Designation: A1063/A1063M – 17

Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process[1]

This standard is issued under the fixed designation A1063/A1063M; 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.

1. Scope*

1.1 This specification covers steel sheet, produced by the Twin-Roll Cast Process (see Appendix X2) and zinc-coated (galvanized) by the hot-dip process in coils and cut lengths.

NOTE 1—See Appendix X2 for a description of the Twin-Roll Cast process.

1.2 The product is produced in various zinc coating weights [masses] or coating designations as shown in Table 1.

1.3 Product furnished under this specification shall conform to the applicable requirements of the latest issue of Specification A924/A924M unless otherwise provided herein.

1.4 The product is available in a number of designations, grades and classes and in the two following general categories that are designed to be compatible with different application requirements.

1.4.1 Steels with mandatory chemical requirements and typical mechanical properties.

1.4.2 Steels with mandatory chemical requirements and mandatory mechanical properties.

1.5 This material is available in the following sizes:

1.5.1 *Thickness*—up to 0.078 in. [2.0 mm]

1.5.2 *Width*—up to 79 in. [2000 mm]

1.6 The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this specification.

1.7 This specification is applicable to orders in either inch-pound units (as A1063) or SI units (as A1063M). Values in inch-pound and SI units are not necessarily equivalent. Within the text, SI units are shown in brackets. Each system shall be used independently of the other.

1.8 Unless the order specifies the "M" designation (SI units), the product shall be furnished to inch-pound units.

1.9 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

A902 Terminology Relating to Metallic Coated Steel Products

A924/A924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

B6 Specification for Zinc

B852 Specification for Continuous Galvanizing Grade (CGG) Zinc Alloys for Hot-Dip Galvanizing of Sheet Steel

3. Terminology

3.1 *Definitions*—See Terminology A902 for definitions of general terminology relating to metallic-coated hot-dip products.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *differentially coated, n*—galvanized steel sheet having a specified "coating designation" on one surface and a significantly lighter specified "coating designation" on the other surface.

3.2.1.1 *Discussion*—The single side relationship of either specified "coating designation" is the same as shown in the note of Table 1 regarding uniformity of coating.

3.2.2 *high strength low alloy steel, n*—a specific group of sheet steels whose strength is achieved through the use of

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 Weight [Mass] of Coating Requirements[A,B,C]

NOTE 1— Use the information provided in 8.1.2 to obtain the approximate coating thickness from the coating weight [mass].

		Minimum Requirement		
		Triple-Spot Test		Single-Spot Test
Inch-Pound Units				
Type	Coating Designation	Total Both Sides, oz/ft^2	One Side, oz/ft^2	Total Both Sides, oz/ft^2
Zinc	G01[C]	no minimum	no minimum	no minimum
	G30	0.30	0.10	0.25
	G40	0.40	0.12	0.30
	G60	0.60	0.20	0.50
	G90	0.90	0.32	0.80
	G100	1.00	0.36	0.90
	G115	1.15	0.40	1.00
	G140	1.40	0.48	1.20
	G165	1.65	0.56	1.40
	G185	1.85	0.64	1.60
SI Units				
Type	Coating Designation	Total Both Sides, g/m^2	One Side, g/m^2	Total Both Sides, g/m^2
Zinc	Z001[C]	no minimum	no minimum	no minimum
	Z90	90	30	75
	Z120	120	36	90
	Z180	180	60	150
	Z275	275	94	235
	Z305	305	110	275
	Z350	350	120	300
	Z450	450	154	385
	Z500	500	170	425
	Z550	550	190	475
	Z600	600	204	510

[A]The coating designation number is the term by which this product is specified. Because of the many variables and changing conditions that are characteristic of continuous hot-dip coating lines, the zinc coating is not always evenly divided between the two surfaces of a coated sheet; nor is it always evenly distributed from edge to edge. However, the minimum triple-spot average coating weight (mass) on any one side shall not be less than 40 % of the single-spot requirement.
[B]As it is an established fact that the atmospheric corrosion resistance of zinc coated sheet products is a direct function of coating thickness (weight (mass)), the selection of thinner (lighter) coating designations will result in almost linearly reduced corrosion performance of the coating. For example, heavier galvanized coatings perform adequately in bold atmospheric exposure whereas the lighter coatings are often further coated with paint or a similar barrier coating for increased corrosion resistance. Because of this relationship, products carrying the statement "meets ASTM A1063/A1063Mrequirements" should also specify the particular coating designation.
[C]No minimum means that there are no established minimum requirements for triple- and single-spot tests.

microalloying elements such as columbium (niobium), vanadium, titanium, and molybdenum resulting in improved formability and weldability than is obtained from conventional carbon-manganese steels.

3.2.3 *minimized spangle, n*—the finish produced on hot-dip zinc-coated steel sheet in which the grain pattern is visible to the unaided eye, and is typically smaller and less distinct than the pattern visible on regular spangle.

3.2.3.1 *Discussion*—This finish is produced by one of two methods: either (*1*) the zinc crystal growth has been started but arrested by special production practices during solidification of the zinc, or (*2*) the zinc crystal growth is inhibited by a combination of coating-bath chemistry plus cooling during solidification of the zinc. Minimized spangle is normally produced in coating designations G90 [Z275] and lighter.

3.2.4 *regular spangle, n*—the finish produced on hot-dip zinc-coated steel sheet in which there is a visible multifaceted zinc crystal structure.

3.2.4.1 *Discussion*—Solidification of the zinc coating is typically uncontrolled, which produces the variable grain size associated with this finish.

3.2.5 *spangle-free, n*—the uniform finish produced on hot-dip zinc-coated steel sheet in which the visual spangle pattern, especially the surface irregularities created by spangle formation, is not visible to the unaided eye.

3.2.5.1 *Discussion*—This finish is produced when the zinc crystal growth is inhibited by a combination of coating-bath chemistry, or cooling, or both during solidification of the zinc.

4. Classification

4.1 The material is available in several designations as follows:

4.1.1 Commercial steel (CS Types A, B, and C),

4.1.2 Structural steel (SS)

4.1.3 High strength low alloy steel (HSLAS)

4.2 Structural steel and high-strength low-alloy steel are available in several grades based on mechanical properties. Structural steel Grade 80 is available in two classes and high-strength low-alloy grades 45 through 80 are available in two classes.

4.3 The material is available zinc-coated in several coating weights [masses] or coating designations as shown in Table 1, and

4.3.1 The material is available with the same or different coating designations on each surface.

TABLE 2 Chemical Requirements[A] for Twin Roll Cast Hot Rolled Steel Sheet Designations CS

Designation	Composition, %—Heat Analysis Element, Maximum (unless otherwise shown)													
	C	Mn	P	S	Al[B,C]	Si[C]	Cu[D]	Ni	Cr	Mo	V	Cb	Ti	N
CS Type A	0.10	0.70	0.030	0.035	. . .	. . .	0.25	0.20	0.15	0.06	0.008	0.008	0.008	. . .
CS Type B[E]	0.02 to 0.15	0.70	0.030	0.035	. . .	. . .	0.25	0.20	0.15	0.06	0.008	0.008	0.008	. . .
CS Type C	0.15	0.80	0.030	0.035	. . .	. . .	0.50	0.30	0.30	0.15	0.008	0.008	0.008	. . .

[A]Where an ellipsis (. . .) appears in this table there is no requirement, but the analysis shall be reported.
[B]When aluminum deoxidized steel is required, it may be ordered to a minimum of 0.01 % total aluminum.
[C]Twin-roll cast product shall be deoxidized using either silicon or aluminum.
[D]When copper steel is specified, the copper limit is a minimum of 0.20 %.
[E]Specify Type B to avoid carbon levels below 0.02 %.

5. Ordering Information

5.1 Zinc-coated sheet in coils and cut lengths is produced to thickness requirements expressed to 0.001 in. [0.01 mm]. The thickness of the sheet includes both the base metal and the coating.

5.2 Orders for product to this specification shall include the following information, as necessary, to adequately describe the desired product:

5.2.1 Name of product (steel sheet, twin-roll cast, zinc-coated (galvanized),

5.2.2 Designation of sheet [CS (Types A, B, and C), SS (Limits L or H), and HSLAS (Limits L or H)].

5.2.2.1 When a CS type is not specified, CS Type B will be furnished.

5.2.3 When a SS or HSLAS designation is specified, state the appropriate grade, or class, or combination thereof.

5.2.3.1 When a class for SS Grade 80 is not specified, class 1 will be provided

5.2.3.2 When a class for HSLAS is not specified, class 1 will be provided.

5.2.4 Specify Limit L or Limit H for Cu, Ni, Cr, and Mo,

5.2.4.1 When the limit L or H is not specified, limit H will be furnished.

5.2.5 ASTM designation number and year of issue as A1063 for inch-pound units or A1063M for SI units.

5.2.6 Coating designation,

5.2.7 Chemically treated or not chemically treated,

5.2.8 Oiled or not oiled,

5.2.9 Minimized spangle (if required),

5.2.10 Extra smooth (if required),

5.2.11 Dimensions (show thickness, minimum or nominal, width, flatness requirements, and length, if cut lengths). The purchaser shall specify the appropriate table of thickness tolerances in Specification A924/A924M that applies to the order, that is, the table of thickness tolerances for 3/8-in. [10-mm] edge distance, or the table of thickness tolerances for 1-in. [25-mm] edge distance.

5.2.12 Coil size requirements (specify maximum outside diameter (OD), acceptable inside diameter (ID), and maximum weight [mass]),

5.2.13 Packaging,

5.2.14 Certification, if required, heat analysis and mechanical property report,

5.2.15 Application (part identification and description), and

5.2.16 Special requirements (if any).

5.2.17 Supplementary Requirement, please specify.

NOTE 2—Typical ordering descriptions are as follows: steel sheet, zinc-coated, commercial steel Type A, Limit H, ASTM A1063, Coating Designation G90, chemically treated, oiled, minimum 0.040 by 34 by 117 in., for stock tanks, or steel sheet, zinc-coated, high strength low alloy steel Grade 340, class 1, Limit L, ASTM /A 1063M, Coating Designation Z275, minimized spangle, not chemically treated, oiled, minimum 1.00 by 920 mm by coil, 1520-mm maximum OD, 600-mm ID, 10 000-kg maximum, for tractor inner fender.

NOTE 3—The purchaser should be aware that there are variations in manufacturing practices among the producers and therefore is advised to establish the producer's standard (or default) procedures for thickness tolerances.

6. Chemical Composition

6.1 *Base Metal:*

6.1.1 The heat analysis of the base metal shall conform to the requirements shown in Table 2 for CS (Types A, B, and C), and Table 3 for SS and HSLAS and Table 4 for Cu, Ni, Cr, and Mo.

6.1.2 Each of the elements listed in Tables 2-4 shall be included in the report of heat analysis. When the amount of copper, nickel, chromium, or molybdenum is less than 0.02 %, report the analysis as either <0.02 % or the actual determined value. When the amount of vanadium, titanium, or columbium is less than 0.008 %, report the analysis as either <0.008 % or the actual determined value.

6.1.3 See Specification A924/A924M for chemical analysis procedures and product analysis tolerances.

6.2 *Zinc Bath Analysis*—The bath metal used in continuous hot-dip galvanizing shall contain not less than 99 % zinc, with a lead level not exceeding 0.009 %.

NOTE 4—To control alloy formation and promote adhesion of the zinc coating with the steel base metal, the molten coating metal composition normally contains a percentage of aluminum usually in the range from 0.05 to 0.25. This aluminum is purposely supplied to the molten coating bath, either as a specified ingredient in the zinc spelter or by the addition of a master alloy containing aluminum. Specification B852 specifies continuous galvanizing grade (CGG) zinc alloys, including multiple zinc alloys, that enable the molten coating metal to be controlled within 0.05

TABLE 3 Chemical Requirements[A,B] for Twin Roll Cast Hot Rolled Steel Sheet Designations SS and HSLAS

Designation	Composition, %—Heat Analysis Element, max (unless otherwise shown)									
	C	Mn	P	S	Al[C]	Si[C]	V	Cb	Ti	N
SS:[D]										
Grade 33 [230]	0.20	1.35	0.035	0.04			0.008	0.008	0.008	
Grade 37 [255]	0.20	1.35	0.035	0.04			0.008	0.008	0.008	
Grade 40 [275]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 45 [305]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 50 [340]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 55 [380]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 60 [410]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 70 [480]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Grade 80 [550]	0.25	1.35	0.035	0.04	. . .	. . .	0.008	0.008	0.008	. . .
Classes 1 and 2										
HSLAS:[E]										
Grade 45 [310] Class 1[D]	0.22	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 45 [310] Class 2	0.15	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 50 [345] Class 1[D]	0.23	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 50 [345] Class 2	0.15	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 55 [380] Class 1[D]	0.25	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 55 [380] Class 2	0.15	1.35	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 60 [410] Class 1	0.26	1.50	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 60 [410] Class 2	0.15	1.50	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	. . .
Grade 65 [450] Class 1	0.26	1.50	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]
Grade 65 [450] Class 2	0.15	1.50	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]
Grade 70 [480] Class 1	0.26	1.65	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]
Grade 70 [480] Class 2	0.15	1.65	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]
Grade 80 [550] Class 1	0.26	1.65	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]
Grade 80 [550] Class 2	0.15	1.65	0.04	0.04	. . .	. . .	0.005 min	0.005 min	0.005 min	[F]

[A]Where an ellipsis (. . .) appears in this table there is no requirement, but the analysis shall be reported.
[B]The limits for Copper, Nickel, Chromium and Molybdenum are shown in Table 4.
[C]The twin-roll cast product shall be deoxidized using either silicon or aluminum
[D]For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.50 % .
[E]HSLAS steels contain the strengthening elements columbium (niobium), vanadium, titanium, and molybdenum added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.
[F]The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example, use of vanadium) of the producer, nitrogen is permitted as a deliberate addition. Consideration should be made for the use of nitrogen binding elements (for example).

to 0.25 % aluminum and to not exceed 0.009 % lead. Specification B6 specifies certain grades of zinc that do not exceed 0.009 % lead but contain lower levels of aluminum.

NOTE 5—The producer can demonstrate compliance to the maximum lead level through reference to the chemical test certificates received from the zinc supplier.

7. Mechanical Properties

7.1 Structural steel, and high-strength low-alloy steel, shall conform to the mechanical property requirements in Table 5 for the grade, or class, or both. The typical ranges of mechanical properties (nonmandatory) for CS types A, B, and C are shown in Table 6.

8. Coating Properties

8.1 *Coating Weight [Mass]:*

8.1.1 Coating weight [mass] shall conform to the requirements as shown in Table 1 for the specific coating designation.

8.1.2 Use the following relationships to estimate the coating thickness from the coating weight [mass]:

8.1.2.1 1.00 oz/ft^2 coating weight = 1.68 mils coating thickness, and

8.1.2.2 7.14 g/m^2 coating mass = 1.00 µm coating thickness.

8.1.3 Use the following relationship to convert coating weight to coating mass:

8.1.3.1 1.00 oz/ft^2 coating weight = 305 g/m^2 coating mass.

8.2 *Coating Weight [Mass] Tests:*

8.2.1 Coating weight [mass] tests shall be performed in accordance with the requirements of Specification A924/A924M.

TABLE 4 Chemical Requirements: Cu, Ni, Cr, and Mo for Structural Steels, and High-Strength Low-Alloy Steels

% Heat Analysis, maximum Unless Otherwise Specified					
Designation	Limits	Cu[A,B]	Ni[B]	Cr[B,C]	Mo[B,C]
SS:	L	0.35	0.20	0.15	0.06
All Grades and classes	H	0.50	0.30	0.30	0.16
HSLAS:	L	0.35	0.20	0.15	0.06
All grades and classes	H	0.50	0.30	0.30	0.16

[A]When copper is specified, a minimum of 0.20 % is required. When copper steel is not specified, the copper limit is a maximum requirement.
[B]For limits H steels, the sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00 % on heat analysis. When one or more of these elements are specified by the purchaser, the sum does not apply; in which case only the individual limits on the remaining elements shall apply.
[C]For limit H steels, the sum of chromium and molybdenum shall not exceed 0.32 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements shall apply.

8.2.2 The referee method to be used shall be Test Method A90/A90M.

8.3 *Coating Bend Test:*

8.3.1 The bend test specimens of coated sheet designated by prefix "G" ["Z"] shall be capable of being bent through 180° in any direction without flaking of the coating on the outside of the bend only. The coating bend test inside diameter shall have a relation to the thickness of the specimen as shown in Table 7. Flaking of the coating within 0.25 in. [6 mm] of the edge of the bend specimen shall not be cause for rejection.

9. Retests and Disposition of Non-Conforming Material

9.1 Retests, conducted in accordance with the requirements of the section on Retests and Disposition of Non-Conforming Material of Specification A924/A924M, are permitted when an unsatisfactory test result is suspected to be the consequence of the test method procedure.

9.2 Disposition of non-conforming material shall be subject to the requirements of 9.2 of Specification A924/A924M.

10. Dimensions and Permissible Variations

10.1 All dimensions and permissible variations shall comply with the requirements of Specification A924/A924M.

11. Keywords

11.1 alloyed coating; direct cast steel; high strength low alloy; minimized spangle coating; sheet steel; spangle; steel; steel sheet; structural steel; zinc; zinc coated (galvanized); zinc iron-alloy; zinc iron-alloy coated

TABLE 5 Mechanical Property Requirements for Steel Sheet designations SS and HSLAS[A]

Designation	Yield Strength ksi [MPa] min	Tensile Strength ksi [MPa] min	Elongation in 2 in. [50 mm] min, %
SS:			
Grade 33 [230]	33 [230]	45 [310]	20
Grade 37 [255]	37 [255]	52 [360]	18
Grade 40 [275]	40 [275]	55 [380]	15
Grade 45 [305]	45 [305]	60 [410]	13
Grade 50 [345]	50 [340]	65 [450]	11
Grade 55 [380]	55 [380]	70 [480]	9
Grade 60 [410]	60 [410]	70 [480]	8
Grade 70 [480]	70 [480]	80 [550]	7
Grade 80 [550] Class 1	80 [550]	90 [620]	6
Grade 80 [550] Class 2[B]	80 [550]	83 [570]	. . .
HSLAS:			
Grade 45 [310] Class 1	45 [310]	60 [410]	18
Grade 45 [310] Class 2	45 [310]	55 [380]	18
Grade 50 [340] Class 1	50 [340]	65 [450]	15
Grade 50 [340] Class 2	50 [340]	60 [410]	15
Grade 55 [380] Class 1	55 [380]	70 [480]	13
Grade 55 [380] Class 2	55 [380]	65 [450]	13
Grade 60 [410] Class 1	60 [410]	75 [520]	11
Grade 60 [410] Class 2	60 [410]	70 [480]	11
Grade 65 [450] Class 1	65 [450]	80 [550]	11
Grade 65 [450] Class 2	65 [450]	75 [520]	11
Grade 70 [480] Class 1	70 [480]	85 [585]	8
Grade 70 [480] Class 2	70 [480]	80 [550]	8
Grade 80 [550] Class 1	80 [550]	95 [565]	7
Grade 80 [550] Class 2	80 [550]	90 [820]	7

[A]Where an ellipsis appears in this table, there is no requirement.
[B]SS Grade 80 [550] Class 2 may exhibit different characteristics than class 1 due to differences in processing.

TABLE 6 Typical Ranges of Mechanical Properties[A,B] (Nonmandatory)

Designation	(Longitudinal Direction)		
	Yield Strength		Elongation[C] in 2 in. [50 mm], %
	ksi	[MPa]	
CS Type A and B	40 to 55	[250 to 340]	≥20
CS Type C	40 to 60	[250 to 410]	≥15

[A]The yield strength tends to increase and the elongation tends to decrease as the sheet thickness decreases. These properties represent those typical of material in the thickness range of 0.050 in. [1.27 mm] to 0.065 in. [1.65 mm].
[B]The typical mechanical property values presented here are nonmandatory.
[C]Yield strength and elongation are measured in the longitudinal direction in accordance with Test Methods and Definitions of A370.

TABLE 7 Coating Bend Test Requirements

NOTE 1—If other coatings are required, the user should consult the producer for availability and suitable bend test requirements.

Inch-Pound Units									
Ratio of the Inside Diameter to the Specimen (Any direction)									
Coating Designation	CS Sheet Thickness			SS Grade[A]			HSLAS[A]		
	Through 0.039 in.	Over 0.039 through 0.079 in.	Over 0.079 in.	33	37	40	45	50	55
G01	0	0	0	1½	2	2½	1½	1½	3
G30	0	0	0	1½	2	2½	1½	1½	3
G40	0	0	0	1½	2	2½	1½	1½	3
G60	0	0	0	1½	2	2½	1½	1½	3
G90	0	0	0	1½	2	2½	1½	1½	3
G100	0	0	1	1½	2	2½	1½	1½	3
G115	0	0	1	1½	2	2½	1½	1½	3
G140	1	1	2	1½	2	2½			
G165	2	2	2	1½	2	2½			
G185	2	2	2	1½	2	2½			
G210	2	2	2	1½	2	2½			
SI Units									
Ratio of the Inside Diameter to the Specimen (Any direction)									
Coating Designation	CS Sheet Thickness			SS Grade[A]			HSLAS[A]		
	Through 1.0 mm	Over 1.0 mm through 2.0 mm	Over 2.0 mm	230	255	275	310	340	380
Z001	0	0	0	1½	2	2½	1½	1½	3
Z90	0	0	0	1½	2	2½	1½	1½	3
Z120	0	0	0	1½	2	2½	1½	1½	3
Z180	0	0	0	1½	2	2½	1½	1½	3
Z275	0	0	1	1½	2	2½	1½	1½	3
Z305	0	0	1	1½	2	2½	1½	1½	3
Z350	0	0	1	1½	2	2½	1½	1½	3
Z450	1	1	2	1½	2	2½			
Z500	2	2	2	1½	2	2½			
Z550	2	2	2	1½	2	2½			
Z600	2	2	2	1½	2	2½			

[A]SS Grade 50 [340] through 80 [550] and HSLAS Grade 60 [410] through 80 [550] are not subject to bend test requirements.

APPENDIXES

(Nonmandatory Information)

X1. BENDING PROPERTIES

X1.1 Table X1.1 lists suggested minimum inside radii for cold bending.

TABLE X1.1 Suggested Minimum Inside Radius for Cold Bending

NOTE 1—(t) equals a radius equivalent to the steel thickness.

NOTE 2—The suggested radius should be used as a minimum for 90° bends in actual shop practice.

Designation	Grade	Minimum Inside Radius for Cold Bending	
Structural Steel (SS)			
	33 [230]	1½ t	
	37 [255]	2t	
	40 [275]	2t	
	50 [340]	2½ t	
	55 [380]	3t	
	60 [410]	3t	
	70 [480]	3½ t	
	80 [550]	4t	
High-Strength Low-Alloy Steel		Class 1	Class 2
	45[310]	1½ t	1½ t
	50[340]	2t	1½ t
	55[380]	2t	2t
	60[410]	2½ t	2t
	65[450]	3t	2½ t
	70[480]	3½ t	3 t
	80[550]	4t	3½ t

X2. TWIN-ROLL CASTING PROCESS

X2.1 Overview of the Twin-Roll Casting Process for the Production of Steel Sheet

X2.1.1 *Twin-Roll Casting Process Development*

X2.1.1.1 Sir Henry Bessemer originally conceived and patented the concept of casting sheet and strip directly from liquid metal about 150 years ago. Despite decades of research and development, twin-roll casting has now achieved commercial success for the production of plain-carbon steel sheet. Key breakthroughs in the areas of mold/refractory materials, a better understanding of the fundamentals of metal solidification, and process control have contributed to the successful commercialization of this process. Twin-roll cast material has been produced and successfully manufactured into a range of steel products. As-cast, hot rolled and cold rolled steel sheet coils have been successfully formed into square tubes, decking, and other structural products. Initial trials by users of these products include manufacturers of metal building and agricultural products. These customers report that the twin-roll cast material performed satisfactorily and that manufacturing equipment did not require adjustments to accommodate the twin-roll cast product.

X2.1.2 *Overview of Process Fundamentals*

X2.1.2.1 The twin-roll process directly casts a solid strip approximately 0.038 in. [1 mm] to 0.075 in. [2 mm] thick directly from liquid metal. Solidification of liquid steel occurs over two counter-rotating water-cooled rolls as schematically illustrated in Fig. X2.1.

X2.1.2.2 Twin-roll casting facilities are equipped with one or more rolling stands whereby the thickness of the as-cast strip is further reduced by hot reduction (see Fig. X2.2).

X2.1.2.3 In comparison to conventional slab casting processes, twin-roll casting produces significantly higher interfacial heat transfer rates resulting from the direct contact of the steel with the casting roll surface (see Table X2.1). This rapid solidification results in the production of unique microstructures that can be manipulated to produce conventional low-carbon steels as well as steels not easily produced from conventional sheet steel production (for example, thick slab casting and thin slab casting processes coupled with conventional hot rolling mills).

X2.1.3 *Overview of Product Attributes*

X2.1.3.1 Product attributes of twin-roll cast material are comparable to conventional hot strip mill products with regard to strength levels, elongation, mechanical property variation within a steel designation, surface quality, and dimensional tolerances. A significant quantity of twin-roll cast material has been successfully roll formed, punched, welded, cold rolled in both tandem and reversing mills, galvanized, and painted.

X2.1.4 *Mechanical Property Variation*

X2.1.4.1 Variation of mechanical properties was determined during an extended production run at the Australian development plant for twin roll casting technology. Mechanical testing was performed on 143 coils and the results compared to available data from a similar low-carbon commercial steel designation produced on a conventional hot rolling mill. The results are shown below in Table X2.2.

X2.1.5 *Surface Condition*

X2.1.5.1 The surface condition of twin-roll cast products has been shown to be satisfactory for direct processing into pipe and tube, cold rolled products, and coated products. As with conventional processes, surface defect formation can be controlled with adequate process control. Surface roughness of twin-roll cast and hot rolled material is slightly smoother than hot rolled produced by a conventional 5-7 stand hot mill as indicated in Fig. X2.3.

X2.1.6 *Tolerances*

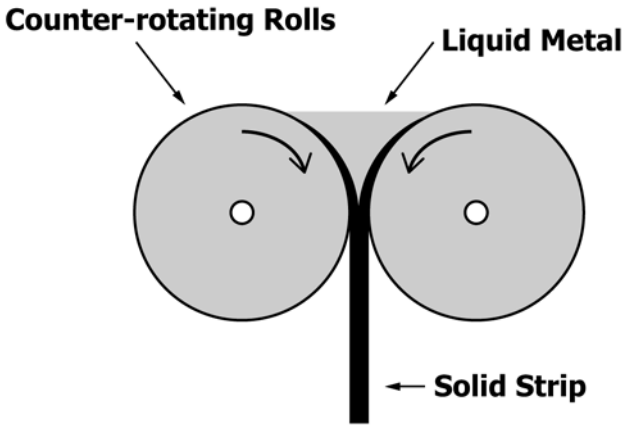

FIG. X2.1 Schematic of the Twin-Roll Casting Process Showing Shell Formation Over the Two Rolls and Joining of the Two Shells to Form the Strip

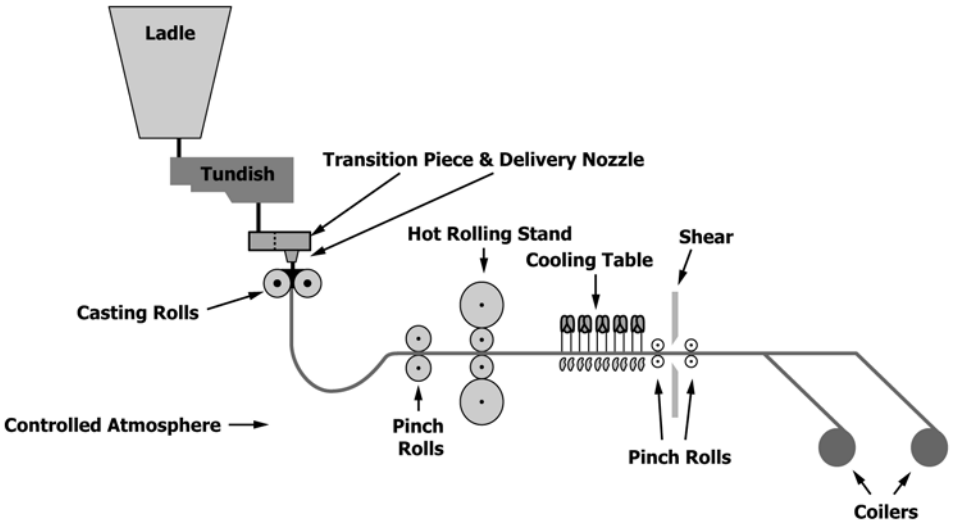

FIG. X2.2 Layout of a Twin-Roll Casting Machine Showing the In-Line Hot Rolling Mill

TABLE X2.1 Comparison of Typical Process Parameters of Twin-Roll Casting, Thin Slab Casting and Thick Slab

	Twin Roll Process	Thin Slab	Thick Slab
Strip thickness, mm	1.6	50	220
Casting speed, m/min	80	6	2
Average mould heat fluxes, MW/m^2	14	2.5	1.0
Total solidification time, s	0.15	45	1070
Average shell cooling rate in mould, °C/s	1700	50	12

TABLE X2.2 Mechanical Property Comparison—Twin-Roll Cast and Conventional Hot Rolling Mill Product

	Yield Strength Average (ksi)	Standard Deviation (ksi)	Tensile Strength Average (ksi)	Standard Deviation (ksi)	% Elongation Average	Standard Deviation (%)
Twin-roll process	44.1	3.34	64.4	2.90	25	3
Hot rolling mill	46.7	2.53	61.8	2.01	32	2

X2.1.6.1 Thickness tolerances for twin-roll cast products are similar to conventional hot rolled products, with total thickness variation (centerline variation + profile) less than half of the current ASTM thickness tolerance in accordance with Specification A568/A568M.

X2.1.7 *Internal Soundness/Inclusions*

X2.1.7.1 Full width X-ray mapping has been used to characterize internal soundness. Twin-roll cast material has been produced free of porosity.

X2.1.7.2 Inclusion size distributions were obtained from SEM analysis. Typical inclusion size is very fine (5 to 8 μm) due to rapid solidification.

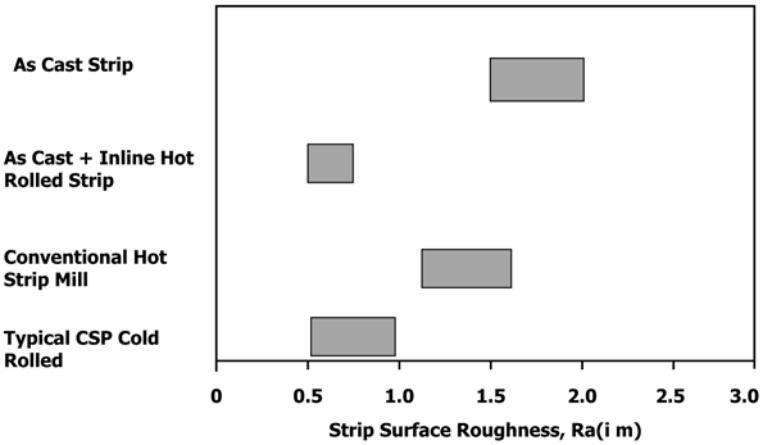

FIG. X2.3 Surface Roughness Comparison—Conventional and Strip Cast Material

X2.1.8 *Grain Morphology and Size*

X2.1.8.1 The twin-roll process produces substantially larger austenite grains than conventional hot rolling processes (see Table X2.3 for the differences in austenite microstructures)

X2.1.8.2 The coarse austenite grains in twin-roll cast material can be easily transformed to a variety of ferrite microstructures by varying the cooling practice on the rolling mill run-out-table. For this reason, the strength of the material can be manipulated more easily than conventional hot rolled material. Low-carbon, manganese steels with appropriate run-out-table cooling rates can be produced with strength levels ranging from 45 to 80 ksi yield strength, utilizing the twin-roll strip cast process. Please see Fig. X2.4 for details of the strength-cooling rate relationship.

TABLE X2.3 Differences in Austenite Grain Morphology and Size

	Twin-Roll Strip Casting	Hot Strip Mill
Prior austenite grain morphology	Columnar shape	Equiaxed
Grain size	100 to 250 μm wide 300 to 700 μm long	25 μm

X2.1.9 *Manganese Limits in Twin-Roll Cast Products*

X2.1.9.1 The upper limit of manganese for most commercial and structural steels is currently 0.60 or 0.90 %. The stability of the twin-roll casting process is governed by the heat transfer rates in the vicinity of the meniscus. Manganese tends to affect the nature of the initial contact between the steel and the roll surface and thus plays a key role in both heat transfer and meniscus stability. As a result, the manganese levels utilized for steel sheet production via the twin-roll casting process are generally slightly higher than the traditional low-carbon heats. Consequently, the upper level of the manganese specification is increased for some twin-roll cast grades.

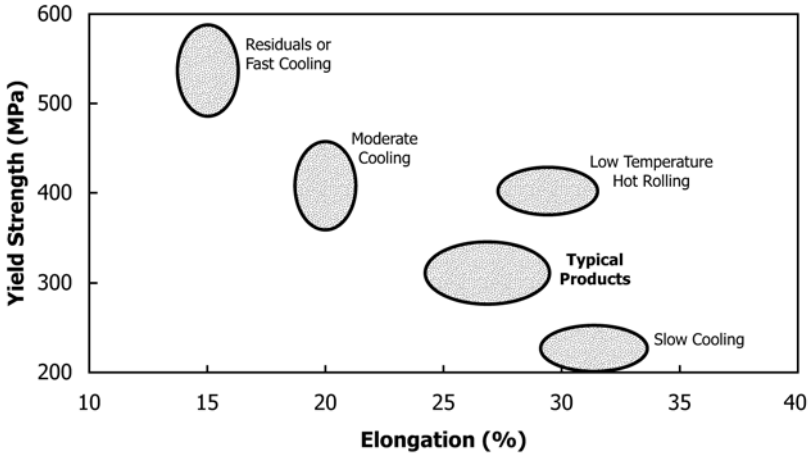

FIG. X2.4 Examples of Strength Versus Elongation with a Low-Carbon Steel Chemistry via the Twin-Roll Casting Process

SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue (A1063/A1063M - 11a) that may impact the use of this standard. (January 1, 2017)

(1) Added Specification B6 and Specification B852 references to Section 2.
(2) Added lead restriction in 6.2 and references to Specification B6 and Specification B852 in Note 4.
(3) Added Note 5.