

CRA Clad or Lined Steel Pipe

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Foreword

This edition of API Specification 5LD supersedes the Third Edition and includes items approved by letter ballot from January 2014. Portions of this publication have been changed from the previous edition. Substantive changes are indicated with [gray shading and blue font](#), but API makes no warranty as to the accuracy of such notations. Nonsubstantive changes will not be indicated with shading and colored font.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Washington, DC 20001, standards@api.org.

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CRA Clad or Lined Steel Pipe

1 Scope

This specification covers seamless and welded clad steel line pipe and lined steel line pipe with enhanced corrosion-resistant properties suitable for use in pipeline transportation systems in the petroleum and natural gas industries. The clad and lined steel line pipe specified herein is composed of a carbon steel backing or base material outside (in some cases inside and/or outside) and a corrosion-resistant alloy (CRA) layer or lining inside of the pipe. The base material conforms to API 5L (45th Ed.), product specification level (PSL) 2 and applicable annex(es), except as modified herein.

Grades of base material covered by this specification include X42, X46, X52, X56, X60, X65, X70, X80, and grades intermediate to these. Grades of the CRA layer are LC 1812, 2205, 2506, 2242, 2262, unified numbering system (UNS) S31703, UNS N08904, UNS N10276, Alloy 31^{TM1} (UNS N08031), Alloy 59 (UNS N06059), Alloy 254 SMOTM 1¹ (UNS S31254), Alloy 400 (UNS N04400), AL6NX (UNS N08367), and EN 1.4529 (UNS N08926). Other grades are subject to agreement between the purchaser and the manufacturer.

The delivered product usually has square ends, but other special ends may be furnished by agreement between the purchaser and manufacturer. Included are nominal pipe sizes (NPS) 25 mm (1 in.) through 2134 mm (84 in.). Sizes greater than 2134 mm (84 in.) are outside of the range of API 5L (45th Ed.) but may be supplied up to 2500 mm (100 in.) by agreement, including requirements for materials.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. For a list of other documents and articles associated with this standard, please see the Bibliography.

API Specification 5L, *Specification for Line Pipe*, 45th Edition, December 2012 (Effective July 1, 2013)

API Specification 5LC, *Specification for CRA Line Pipe*, Fourth Edition

ANSI ²/NACE ³ MR0175/ISO 15156-3:2009(E), *Petroleum and natural gas industries—Materials for use in H₂S-containing environments in oil and gas production—Parts 1, 2, and 3*

ASME Boiler and Pressure Vessel Code (BPVC) ⁴, Section II, Part C: *Specifications for Welding Rods, Electrodes and Filler Metals* (2013.07.01)

ASME BPVC, Section IX: *Welding and Brazing Qualifications* (2013.07.01)

ASTM A240-14 ⁵, *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

ASTM A262-13, *Standard Practices for Detecting Susceptibility of Intergranular Attack in Austenitic Stainless Steels*

¹ This term is used as an example only, and does not constitute an endorsement of this product by API.

² American National Standards Institute, 1899 L Street, NW, 11th Floor, Washington, DC 20036, www.ansi.org.

³ NACE International, 1440 South Creek Drive, Houston, Texas 77084, www.nace.org.

⁴ ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

⁵ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM A263-12, *Standard Specification for Stainless Chromium Steel-Clad Plate*

ASTM A264-12, *Specification for Stainless Chromium-Nickel Steel Clad Plate*

ASTM A265-12, *Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate*

ASTM A578-07, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A751-14, *Standard Test Methods, Practices and Terminology for Chemical Analysis of Steel Products*

ASTM B424-11, *Standard Specification for Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825 and UNS N08221) Plate, Sheet, and Strip*

ASTM B443-00, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip*

ASTM B619-10, *Standard Specification for Welded Nickel and Nickel-Cobalt Alloy Pipe*

ASTM B622-10, *Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube*

ASTM B675-01 (2013), *Standard Specification for UNS N08367 Welded Pipe*

ASTM E18-14, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E165-12, *Standard Test Method for Liquid Penetrant Examination*

ASTM E353-1993, *Standard Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys*

ASTM E384-11, *Standard Test Method for Knoop and Vickers Hardness of Materials*

ASTM E562-11, *Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count*

ASTM G28-02, *Standard Test Methods of Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys*

ASTM G48-11, *Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution*

ISO/TR 9769:1991 ⁶, *Steel and iron—Review of available methods of analysis*

⁶ International Organization for Standardization, 1, ch. de la Voie-Creuse, CH-1211 Geneva 20, Switzerland, www.iso.org.

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

For the purposes of this specification the following definitions apply.

3.1.1

backing steel

The outer wall thickness pipe of a clad or lined pipe (for pipe clad on the outside and inside, the backing steel is the core material).

NOTE Backing steel is sometimes referred to as base material or steel backing.

3.1.2

clad

cladding

Refers to a metallurgically bonded CRA layer produced by roll bonding, weld overlaying, powder metallurgy, or explosively cladding a carbon steel plate or pipe.

3.1.3

CRA layer

A general term referring to any internal corrosion-resistant alloy layer.

3.1.4

lined

Refers to a mechanically expanded, fitted or installed ("mechanical bond") CRA layer with a carbon backing steel.

3.1.5

manufacturer

As used throughout this specification refers to the firm, company, or corporation responsible for marking the product and warrants that the product conforms to the specification.

NOTE The manufacturer may be either a pipe mill or a processor, as applicable. The manufacturer is responsible for compliance with all of the applicable provisions of the specification.

3.1.6

pipe mill

A firm, company, or corporation that operates pipe-making facilities.

3.1.7

processor

A firm, company, or corporation that operates facilities capable of heat treating pipe made by a pipe mill.

3.2 Abbreviations

For the purposes of this specification the following abbreviations apply.

CVN	Charpy V-notch
CRA	corrosion-resistant alloy
DWTT	drop weight tear tests
GTAW	gas tungsten arc welding
HAZ	heat-affected zone
MPQT	manufacturing procedure qualification test
MPS	manufacturing procedure specification
NPS	nominal pipe size

PAW (PTA)	plasma arc welding (sometimes referred to as plasma tungsten arc)
PREN (PREW)	pitting resistance equivalent number
PSL	product specification level
RES	resistance electroslag welding
SMYS	specified minimum yield strength
TMCP	thermomechanical controlled processing
UNS	unified numbering system
UT	ultrasonic testing
WPS	welding procedure specification

4 General Information

4.1 Pipe Size

The size designations are nominal pipe sizes. In the text, where pipe size limits (or size ranges) are given, these are outside-diameter sizes except where stated to be nominal. These outside-diameter size limits and ranges apply also to the corresponding nominal sizes.

USC units in this specification are shown in parentheses in the text and in many tables. Outside diameters and wall thicknesses are converted from inch dimensions. The converted diameters are rounded to the nearest 0.1 mm for diameters less than 18 in. and to the nearest 1 mm for diameters 18 in. and larger. Wall thicknesses are rounded to the nearest 0.1 mm.

Metric plain-end weights are calculated from the metric outside diameters and wall thicknesses using the equations in 10.1 and rounded to the nearest 0.01 kg/m (0.01 lb/ft).

Metric hydrostatic pressures are calculated from metric outside diameters and wall thicknesses and metric fiber stresses shown in Section 9.

The factors used where conversions are appropriate are as follows:

1 inch (in.)	=	25.4 millimeters (mm) exactly
1 square inch (in. ²)	=	645.16 square millimeters (mm ²) exactly
1 foot (ft)	=	0.3048 meters (m) exactly
1 pound (lb)	=	0.45359 kilograms (kg)
1 pound per foot (lb/ft)	=	1.4882 kilograms per meter (kg/m)
1 pound per square inch (psi)	=	6.895 kilopascals (kPa) for pressure
	=	0.006895 megapascals (MPa) for stress
1 foot-pound (ft-lb)	=	1.3558 Joules (J) for impact energy

Equation (1) below was used to convert degrees Fahrenheit (°F) to degrees Celsius (°C):

$$^{\circ}\text{C} = \frac{5}{9}(^{\circ}\text{F} - 32) \quad (1)$$

4.2 Information to be Supplied by the Purchaser

In placing orders for CRA clad or lined pipe in accordance with API 5LD, the purchaser shall specify the following from Table 1 on the purchase order.

Table 1—Purchaser Supplied Information

Requirement	API 5LD or API 5L (if Noted) Section/Table/Figure Number
Specification	5LD
Quantity of pipe in feet or meters	As specified on the purchase order
Type of pipe: clad or lined	Section 5.2
Process of manufacture: seamless, welded	Section 5.2
Grade of backing steel material (PSL 2 only)	5L (45th Ed.), Table 1
Material or CRA clad or liner material	Table 3
Type of CRA layer	Section 5.2
Nominal diameter (size) of backing steel	5L (45th Ed.), Table 9
Wall thickness (nominal) of backing steel	5L (45th Ed.), Table 9
Minimum thickness of CRA cladding or liner	Section 5
Nominal length of joint	5L (45th Ed.), Section 9.11.1.3
End finish	5L (45th Ed.), Section 9.12
The purchaser shall also state on the purchase order requirements concerning the following stipulations	API 5LD Section/Table/Figure Number
Chemical analysis reports	Sections 6.1 to 6.6
PREN or PREW if required	Section 6.1
Defect repair procedures	Section 12.3
Chemical requirements for the CRA layer	Table 3
Mechanical properties of CRA layer and backing	Section 7; 5L (45th Ed.), Section 9.3
CVN shear requirements	Section 7.11.3
CRA layer bonding test	Section 8.3
OD tolerance applied to ID	Section 10.2 and Table 10
Wall thickness positive tolerance for clad pipe	Table 10
Jointers	Section 10.7
NDT of welded clad pipe	Section 11.1
NDT of seamless clad pipe	Section 11.2
NDT of lined pipe	Section 11.3
Continuity of CRA layer	Section 12.2
Repair of defects in CRA layer	Section 12.3
Certification	Section 14.1
Annexes	
Manufacturing procedure specification	Annex B
Welding procedure specification (WPS) requirements	Annex C
Manufacturing procedure qualification test	Annex D
Jointer requirements	Annex E
Purchaser Inspection	Annex F

5 Manufacturing of Clad and Lined Steel Pipe

5.1 General

Clad pipe or lined steel pipe furnished to this specification shall be seamless or welded, as defined below. All welding consumables shall comply with the requirements of ASME *BPVC* Section II, Part C (2013.07.01). The thickness of the CRA layer shall be a minimum of 2.5 mm (0.100 in.) unless otherwise agreed to.

NOTE Thinner CRA cladding has been used for some applications.

5.2 Description of Clad and Lined Steel Pipe

5.2.1 Clad Pipe

Clad pipe is a bimetallic pipe composed of an internal (and in some cases external) CRA layer that is metallurgically bonded to the backing steel. The cladding may be bonded by hot rolling, coextrusion, weld overlay, explosion bonding, powder metallurgy, or some other process that produces a metallurgical bond. Clad pipe may be either seamless or welded as follows.

- a) *Seamless*. Seamless clad pipe is produced by the seamless process defined in API 5L (45th Ed.), Section 8.1 and shall meet the requirements of API 5L (45th Ed.), PSL 2.
- b) *Welded*. Welded clad pipe is produced from plate or skelp that has been clad by one of the processes described in 5.2.1. The backing material shall meet the requirements of API 5L (45th Ed.), PSL 2. The longitudinal seam of the backing steel shall be welded by one of the welding processes included in API 5L (45th Ed.), Section 8.1 except as follows. In addition, gas tungsten arc welding (GTAW) is acceptable for the tack welds, and plasma arc welding (plasma tungsten arc) [PAW (PTA)] is acceptable for the seam welds provided appropriate qualifications to API 5L (45th Ed.), Annex B are performed. For welding of the cladding material, processes in API 5LC (4th Ed.), Section 5.1 b) or resistance electroslag welding (RES) welding and PAW are permitted.

5.2.2 Lined Pipe

Lined pipe consists of a carbon steel pipe meeting the requirements of API 5L (45th Ed.), PSL 2 with an internal or external CRA liner. The CRA liner is affixed or tightly fitted to the external pipe full length by expansion, compression cold forming, or some other means. The CRA liner may be a tube or pipe inserted into a steel pipe, a plate or sheet rolled into a cylinder by expanding the liner and/or shrinking the pipe, or by some other applicable processes. Lined pipe may be either seamless or welded as follows.

- a) *Seamless*. Seamless lined pipe consists of an outer seamless pipe made to the requirements of API 5L (45th Ed.), PSL 2.
- b) *Welded*. Welded lined pipe consists of an outer welded pipe made to the requirements of API 5L (45th Ed.), PSL 2. The liner may be either seamless or welded manufactured to the requirements of API 5LC (4th Ed.) or other appropriate industry standard. Alternatively, weld lined pipe may be made by co-rolling a sandwich of a carbon steel plate and a CRA plate into a cylinder followed by longitudinally welding the long edges to form a seam in the backing steel and CRA liner materials.

5.3 Cold Sizing and Cold Expansion

5.3.1 Unless otherwise agreed, the sizing ratio for the backing steel shall not be more than 1.5 % unless the entire part of the pipe that is cold sized is subsequently normalized, quenched, and tempered or stress relieved.

5.3.2 If cold sized or cold expanded pipe, which is not subsequently heat treated or stress relieved, is used as the backing steel, the strains applied during manufacturing of the pipe used as the backing steel shall be considered in addition to those applied during lining or sizing of the pipe after lining or cladding. In this case, the

sum of the sizing ratios for all manufacturing steps applied to the backing steel shall not exceed 2.0 % unless otherwise agreed.

5.3.3 Sizing ratio shall be determined as described in API 5L (45th Ed.), Section 8.9.3.

5.3.4 Following all sizing operations and processing the produced pipe shall be tested for conformance to mechanical and Charpy toughness properties per the requirements of Section 7.

5.4 Heat Treatment

Pipe furnished to this specification may be as-rolled, solution-annealed (for the CRA liner), normalized, thermomechanical controlled processing (TMCP), TMCP with accelerated cooling, or quench-and-tempered. For lined pipe, heat treatment may be applied to the outer pipe and the inner pipe, individually, before inserting the liner. The CRA inner pipe shall be supplied in the solution annealed condition unless otherwise agreed. Other appropriate heat treatments may be agreed upon between purchaser and manufacturer.

NOTE In order to ensure that satisfactory corrosion properties are consistently achieved in the clad layer, it is important to generate a high level of reproducibility in any heat treatment cycle.

Consequently, the manufacturer should minimize the heat treatment time and temperature tolerances. Following heat treatment, the CRA material shall demonstrate appropriate microstructure and anti-corrosion properties.

6 Chemical Properties and Tests

6.1 Composition

The composition of the CRA layer furnished to this specification, as determined by heat or deposit analyses, shall conform to the chemical requirements specified in Table 1. Chemical composition of the as deposited overlay of the seam or girth weld (in the case of a jointer) shall be within the tolerances of the clad layer or as agreed upon between the purchaser and manufacturer.

When agreed and specified on the purchase order or datasheet, the chemical composition of any CRA cladding or liner may be further restricted by specification of a minimum pitting resistance equivalent number (PREN) ($\% \text{Cr} + 3.3 \% \text{Mo} + 16 \% \text{N}$) or PREW [$\% \text{Cr} + 3.3 (\% \text{Mo} + 0.5 \% \text{W}) + 16 \% \text{N}$] value. If this is the case, the actual values shall be reported on the material test certificate.

6.2 Heat Analyses of the CRA Layer

The manufacturer shall furnish a report containing the heat analysis of each heat of material used in the manufacture of the CRA layer for pipe furnished on the purchase order. The analysis so determined shall conform to the requirements specified in 6.1.

If alloying elements other than those specified in Table 3 for a particular grade of CRA layer are added for other than deoxidation purposes, the heat analyses, including the alloy additions, shall be reported for each heat applied to the purchaser's order.

6.3 Product Analyses of Backing Steel, Welds, and CRA

One test from each of two lengths of pipe or plate or skelp from each lot size as indicated in Table 2 shall be analyzed for product analyses. Both the CRA layer and the backing steel shall be analyzed. The analysis may be taken from the plate for clad pipe prior to rolling into pipe, and from the outer and inner pipes for lined pipe prior to insertion of the CRA pipe in the backing steel pipe. The results of the analyses shall be provided to the purchaser.