

Welding Guidelines for the Chemical, Oil, and Gas Industries

API RECOMMENDED PRACTICE 582
FOURTH EDITION, MAY 2023



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. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

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 ensure 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 proper, 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 prohibit 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.

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

Users of this recommended practice 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.

Where applicable, authorities having jurisdiction should be consulted.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises and determining the appropriateness of applying the recommended practice. At all times users should employ sound business, scientific, engineering, and judgment safety when using this recommended practice.

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.

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.

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 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, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. 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, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Currently in preview, click buy full version

Contents

1	Scope	1
2	Normative References	2
3	Terms, Definitions, Acronyms, and Abbreviations	7
3.1	Terms and Definitions	7
3.2	Acronyms and Abbreviations.....	10
4	General Welding Requirements	12
5	Welding Processes.....	12
5.1	Acceptable Welding Processes	12
5.2	Limitations of Fusion Welding Processes	13
5.3	Single-sided Welded Joints.....	15
5.4	Combining Filler Metals of Different Compositions.....	15
5.5	Automated Welding Processes	15
6	Welding Consumables (Filler Metal and Flux).....	15
6.1	General.....	15
6.2	Welding of Carbon Steel for Hydrofluoric Acid Service	17
6.3	Dissimilar Metal Welding	18
6.4	Low-alloy Steel Welding (P-No. 3 to P-No. 5).....	19
6.5	Ferritic and Martensitic Stainless Steel Welding (P-No. 6 and P-No. 7).....	19
6.6	Austenitic Stainless Steel Welding (P-No. 8).....	19
6.7	Duplex Stainless Steel Welding (P-No. 10H).....	19
6.8	9Cr-1Mo-V Welding (P-No. 15E)	19
6.9	Submerged Arc Welding.....	19
6.10	Electroslag Welding (for Corrosion-resistant Strip Overlay Cladding)	20
6.11	Consumable Storage and Handling.....	21
6.12	Alloy Consumable Controls	21
7	Shielding and Purging Gases	21
8	Preheating and Interpass Temperature.....	23
9	Post-weld Heat Treatment.....	24
10	Repairing a Post-weld Heat Treatment Component Without Post-weld Heat Treatment.....	29
11	Cleaning and Surface Preparation.....	29
12	Special Procedure Qualification Requirements/Testing	30
12.1	General.....	30
12.2	Tube-to-Tubesheet Welding	31
12.3	Macroscopic Examination	31
13	Other Items.....	31
13.1	Backing Materials	31
13.2	Peening	32
13.3	Weld Overlay and Clad Restoration (Back Cladding).....	32
13.4	Temporary Attachments	32

13.5	Stud Welding	32
13.6	Hardness Testing—Weld Procedure Qualification and Production Testing	32
13.7	Single-pass Welds	33
13.8	Welding and Hot Tapping Equipment or Piping In-service	33
13.9	Seal Welded Threaded Connections and Seal Welded Repairs	33
13.10	Calibration of Welding and Measuring Equipment	33
Annex A (informative) Welding Consumables for Shielded Metal Arc Welding		34
Annex B (normative) Weld Overlay and Clad Restoration (Back Cladding)		35
Annex C (normative) Additional Considerations for Welding Austenitic Stainless Steel Alloy		41
Annex D (normative) Welding Guidelines for Duplex Stainless Steel		47
Annex E (normative) Welding of High-temperature Heat-resistant Alloys		57
Annex F (normative) Welding Guidelines for P91 (9Cr-1Mo-V) Steels		59
Annex G (normative) Controlled-deposition Welding as an Alternative to Post-weld Heat Treatment of Weld Repairs		65
Bibliography		69
Figures		
D.1	Root and “Cold Pass” Schematic	49
F.1	Wide Bevel or Wide Cap for Welding P91 to Austenitic Stainless or Nickel-base Alloys	63
F.2	Step Bevel for Welding P91 to Austenitic Stainless or Nickel-base Alloys	64
Tables		
1	Diffusible Hydrogen Limits for Hydrogen-controlled FCAW Consumables for Carbon, Low-alloy, and 2.5–3.5 % Ni Alloy Steels	17
2	Diffusible Hydrogen Limits for Low-hydrogen Consumables	17
3	Application of Nickel-base Electrodes in Sulfidation and Nonsulfidation Environments	19
4	Maximum Oxidation Levels for Titanium	22
5	Maximum Oxidation Levels for Nickel Alloys	22
6	Recommended Maximum Interpass Temperatures	23
7	Recommended Post-weld Heat Treatment Temperatures and Holding Times	25
A.1	Filler Metals for Carbon and Low-alloy Steel	35
A.2	Filler Metals for Copper-nickel and Nickel-base Alloys	36
B.1	Filler Metals for Overlay of Carbon and Low-alloy Steels	38
B.2	Chemical Composition Requirements for Austenitic Stainless Steel Overlays	40
C.1	Austenitic Stainless Steel Alloy Filler Metals	42
C.2	Post-weld Heat Treatment Temperatures and Holding Times for Austenitic Stainless Steel	45
D.1	Welding Consumables for Duplex Stainless Steels	49
D.2	Maximum Recommended Interpass Temperatures for Duplex Stainless Steels	53
D.3	Heat Input Guidelines for Duplex Stainless Steels	53
D.4	Ferrite Test Requirements for Duplex Stainless Steel Piping Joints	54
D.5	Filler Metals for Shielded Metal Arc Welding of Duplex Stainless Steels	56

E.1	Typical Chemical Composition and Product Forms for High-temperature Heat-resistant Alloys.....	57
E.2	Base Metals Used for Procedure Qualification and Qualified Materials	58
E.3	Alternate Base Materials for Welder Qualifications	59
G.1	Controlled-deposition Welding as an Alternative to Post-weld Heat Treatment Qualification Thicknesses for Test Plate and Repair Grooves	67

Currently in preview, click buy full version

Welding Guidelines for the Chemical, Oil, and Gas Industries

1 Scope

1.1 This recommended practice provides supplementary guidelines and practices for welding and welding-related topics for shop and field fabrication, repair, and modification of the following:

- a) pressure-retaining equipment, such as pressure vessels, heat exchangers, piping, heater tubes, and pressure boundaries of rotating equipment and attachment welds;
- b) tanks and attachment welds;
- c) nonremovable internals for process equipment;
- d) structural items attached and related to process equipment;
- e) other equipment or component items when referenced by an applicable purchase document.

1.2 This document is general in nature and augments the welding requirements of ASME *Boiler and Pressure Vessel Code (BPVC)* Section IX, ISO 15614, and similar codes, standards, specifications, and practices, such as those listed in Section 2 of this document. The intent of this document is to be inclusive of chemical, oil, and gas industry standards, although there are many topics not covered herein.

1.3 Welding related to fabrication of the following equipment or components is excluded from the scope of this specification:

- a) structures;
- b) pipelines;
- c) subsea production systems;
- d) marine related equipment (e.g. ballast and pipework, systems covered by classification societies);
- e) wellheads, drilling, and downhole equipment;
- f) bulk material components covered by a manufacturer's material certificate (e.g. seam welded pipe and fittings, clad pipe);
- g) heating, cooling, and air conditioning;
- h) nonmetallic materials;
- i) other fabrication methods (e.g. bending and forming, brazing, and mechanical connections).

1.4 This document is based on industry experience. Restrictions or limitations may be waived or augmented by the owner/operator or purchaser.

1.5 Structural welds that are not welded to process equipment are outside the scope of this document.

1.6 Safety and health issues and concerns are beyond the scope of this recommended practice and, therefore, are not fully addressed herein. Safety and health information is available from other sources, including, but not limited to, the following: