Welded Tanks for Oil Storage

API STANDARD 650
THIRTEENTH EDITION, MARCH 2020
API MONOGRAM PROGRAM EFFECTIVE DATE: SEPTEMBER 1, 2020
ERRATA 1, JANUARY 2021



Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Copyright © 2019 American Petroleum Institute

Notice

Instructions for Submitting a Proposed Revision to this Standard Under Continuous Maintenance

The American Petroleum Institute maintains this standard under continuous maintenance procedures. These procedures establish a documented program for regular publication of addenda or revisions, including timely and documented consensus action on requests for revisions to any part of the standard. See Annex D for additional information. Proposed revisions shall be submitted to the Director, Standards Department, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Foreword

This Standard is based on the accumulated knowledge and experience of Purchasers and Manufacturers of welded oil storage tanks of various sizes and capacities for internal pressures not more than 17.2 kPa (2¹/₂ pounds per square inch) gauge. This Standard is meant to be a purchase specification to facilitate the manufacture and procurement of storage tanks for the petroleum industry.

If the tanks are purchased in accordance with this Standard, the Purchaser is required to specify certain basic requirements. The Purchaser may want to modify, delete, or amplify sections of this Standard, but reference to this Standard shall not be made on the nameplates of or on the Manufacturer's certification for tanks that do not fulfill the minimum requirements of this Standard or that exceed its limitations. It is strongly recommended that any modifications, deletions, or amplifications be made by supplementing this Standard rather than by rewriting or incorporating sections of it into another complete standard.

The design rules given in this Standard are minimum requirements. More stringent design rules specified by the Purchaser or furnished by the Manufacturer are acceptable when mutually agreed upon by the Purchaser and the Manufacturer. This Standard is not to be interpreted as approving, recommending, or endorsing any specific design or as limiting the method of design or construction.

The verbal forms used to express the provisions in this document are as follows.

Shall: As used in a standard, "shall" denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, "should" denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, "may" denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, "can" denotes a statement of possibility or capability.

• This Standard is not intended to cover storage tanks that are to be erected in areas subject to regulations more stringent than the specifications in this Standard. When this Standard is specified for such tanks, it should be followed insofar as it does not conflict with local requirements. The Purchaser is responsible for specifying any jurisdictional requirements applicable to the design and construction of the tank.

After revisions to this Standard have been issued, they may be applied to tanks that are to be completed after the date of issue. The tank nameplate shall state the date of the edition of the Standard and any revision to that edition to which the tank has been designed and constructed.

• Each edition, revision, or addenda to this API Standard may be used beginning with the date of issuance shown on the cover page for that edition, revision, or addenda. Each edition, revision, or addenda to this API Standard becomes effective six months after the date of issuance for equipment that is certified as being constructed, and inspected per this Standard. During the six-month time between the date of issuance of the edition, revision, or addenda and the effective date, the Purchaser and the Manufacturer shall specify to which edition, revision, or addenda the equipment is to be constructed and inspected.

Important Information Concerning Use of Asbestos or Alternative Materials

Asbestos is specified or referenced for certain components of the equipment described in some API standards. It has been of extreme usefulness in minimizing fire hazards associated with petroleum processing. It has also been a universal sealing material, compatible with most refining fluid services.

Certain serious adverse health effects are associated with asbestos, among them the serious and often fatal diseases of lung cancer, asbestosis, and mesothelioma (a cancer of the chest and abdominal linings). The degree of exposure to asbestos varies with the product and the work practices involved.

Consult the most recent edition of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Occupational Safety and Health Standard for Asbestos, Tremolite, Anthophyllite, and Actinolite, 29 *Code of Federal Regulations* Section 1910.1001; the U.S. Environmental Protection Agency, National Emission Standard for Asbestos, 40 *Code of Federal Regulations* Sections 61.140 through 61.156; and the U.S. Environmental Protection Agency (EPA) rule on labeling requirements and phased banning of asbestos products (Sections 763.160-179).

There are currently in use and under development a number of substitute materials to replace asbestos in certain applications. Manufacturers and users are encouraged to develop and use effective substitute materials that can meet the specifications for, and operating requirements of, the equipment to which they would apply.

SAFETY AND HEALTH INFORMATION WITH RESPECT TO PARTICULAR PRODUCTS OR MATERIALS CAN BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT PRODUCT OR MATERIAL, OR THE MATERIAL SAFETY DATASHEET.

Contents

		Page
1 1.1 1.2 1.3 1.4 1.5	Scope General Limitations Responsibilities Documentation Requirements Formulas	1-1 1-3 1-4 1-4
2	Normative References	2-1
3	Terms and Definitions	3-1
4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9	Materials General Plates Sheets Structural Shapes Piping and Forgings Flanges Bolting. Welding Electrodes Gaskets	4-1 4-2 4-9 .4-14 .4-17 .4-17
5.11 5.12	Design Joints Design Considerations Special Considerations Bottom Plates. Annular Bottom Plates Shell Design Shell Openings Shell Attachments and Tank Appurtenances Top and Intermediate Stiffening Rings (Wind Girders) Roofs. Wind Load on Tanks (Overturning Stability) Tank Anchorage. Downward Reactions on Foundations.	5-1 5-9 .5-14 .5-15 .5-16 .5-28 .5-67 .5-81 .5-92 5-100
6 6.1 6.2	Fabrication	6-1
7 7.1 7.2 7.3 7.4 7.5	Erection General Details of Welding Examination, Inspection, and Repairs Repairs to Welds Dimensional Tolerances	7-1 7-1 7-5 .7-11
8 8.1 8.2 8.3 8.4	Methods of Examining Joints Radiographic Method Magnetic Particle Examination Ultrasonic Examination Liquid Penetrant Examination	8-1 8-5 8-5

		Page
8.5 8.6	Visual Examination	
9	Welding Procedure and Welder Qualifications	9-1
9.1	Definitions	9-1
9.2	Qualification of Welding Procedures	
9.3 9.4	Qualification of Welders	
10 10 1	Marking Nameplates	
	Division of Responsibility	
10.3	Certification	10-3
Ann	ex A (normative) Optional Design Basis for Small Tanks	A- 1
Ann	ex AL (normative) Aluminum Storage Tanks	AL -1
Ann	ex B (informative) Recommendations for Design and Construction of Foundations for	
	Aboveground Oil Storage Tanks	B-1
Ann	ex C (normative) External Floating Roofs	C-1
Ann	ex D (informative) Inquiries and Suggestions for Change	D -1
Ann	ex E (normative) Seismic Design of Storage Tanks	E-1
Ann	ex EC (informative) Commentary on Annex E	EC-1
Ann	ex F (normative) Design of Tanks for Small Internal Pressures	F-1
Ann	ex G (normative) Structurally-Supported Aluminum Dome Roofs	G -1
	ex H (normative) Internal Floating Roofs	
Ann	ex I (normative) Undertank Leak Detection and Subgrade Protection	I-1
Ann	ex J (normative) Shop-assembled Storage Tanks	J-1
Ann	ex K (informative) Sample Applications of the Variable-Design-Point Method to Determine Shell-Plate Thickness	K -1
Ann	ex L (normative) API Standard 650 Storage Tank Data Sheet	L-1
Ann	ex M (normative) Requirements for Tanks Operating at Elevated Temperatures	M-1
Ann	ex N (normative) Use of New Materials That Are Not Identified	N- 1
Ann	ex O (normative) Under-bottom Connections	0-1
Ann	ex P (normative) Allowable External Loads on Tank Shell Openings	P-1
Ann	ex R (informative) References for Tanks in Non-petroleum Product Service	R-1
Ann	ex S (normative) Austenitic Stainless Steel Storage Tanks	S-1
Ann	ex SC (normative) Stainless and Carbon Steel Mixed Materials Storage Tanks	SC-1
Ann	ex T (informative) NDE Requirements Summary	T-1
Ann	ex U (normative) Ultrasonic Examination in Lieu of Radiography	U-1
Ann	ex V (normative) Design of Storage Tanks for External Pressure	V-1
Ann	ex W (normative) Commercial and Documentation Recommendations	W -1
Ann	ex X (normative) Duplex Stainless Steel Storage Tanks	X- 1
Δnn	ex Y (normative) API Monogram	Y_1

		Page
Biblio	graphy	Y-5
Figure	es	
4.1a	Minimum Permissible Design Metal Temperature for Materials Used in Tank Shells	4 8
	without Impact Testing (SI)	4-7
4.1b	Minimum Permissible Design Metal Temperature for Materials Used in Tank Shells	
	without Impact Testing (USC)	
4.2	Isothermal Lines of Lowest One-day Mean Temperatures (°F)	
4.3	Governing Thickness for Impact Test Determination of Shell Nozzle and Manhole Materials	
5.1	Typical Vertical Shell Joints	
5.2	Typical Horizontal Shell Joints	
5.3a	Typical Roof and Bottom Joints	
5.3b	Method for Preparing Lap-welded Bottom Plates under Tank Shell	5-6
5.3c	Detail of Double Fillet-groove Weld for Annular Bottom Plates with a Nominal Thickness Greater than 13 mm (¹ / ₂ in.)	E (
5.3d	Spacing of Three-plate Welds at Annular Plates	
5.3u 5.4		
5.4 5.5	Storage Tank	
5.6	Drip Ring (Suggested Detail)	
	Minimum Weld Requirements for Openings in Shells According to 5.7.3	
5.7a	Shell Manhole	
5.7b	Details of Shell Manholes and Nozzles	
5.8	Shell Nozzles	
5.9	Minimum Spacing of Welds and Extent of Related Radiographic Examination	
5.10	Shell Nozzle Flanges	
5.11	Area Coefficient for Determining Minimum Reinforcement of Flush-type Cleanout Fittings	
5.12	Flush-type Cleanout Fittings	
5.13	Flush-type Cleanout Fitting Supports	
5.14	Flush-type Shell Connection.	
5.15	Rotation of Shell Connection	
5.16	Roof Manholes	
5.17	Rectangular Roof Openings with Flanged Covers	
5.18	Rectangular Roof Openings with Hinged Cover	
5.19	Flanged Roof Nozzles	
5.20	Threaded Roof Nozzles	
5.21	Drawoff Sump	
5.22	Scaffold Cable Support	
5.23	Grounding Lug	
5.24	Typical Stiffening-ring Sections for Tank Shells	
5.25	Stairway Opening through Stiffening Ring	
5.26	Some Acceptable Column Base Details	
5.27	Overturning Check for Self-anchored Tanks	
5.28	Typical Anchor Chair	
5.29	Typical Anchor Strap Welded Attachment (for Carbon Steel Tank)	
5.30	Typical Hold-Down Strap Configuration (for Carbon Steel Tank)	
5.31	Butt Weld Joint with Back-up Bar	
6.1	Shaping of Plates	
8.1	Radiographic Requirements for Tank Shells	
10.1	Manufacturer's Nameplate	
10.2	Manufacturer's Certification Letter	
AL.1	Cover Plate Thickness for Shell Manholes and Cleanout Fittings	
AL.2	Flange Plate Thickness for Shell Manholes and Cleanout Fittings	
ΔΙ 3	Rottom Reinforcing Plate Thickness for Cleanout Fittings	ΔI _1 <i>F</i>

		Page
AL.4	Stresses in Roof Plates	
B.1	Example of Foundation with Concrete Ringwall	
B.2	Example of Foundation with Crushed Stone Ringwall	B-5
E.1	Coefficient C_i	
EC.1	Maximum Earthquake Response Spectrum	EC-4
EC.2	Earthquake Response Spectrum Notation	EC-4
EC.3	Site Specific Response Spectrum	EC-
EC.4	Deterministic Lower Limit on MCE Response Spectrum	
EC.5	Relationship of Probabilistic and Deterministic Response Spectra	EC-6
EC.6	Sloshing Factor, K_s	EC-7
EC.7	Design Response Spectra for Ground-Supported Liquid Storage Tanks	EC-8
EC.8	Effective Weight of Liquid Ratio	EC-10
EC.9	Center of Action of Effective Forces	EC-10
EC.10	Overturning Moment	EC-12
F.1	Annex F Decision Tree	F-2
F.2	Permissible Details of Compression Rings	F-3
G.1	Data Sheet for a Structurally-Supported Aluminum Dome Added to an Existing Tank	
G.2	Typical Roof Nozzle	
I.1	Concrete Ringwall with Undertank Lead Detection at the Tank Perimeter	
	(Typical Arrangement)	I-2
I.2	Crushed Stone Ringwall with Undertank Leak Detection at the Tank Perimeter	
	(Typical Arrangement)	1-3
I.3	Earthen Foundation with Undertank Leak Detection at the Tank Perimeter	
	(Typical Arrangement)	I-3
1.4	Double Steel Bottom with Leak Detection at the Tank Perimeter (Typical Arrangement)	
1.5	Double Steel Bottom with Leak Detection at the Tank Perimeter (Typical Arrangement)	
1.6	Reinforced Concrete Slab with Leak Detection at the Perimeter (Typical Arrangement)	
1.7	Reinforced Concrete Slab	
I.8	Typical Drawoff Sump	
1.9	Center Sump for Downward-Sloped Bottom	
I.10	Typical Leak Detection Wells	
I.11	Tanks Supported by Grillage Members (General Arrangement)	
0.1	Example of Under-bottom Connection with Concrete Ringwall Foundation	
0.2	Example of Under-bottom Connection with Concrete Ringwall Foundation and Improved	
	Tank Bottom and Shell Support	0-4
O.3	Example of Under-bottom Connection with Earth-type Foundation	
P.1	Nomenclature for Piping Loads and Deformation	
P.2a	Stiffness Coefficient for Radial Load: Reinforcement on Shell (L/2a = 1.0)	P-6
P.2b	Stiffness Coefficient for Longitudinal Moment: Reinforcement on Shell ($L/2a = 1.0$)	P-6
P.2c	Stiffness Coefficient for Circumferential Moment: Reinforcement on Shell ($L/2a = 1.0$)	
P.2d	Stiffness Coefficient for Radial Load: Reinforcement on Shell (L/2a = 1.5)	
P.2e	Stiffness Coefficient for Longitudinal Moment: Reinforcement on Shell ($L/2a = 1.5$)	
P.2f	Stiffness Coefficient for Circumferential Moment: Reinforcement on Shell (L/2a = 1.5)	
P.2g	Stiffness Coefficient for Radial Load: Reinforcement in Nozzle Neck Only ($L/2a = 1.0$)	
P.2h	Stiffness Coefficient for Longitudinal Moment: Reinforcement in Nozzle Neck Only	
	(L/2a = 1.0)	P-9
P.2i	Stiffness Coefficient for Circumferential Moment: Reinforcement in Nozzle Neck Only	
-	(<i>L</i> /2 <i>a</i> = 1.0)	P-10
P.2j	Stiffness Coefficient for Radial Load: Reinforcement in Nozzle Neck Only ($L/2a = 1.5$)	
P.2k	Stiffness Coefficient for Longitudinal Moment: Reinforcement in Nozzle Neck Only	
	(<i>L</i> /2 <i>a</i> = 1.5)	P-11

		Page
P.2I	Stiffness Coefficient for Circumferential Moment: Reinforcement in Nozzle Neck Only	
	(<i>L</i> /2 <i>a</i> = 1.5)	
P.3a	Construction of Nomogram for b_1 , b_2 , c_1 , c_2 Boundary	
P.3b	Construction of Nomogram for b_1 , c_3 Boundary	
P.4a	Obtaining Coefficients Y_F and Y_L	
P.4b	Obtaining Coefficient Y _C	
P.5a	Determination of Allowable Loads from Nomogram: F_R and M_L	
P.5b	Determination of Allowable Loads from Nomogram: F_R and M_C	
P.6	Low-type Nozzle with Reinforcement on Shell	
P.7	Allowable-load Nomograms for Sample Problem	
V.1a	Dimensions for Self-supporting Cone Roof	
V.1b	Dimensions for Self-supporting Dome Roof	V-9
Tables	S Company of the comp	
1.1	Deleted	
4.1	Maximum Permissible Alloy Content	4-5
4.2	Acceptable Grades of Plate Material Produced to National Standards	4-5
4.3a	Linear Equations for Figure 4.1a (SI)	4-9
4.3b	Linear Equations for Figure 4.1b (USC)	4-9
4.4a	Material Groups (SI)	4-11
4.4b	Material Groups (USC)	4-12
4.5a	Minimum Impact Test Requirements for Plates (SI)	.4-13
4.5b	Minimum Impact Test Requirements for Plates (USC)	4-13
5.1a	Annular Bottom-plate Thicknesses (t_b) (SI)	5-16
5.1b	Annular Bottom-plate Thicknesses (t_b) (USC)	5-17
5.2a	Permissible Plate Materials and Allowable Stresses (SI)	.5-18
5.2b	Permissible Plate Materials and Allowable Stresses (USC)	5-21
5.3a	Thickness of Shell Manhole Cover Plate and Bolting Flange (SI)	5-30
5.3b	Thickness of Shell Manhole Cover Plate and Bolting Flange (USC)	5-30
5.4a	Dimensions for Shell Manhole Neck Thickness (SI)	5-31
5.4b	Dimensions for Shell Manhole Neck Thickness (USC)	.5-32
5.5a	Dimensions for Bolt Circle Diameter D_b and Cover Plate Diameter D_b for Shell Manholes (SI)	5-33
5.5b	Dimensions for Bolt Circle Diameter D_b and Cover Plate Diameter D_b for Shell Manholes (USC).	5-33
5.6a	Dimensions for Shell Nozzles (SI)	. 5-37
5.6b	Dimensions for Shell Nozzles (USC)	. 5-39
5.7a	Dimensions for Shell Nozzles: Pipe, Plate, and Welding Schedules (SI)	5-40
5.7b	Dimensions for Shell Nozzles: Pipe, Plate, and Welding Schedules (USC)	5-42
5.8a	Dimensions for Shell Nozzle Flanges (SI)	.5-43
5.8b	Dimensions for Shell Nozzle Flanges (USC)	.5-44
5.9a	Dimensions for Flush-type Cleanout Fittings (SI)	.5-45
5.9b	Dimensions for Flush-type Cleanout Fittings (USC)	.5-45
5.10a	Minimum Thickness of Cover Plate, Bolting Flange, and Bottom Reinforcing Plate	
	for Flush-Type Cleanout Fittings (SI)	.5-46
5.10b		
	for Flush-Type Cleanout Fittings (USC)	5-46
5.11a	Thicknesses and Heights of Shell Reinforcing Plates for Flush-type Cleanout Fittings (SI)	.5-47
	Thicknesses and Heights of Shell Reinforcing Plates for Flush-type Cleanout Fittings (USC)	
	Dimensions for Flush-type Shell Connections (SI)	
	Dimensions for Flush-type Shell Connections (USC)	
	Dimensions for Roof Manholes (SI)	
	Dimensions for Roof Manholes (USC)	
	Dimensions for Flanged Roof Nozzles (SI)	

		Page
5.14b	Dimensions for Flanged Roof Nozzles (USC)	5-73
5.15a	Dimensions for Threaded Roof Nozzles (SI)	5-74
5.15b	Dimensions for Threaded Roof Nozzles (USC)	5-74
5.16a		5-78
5.16b	Dimensions for Drawoff Sumps (USC)	5-78
5.17	Requirements for Platforms and Walkways	5-79
5.18	Requirements for Stairways	
5.19a	Section Moduli (cm ³) of Stiffening-Ring Sections on Tank Shells (SI)	5-85
5.19b	Section Moduli (in.3) of Stiffening-Ring Sections on Tank Shells (USC)	5-86
5.20a	Uplift Loads (SI)	5-103
5.20b	Uplift Loads (USC)	
5.21	Unfactored (Working Stress) Downward Reactions on Foundations	5-111
7.1a	Minimum Preheat Temperatures (SI)	
7.1b	Minimum Preheat Temperatures (USC)	7-2
A.1a	Typical Sizes and Corresponding Nominal Capacities (m ³) for Tanks with 1800-mm	
	Courses (SI)	A-2
A.1b	Typical Sizes and Corresponding Nominal Capacities (Barrels) for Tanks with 72-in.	
	Courses (USC)	A-3
A.2a	Typical Sizes and Corresponding Nominal Capacities (m ³) for Tanks with 2400-mm	
	Courses (SI)	A-4
A.2b	Typical Sizes and Corresponding Nominal Capacities (Barrels) for Tanks with 96-in.	
	Courses (USC)	
AL.1	Material Specifications	
AL.2	Joint Efficiency	
	Minimum Mechanical Properties (SI)	
	Minimum Mechanical Properties (USC)	
	Annular Bottom Plate Thickness (SI)	
	Annular Bottom Plate Thickness (USC)	
	Minimum Shell Thickness (SI)	
	Minimum Shell Thickness (USC)	
	Allowable Tensile Stresses for Tank Shell (for Design and Test) (SI)	
	Allowable Tensile Stresses for Tank Shell (for Design and Test) (USC)	
	Allowable Stresses for Roof Plates (SI)	
	Allowable Stresses for Roof Plates (USC)	
	Compressive Moduli of Elasticity E (MPa) at Temperature (°C) (SI)	
AL.OD	Shell Nozzle Welding Schedule (SI)	AL-19
	Shell Nozzle Welding Schedule (USC)	
E.1	Value of F_a as a Function of Site Class	
E.2	Value of F_q as a Function of Site Class	
E.3	Site Classification.	
L.3 E.4	Response Modification Factors for ASD Methods	
⊑. ∓ E.5	Importance Factor (I) and Seismic Use Group Classification	
E.6	Anchorage Ratio Criteria	
E.7	Minimum Required Freeboard	
E.8	Design Displacements for Piping Attachments	
₀ J.1а	Minimum Roof Depths for Shop-assembled Dome-roof Tanks (SI)	
J.1b	Minimum Roof Depths for Shop-assembled Dome-roof Tanks (USC)	
K.1a	Shell-plate Thicknesses Based on the Variable-design-point Method Using 2400-mm	
	Courses and an Allowable Stress of 159 MPa for the Test Condition (SI)	K-18
K.1b	Shell-plate Thicknesses Based on the Variable-design-point Method Using 96-in.	
	Courses and an Allowable Stress of 23,000 lbf/in. ² for the Test Condition (USC)	K-19

		Page
K.2a	Shell-plate Thicknesses Based on the Variable-design-point Method Using 2400-mm	
	Courses and an Allowable Stress of 208 MPa for the Test Condition (SI)	K-20
K.2b	Shell-plate Thicknesses Based on the Variable-design-point Method Using 96-in.	
	Courses and an Allowable Stress of 30,000 lbf/in. ² for the Test Condition (USC)	K-21
K.3a	Shell-plate Thicknesses Based on the Variable-design-point Method Using 2400-mm	
	Courses and an Allowable Stress of 236 MPa for the Test Condition (SI)	K-22
K.3b	Shell-plate Thicknesses Based on the Variable-design-point Method Using 96-in.	
	Courses and an Allowable Stress of 34,300 lbf/in. ² for the Test Condition (USC)	K-23
L.1	Index of Decisions or Actions That May be Required of the Tank Purchaser	L-28
M.1a	Yield Strength Reduction Factors (SI)	
M.1b	Yield Strength Reduction Factors (USC)	
M.2a	Modulus of Elasticity at the Maximum Design Temperature (SI)	M-6
M.2b	Modulus of Elasticity at the Maximum Design Temperature (USC)	
O.1a	Dimensions of Under-Bottom Connections (SI)	
0.1b	Dimensions of Under-Bottom Connections (USC)	0-2
P.1a	Modulus of Elasticity and Thermal Expansion Coefficient at the Design Temperature (SI)	
P.1b	Modulus of Elasticity and Thermal Expansion Coefficient at the Design Temperature (USC)	
S.1a	ASTM Materials for Stainless Steel Components (SI)	
S.1b	ASTM Materials for Stainless Steel Components (USC)	S-3
S.2a	Allowable Stresses for Tank Shells (SI)	S-8
S.2b	Allowable Stresses for Tank Shells (USC)	S-8
S.3a	Allowable Stresses for Plate Ring Flanges (SI)	
S.3b	Allowable Stresses for Plate Ring Flanges (USC)	S-9
S.4	Joint Efficiencies	
S.5a	Yield Strength Values in MPa (SI)	S-10
S.5b	Yield Strength Values in psi (USC)	S-10
S.6a	Modulus of Elasticity at the Maximum Design Temperature (SI)	S-11
S.6b	Modulus of Elasticity at the Maximum Design Temperature (USC)	
U.1a	Flaw Acceptance Criteria for UT Indications May be Used for All Materials (SI)	U-5
U.1b	Flaw Acceptance Criteria for UT Indications May be Used for All Materials (USC)	
X.1	ASTM Materials for Duplex Stainless Steel Components	X-2
X.2a	Allowable Stresses for Tank Shells (SI)	X-5
X.2b	Allowable Stresses for Tank Shells (USC)	X-6
X.3	Joint Efficiencies	X-6
X.4a	Yield Strength Values in MPa	X-8
X.4b	Yield Strength Values in PSI	
X.5a	Modulus of Elasticity at the Maximum Design Temperature (SI)	
X.5b	Modulus of Elasticity at the Maximum Design Temperature (USC)	X-9
X.6a	Hot Forming Temperatures (SI)	
X.6b	Hot Forming Temperatures (USC)	X-10