

Inspection Practices for Pressure Vessels

API RECOMMENDED PRACTICE 572
FOURTH EDITION, DECEMBER 2016



AMERICAN PETROLEUM INSTITUTE

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.

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, 1220 L Street, NW, Washington, DC 20005.

Copyright © 2016 American Petroleum Institute

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

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

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

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

	Page
1	Scope 1
2	Normative References 1
3	Terms and Definitions 1
3.1	Definitions 1
3.2	Acronyms and Abbreviations 6
4	Introduction to Pressure Vessels 6
4.1	General 6
4.2	Methods of Construction 6
4.3	Materials of Construction 7
4.4	Internal Components and Equipment 8
4.5	Uses of Pressure Vessels 11
4.6	Design and Construction Standards 12
5	Reasons for Inspection 15
5.1	General 15
5.2	Safety 15
5.3	Reliability and Efficient Operation 16
5.4	Regulatory Requirements 16
6	Inspection Plans 17
6.1	General 17
6.2	Inspection for Specific Types of Damage 17
6.3	Developing Inspection Plans 18
6.4	Reviewing and Updating Inspection Plans 18
6.5	RBI 19
7	Frequency and Extent of Inspection 19
7.1	General 19
7.2	Opportunities for Inspection 20
8	Safety Precautions and Preparatory Work 21
8.1	Safety Precautions 21
8.2	Preparatory Work 21
9	Inspection Methods and Limitations 24
9.1	General 24
9.2	Thickness Measurements 24
9.3	External Inspection 27
9.4	Internal Inspection 36
9.5	Special Methods of Detecting Mechanical Damage 48
9.6	Metallurgical Changes and In-situ Analysis of Metals 49
9.7	Testing 49
10	Condition Assessment and Repair 53
10.1	General 53
10.2	Visual Inspection 53
10.3	Thickness Measurements 54
10.4	Remaining Life 54
10.5	Methods of Repair 54
10.6	Repair of Supporting Vessel Equipment 55

Contents

Page

11	Records and Reports	56
11.1	Records	56
11.2	Reports	56
	Annex A (informative) Exchangers	57
	Annex B (informative) Towers	74
	Annex C (informative) Sample Record Forms	131
	Bibliography	144

Figures

1	Type 3016 Stainless-clad Vessel	8
2	Weld Metal Surfacing	9
3	Strip-lined Vessel	9
4	Principal Strip-lining Methods	10
5	Hex Mesh Installation for Refractory Lining	10
6	Reinforced Refractory	11
7	Vertical Heat Exchanger	12
8	Horizontal Vessel	13
9	Spheres	14
10	Horton Spheroid (Noded)	14
11	Process Tower	15
12	Exchangers	16
13	Exchanger Installation and Foundation	28
14	Severe Deterioration of Anchor Bolts	29
15	Method of Obtaining Vessel Profile Measurements	35
16	Corrosion in Channel	38
17	Crack in Weld Seen by PT	39
18	Hydrogen Blistering	41
19	Self-vented Hydrogen Blisters	41
20	Radiograph of Self-vented Hydrogen Blisters in Carbon Steel	42
21	Catalytic Reactor Internals—Cyclones	43
22	Corrosion Tab Method of Determining Metal Loss on Vessel Linings	45
23	Strip-liner Damage	46
24	Deteriorated Refractory-tile Lining	48
25	Steps in Using Special Equipment to Test Individual Tubes	52
A.1	Properly Rolled Tube	58
A.2	Tube-bundle Type of Tank Heater	60
A.3	Air-cooled Exchangers	61
A.4	Clean-service Double-pipe Coils	62
A.5	Tank Suction Heater with Everything but Forward End Enclosed; Shell Suction Nozzle Enclosed in Far End	63
A.6	Fin-type Tubes in Double-pipe Coil	64
A.7	Plate-type Exchanger	64
A.8	Tubes Thinned at Baffles	66
A.9	Tubes Fretting at Baffles	67
A.10	Erosion–Corrosion Attack at Tube Ends	67
A.11	Heat Exchanger Parts	70
A.12	Heat Exchanger Types	73
B.1	Typical Trays in a Tower	74
B.2	Random Packing in a Tower	74

Contents

Page

B.3	Trays with Downcomers	75
B.4	Bubble Cap Flow Path	75
B.5	Tower Stripping and Rectification Section	76
B.6	Disk/Donut Tray	77
B.7	Baffle Tray Arrangement	78
B.8	Figure Tray	79
B.9	Sieve Tray Distortion	79
B.10	Typical Trayed Tower	82
B.11	Float Valves with Two Weights	83
B.12	Fixed Valves	83
B.13	Bubble Cap Valves	84
B.14	Extruded Valves	84
B.15	New Floating Valve Tray	85
B.16	Caged Valves	85
B.17	Typical Packed Tower Drawing	86
B.18	Random Packing, Pall Rings	87
B.19	Structured Packing	87
B.20	Grid-style Packing	88
B.21	Diagram of Required Scaffolding	90
B.22	Hexagonal Manways	91
B.23	Standing Oil and Water	91
B.24	Trays Collapsed	92
B.25	Corroded Anchor Bolting	92
B.26	Corroded Anchor Bolting	93
B.27	Cracked and Bulged Fireproofing	93
B.28	Debris in Skirt	94
B.29	Preliminary Inspection	94
B.30	Bed Damage at Preliminary Inspection	95
B.31	Manway Corrosion	95
B.32	Manway Liner Damage	96
B.33	Corrosion on Gasket Seating Surface	96
B.34	Corrosion on Gasket Seating Surface	97
B.35	Surface Corrosion of Shell	97
B.36	Inspection from the Bottom Head	98
B.37	Inspection of Packing via Riser	98
B.38	Demister Bypass Deposits	99
B.39	Fouled Demister Pads	99
B.40	Faulty Demister Installation	100
B.41	Preferential Corrosion of the Head-to-Shell Weld	100
B.42	Head Seam Preferential Corrosion	101
B.43	Preferential Corrosion of the Shell	101
B.44	Perforation Degradation	102
B.45	Chimney Tray Deformation at Draw Sump	102
B.46	Fouled Troughs on Box and Trough Distributor	103
B.47	Obstructed Pipe Distributor Perforations	103
B.48	Box and Troughs	104
B.49	Hit the Washers, Not the Bolts	104
B.50	Random Packing on Valve Tray	105
B.51	Bed Limiter Above Random Packing	105

Contents

	Page
B.52 Dislodged Packing	106
B.53 Damaged Packing Support Grid	106
B.54 Support Grid from Below	107
B.55 Corrosion Inside Sightglass Nozzle	107
B.56 Bottom Head, Vortex Breaker, and Debris	108
B.57 Fouled Grid-type Packing	109
B.58 Cracked Plug Weld	109
B.59 Stainless Steel Donut Cladding Breach	110
B.60 Cladding Breach at Gouges in Bottom Head	110
B.61 410 Stainless Steel Clad to Carbon Steel Interface Weld	111
B.62 Supplemental UT Markings	111
B.63 Cracking at Tray Support Ring Weld	112
B.64 WFMPD Discovered Cracking	113
B.65 Supplemental NDE May Be Needed	113
B.66 Areas of Chemical Activity	114
B.67 Areas of Activity	114
B.68 Hardware Corrosion	115
B.69 Stuck Valves Always Open	115
B.70 Clean Square-edged Perforation	116
B.71 Valve Fretting	116
B.72 Slotting from Below	117
B.73 Valve Leg and Perforation Inspection	117
B.74 Indentation of Valves	118
B.75 New Caged Valves with Dimples	118
B.76 New Caged Valve Cage Tabs	119
B.77 Small Fixed Valves	120
B.78 Fixed Valved Lateral Vapor Directional Flow	120
B.79 Removable Fixed Valves Reduce Fouling	121
B.80 Removable Fixed Valves Tray Damage	121
B.81 Bubble Caps on Stepped Trays	122
B.82 Fibrous Deposits and Fouling Under Bubble Caps	122
B.83 Tray Deck Should Be Scraped Clean	123
B.84 Tray Fatigue Cracking	124
B.85 Light-to-moderate Weir Corrosion	124
B.86 Loose and Missing Hardware Failure	125
B.87 Downcomer and Seal Pan Clamps Loose	125
B.88 Downcomer Clamp Loose	126
B.89 Tray Support Ring Corroded to Failure	126
B.90 Shell Corroded to Half Wall Adjacent Top Three Rings	127
B.91 Support Ring Grooving	127
B.92 Deposits Adjacent to Shell Are on Ring	128
B.93 Cracking of Ring Attachment Weld	128
B.94 Tray Support Ring Butt Weld Cracking	129
B.95 Breaching of the Seal Weld	129
B.96 Shadowing Inside the Downcomer	130
B.97 Shadow the Downcomer Shell Every Tray	130

Inspection Practices for Pressure Vessels

1 Scope

This recommended practice (RP) supplements API 510 by providing pressure vessel inspectors with information that can improve skills and increase basic knowledge of inspection practices. This RP describes inspection practices for the various types of pressure vessels (e.g. drums, heat exchangers, columns, reactors, air coolers, spheres) used in petroleum refineries and chemical plants. This RP addresses vessel components, inspection planning processes, inspection intervals, methods of inspection and assessment, methods of repair, records and reports. API 510 has requirements and expectations for inspection of pressure vessels.

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.

API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration*

API Recommended Practice 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

API Recommended Practice 574, *Inspection Practices for Piping System Components*

API 579-1/ASME FFS 1¹, *Fitness-For-Service*

API Recommended Practice 580, *Risk-Based Inspection*

API Publication 2217A, *Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries*

ASME *Boiler and Pressure Vessel Code (BPVC), Section VIII: Pressure Vessels*

3 Terms and Definitions

3.1 Definitions

For the purposes of this document, the following definitions apply.

3.1.1

alteration

A physical change in any component that has design implications that affect the pressure-containing capability of a pressure vessel beyond the scope described in existing data reports. The following should not be considered alterations: any comparable or duplicate replacement, the addition of any reinforced nozzle less than or equal to the size of existing reinforced nozzles, and the addition of nozzles not requiring reinforcement.

3.1.2

cladding

A metal integrally bonded onto another metal under high pressure and temperature whose properties are better suited to resist damage from the process than the substrate material.

¹ ASME International, 3 Park Avenue, New York, New York 10016, www.asme.org.