

# Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers, and Condensers)

RECOMMENDED PRACTICE 572  
SECOND EDITION, FEBRUARY 2001



**Helping You  
Get The Job  
Done Right.<sup>SM</sup>**



# Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers, and Condensers)

**Downstream Segment**

RECOMMENDED PRACTICE 572  
SECOND EDITION, FEBRUARY 2001



**American  
Petroleum  
Institute**

**Helping You  
Get The Job  
Done Right.<sup>SM</sup>**

## 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.

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 under local, state, or federal laws.

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 data sheet.

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.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Downstream Segment [telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

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 standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the general manager.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards 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, 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, N.W., Washington, D.C. 20005.*

## FOREWORD

This recommended practice covers the inspection of pressure vessels. It is based on the accumulated knowledge and experience of engineers and other personnel in the petroleum industry.

The information contained in this publication was previously presented as Chapter VI and Chapter VII of the Guide for Inspection of Refinery Equipment. The information in this recommended practice does not constitute and should not be construed as a code of rules, regulations, or minimum safe practices. The practices described in this publication are not intended to supplant other practices that have proven satisfactory, nor is this publication intended to discourage innovation and originality in the inspection of refineries. Users of this recommended practice are reminded that no book or manual is a substitute for the judgment of a responsible, qualified person.

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 federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

## **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 DATA SHEET.**

# CONTENTS

	Page
1 SCOPE.....	1
2 REFERENCES .....	1
3 DEFINITIONS.....	1
4 TYPES OF PRESSURE VESSELS .....	2
4.1 Description.....	2
4.2 Methods of Construction .....	2
4.3 Materials of Construction .....	2
4.4 Internal Equipment .....	4
4.5 Uses of Pressure Vessels .....	4
5 CONSTRUCTION STANDARDS.....	4
6 MAINTENANCE INSPECTION.....	6
7 REASONS FOR INSPECTION .....	8
7.1 General.....	8
7.2 Safety .....	8
7.3 Continuity.....	8
7.4 Reliability.....	8
8 CAUSES OF DETERIORATION .....	8
8.1 General.....	8
8.2 Corrosion Mechanisms .....	8
8.3 Metallurgical and Physical Changes .....	14
8.4 Faulty Material.....	16
8.5 Faulty Fabrication .....	16
9 FREQUENCY AND TIME OF INSPECTION .....	17
9.1 Factors Governing Frequency of Inspection .....	17
9.2 Opportunities for Inspection .....	17
9.3 Inspection Schedule.....	18
9.4 Alternative Rules for Exploration and Production Vessels.....	18
10 INSPECTION METHODS AND LIMITATIONS .....	18
10.1 General.....	18
10.2 Safety Precautions and Preparatory Work.....	19
10.3 External Inspection .....	20
10.4 Internal Inspection .....	26
10.5 Thickness-measuring Methods .....	33
10.6 Special Methods Of Detecting Mechanical Defects.....	34
10.7 Metallurgical Changes And In-situ Analysis Of Metals .....	34
10.8 Testing .....	34
10.9 Limits of Thickness .....	36
11 METHODS OF REPAIR .....	37

## CONTENTS

	Page
12 RECORDS AND REPORTS .....	38
12.1 Records.....	38
12.2 Reports.....	38
APPENDIX A—EXCHANGERS .....	39
APPENDIX B—SAMPLE RECORD FORMS .....	53
 Figures	
1—Type 316 Stainless-Clad Vessel .....	3
2—Weld Metal Surfacing .....	3
3—Strip-Lined Vessel.....	3
4—Principal Strip-Lining Methods .....	4
5—Reinforced Refractory Lining for Regenerator Lines and Slide Valves .....	4
6—Catalyst Storage Hoppers .....	5
7—Horizontal Drums .....	5
8—Spheres .....	6
9—Horton Spheroid (Noded) .....	6
10—Process Towers and Drums .....	7
11—Fluid Catalytic Regenerator .....	8
12—Caustic-Stress Corrosion .....	9
13—Severe Graphitic Corrosion of Floating-Head Cover .....	9
14—Plug-Type Dezincification .....	9
15—Layer-Type Dezincification .....	9
16—Tube Sheet Fouled With Marine Growth .....	10
17—Tube Sheet Corroded Beneath Marine Growth .....	10
18—Internal Vessel Corrosion .....	11
19—Erosion .....	11
20—Condensate Grooving of Tube in Area Adjoining Tube Sheet .....	11
21—Intergranular Corrosion .....	14
22—Thermal and Pressure Damage .....	14
23—Fatigue Cracking at Nozzle .....	14
24—Exchanger Installation and Foundation .....	21
25—Severe Deterioration of Anchor Bolts .....	22
26—Method of Obtaining Vessel Profile Measurements .....	25
27—Pitting in Channel .....	27
28—Crack in Shell Weld .....	28
29—Catalytic-Reactor Internals—Cyclones .....	29
30—Hydrogen Blistering .....	29
31—Cross Section Through Hydrogen Blisters Showing Various Types of Crack Propagation .....	30
32—Corrosion Tab Method of Determining Metal Loss on Vessel Linings .....	31
33—Strip-Liner Deterioration .....	32
34—Deteriorated Refractory-Tile Lining .....	32
35—Steps in Using Special Equipment to Test Individual Tubes .....	36
A-1—Properly Rolled Tube .....	39
A-2—Tube-Bundle Type of Tank Heater .....	41
A-3—Air-Cooled Exchangers .....	41
A-4—Clean-Service Double-Pipe Coils .....	42

## CONTENTS

	Page
A-5—Tank Suction Heater With Everything But Forward End Enclosed; Shell Suction Nozzle Enclosed in Far End . . . . .	43
A-6—Fin-Type Tubes in Double-Pipe Coil . . . . .	44
A-7—Plate-Type Exchanger . . . . .	44
A-8—Tubes Thinned at Baffles . . . . .	45
A-9—Erosion-Corrosion Attack at Tube Ends . . . . .	46
A-10—Heat Exchanger Parts . . . . .	48
A-11—Heat Exchanger Types . . . . .	52



# Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers, and Condensers)

## 1 Scope

This Recommended Practice (RP) covers the inspection of pressure vessels. It includes a description of the various types of pressure vessels and the standards for their construction and maintenance. The reasons for inspection, causes of deterioration, frequency and methods of inspection, methods of repair, and preparation of records and reports are covered. Safe operation is emphasized.

## 2 References

The latest editions of the following standards, codes, and recommended practices shall, to the extent specified herein, form a part of this recommended practice.

### API

- IRE, Chapter II *Guide for Inspection of Refinery Equipment, Conditions Causing Deterioration or Failures (out of print; to be replaced by RP 571, currently under development)*
- Std 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration*
- RP 574 *Inspection Practices for Piping System Components*
- RP 575 *Inspection of Atmospheric and Low-Pressure Storage Tanks*
- RP 576 *Inspection of Pressure-Relieving Devices*
- RP 579 *Fitness-for-Service*
- Std 660 *Shell-and-Tube Heat Exchangers for General Refinery Service*
- Std 661 *Air-Cooled Heat Exchangers for General Refinery Services*
- Publ 938 *An Experimental Study of Causes and Repair of Cracking of 1<sup>1</sup>/<sub>4</sub> Cr-1<sup>1</sup>/<sub>2</sub> Mo Steel Equipment*
- Publ 939 *Research Reporting on Characterization and Monitoring of Cracking in Wet H<sub>2</sub>S Service*
- RP 941 *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petroleum Plants*
- RP 945 *Avoiding Environmental Cracking of Carbon Steels in Amine Units*
- Publ 2214 *Spark Ignition Properties of Hand Tools*
- Publ 2217A *Guidelines for Work in Inert Confined Spaces in the Petroleum Industry*

### ASME<sup>1</sup>

*Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels"*

### NB<sup>2</sup>

NB-23 *National Board Inspection Code*

### TEMA<sup>3</sup>

*Standards of Tubular Exchanger Manufacturers Association*

### WRC<sup>4</sup>

Bulletin 411 *An Experimental Study of Causes and Repair of Cracking of 1<sup>1</sup>/<sub>4</sub> Cr-1<sup>1</sup>/<sub>2</sub> Mo Steel Equipment*

## 3 Definitions

For the purposes of this publication, the following definitions apply:

**3.1 CUI:** Corrosion under insulation, which includes stress corrosion cracking under insulation.

**3.2 defect:** In NDE usage, a defect is an imperfection of a type or magnitude exceeding the acceptable criteria.

**3.3 inspector:** An authorized pressure vessel inspector.

**3.4 jurisdiction:** A legally constituted government administration that may adopt rules relating to pressure vessels.

**3.5 on-stream:** Pressure vessels containing any amount of process fluid.

**3.6 PT:** Liquid penetrant testing.

**3.7 pressure vessel:** A container that falls within the scope of Section VIII of the *ASME Boiler & Pressure Vessel Code* and is subject to an external or internal design pressure greater than 15 lbf/in.<sup>2</sup> (103 kPa).

**3.8 pressure vessel engineer:** One or more persons or organizations acceptable to the owner-user who are knowledgeable and experienced in the engineering disciplines associated with evaluating mechanical and material characteristics that affect the integrity and reliability of pressure vessels. The pressure vessel engineer, by consulting with appropriate specialists, should be regarded as a composite of all entities necessary to properly address a technical requirement.

<sup>1</sup>ASME International, Three Park Avenue, New York, New York 10016-5990, [www.asme.org](http://www.asme.org).

<sup>2</sup>National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Ave, Columbus, Ohio 43229, [www.nationalboard.com](http://www.nationalboard.com).

<sup>3</sup>Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, [www.tema.org](http://www.tema.org).

<sup>4</sup>Welding Research Council, ThreePark Avenue, 27th Floor, New York, New York 10016, [www.forengineers.org](http://www.forengineers.org).