 applies (see 21.2).

4. Materials and Manufacture

4.1 The steel for both seamless and welded pipe shall be made by one or more of the following processes: open-hearth, electric-furnace, or basic-oxygen.
4.2 When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.
4.3 The weld seam of electric-resistance welded pipe in Grade B shall be heat treated after welding to a minimum of 1000°F [540°C] so that no untempered martensite remains, or otherwise processed in such a manner that no untempered martensite remains.
4.4 When pipe is cold expanded, the amount of expansion shall not exceed 1½ % of the outside diameter pipe size.

5. Chemical Composition

5.1 The steel shall conform to the requirements as to chemical composition in Table 1 and the chemical analysis

[9] *Annual Book of ASTM Standards*, Vol 03.03.
[10] *Annual Book of ASTM Standards*, Vol 03.06.
[11] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.
[12] Available from ASME International, Three Park Avenue, New York, NY 10016–5990.
[13] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[14] Available from General Services Administration, Washington, DC 20405.
[15] Available from American Petroleum Institute, 1220 L Street, Northwest, Washington, DC 20005–4070.

TABLE 1 Chemical Requirements

	Composition, max, %								
	Carbon	Manganese	Phosphorus	Sulfur	Copper[A]	Nickel[A]	Chromium[A]	Molybdenum[A]	Vanadium[A]
Type S (seamless pipe)									
Open-hearth, electric-furnace or basic-oxygen:									
Grade A	0.25	0.95	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Type E (electric-resistance-welded)									
Open-hearth, electric-furnace or basic-oxygen:									
Grade A	0.25	0.95	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Type F (furnace-welded pipe)									
Open-hearth, electric-furnace, or basic oxygen									
Grade A	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08

[A] The combination of these five elements shall not exceed 1.00 %.

TABLE 2 Tensile Requirements

	Type F	Types E and S	
	Open-Hearth, Basic Oxygen, or Electric-Furnace, Grade A	Grade A	Grade B
Tensile strength, min, psi [MPa]	48 000 [330]	48 000 [330]	60 000 [415]
Yield strength, min, psi, [MPa]	30 000 [205]	30 000 [205]	35 000 [240]
Elongation in 2 in. [50 mm]	[A,B]	[A,B]	[A,B]

[A] The minimum elongation in 2 in. [50 mm] shall be that determined by the following equation:

$$e = 625\ 000\ [1940]\ A^{0.2}/U^{0.9}$$

where:

e = minimum elongation in 2 in. [50 mm] in percent rounded to the nearest percent,
A = cross-sectional area of the tension specimen, rounded to the nearest 0.01 in.^{2} [1 mm^2], based on the specified outside diameter or the nominal specimen width and specified wall thickness. If the area calculated is equal to or greater than 0.75 in.^{2} [500 mm^2], then the value 0.75 in.^{2} [500 mm ^{2}] shall be used, and
U = specified tensile strength, psi [MPa].

[B] See Table X4.1 or Table X4.2, whichever is applicable, for minimum elongation values for various size tension specimens and grades.

shall be in accordance with Test Methods, Practices, and Terminology A 751.

6. Product Analysis

6.1 The purchaser is permitted to perform an analysis of two pipes from each lot of 500 lengths, or fraction thereof. Samples for chemical analysis, except for spectrographic analysis, shall be taken in accordance with Practice E 1806. The chemical composition thus determined shall conform to the requirements specified in Table 1.

6.2 If the analysis of either pipe does not conform to the requirements specified in Table 1, analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to the requirements specified.

7. Tensile Requirements

7.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2.

7.2 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen or to a total extension of 0.5 % of the gage length under load shall be determined.

7.3 The test specimen taken across the weld shall show a tensile strength not less than the minimum tensile strength specified for the grade of pipe ordered. This test will not be required for pipe under NPS 8 [DN 200].

7.4 Transverse tension test specimens for electric-welded pipe NPS 8 [DN 200] and larger shall be taken opposite the weld. All transverse test specimens shall be approximately 1½ in. [40 mm] wide in the gage length, and shall represent the full wall thickness of the pipe from which the specimen was cut. This test is required for NPS 8 [DN 200] and larger.

8. Bending Requirements

8.1 For pipe NPS 2 [DN 50] and under, a sufficient length of pipe shall be capable of being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter of the pipe, without developing cracks at any portion and without opening the weld.

8.2 When ordered for close coiling, the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the outside diameter of the pipe, without failure.

8.3 Double-extra-strong pipe over NPS 1¼ [DN 32] need not be subjected to the bend test.

9. Flattening Test

9.1 The flattening test shall be made on pipe over NPS 2 [DN 50] with all thicknesses extra strong and lighter.

9.2 *Seamless Pipe*:

9.2.1 For seamless pipe, a test specimen at least 2 ½ in. [60 mm] in length shall be flattened cold between parallel plates in two steps. During the first step, which is a test for ductility, no cracks or breaks on the inside, outside, or end surfaces, except as provided for in 9.7, shall occur until the distance between the plates is less than the value of H calculated as follows:

$$H = (1 + e)t/(e + t/D)$$

where:

H = distance between flattening plates, in. [mm] (Note 4),
e = deformation per unit length (constant for a given grade of steel, 0.09 for Grade A, and 0.07 for Grade B),
t = nominal wall thickness, in. [mm], and
D = specified outside diameter, in. [mm]

9.2.2 During the second step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite sides of the pipe meet. Evidence of laminated or unsound material that is revealed during the entire flattening test shall be cause for rejection.

NOTE 4—The H values have been calculated for standard and extra-heavy weight sizes from NPS 2½ to NPS 24 [DN 65 to DN 600], inclusive, and are shown in Table X2.1.

9.3 *Electric-Resistance-Welded Pipe*— A test specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps, with the weld located either 0° or 90° from the line of direction of force as required in 9.3.1 or 9.3.2, whichever is applicable. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside or outside surfaces at the weld shall occur until the distance between the plates is less than two thirds of the specified diameter of the pipe. As a second step, the flattening shall be continued as a test for ductility away from the weld. During the second step, no cracks or breaks on the inside or outside surfaces away from the weld, except as provided for in 9.7, shall occur until the distance between the plates is less than one third of the specified outside diameter of the pipe but is not less than five times the wall thickness of the pipe. During the third step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material or of incomplete weld that is revealed by the flattening test shall be cause for rejection.

9.3.1 For pipe produced in single lengths, the flattening test

Ficha Técnica de Planchas Bimetálicas RECSOL®

COMO SON LAS PLANCHAS BIMETALICAS RECSOL®

Existen hoy, fundamentalmente, dos tipos de fabricación de Planchas Bimetálicas. La primera consiste en depositar soldadura tubular sobre un material base. Este sistema permite aportar solamente un máximo de 1/1 de relación entre acero y ferro-aleaciones. Este sistema no tiene la flexibilidad de variar las fórmulas que son entregadas por el proveedor de la soldadura.

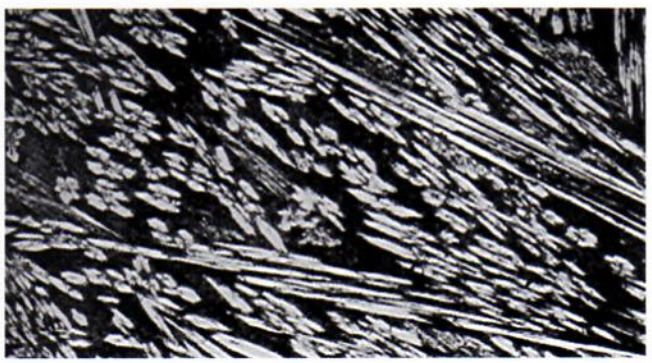
El segundo sistema, es el que usamos en **RECSOL**, consiste en un proceso de fusión continua sobre el material base, y se produce por medio de un electrodo al que en su base del arco eléctrico se le adicionan las ferro-aleaciones, que se formulan para cada aplicación. Este proceso permite aportar hasta un 50% más de carburos que los procesos tradicionales con soldadura.

Las planchas fabricadas con el proceso de fusión de **RECSOL**, tienen como promedio un 30% más de resistencia a la abrasión, que las fabricadas con alambre tubular.

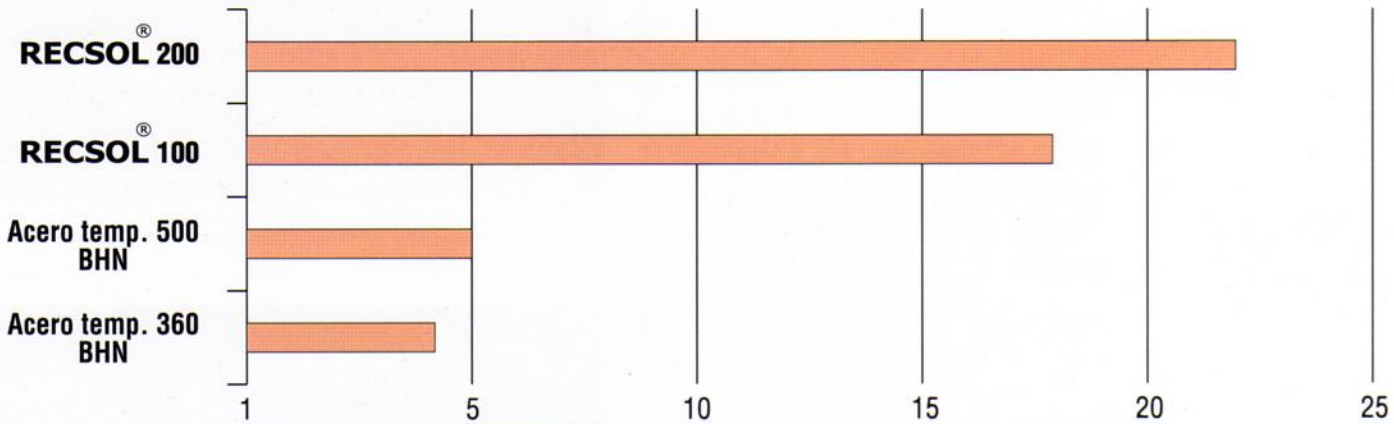
COMPOSICION QUIMICA DE LA PLANCHA ESTANDAR RECSOL®

	RECSOL® 100	RECSOL® 200
Carbono	4.8%	4.5%
Cromo	30-32%	28-30%
Manganeso	3.3%	3.0%
Boro	0.5%	1.5%
Niobio	-----	1.5%
Otros	0.5%	1.0%
Dureza	55-60 HRC	58-62 HRC

MICROFOTOGRAFIA DE DISTRIBUCION DE CARBUROS EN RECUBRIMIENTO RECSOL® 100



COMPARACION DE LA RESISTENCIA AL DESGASTE POR ARRANQUE DE PARTICULAS



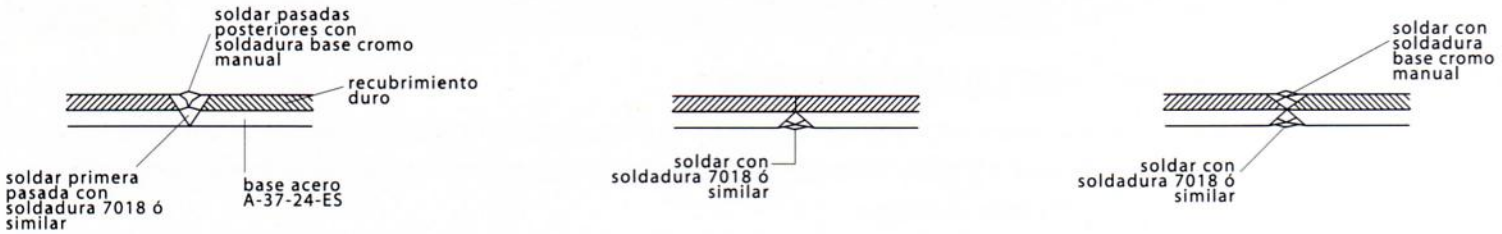
ACERO ESTRUCTURAL NORMA ASTM A36 ES = 1

FORMATO ESTANDAR 2950 X 1900 ESPESORES	
6+4	10+5
6+6	10+9
8+6	10+12
8+10	12+12

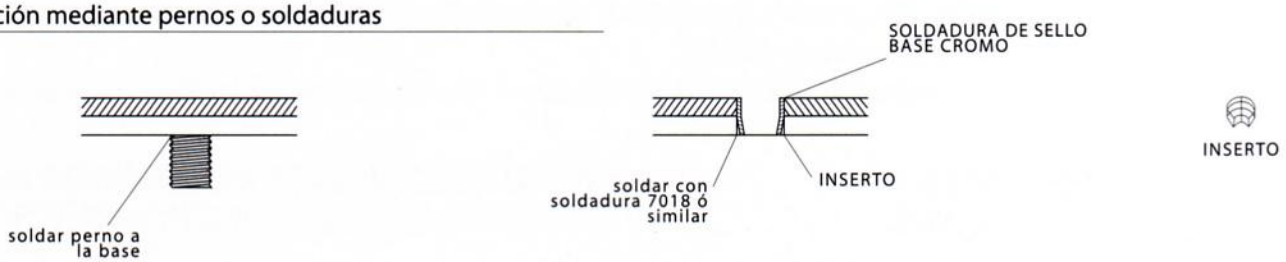
El primer número corresponde al material base y el segundo al material de aporte.
Estas medidas tienen una tolerancia de fabricación de +-1 mm. en el espesor final.

SISTEMAS DE FIJACION DE PLACAS BIMETALICAS RECSOL®

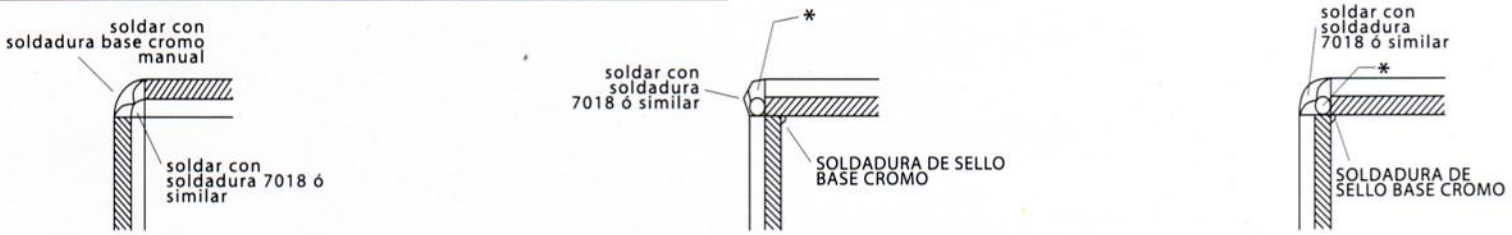
1.- Unión entre planchas bimetálicas



2.- Instalación mediante pernos o soldaduras



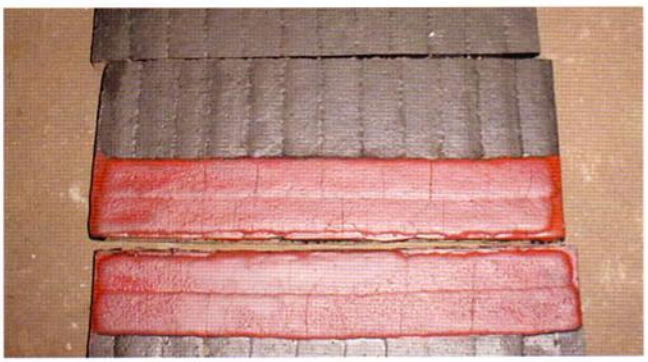
3.- Unión de planchas en filete



*: Se recomienda colocar una barra de fierro para no contaminar la placa base

NUESTRAS VENTAJAS

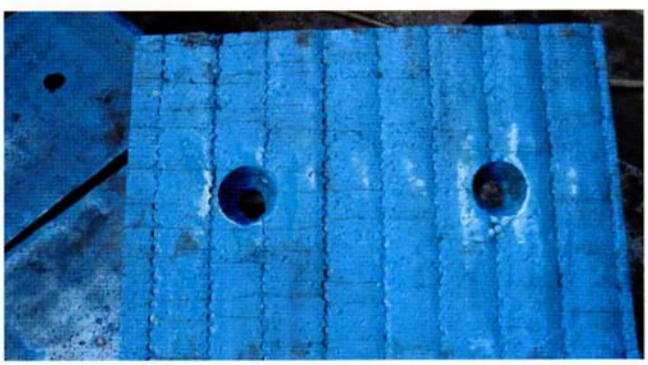
Al fabricar nuestras planchas en Chile, tenemos una muy rápida respuesta de entrega, por lo que bajamos los costos de inventario de nuestros clientes. Con nuestro método de fabricación podemos formular distintas aleaciones para adecuarnos a los requerimientos del usuario. El uso de Planchas Bimetálicas **RECSOL** reduce las paradas de los equipos y baja los costos de mantención.



APLICACIONES

Los productos Bimetálicos tienen hoy una gran aplicación en industrias tales como:

Minería, cementeras, celulosa, plantas termoeléctricas, procesadoras de hormigón y en cualquier lugar en que el desgaste sea problema.



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Santiago - Chile
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CREUSABRO® 4800(P)

A high wear resistant steel

CREUSABRO® 4800(P) is a high wear resistant steel, offering a 50% extra in service life compared to a conventional 400 HB water quenched.

Improved properties of CREUSABRO® 4800(P) are the result of the combination of an enriched analysis (chromium, molybdenum and titanium) and specific heat treatment procedures.

More than hardness, the wear resistance of CREUSABRO® 4800(P) is based on:

- a very fine distribution of chromium, molybdenum, and titanium microcarbides reinforcing the microstructure with the same principal as composite materials.
- a very efficient work hardening capability in service, coming from a metallurgic effect called "**TRIP** effect" (**TR**ansformation **I**nduced by **P**lasticity).
- Reinforcement of the grain structure with titanium carbides.

Together with its high wear properties, CREUSABRO® 4800(P) exhibits very good aptitude to processing. Especially, the limited hardness in delivery condition, strongly facilitates processing operations like cutting, machining and forming.

Application markets of CREUSABRO® 4800(P) are: mines, quarries, cement industries, steel making, public works - It can be used in all environments, sliding, impact abrasion, in dry, wet or hot conditions (350°C max).

STANDARD CREUSABRO® 4800(P)

CHEMICAL ANALYSIS

Guaranteed values (Weight %)

C	Mn	Ni	Cr	Mo	S	Tl
≤ 0.20	≤ 1.60	≈ 0.20	≤ 1.90	≤ 0.40	≤ 0.005	≤ 0.20

MECHANICAL PROPERTIES

Indicative values (As delivered)

Hardness HB	YS 0.2 MPa	UTS MPa	El. %	KCVL-20°C J/Cm²	E GPa
370	900	1200	12	45	205

Guaranteed values (As delivered)

Hardness: 340/400 HB

Toughness: KCVL -20°C ≥ 30 J/cm²

Hot mechanical properties (indicative values)

Rp YS MPa			Rm UTS MPa		
200°C	400°C	500°C	200°C	400°C	500°C
940	920	820	1220	1120	900

PHYSICAL PROPERTIES

Expansion coefficient (x 10^{-6}.°C^{-1})

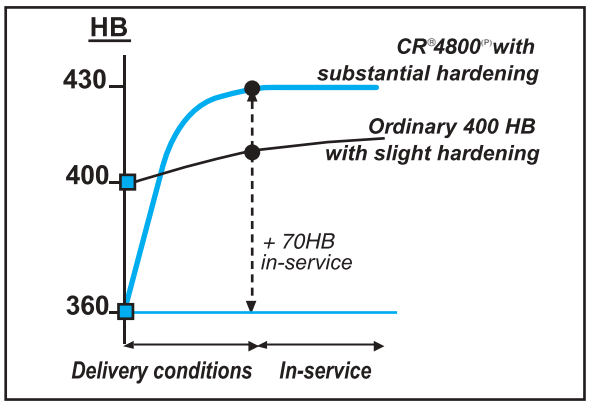
20/100°C	20/200°C	20/300°C	20/400°C	20/500°C
12.4	13.1	13.9	14.4	14.7

METALLURGICAL CONCEPT

Abrasion resistance is not exclusively connected to the hardness of the steel in delivered condition. Its components and its structure strongly influence its performance. Chemical balance and manufacturing processes of CREUSABRO® 4800(P) impart a metallurgical structure to the steel which strongly improves its wear resistance through the following properties.

When entering into service, CREUSABRO® 4800(P) takes advantage of a surface hardening effect of about 70 HB, whatever the applied strain level is (impact, pressure...)

In service work hardening thanks to TRIP effect



"TRIP effect": TRansformation Induced by Plasticity

CREUSABRO® 4800(P), due to its initial structure containing retained austenite, has the capability to work-harden in service under the action of local plastic deformations.

These plastic deformations create a hardening effect by transformation of retained austenite into very hard fresh martensite.

TRIP effect also contributes to the delay of chip removal from the steel under the action of abrasive particles.

The steel consequently becomes harder and remains very resistant to wear by chip removal.

Fine dispersion of micro carbides

The fine structure of CREUSABRO® 4800(P) is obtained by a fine dispersion of micro-carbides.

This structure is just the opposite of the rough acicular lamellar structure typical of 400HB water quenched steels.

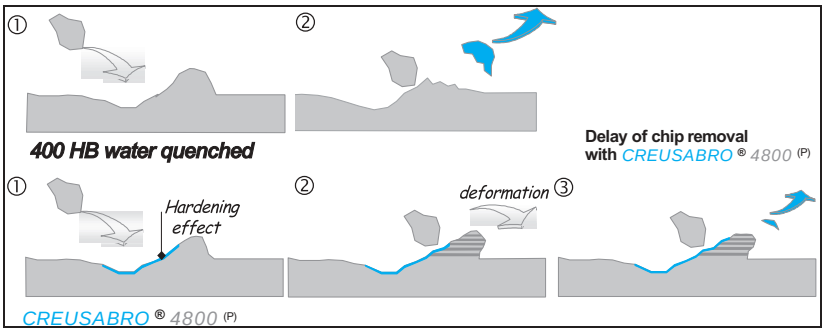
In water quenched steel, cracking along lamellas leads easily to the chip removal effect under the action of abrasion.

Titanium carbides

In addition to the fine and homogeneous distribution of chromium and molybdenum carbides (respectively 1500 HV and 1800 HV) common to CREUSABRO® steels. Creusabro® 4800(P) is a new generation steel in the field of wear resistance steels with a significant addition of Titanium resulting in the formation of a structure with very hard and fine particles of titanium carbide, TiC reaching a hardness level of 3200 Hv. These carbides give to the steel an increased wear resistance.

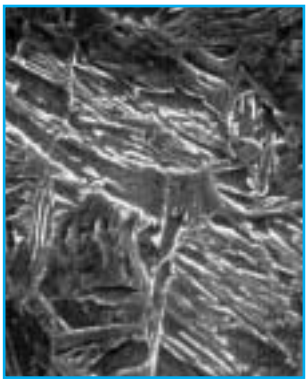
Delay of chip removal

Creusabro® 4800(P) has the advantage of a higher capacity for plastic deformation caused by impacts. This extra-ductility induces a delay in the chip removal ensuring a slower wear rate (weight loss) than on 400HB water quenched steels.

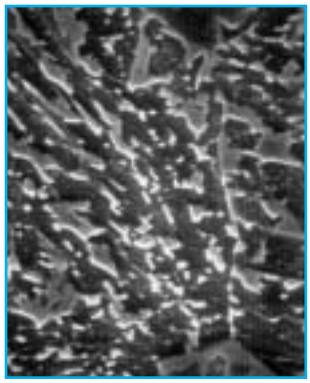


This effect is strongly reduced in CREUSABRO® 4800(P) which does not have this lamellar structure.

More over, this fine dispersion of carbides reinforces the steel and works in combination with the work hardening effect to delay chip removal in service.



400 HB Water quenched Microstructure



CR® 4800(P) Microstructure

Summary

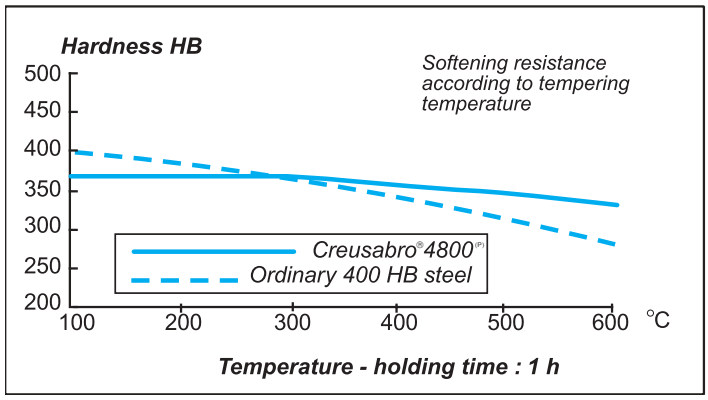
	400HB water quenched Conventional route Passive material	Creusabro® 4800(P) Innovative route Active material
Wear resistance	Just connected to supplied hardness **PASSIVE STEEL**	Combining • In service hardening • TRIP effect • Microcarbides + Titanium effect **REACTIVE STEEL**
Process	• Low alloyed steel (C, Mn, B) • Water quenching	• Specific additions of alloying elements (Cr, Mo, B, Ti...) • Controlled cooling rate
Structure	• 100% martensitic lamellar structure	• Structure: bainite/martensite + retained austenite + micro-carbides → Transformation of retained austenite into fresh martensite under abrasive effect → Fine micro-carbides, homogeneously dispersed + very hard Titanium carbides

PROPERTIES AT HIGH TEMPERATURE

Chemical analysis of CREUSABRO® 4800(P), specifically its chromium and molybdenum contents, imparts a high softening resistance in hot conditions, much better than that of 400HB water quenched steel.

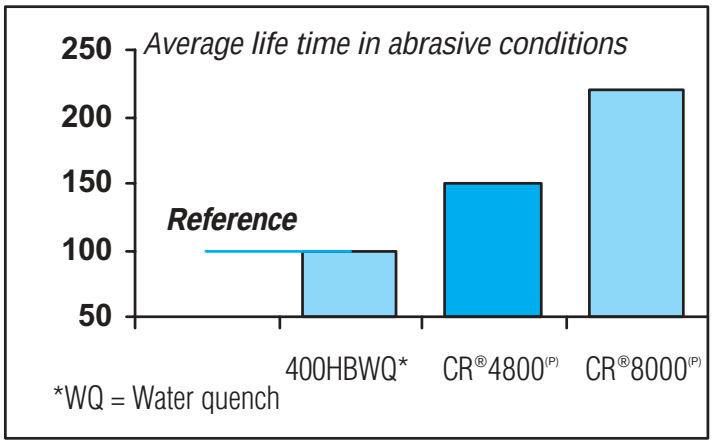
This property allows processing of the steel in hot conditions (450/500°C), hot forming for example, and cooling down in air without inducing any significant drop of hardness.

The hot resistance of CREUSABRO® 4800(P) allows its use in hot environments where pieces are heated up to 350°C max.

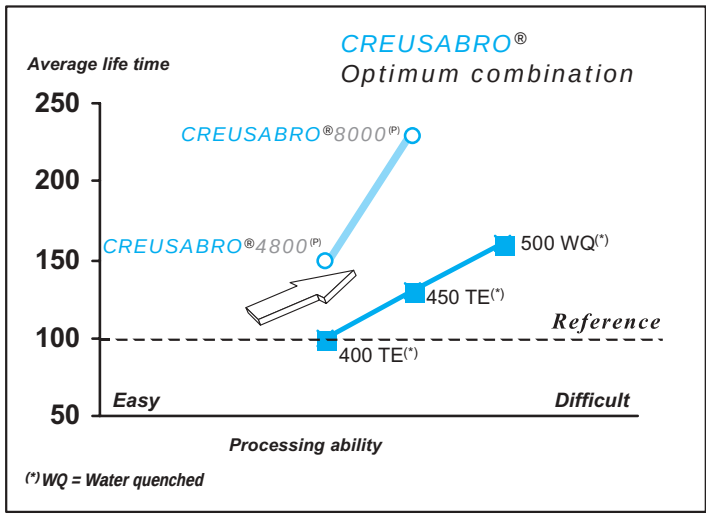


SERVICE LIFE

CREUSABRO® 4800(P) metallurgical concept improves its wear resistance compared to other anti-abrasion grades available in the market, and in all service conditions.



CREUSABRO® 4800(P) benefits trom the optimum compromise between wear resistance and ease of processing.



PROCESSING

Cutting

All classical thermal processes (gas-plasma-laser) can be used. Plasma/laser processes are especially recommended. They provide better precision and cutting aspects and induce a thinner Heat Affected Zone (HAZ).

Whatever process (thermal) is used, the following conditions are sufficient to avoid cold cracking:

Plate temperature	Thicknesses ≤ 60 mm	Thicknesses > 60mm
≥ 10°C	No preheating	Preheating: 150°C
< 10°C	All thicknesses: Preheating 150°C	

Water jet cutting can be used.

Machining

Drilling and milling operations can be done by utilising Sandvik Coromant drills and inserts.

Drilling can be done with high speed tools, HSSCO type.
(ex. AR.2.9.1.8 according to AFNOR, M42 according to AISI).
Lubrication with soluble oil diluted to 20%.

Tool	ø mm	Cutting speed (m/min)	Revolution speed (rev/min)	Feed (mm/rev)
HSSCO	5	15-20	950-1250	0.07
AR.2.9.1.8	10	13-17	415-540	0.09
(M42)	15	12-15	255-320	0.10
	20	11-14	175-220	0.12
	25	9-12	115-150	0.15
	30	8-10	85-105	0.20

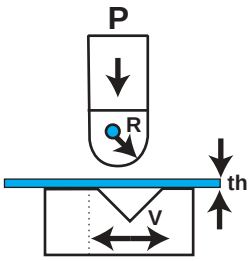
Indicative parameters

PROCESSING

Forming

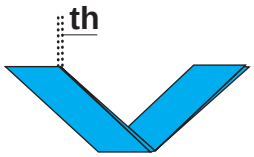
Cold forming can be done as long as the following conditions are met:

- edge preparation by grinding to remove flame cutting heterogeneities
- minimum internal bending radius (table below)
- plate temperature at 10°C minimum



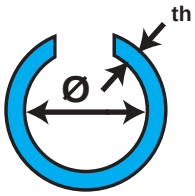
Internal bending radius (min.)	⊥ Direction	$r_i \geq$ 3rd
Internal bending radius (min.)	// Direction	$r_i \geq$ 4th
Die opening V (mini)		V ≥ 12th

According to the above parameters, bending strength depends on bending length, piece thickness, die opening...



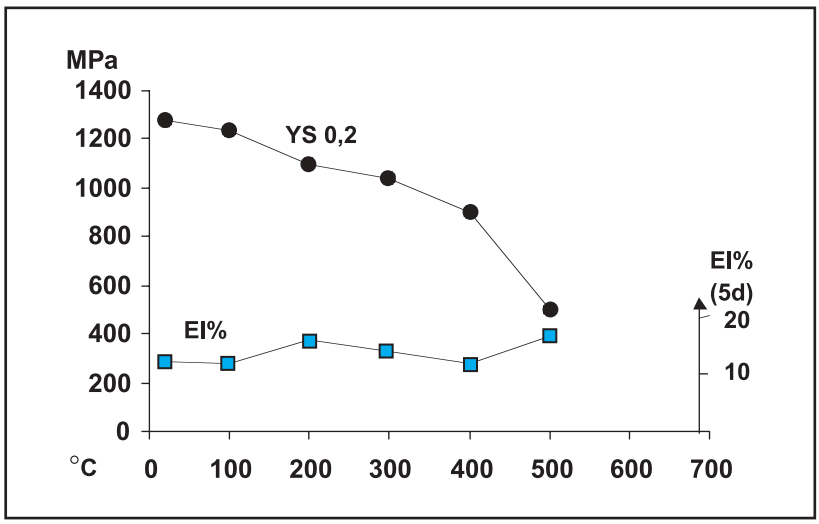
Thickness mm	Bending strength per meter (Tons/m)
10	130
20	250

Above table gives indicative power needed to bend for a die opening of 12 times the thickness.



Rolling shall be performed in following conditions.
Øi ≥ 30 th (temperature of the piece ≥ 10°C)

CREUSABRO® 4800(P) can be formed at a temperature of 450/500°C without any further heat treatment. At this temperature, forming require lower power than at room temperature, proportionally to the reduction of its yield strength YS 0,2.



For thickness up to 15mm, it is possible to perform hot forming within the range 870/1000°C followed by air cooling without impairing steel properties.

Welding

CREUSABRO® 4800(P) can be welded with all classical processes: manual, semi-automatic under gas protection, automatic under flux.

For welds non subjected to wear, following welding products can be used.

Processes	AWS
Manual Coated electrode	AWS 5-1 Class E7016 or 7018
Semi-automatic Under gas	AWS A-5-18 Class ER70S4 or ER 70S6
	AWS-5-20 Class ER 71T5

For welds subjected to wear, ask us for the best choice of welding consumables.

Welded areas should be clean, free of grease, water, oxides,...

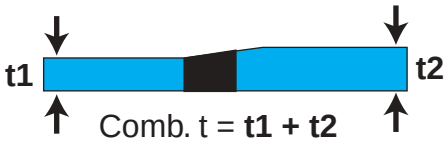
Electrodes and flux shall be stoved according to supplier's recommendations.

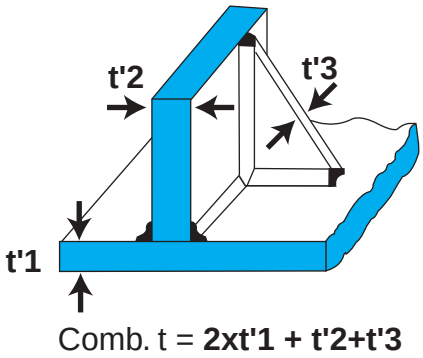
Following preheating conditions shall be respected (for welded structure without excessive stresses).

Welding process	Heat input (kj/mm)	Pre/Postheating conditions: Combined thickness (mm) 30	40	50	60	70	80	90
1 Solid wire with gas (GMAW)	1.5							
	3.0							
2 Manual or flux cores wire welding (SMAW or FCAW)	1.0							
	2.0							
3 Submerged arc welding (SAW)	2.0							
	3.0							

Without pre-heating | Pre-post heating at 75˚C | Pre-post heating at 125˚C

Combined thickness calculation





APPLICATIONS

- **Quarries - Public works**

  Blades, bucket liners, chute plate liners, crusher lateral armouring, screens, dumper bodies, trommels, ...
- **Mines**

  Extraction equipment, conveyor bottom plates, hoppers, helical gravity and screw conveyors, skips, ventilators, discharge plates, ...
- **Cement plants**

  Wheel excavator buckets, crusher lateral shields, clinker chutes, buckets, ventilators, dust separators, bagging machines...
- **Steel plants**

  Guiding plates, hoppers, chutes, discharge plates, scrap containers / charging boxes ...

DIMENSIONAL PROGRAM

Thicknesses 5mm to 100 mm

Standard sizes	1500 x 3000 mm
	2000 x 6000 mm
	2500 x 7500 mm

Other dimensions available on request

NOTE:

1. This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research programme on abrasion resistant grades.

We therefore suggest that information be verified at time of enquiry or order.

Furthermore, in service, real conditions are specific for each application. The data presented here is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval.

2. Creusabro® 4800(P): Application range.

Creusabro® 4800(P) has been developed specifically for its abrasion resistance.

In addition to the recommendations given in this document, Customer will have to follow the Industry standard quality rules for any processing operation performed on this material.

Further information may be obtained from the following address.

FOR FURTHER INFORMATION CONTACT YOUR LOCAL SALES REPRESENTATIVE

Email: sales.steelau@sandvik.com

ADELAIDE	08 8243 7700
BRISBANE	07 3347 0500
MELBOURNE	03 9238 7200
NEWCASTLE	02 4924 2130
PERTH	08 9351 1500
SYDNEY	02 9828 0600
TOWNSVILLE	07 4722 4100

SANDVIK

INDUSTEEL Arcelor Group

CREUSABRO® 8000 (P)

Un acero de alta resistencia a la abrasión

CREUSABRO® 8000(P) es un acero resistente a la abrasión caracterizado por un alto rendimiento, y que ofrece una resistencia al desgaste 50% superior a la de los aceros clásicos templados en agua.

CREUSABRO® 8000(P) aprovecha un concepto innovador, basado en una combinación original de análisis químico y de tratamientos térmicos (temple en aceite). Esta combinación provee al acero una resistencia incrementada a la abrasión gracias a la contribución:

- de microcarburos finos de cromo y de molibdeno que refuerzan la estructura como lo hacen los materiales compuestos.
- de una aptitud excepcional de endurecimiento en línea procedente de un proceso metalúrgico llamado el efecto **TRIP** (**TR**ansformation **I**nduced by **P**lasticity).

Además de su alta resistencia al desgaste, el CREUSABRO® 8000(P) preserva una aptitud excelente para ser procesado y transformado en piezas y partes para aplicaciones antiabrasivas, muy superior a la de los aceros 500 HB clásicos. El CREUSABRO® 8000(P) ofrece la mejor combinación entre una resistencia excepcional al desgaste y una puesta en aplicación satisfactoria.

ESTANDAR CREUSABRO® 8000

ANALISIS QUIMICO

Valores garantizados (Peso %)

C	Mn	Ni	Cr	Mo	S
≤ 0.28	≤ 1.60	≈ 0.40(*)	≤ 1.60	≥ 0.20	≤ 0.002

(*) para anchos sobre 2500mm, Ni ≈1.25%

PROPIEDADES MECANICAS

Valores indicativos (En el estado de suministro)

Hardness HB	YS 0.2 MPa	UTS MPa	El. %	KCVL-20℃ J/Cm^2	E GPa
470	1250	1630	12	55	205

Valores garantizados (en el estado del suministro)
Dureza: 430/500 HB
Tenacidad: KCVL -20℃ ≥ 40 J/cm^2
KCVL -40℃ ≥ 30 J/cm^2

® Marca registrada INDUSTEEL

(P) Grado patentado por INDUSTEEL

Propiedades mecánicas en caliente (valores indicativos)

YS MPa			UTS Mpa		
200℃	400℃	500℃	200℃	400℃	500℃
1080	880	520	1650	1250	900

PROPIEDADES FISICAS

Densidad a +20℃: 7,85kg/dm^3

Coeficiente de dilatación (x 10^{-6}.℃$^{-1}$)

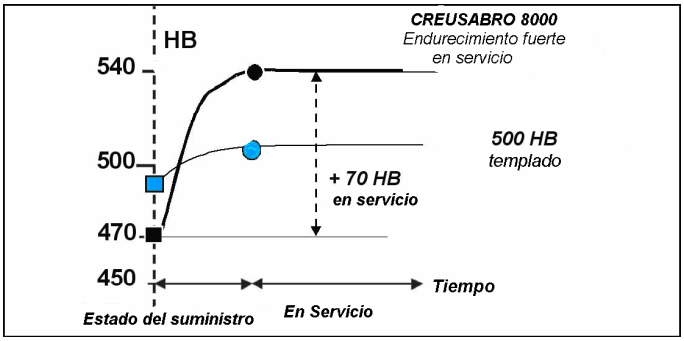
20/100℃	20/200℃	20/300℃	20/400℃	20/500℃
11.2	12.0	12.5	13.2	13.8

CONCEPTO METALURGICO

La resistencia a la abrasión no está relacionada exclusivamente a la dureza del acero en el estado de suministro. Sus componentes y su estructura influyen fuertemente en su rendimiento. El equilibrio químico y los procesos de producción del CREUSABRO® 8000(P) confieren una estructura metalúrgica que contribuye a mejorar su resistencia a la abrasión a través de las siguientes propiedades.

Durante su puesta en aplicación, el CREUSABRO® 8000(P) aprovecha un endurecimiento de superficie de aproximadamente 70 HB, sean los niveles de trabajo que sean aplicados (impacto, presión…)

Endurecimiento en servicio gracias al efecto TRIP



“Efecto TRIP”: Transformación Inducida por deformación Plástica

El material posee, gracias a su estructura inicial que contiene austenita retenida, una aptitud de endurecimiento en servicio bajo el efecto de las deformaciones plásticas locales.

Estas deformaciones suponen un endurecimiento por transformación de la austenita retenida en martensita fresca muy dura.

El efecto TRIP toma parte también en el retraso de la pérdida de metal bajo la acción de las partículas abrasivas

Pues, el material llega a ser más duro en servicio, ofreciendo una resistencia más alta al deterioro por pérdida del material.

Dispersion fina de microcarburos

La fina estructura del CREUSABRO® 8000(P) se obtiene por una fina dispersión de microcarburos.

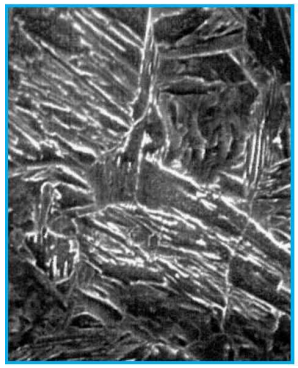
Esta estructura contrasta con la estructura laminar acicular (con agujas) típica de los aceros de 500 HB templados en agua.

El los aceros enfriados al agua, la fisuración del material a lo largo de las agujas conduce fácilmente la pérdida de las partículas metálicas bajo la acción de la abrasión.

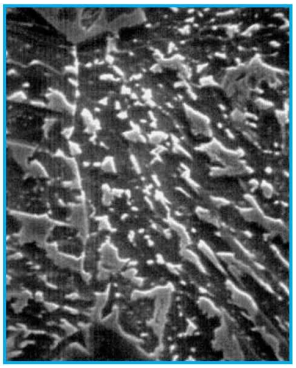
la fisuración del material a lo largo de las agujas conduce fácilmente a la pérdida de las partículas metálicas bajo la acción de la abrasión.

Este efecto se reduce fuertemente en el CREUSABRO® 8000(P) que no tiene esta estructura laminar.

Además, esta fina dispersión de micro carburos refuerza el acero y trabaja en combinación con el efecto de endurecimiento para retrasar el desgarramiento de las partículas metálicas, en servicio



Microestructura acero 500 HB templado en agua



Microestructura CREUSABRO® 8000(P)

Resumen

Acero 500HB templado en agua Proceso tradicional Material Pasivo	**CREUSABRO® 8000(P)** Proceso innovador Material reactivo
• Acero de baja aleación	• Adición de elementos de aleación específicos
• Temple en agua ↓ • Estructura 100% martensitica laminar	• Enfriamiento controlado (tratamiento térmico) ↓ • Estrructura: martensita + austenita retenida + micro-carburos → Transformación de la austenita retenida en martensita fresca bajo el efecto de abrasión → Micro carburos finos uniformemente distribuídos
Resistencia al desgaste sólo por dureza en estado de suministro, propagación de las fisuras a lo largo de las láminas.	Resistencia al desgaste y a la pérdida de las partículas metálicas, gracias a los efectos combinados de dureza, el efecto TRIP y de los micro carburos.

Soldadura

CREUSABRO® 8000(P) puede ser soldado con todos los procesos clásicos: manual, semi-automático con gas de protección, automático tubular.

Para soldaduras no sometidas a abrasión, se pueden usar los siguientes productos de aporte:

Procesos	AWS
Manual Electrodo recubierto	AWS 5-1 Clase E7016 ó 7018
Semi-automatico gaseoso	AWS A-5-18 Clase ER70S4 ó ER 70S6
	AWS-5-20 Clase ER 71T1

Para soldaduras sometidas a abrasión, consúltenos para la elección de los productos de aporte.

Las áreas a soldar deben estar limpias, sin grasa, agua ni óxidos,...

Toda la soldadura debe mantenerse de acuerdo a las recomendaciones del proveedor.

Las siguientes condiciones de pre-calentamiento tienen que ser respetadas (para estructura soldada sin esfuerzos residuales excesivos).

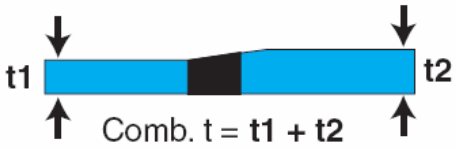
Procesos de soldadura		Energía liberada (kJ/Cm)	Condiciones de pre-y post-calentamiento								
			Espesor combinado (mm)								
			10	20	30	40	50	60	70	80	90
1	Soldadura manual Electrodo recubierto	15/20									
2	Semi-automático gaseoso	15									
		30									
3	Automático tubular	20									
		30									

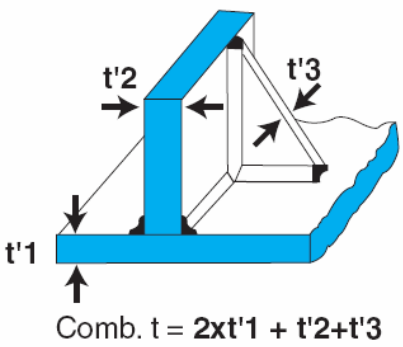
Sin precalentamiento

Pre/post calentamiento a 100 ℃

Pre/post calentamiento a 150℃

Cálculo del espesor combinado





NOTA:

1. Estos datos técnicos e información presentan lo aportado por nuestros laboratorios al momento de la impresión. Sin embargo, podría estar sujeto a variaciones debido al contínuo programa de desarrollo sobre los aceros resistentes a la abrasión.

Por tanto, le sugerimos que al momento de cotizar u ordenar, la información sea verificada.

Además, las condiciones reales encontradas en servicio son las específicas para cada aplicación. La información presentada aquí es sólo con el propósito de presentar una indicación, y sólo pueden ser consideradas como garantía en servicio cuando nuestros expertos lo hayan aprobado formalmente.

2. Límites de empleo de CREUSABRO® 8000(P):

El CREUSABRO® 8000(P) ha sido desarrollado específicamente para su resistencia a la abrasión.

Además de las recomendaciones dadas en este documento, el cliente tendrá que seguir las recomendaciones industriales estándar para cualquier proceso de operación desarrollada sobre este material.

Mayor información puede ser obtenida dirigiéndose a:

PARA MAYOR INFORMACION

Sandvik Materials Technology Casa Matriz

Barón de Juras Reales N°5050 - Conchalí

Ventas

• Tel: 02 6760200 • Fax: 02 623 5300 ó nuestro representante de ventas local
Contacto: Juan Moreno

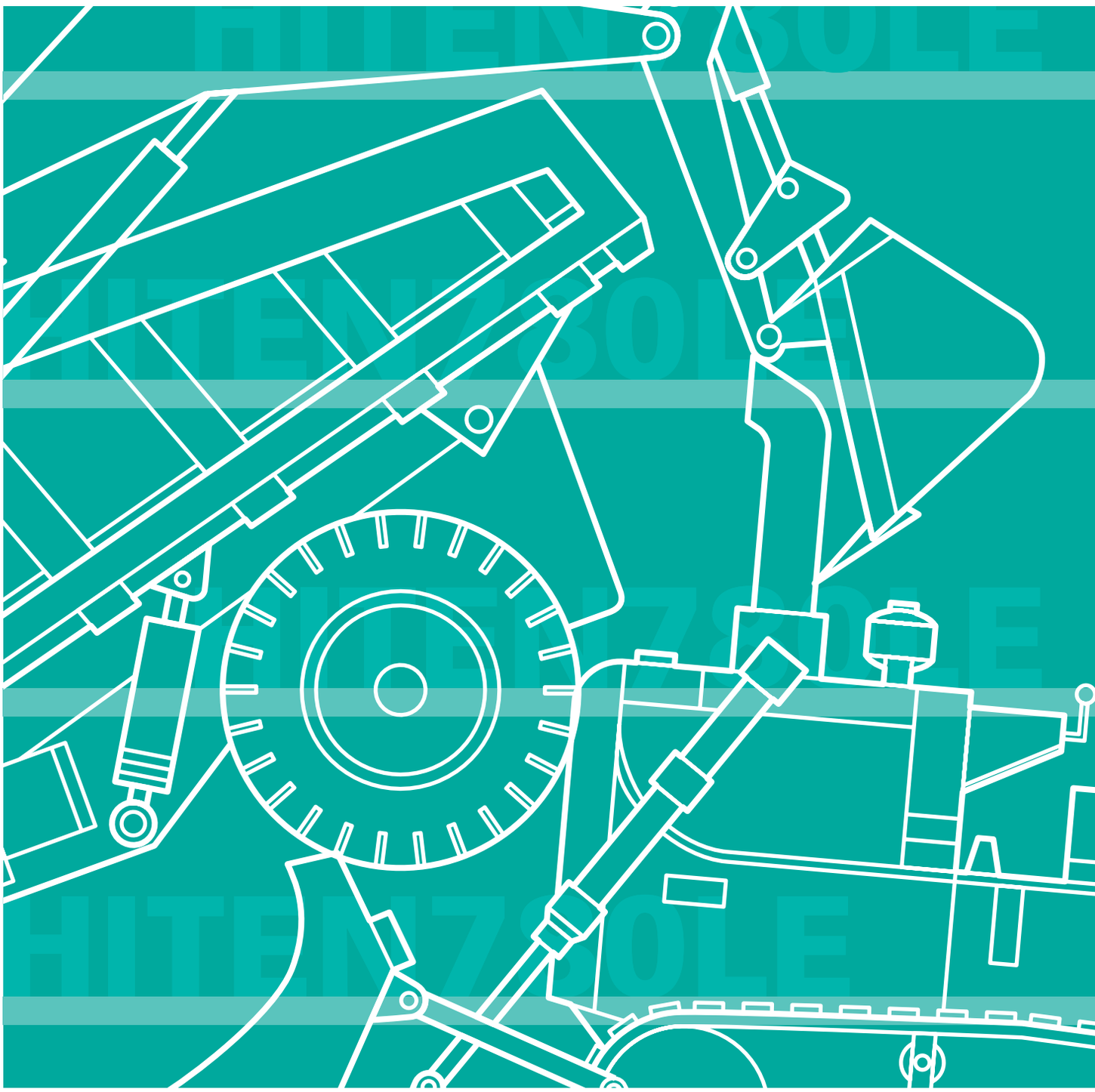
Asistencia Técnica

• Tel:+02 676 0222 • Fax:02 623 5300
Contact: Juan Moreno

JFE-HITEN780LE

JFE's High Strength Steel Plates by The Leading Edge of Production Technology

最先端技術による建設機械、産業機械用
高靭性・高溶接性780N/mm^{2}級高張力鋼板



JFE Steel Corporation

What's New

JFE Steel, the pioneer of TMCP technology in the world, has succeeded in developing new high strength steel plates by the leading edge of technology, “Micro-alloying Technology and TMCP”, and is pleased for customers to enjoy the new plates.

TMCP : Thermo-Mechanical Control Process

JFE-HITEN780LEはJFEスチールの“マイクロアロイング技術とTMCP技術”を適用することにより、低温靭性、溶接性を兼ね備えた、革新的な建設機械、産業機械用高張力鋼板です。

Guaranteed Low Temperature Toughness

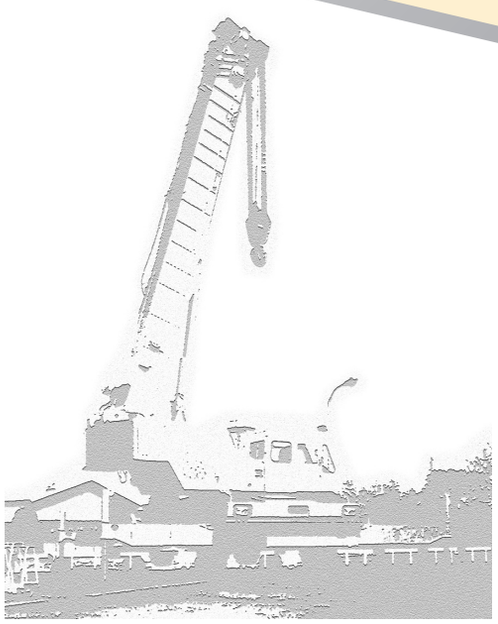
JFE Steel guarantees the absorbed energy of Charpy impact test at -40˚C, then the plate shows not only high strength but also high toughness.

Excellent Weldability

Micro-alloying technology in combination with TMCP enables to reduce carbon equivalent, and then excellent weldability is given.

Excellent Formability

JFE-HITEN780LE shows excellent formability as the same level as conventional one.



低温靭性保証

JFE-HITEN780LEは－40℃のシャルピー衝撃試験値を保証しており、優れた低温靭性を有しています。

優れた溶接性

JFE-HITEN780LEは“マイクロアロイング技術とTMCP技術”を適用することにより炭素当量を低く抑え、優れた溶接性を有しています。

優れた加工性

JFE-HITEN780LEは従来のJFE-HITENシリーズ同様に、優れた加工性を有しています。

Specification & Typical Technical Properties　規格と性能例

Chemical Compositions　化学成分

Item 項目		Typical Value 性能例	Specification 規格値	
Plate Thickness　板厚		25 mm	～19 mm	19.1～32 mm
Chemical Compositions 化学成分(%)	C	0.15	0.20 max.	
	Si	0.38	0.40 max.	
	Mn	1.18	1.40 max.	
	P	0.012	0.025 max.	
	S	0.002	0.015 max.	
	Cr	Micro-alloying adjustment	0.20 max.	
	Mo		0.15 max.	
	V		0.08 max.	
	B		0.005 max.	
	Ceq[1)]	0.39	0.40 max.	0.43 max.

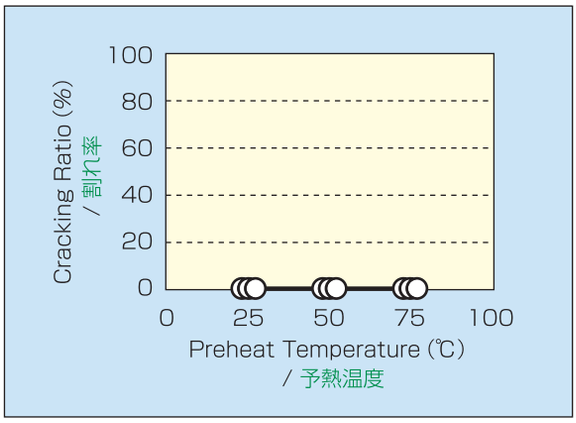
Notes　1) Ceq = C+Mn/6+(Cu+Ni)/15+(Cr+Mo+V)/5
Other micro-alloying elements are added if necessary.

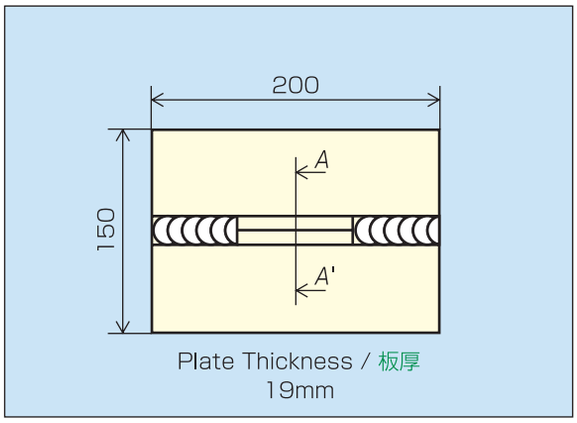
Mechanical properties　機械的特性

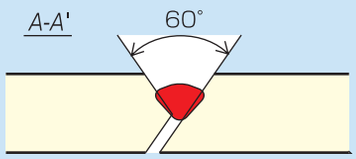
Item 項目		Typical Value 性能例	Specification 規格値
Plate Thickness　板厚		25 mm	6 ～ 32 mm
Tensile Property[1)] 引張特性	Yield Strength　降伏強さ	777 N/mm^2	685 N/mm^2 min.
	Tensile Strength 引張強さ	835 N/mm^2	780～930 N/mm^2
	Elongation　伸び	33 %[2)]	16% min.（～16mm）[2)] 24% min.（16.1～32mm）[2)] 16% min.（20.1～32mm）[3)]
Bending Property[4)] 曲げ特性	Specimen　試験片	Full thickness x25mm	Full thickness x25mm
	Bending Angle　曲げ角度	180°	180°
	Inside Radius　曲げ半径	1.5xThickness	1.5xThickness
Charpy Impact Property[5)] 衝撃特性	Temperature　温度	−40℃	−40℃
	Specimen　試験片	2mm V-Notched	2mm V-Notched
	Absorbed Energy 吸収エネルギー	145 J	40 J min.[6)]

Notes　1) Direction　: Transverse to rolling direction　T方向
2) Specimen　: 25mm width × 50mm G.L.
3) Specimen　: 14mm diameter × 50mm G.L.
4) Bending test is carried out when required in purchaser's specification
5) Direction : Longitudinal　L方向
6) 6≦t<8.5mm　: 20 J min.
8.5≦t≦12mm : 30 J min.
t : plate thickness　板厚

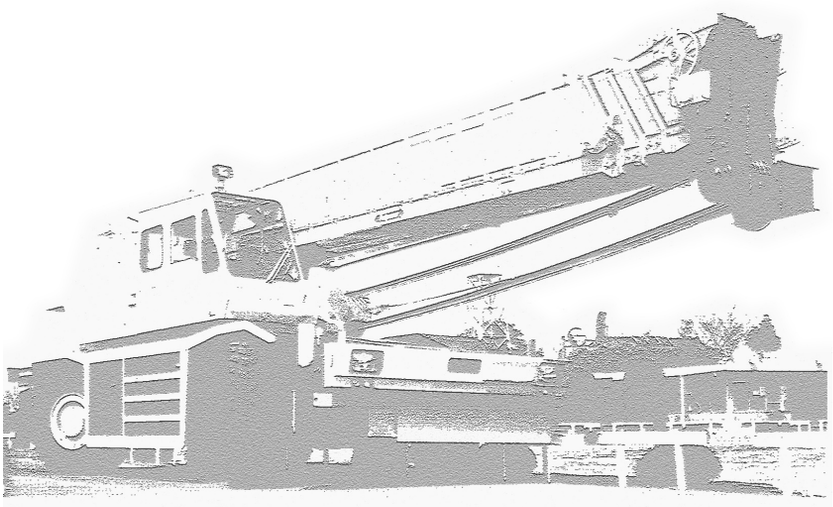
y-Groove Weld Cracking Test　y形溶接割れ試験（JIS Z 3158）







Welding method 溶接方法　: GMAW
Heat input 入熱　: 1.7kJ/mm
Atmospheric condition 雰囲気　: 20℃-60% (Relative Humidity / 相対湿度)



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JFE

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北陸支社	〒930-0004	富山市桜橋通り3番1号（富山電気ビル3F）	TEL 076(441)2056	FAX 076(441)2058
岡山支社	〒700-0821	岡山市中山下1丁目8番45号（NTTクレド岡山ビル19F）	TEL 086(224)1281	FAX 086(224)1285
中国支社	〒730-0036	広島市中区袋町4番21号（広島富国生命ビル7F）	TEL 082(245)9700	FAX 082(245)9611
四国支社	〒760-0017	高松市番町1丁目1番5号（日本生命高松ビル9F）	TEL 087(822)5100	FAX 087(822)5105
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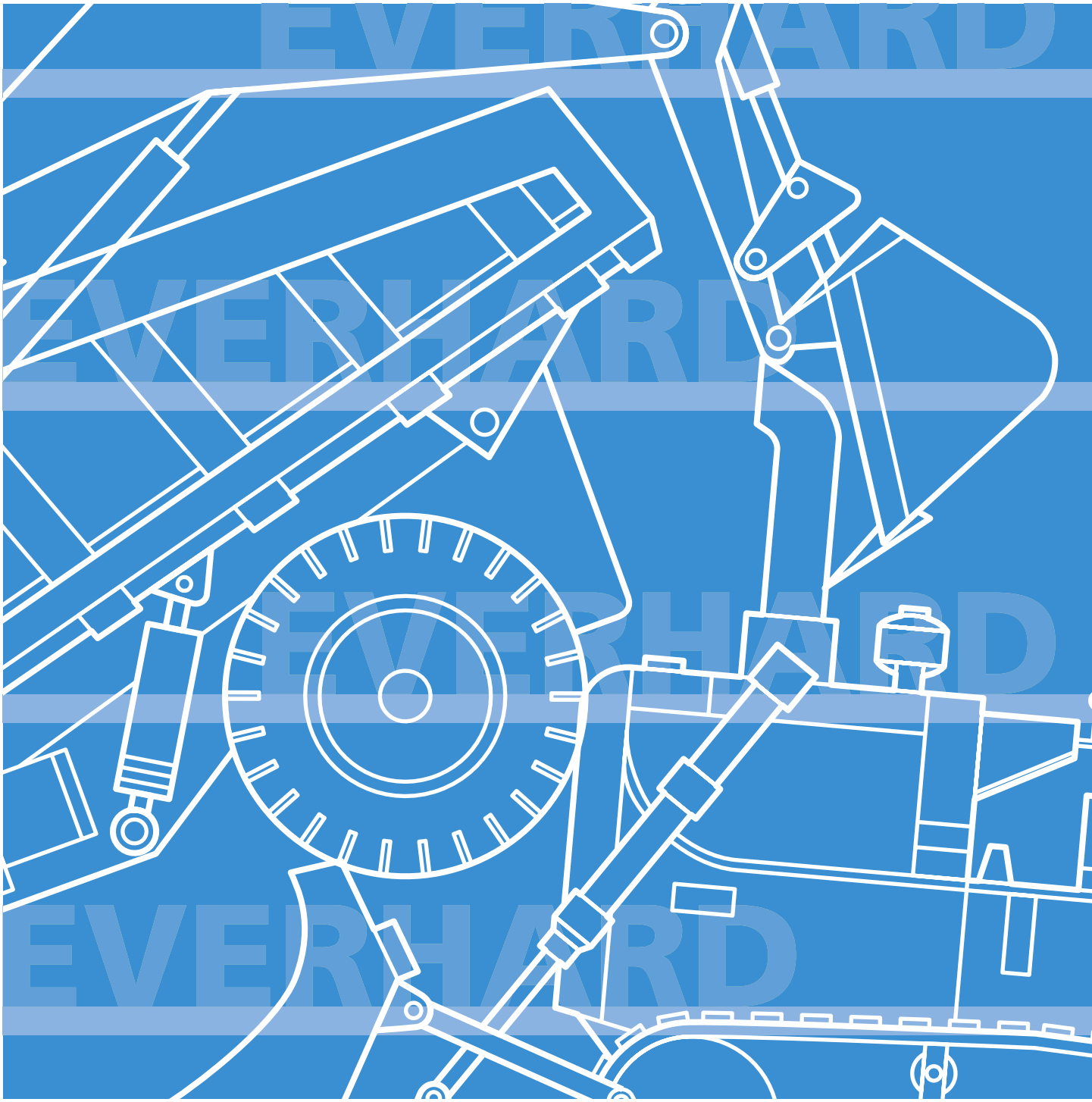
JFE EVERHARD

JFE-EH Series
Abrasion-Resistant Steel Plate



JFE Steel Corporation

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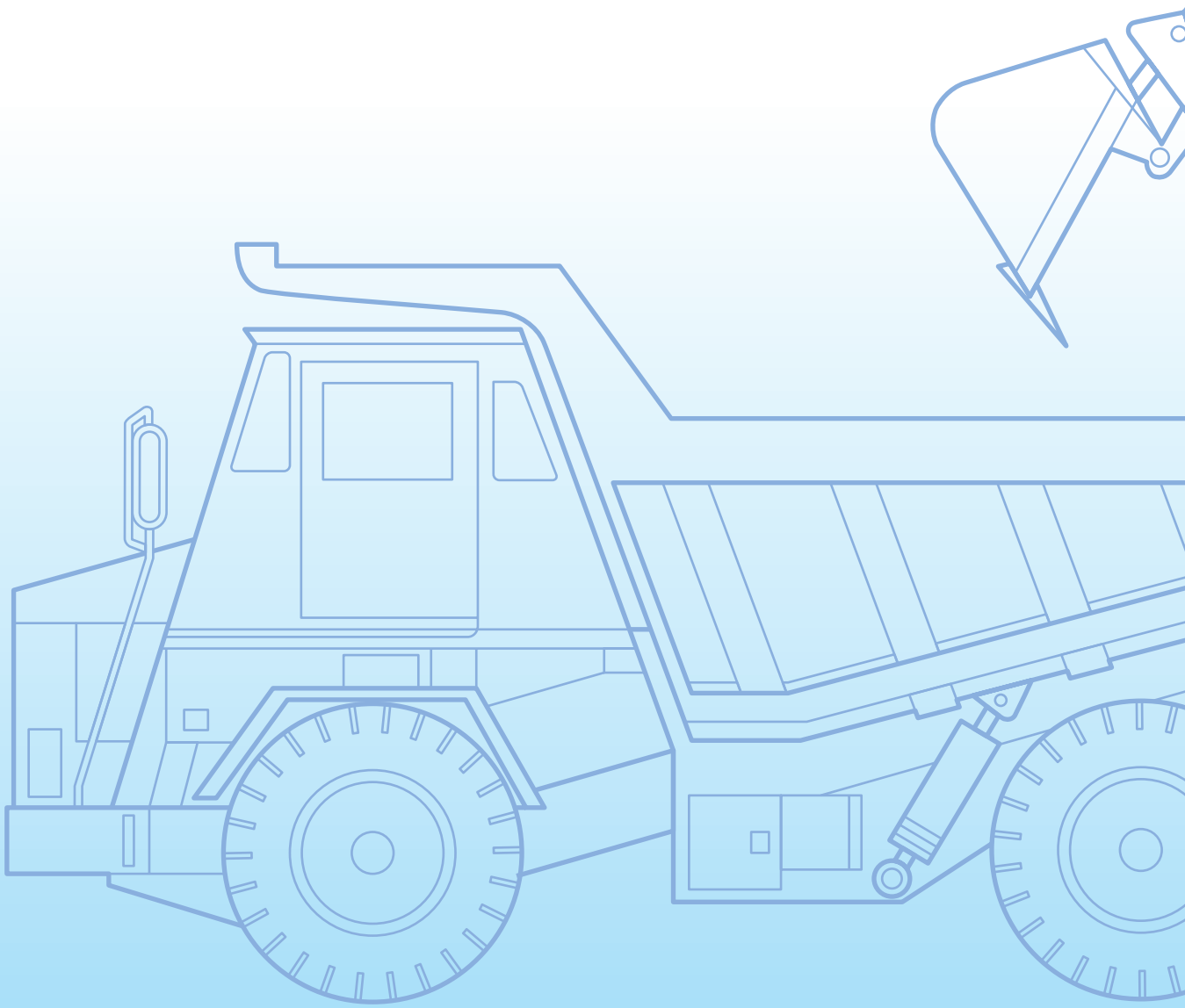
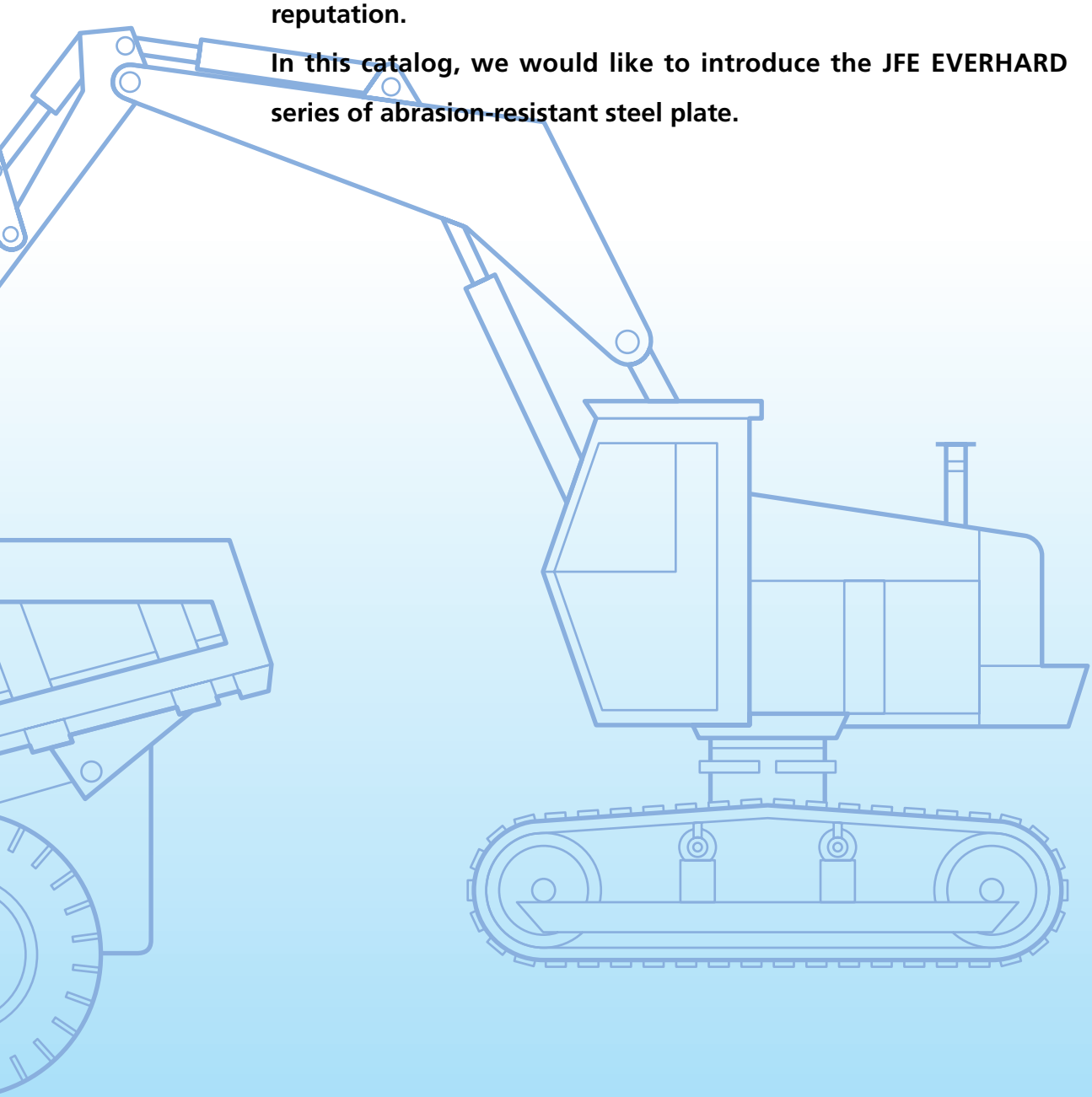


JFE Steel Co. pioneered the production and sale of abrasion-resistant steel plate in Japan in the mid-1950s, and JFE abrasion-resistant steel plate (JFE EVERHARD) enjoyed widespread use as a vital material for construction, mining, civil engineering and farming equipment.

Furthermore, JFE Steel Co. has succeeded in developing super abrasion-resistant steel plate EH-SP with higher abrasion-resistance than that of the Brinell 500 grade, and EH360LE, EH500LE with excellent toughness through the leading edge of production technology. Those products enjoy customer's reputation.

In this catalog, we would like to introduce the JFE EVERHARD series of abrasion-resistant steel plate.



Special Features of JFE EVERHARD

A variety of available grades

A total of 11 grades are available ; the standard series and the alloy series with 5 and 3 grades of hardness respectively, a new super abrasion resistant grade, as well as 360 grade and 500 grade with high toughness, providing a complete product line that can meet a wide range of applications.

Standard Series

This series consists of grades produced with the main emphasis on their hardness levels, the chemical composition being basically simple with boron added while the additon of other alloying elements is restrained.

Alloy Series

This series contains alloying elements in greater quantities than the standard series. The prescribed hardness is guaranteed for plate thickness of up to 100mm and, at the same time, carefull consideration has been given to low-temperature toughness.

Super Abrasion resistant plate EH-SP

Customers often call for the development of a longer-lasting abrasion-resistant plate in order to reduce running cost. However up to now, it has been difficult to develop an abrasion resistant plate that performs better than the conventional 500 grade plate, without reducing the plate's weldability and formability.
Our new higher abrasion resistant plate succeeds in doing this.

Abrasion-resistant steel plate with excellent toughness EH360LE, EH500LE

High toughness at -40˚C of abrasion-resistant steel plate was generally difficult to be guaranteed.
JFE has succeeded in developing abrasion-resistant steel plate including 500 grade with excellent toughness guaranteed at -40˚C. EH360LE and EH500LE are the most suitable plates when high toughness is required because of the application in low temperature environment and/or suffering with high impact.
EH360LE has also high resistance to weld cracking, then presents high quality and safety of welded joint.

Superb quality

JFE's abrasion-resistant steel plates are produced at modern Works. Based on many years of experience, production incorporates the latest in heat treatment technology and proceeds under strict quality control. The result is high-quality steel plate that offers not only outstanding abrasion-resistance but good weldability and workability as well.

Specifications of JFE EVERHARD

1. Chemical composition

Type	Grade	Available thickness mm	Heat treatment	Chemical composition %*										
				C	Si	Mn	P	S	Cr	Mo	V	Ti	B	Ceq
Standard	JFE-EH320	6～50	Controlled Heat Treatment	0.20max.	0.55 max.	1.60 max.	0.030 max.	0.030 max.	0.40max.	—	—	0.005 ～0.020	0.004 max.	—
	JFE-EH360			0.20max.					0.40max.					
	JFE-EH400			0.25max.					0.40max.					
	JFE-EH450			0.35max.					0.80max.					
	JFE-EH500			0.35max.					0.80max.					
Alloyed	JFE-EH360A	6～100	Controlled Heat Treatment	0.20max.	0.55 max.	1.60 max.	0.030 max.	0.030 max.	0.40 ～1.20	0.10 ～0.50	0.10 max.	0.020 max.	0.004 max.	—
	JFE-EH400A			0.25max.										
	JFE-EH500A			0.35max.										
JFE-EH-SP		6～65	Controlled Heat Treatment	0.35 max.	0.55 max.	1.60 max.	0.030 max.	0.030 max.	0.50 ～1.50	Other alloying elements are added.				
JFE-EH360LE		6～19	Controlled Heat Treatment	0.17 max.	0.55 max.	1.60 max.	0.020 max.	0.010 max.	0.40 max.	0.35 max.	—	0.020 max.	0.004 max.	0.40max.
		19.1～32												0.43max.
JFE-EH500LE		6～19	Controlled Heat Treatment	0.29 max.	0.55 max.	1.60 max.	0.020 max.	0.010 max.	0.40 max.	0.35 max.	—	0.020 max.	0.004 max.	0.55max.
		19.1～32												0.58max.

*Elements that are not given in the above table may be added.

2. Mechanical properties

Type	Grade	Hardness test*		Charpy impact test		
		Thickness mm	Brinell hardness (3000) (Average of 5 values)	Thickness mm	Test temperature ˚C	Impact value J (Average of 3 specimens)
Standard	JFE-EH320	6～50	321min.	—	—	—
	JFE-EH360	6～50	361min.	—	—	—
	JFE-EH400	6～50	401min.	—	—	—
	JFE-EH450	6～50	441min.	—	—	—
	JFE-EH500	6～50	477min.	—	—	—
Alloyed	JFE-EH360A	6～100	361min.	13.1～50.0	0	21min.
	JFE-EH400A	6～100	401min.	13.1～50.0	0	21min.
	JFE-EH500A	6～100	477min.	13.1～25.0**	0	21min.
JFE-EH-SP		6～65	401min.	—	—	—
JFE-EH360LE		6～32	361～440	12.0～32.0	-40	27min.
JFE-EH500LE		6～32	477～556	12.0～32.0	-40	21min.

*Test for plate surface.
**For plates in thickness over 25 up to 50mm, please consult with JFE.

3. Appearance, shape, dimensions, mass and their tolerances comply with JIS G3193.

Typical Mechanical Properties of JFE EVERHARD

Grade	Thick-ness mm	Mechanical properties										
		Tensile test					Bend test			Charpy impact test		Hardness test
		Test specimen	Sampling direction	Yield strength N/mm²	Tensile strength N/mm²	Elongation %	Test specimen	Sampling direction	Bend radius =thickness ×3	Sampling direction	Impact value 0°C Average J	Brinell hardness (3000) Average of 5 values
JFE-EH320	19	JIS-5	C	962	1029	19.9	JIS-1	L	Good	—	—	377
JFE-EH360	19	JIS-5	C	1083	1246	20.8	JIS-1	L	Good	—	—	385
JFE-EH400	19	JIS-5	C	1163	1316	19.8	JIS-1	L	Good	—	—	442
JFE-EH450	19	JIS-5	C	1261	1409	18.5	JIS-1	L	Good	—	—	483
JFE-EH500	19	JIS-5	C	1297	1449	17.7	JIS-1	L	Good	—	—	508
JFE-EH360A	19	JIS-5	C	1147	1203	23.9	JIS-1	L	Good	L	156	388
JFE-EH400A	20	JIS-5	C	1174	1369	23.6	JIS-1	L	Good	L	70	429
JFE-EH500A	20	JIS-5	C	1321	1516	22.9	JIS-1	L	Good	L	65	542
JFE-EH-SP	35	JIS-5	C	1104	1352	10.7	JIS-1	L	Good	—	—	455
JFE-EH360LE	19	JIS-5	C	1058	1308	23.0	JIS-1	L	Good	L	-40°C 61	411
JFE-EH500LE	20	JIS-5	C	1203	1681	17.0	JIS-1	L	Good	L	-40°C 42	502

Maximum Available Sizes

Product length : m

Thickness mm \ Width mm	1501 ∫ 1800	1801 ∫ 2000	2001 ∫ 2200	2201 ∫ 2400	2401 ∫ 2600	2601 ∫ 2800	2801 ∫ 3000	3001 ∫ 3200	3201 ∫ 3400	3401 ∫ 3600	3601 ∫ 3800	3801 ∫ 4000	4001 ∫ 4200	4201 ∫ 4400	4401 ∫ 4600	4601 ∫ 4800	4801 ∫ 5000	5001 ∫ 5200	5201 ∫ 5300
6.0 ～ 6.9	18	16	14	12	12	10	—	—	—	—	—	—	—	—	—	—	—	—	—
7.0 ～ 7.9	18	16	14	12	12	10	—	—	—	—	—	—	—	—	—	—	—	—	—
8.0 ～ 8.9	18	16	14	12	12	10	—	—	—	—	—	—	—	—	—	—	—	—	—
9.0 ～ 9.9	18	16	14	12	12	10	—	—	—	—	—	—	—	—	—	—	—	—	—
10.0 ～ 11.9	22	20	18	16	14	14	12	—	—	—	—	—	—	—	—	—	—	—	—
12.0 ～ 12.9	22	20	18	16	14	14	12	—	—	—	—	—	—	—	—	—	—	—	—
13.0 ～ 13.9	22	20	18	16	14	14	12	—	—	—	—	—	—	—	—	—	—	—	—
14.0 ～ 22.0	22	20	18	16	14	14	12	—	—	—	—	—	—	—	—	—	—	—	—
22.1 ～ 24.0	24	22	22	20	18	16	14	12	—	—	—	—	—	—	—	—	—	—	—
24.1 ～ 26.0	25	24	22	22	20	18	16	14	12	—	—	—	—	—	—	—	—	—	—
26.1 ～ 28.0	25	25	24	24	22	22	20	18	16	14	12	—	—	—	—	—	—	—	—
28.1 ～ 30.0	25	25	25	25	25	24	22	20	20	18	18	16	16	—	—	—	—	—	—
30.1 ～ 35.0	25	25	25	25	25	25	24	22	22	22	20	20	20	18	18	18	—	—	—
35.1 ～ 40.0	25	25	25	25	25	25	25	24	22	22	22	20	20	20	19	18	—	—	—
40.1 ～ 45.0	25	25	25	25	25	25	25	25	24	23	22	20	19	19	18	17	16	16	—
45.1 ～ 50.0	25	25	25	25	25	25	25	23	22	20	20	18	17	17	16	15	15	14	—
50.1 ～ 60.0	25	23	23	21	24	22	20	19	18	17	16	15	14	14	13	13	12	11	—
60.1 ～ 70.0	22	19	20	18	20	19	17	16	15	14	14	13	12	12	11	11	10	10	—
70.1 ～ 80.0	19	17	17	16	18	16	15	14	13	13	12	11	11	10	10	9.7	9.3	8.9	—
80.1 ～ 90.0	17	15	15	14	16	14	13	13	12	11	11	10	9.8	9.4	8.9	8.6	8.2	7.9	—
90.1 ～100.0	15	13	14	12	14	13	12	11	10	10	10	9.3	8.8	8.4	8.0	7.7	7.4	7.1	—

Typical Applications

Industry	Applications
Construction and Automotive Industries	● Bulldozer shovels and buckets Slush plates for bulldozers Exterior linings of bulldozer buckets ● Trailer beds ● Vessels for dump and cargo trucks ● Dredger buckets
Cement and Mining	● Lining material for ready-mixed concrete turbine mixer ● Paddle for above ● Conveyor chute for concrete mixing plant ● Pug mill for soil cement ● Conveyor pipe for solids (pneumatic pipelines for coal mines)
Chemical Industry	● Agitators for asphalt plants and finishers ● Sand conveyor pipe for sand cracking in naphtha cracking plants ● Sulfide mineral bucket elevators
Steel and Gas	● BF top swivel chute BF stationary chute, liner, upper hopper liner, gate liner ● BF gas washing venturi scrubber, and septum valve ● Screens for ores, and switching damper Bypass chute for ore conveyors Chute for ore conveyors Tripper chute for ore conveyors ● Tripper chute for coke conveyors Coke conveyor chute, and stacker chute ● Lining for rotary mixers ● Drop chute receiver for blending conveyor in sintering plants Liner for vibro-feeders in sintering plants ● Raw material and sole roll feeders
Others	● Earth drills ● Shear liners

Recommendations in Fabrication and Welding

Gas cutting

- Gas cutting can be accomplished in the same way as for ordinary steel plate. However, due to the hardness of JFE EVERHARD, it is necessary to prevent the “notches” that occur during gas cutting as they may cause the steel plate to crack.
- Therefore, increase the gas and oxygen pressure and cut at a slower pace, in a range where notches will not occur.
- In particular, when cutting ultra-hard steel plate, such as EH450, 500, 500A, it is recommended to preheat or postheat the steel plate at a temperature under 200˚C to prevent cracking from the cut surface.
- If the surface temperature increases, above 250˚C by such operations as gas cutting into small pieces, please note that there is a possibility of hardness reduction.
- If notches occur during the cutting of high hardness steel plate, cracks might result. Therefore, in such cases, use a grinder or other tool to create a smooth finish.
- Interrupting the cutting process for more than several hours should be avoided for same reasons as given above for notches.
- A thin hardened layer will be formed on the gas-cut surface due to heat effects, its thickness is 2～3mm.

Machining

- For machining tools, Super-harded tools are recommended.
- The machining conditions will vary according to the steel plate hardness level, the tool and cutting method used, etc. As the hardness level increases, it is necessary to decrease the cutting depth and feed speed.
- For EH-SP, the same machining tools as that for EH500 are applicable.

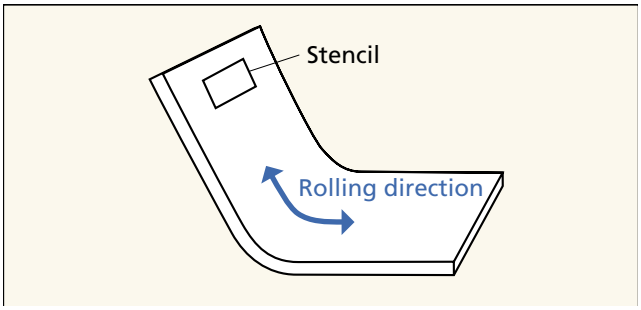
Shot blasting

- If shot blasting is necessary, it is recommendable after cold working, even though the increment of hardness by blasting is small.

Bending

Cold Working

- JFE EVERHARD is formable by cold working such as pressing or roll bending. However, more care is necessary than with high strength steel due to EVERHARD’s high hardness.
- Bending radius more than that shown in Table 1 is recommendable. However the removal of the notches on the cut surface, and the adequate rounding of the edge corner are necessary. For the safety the removal of a hardened layer produced by flame cutting is recommendable.
- Bending or roll forming should be performed transverse to the final direction of rolling.



• In order to prevent inside cracking, overbend using small radius die are not recommended. Please consult with JFE.

Table 1 Recommendable bending radius

Grade	Minimum Bending Radius
JFE-EH320, EH360	4.5t
JFE-EH360A, EH360LE	4.5t
JFE-EH400, EH400A	5t
JFE-EH450,	5t
JFE-EH500, EH500A, EH500LE	6t
JFE-EH-SP	6t

t : plate thickness

Hot working

• All JFE EVERHARD grades of both standard and alloy series are given a special controlled heat treatment. Therefore, avoid hot working.

Storage Method

Because of the high level of hardness, the storage of JFE EVERHARD plates must be so executed that deflection and distortion are minimized, and it is strongly recommended that the plates be waterproofed for storage to prevent the generation of rust and "pit corrosion".

Welding

With JFE EVERHARD, fully satisfactory welded joint can be achieved through low hydrogen welding process, conventional shielded metal arc welding or CO_2 arc welding.

1. Examples of welding materials

Table 2 shows example of welding materials used with JFE EVERHARD.

2. Preheating

Preheating varies with chemical composition, plate thickness and the restraint conditions for weld areas. For reference, recommendable preheating temperature based on test results, under high restraint condition, are given in Table 3.

3. Post heating

In general, if hardfacing welding material is not used, postheating is not necessarily required.

4. Other general items

• Before use, redry the welding electrodes at 350 ～400˚C for approximately 1 hour.
• Remove rust, oil, slag and other undesirable materials from the weld area and maintain it in good condition.
• If arc-striking is done on the surface of the base metal, it may cause cracks. Therefore, use either the back-step welding or waste piece arcing method.
• Keep the arc length as short as possible.
• Avoid weaving as much as possible. If weaving must be performed, restrict it to no more than 1.5 times the diameter of the welding electrode.
• Tack welding can be performed in the same manner as conventional welding, but keep the bead length 50mm or over.
• Heat input is recommended to exceed 2kJ/mm.

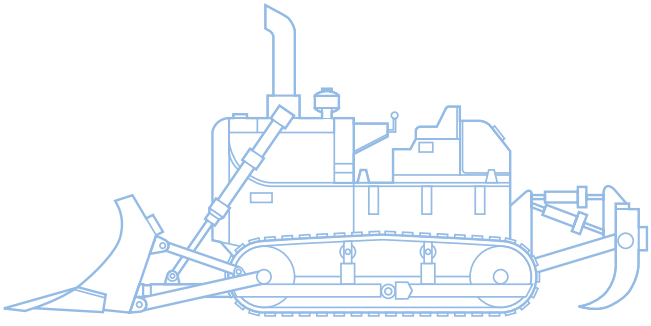


Table 2 Examples of welding materials

Materials applicable to all grades of JFE-EH in terms of weldability

Strength grade of materials	Shield metal arc welding		Gas shielded arc welding	
	Bland*	AWS grade	Bland*	AWS grade
490N/mm^2	KS-76 KSA-76 LB-52 LB-52UL	E7016 E7016-G E7016 E7016	KC-50 KM-50 MG-50 (CO_2) MGS-50 (Ar+CO_2)	ER70S-G ER70S-G ER70S-G ER70S-G
590N/mm^2	KSA-86 LB-62 LB-62UL	E9016-G E9016-G E9016-G	KC-60 (CO_2) MG-60 (CO_2) MGS-63B (Ar+CO_2)	ER80S-G ER80S-G ER90S-G
780N/mm^2	KSA-116 LB-116 LB-80UL	E11016-G E11016-G E11016-G	KM-80 (Ar+CO_2) MGS-80 (Ar+CO_2)	ER110S-G ER110S-G

*JFE Steel Co. or KOBELCO

Table 3 Recommendable preheating temperature

Based on y-groove weld cracking test results under high restraint

Grade	Thickness mm	Shielded metal arc welding*1 (°C)	Gas shielded arc welding*2 (°C)
JFE-EH360LE	19 32	75 100	25 25
JFE-EH360	19 40	75 125	50 100
JFE-EH400	20 40	100 175	50 100
JFE-EH500LE	19 32	125 175	75 125
JFE-EH500	19 40	125 175	75 125
JFE-EH360A	20 40	100 150	75 125
JFE-EH400A	20 40	100 150	75 125
JFE-EH500A	20 40	125 175	100 150
JF-EH-SP	35 51	175 200	175 200

*1 Welding materials : LB-62(AWS E9016-G)
*2 Welding materials : MG-50(AWS ER70S-G)

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