

Isolating Potential Flow Zones During Well Construction

API STANDARD 65—PART 2
SECOND EDITION, DECEMBER 2010

REAFFIRMED, NOVEMBER 2016



AMERICAN PETROLEUM INSTITUTE

Isolating Potential Flow Zones During Well Construction

Upstream Segment

API STANDARD 65—PART 2
SECOND EDITION, DECEMBER 2010

REAFFIRMED, NOVEMBER 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.

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

Users of this Standard 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 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, 1220 L Street, NW, Washington, DC 20005.

Copyright © 2010 American Petroleum Institute

Foreword

This document was prepared with input from oil and gas operators, drilling contractors, service companies, consultants and regulators. It is based mainly on experiences in the United States outer continental shelf (OCS) and deepwater operating areas of the Gulf of Mexico, but may be of utility in other offshore and land operating areas. The content of this document is not all inclusive and not intended to alleviate the need for detailed information found in textbooks, manuals, technical papers, or other documents. The formulation, adoption, and publication of API standards are not intended to inhibit anyone from using any other practices.

A future planned standard, API RP 96, Deepwater Well Design Considerations, will identify considerations for use in deepwater well design. API Std 65-2 has been written to complement the objectives of API RP 90 and API RP 96 and their recommended practices.

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

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.

Informative elements: As used in a standard, “informative” denotes elements that: identify the document, introduce its content and explain its background, development, and its relationship with other documents; or provide additional information intended to assist the understanding or use of the document.

Normative elements: As used in a standard, “normative” denotes elements that describe the scope of the document, and which set out provisions that are required to implement the standard. 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.

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
1.1	Overview	1
1.2	Objectives	1
1.3	Background and Technology Review	1
1.4	Conditions of Applicability	1
1.5	Well Planning and Drilling Plan Considerations	1
1.6	Drilling the Well	2
1.7	Summary of Considerations	2
2	Normative References	2
3	Definitions, and Abbreviated Terms	3
3.1	Definitions	3
3.2	Abbreviations	10
4	Barriers	11
4.1	General	11
4.2	Physical Barrier Elements	12
4.3	Hydrostatic Barrier Elements	12
4.4	Annular Mechanical Barrier Elements	12
4.5	Mechanical Wellbore Barrier Elements	15
4.6	Set Cement as a Barrier Element	16
5	Cementing Practices and Factors Affecting Cementing Success	18
5.1	Introduction	18
5.2	Hole Quality	18
5.3	Drilling Fluid	19
5.4	Casing Hardware	19
5.5	Close-tolerance and Other Flow Restriction Considerations	20
5.6	Engineering Design	20
5.7	Slurry Design and Testing	25
5.8	Wellbore preparation and conditioning	31
5.9	Cement Job Execution	33
5.10	Post Cementing Operations	37
6	Casing Shoe Testing	38
7	Post-cement Job Analysis and Evaluation	39
7.1	Material Inventory	39
7.2	Job Data	39
7.3	Cement Evaluation	39
	Annex A (informative) Background and Technology	40
	Annex B (informative) Well Planning and Drilling Plan Considerations	59
	Annex C (informative) Drilling the Well	68
	Annex D (normative) Process Summary: Isolating Potential Flow Zones During Well Construction	75
	Bibliography	81

Contents

Page

Figures

1	Sonic Strength Anomaly	17
A.1	Effect of Curing Pressure on Bond Failure	42
A.2	Annular Pressure and Temperature—Well G	55
A.3	Annular Pressure and Temperature—Well B	56
A.4	Annular Pressure and Temperature—Well A	57
A.5	Mud Densities Measured By Pressure Sensors in Annulus	58
B.1	Casing Shoe Depths with Pore Pressure/Fracture Gradient Graph	61

Tables

A.1	Most frequent Primary and Secondary Barriers that Failed in all Phases	45
A.2	Drilling and Service Well Control Occurrences, 1998/1999	46
A.3	Drilling and Service Well Control Occurrences, 2003	47
A.4	Surface Casing Vent Flows	47
A.5	Gas Migration Problems	47
A.6	Packer Isolation Testing and Reporting Program Results	47
A.7	Well Status at Time of the Incident	48
A.8	Blowouts by Well Type	49
A.9	Blowouts by Depth Category	49
A.10	1991 API Survey Data on Lost Circulation	51

Isolating Potential Flow Zones During Well Construction

1 Scope

1.1 Overview

This standard contains practices for isolating potential flow zones, an integral element in maintaining well integrity. The focus of this standard is the prevention of flow through or past barriers that are installed during well construction. Barriers that seal wellbore and formation pressures or flows may include mechanical barriers such as seals, cement, or hydrostatic head, or operational barriers such as flow detection practices. Operational barriers are practices that result in activation of a physical barrier. Though physical barriers may dominate, the total system reliability of a particular design is dependent on the existence of both types of barriers.

1.2 Objectives

The objectives of this guideline are two-fold. The first is to help prevent and/or control flows just prior to, during, and after primary cementing operations to install or “set” casing and liner pipe strings in wells. Some of these flows have caused loss of well control. They threaten the safety of personnel, the environment, and the drilling rigs themselves. The second objective is to help prevent sustained casing pressure (SCP), also a serious industry problem.

API RP 90, provides guidelines on managing annular casing pressure (ACP) including SCP, thermal casing pressure, and operator-imposed pressure. These guidelines include monitoring, diagnostic testing, establishing the maximum allowable wellhead operating pressure (MAWOP), documenting annular casing pressure, and risk assessment methodologies.

1.3 Background and Technology Review

A detailed background and technology review are in Annex A. Historical data, perspectives, studies, statistics, lessons learned, etc. are included. All this information has been written to help explain how some practices work, have become proven or invalidated, or had performance limitations placed upon their application.

1.4 Conditions of Applicability

The process of barrier element selection and installation (including cement) is governed by the anticipated presence or absence of potential flow zones that require isolation for well integrity or regulatory purposes. This document applies only when it is deemed necessary that a potential flow zone be isolated. The guidance from this document covers recommendations for pressure-containment barrier (cement, packers, etc.) design and well construction practices that affect the zonal isolation process to prevent or mitigate annular fluid flow or pressure. These practices may also help prevent loss of well control (LWC) incidents and minimize the occurrence of SCP during well construction and production.

As presented earlier herein, the content of this document is not all inclusive and not intended to alleviate the need for detailed information found in textbooks, manuals, technical papers, or other documents. Included are those practices (well design, drilling, completion, etc.) that may positively or negatively affect pressure-containment barrier sealing performance along with methods to enhance the positive effects and to minimize any negative ones.

This document does not address shallow water flow zones in deepwater wells which are covered in API RP 65.

1.5 Well Planning and Drilling Plan Considerations

Annex B includes consideration in well planning and drilling plan determinations, such as evaluation for flow potential, site selection, shallow hazards, deeper hazard contingency planning, well control planning for fluid influxes, planning