

Inspection Practices for Pressure Vessels

Downstream Segment

RECOMMENDED PRACTICE 572
THIRD EDITION, NOVEMBER 2009



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.

Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this recommended practice (RP) should consult with the appropriate authorities having jurisdiction.

Users of this RP should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to hire 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.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety datasheet.

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.

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.

Currently in preview, click buy full version

Contents

	Page
1 Scope	1
2 Normative References.....	1
3 Terms and Definitions.....	2
3.1 Definitions	2
3.2 Acronyms and Abbreviations	5
4 Introduction to Pressure Vessels	5
4.1 General	5
4.2 Methods of Construction	6
4.3 Materials of Construction	6
4.4 Internal Components and Equipment	7
4.5 Uses of Pressure Vessels.....	8
4.6 Design and Construction Standards.....	9
5 Reasons for Inspection.....	12
5.1 General	12
5.2 Safety	15
5.3 Reliability and Efficient Operation.....	15
5.4 Regulatory Requirements.....	15
6 Inspection Plans	15
6.1 General	15
6.2 Inspection for Specific Types of Damage.....	16
6.3 Developing Inspection Plans	16
6.4 RBI.....	17
7 Frequency and Extent of Inspection	17
7.1 General	17
7.2 Opportunities for Inspection	18
8 Safety Precautions and Preparatory Work.....	18
8.1 Safety Precautions	18
8.2 Preparatory Work.....	19
9 Inspection Methods and Limitations.....	21
9.1 General	21
9.2 Thickness Measurements.....	22
9.3 External Inspection	24
9.4 Internal Inspection.....	33
9.5 Special Methods of Detecting Mechanical Damage	46
9.6 Metallurgical Changes and In-situ Analysis of Metals	46
9.7 Testing	47
10 Condition Assessment and Repair	50
10.1 General	50
10.2 Visual Inspection	50
10.3 Thickness Measurements.....	51
10.4 Remaining Life	51
10.5 Methods of Repair	51
10.6 Repair of Supporting Vessel Equipment.....	53

11	Records and Reports	53
11.1	Records	53
11.2	Reports	53
	Annex A (informative) Exchangers	54
	Annex B (informative) Towers	1
	Annex C (informative) Sample Record Forms	24

Figures

1	Type 316 Stainless-clad Vessel	7
2	Weld Metal Surfacing	8
3	Strip-lined Vessel	8
4	Principal Strip-lining Methods	9
5	Hex Mesh Installation for Refractory Lining	9
6	Reinforced Refractory	10
7	Vertical Heat Exchanger	11
8	Horizontal Vessel	12
9	Spheres	13
10	Horton Spheroid (Noded)	13
11	Process Tower	14
12	Exchangers	14
13	Exchanger Installation and Foundation	25
14	Severe Deterioration of Anchor Bolts	27
15	Method of Obtaining Vessel Profile Measurements	32
16	Corrosion in Channel	35
17	Crack in Weld Seen by PT	37
18	Hydrogen Blistering	38
19	Self-vented Hydrogen Blisters	39
20	Radiograph of Self-vented Hydrogen Blisters in Carbon Steel	39
21	Catalytic-reactor Internals—Cyclones	41
22	Corrosion Tab Method of Determining Metal Loss on Vessel Linings	43
23	Strip-liner Deterioration	44
24	Deteriorated Refractory-tile Lining	45
25	Steps in Using Special Equipment to Test Individual Tubes	49
A.1	Properly Rolled Tube	55
A.2	Tube-bundle Type of Tank Heater	57
A.3	Air-cooled Exchangers	58
A.4	Clean-service Double-pipe Coils	59
A.5	Tank Suction Heater with Everything but Forward End Enclosed; Shell Suction Nozzle Enclosed in Forward End	60
A.6	Fin-type Tubes in Double-pipe Coil	60
A.7	Plate-type Exchanger	61
A.8	Tubes Finned at Baffles	61
A.9	Tubes Fitting at Baffles	62
A.10	Erosion-corrosion Attack at Tube Ends	63
A.11	Heat Exchanger Parts	66
A.12	Heat Exchanger Types	70
B.1	Typical Trays in a Tower	71
B.2	Random Packing in a Tower	71
B.3	Trays with Downcomers	72
B.4	Bubble Cap Flow Path	72
B.5	Tower Stripping and Rectification Section	73

B.6	Disk/Donut Tray	74
B.7	Baffle Tray Arrangement	76
B.8	Sieve Tray	77
B.9	Sieve Tray Distortion	78
B.10	Typical Trayed Tower	79
B.11	Float Valves with Two Weights	80
B.12	Fixed Valves	80
B.13	Bubble Cap Valves	81
B.14	Extruded Valves	81
B.15	New Floating Valve Tray	82
B.16	Caged Valves	82
B.17	Typical Packed Tower Drawing	83
B.18	Random Packing, Pall Rings	84
B.19	Structured Packing	84
B.20	Grid-style Packing	85
B.21	Diagram of Required Scaffolding	87
B.22	Hexagonal Manways	88
B.23	Standing Oil and Water	88
B.24	Trays Collapsed	89
B.25	Corroded Anchor Bolting	89
B.26	Corroded Anchor Bolting	90
B.27	Cracked and Bulged Fireproofing	90
B.28	Debris in Skirt	91
B.29	Preliminary Inspection	91
B.30	Bed Damage at Preliminary Inspection	92
B.31	Manway Corrosion	92
B.32	Manway Liner Damage	92
B.33	Corrosion on Gasket Seating Surface	93
B.34	Corrosion on Gasket Seating Surface	93
B.35	Surface Corrosion of Shell	94
B.36	Inspection From the Bottom Head	95
B.37	Inspection of Packing via Riser	95
B.38	Demister Bypass Deposits	95
B.39	Fouled Demister Pads	96
B.40	Faulty Demister Installation	96
B.41	Preferential Corrosion of the Head to Shell Weld	97
B.42	Head Seam Preferential Corrosion	97
B.43	Preferential Corrosion of the Shell	98
B.44	Perforation Degradation	98
B.45	Chimney Tray Deformation at Draw Sump	98
B.46	Fouled Tray on Box and Trough Distributor	99
B.47	Obstructed Tray Distributor Perforations	99
B.48	Box and Troughs	99
B.49	Head Washers, Not the Bolts	100
B.50	Random Packing on Valve Tray	100
B.51	Ball Limiter Above Random Packing	101
B.52	Dislodged Packing	101
B.53	Damaged Packing Support Grid	102
B.54	Support Grid from Below	102
B.55	Corrosion Inside Sightglass Nozzle	103
B.56	Bottom Head, Vortex Breaker, and Debris	103
B.57	Fouled Grid-type Packing	104

B.58 Cracked Plug Weld	104
B.59 Stainless Steel Donut Cladding Breach	105
B.60 Cladding Breach at Gouges in Bottom Head	105
B.61 410 Stainless Steel Clad to Carbon Steel Interface Weld	106
B.62 Supplemental UT Markings	106
B.63 Cracking at Tray Support Ring Weld	107
B.64 WFMPD Discovered Cracking	107
B.65 Supplemental NDE May be Needed	108
B.66 Areas of Chemical Activity	109
B.67 Areas of Activity	109
B.68 Hardware Corrosion	110
B.69 Stuck Valves Always Open	110
B.70 Clean Square-edged Perforation	111
B.71 Valve Fretting	111
B.72 Slotting from Below	111
B.73 Valve Leg and Perforation Inspection	112
B.74 Indentation of Valves	112
B.75 New Caged Valves with Dimples	113
B.76 New Caged Valve Cage Tabs	113
B.77 Small Fixed Valves	114
B.78 Fixed Valves Lateral Vapor Directional Flow	114
B.79 Removable Fixed Valves Reduce Fouling	115
B.80 Removable Fixed Valves Tray Damage	115
B.81 Bubble Caps on Stepped Trays	116
B.82 Fibrous Deposits and Fouling Under Bubble Caps	116
B.83 Tray Deck Should be Scraped Clean	117
B.84 Tray Fatigue Cracking	117
B.85 Light-to-moderate Weir Corrosion	118
B.86 Loose and Missing Hardware Failure	118
B.87 Downcomer and Seal Pan Clamps Loose	119
B.88 Downcomer Clamp Loose	119
B.89 Tray Support Ring Corroded to Failure	120
B.90 Deposits Adjacent to Shell are on Ring	120
B.91 Shell Corroded to Half Wall Adjacent Top Three Rings	121
B.92 Support Ring Grooving	121
B.93 Cracking of Ring Attachment Weld	121
B.94 Tray Support Ring Bolt Weld Cracking	122
B.95 Breaching of the Seal Weld	122
B.96 Shadowing Inside the Downcomer	123
B.97 Shadow the Downcomer Shell Every Tray	123

Inspection Practices for Pressure Vessels

1 Scope

This recommended practice (RP) covers the inspection of pressure vessels. It includes a description of the various types of pressure vessels (including pressure vessels with a design pressure below 15 psig) and the standards for their construction and maintenance. This RP also includes reasons for inspection, causes of deterioration, frequencies and methods of inspection, methods of repair, and preparation of records and reports. Safe operation is emphasized within this RP.

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 Recommended Practice 575, *Guidelines and Methods for Inspection of Existing Atmospheric and Low-pressure Storage Tanks*

API Recommended Practice 576, *Inspection of Pressure-Relieving Devices*

API Recommended Practice 577, *Welding Inspection and Metallurgy*

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

API Standard 660, *Shell-and-Tube Heat Exchangers*

API Standard 661, *Air-Cooled Heat Exchangers for General Refinery Service*

API Recommended Practice 945, *Minimizing Environmental Cracking in Amine Units*

API Publication 2214, *Spark Test Properties of Hand Tools*

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

ASME PCC-2, *Repair of Pressure Equipment and Piping*

NB-23², *National Board Inspection Code*

TEMA³, *Standards of Tubular Exchanger Manufacturers Association*

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

² National Board of Boiler and Pressure Vessel Inspectors, NBBI, 1055 Crupper Avenue, Columbus, Ohio 43229, www.nationalboard.org.

³ Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, www.tema.org.