

Openhole Isolation Equipment

API SPECIFICATION 19OH
FIRST EDITION, JANUARY 2018



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 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 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 © 2018 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.

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, 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 2
4	Abbreviations and Symbols 5
5	Functional Requirements 6
5.1	General 6
5.2	Type Description 6
5.3	Well Parameters 6
5.4	Operational Parameters 7
5.5	Environmental Compatibility 7
5.6	Design Validation 8
5.7	Quality Control 8
5.8	Optional Testing 8
6	Technical Specification 8
6.1	General 8
6.2	Technical Characteristics 8
6.3	Design Requirements 8
6.4	Materials 9
6.5	Design Ratings 11
6.6	Design Verification 11
6.7	Design Validation Requirements 11
6.8	Design Changes 12
6.9	Design Scaling 13
6.10	Design Report 13
7	Supplier/Manufacturer Requirements 13
7.1	General 13
7.2	Documentation and Data Control 13
7.3	Material Requirements 15
7.4	Heat Treating 17
7.5	Quality Requirements 18
7.6	Traceability 18
7.7	Component Dimensional Inspection 18
7.8	Welds 20
7.9	Hardness Inspection of Components 20
7.10	NDE of Components 20
7.11	Shear Device Verification 22
7.12	Functional Testing (Factory Acceptance Testing) 22
7.13	Calibration Systems 22
7.14	Visual Inspections 23
7.15	Coatings and Overlays 23
7.16	Bonding Evaluations 23
8	Repair/Redress/Remanufacture Requirements 23
9	Shipping, Handling, and Storage 23

Contents

	Page
Annex A (informative) API Monogram Program—Use of the API Monogram by Licensees	24
Annex B (normative) Validation Requirements for Inflatable, Expandable, Openhole Mechanical Packers, and Bridge Plugs	28
Annex C (normative) Validation Test Requirements for Swellable Packers	31
Annex D (informative) Additional Validation Test Requirements for Swellable Packers	36
Bibliography	37

Figures

C.1 Pressure Rating Vs Hole Size	34
C.2 Pressure Rating vs Length.	34
C.3 Combined Performance Interpolation of Swell Percentage and Length	35

Tables

1 Design Validation Grade Hierarchy	12
2 Quality Grade Requirements Summary	19
3 Sampling Plan Unit Counts	21

Introduction

This Specification has been developed by users/purchasers and suppliers/manufacturers of openhole isolation equipment intended for use in the petroleum and natural gas industry worldwide. This Specification is intended to give requirements and information to both parties in the selection, manufacture, testing, and use of openhole isolation equipment. Further, this Specification addresses supplier/manufacturer requirements that set the minimum requirements with which suppliers/manufacturers shall comply to claim conformity with this Specification.

This Specification has been structured to allow for grades of increased requirements both in quality control and design validation. These variations allow the user/purchaser to select the grade required for a specific application for openhole isolation equipment.

The quality grades provide the user/purchaser the choice of requirements to meet a specific preference or application. Additional quality requirements may be specified by the user/purchaser as supplemental requirements.

Standard design validation grades provide the user/purchaser the choice of requirements to meet a specific preference or application. Design validation grade V3 OH is the minimum grade and represents equipment where the validation method has been defined by the supplier/manufacturer. The complexity and severity of the validation testing typically increases as the grade number decreases.

Users of this Specification should be aware that requirements above those outlined in this Specification may be needed for individual applications. This Specification is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier/manufacturer should identify any variations from this Specification.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process. This Specification was initiated utilizing information provided by the Advanced Well Equipment Standards Group RP 3362.

Openhole Isolation Equipment

1 Scope

This Specification covers requirements and guidelines for openhole isolation equipment and bridge plugs as defined herein. Openhole isolation equipment includes swellable packers, inflatable packers, expandable packers, and openhole packers that are designed for use in the petroleum and natural gas industries. This Specification provides requirements for design verification, design validation, manufacturing, quality, shipping, handling and storage, and related supporting topics.

Included within this Specification are four Annexes, of them, B and C are normative, and A and D are informative.

Requirements for the end connections to the well conduit are not included in this Specification. Also not covered are downhole anchoring devices (see API 11D1); cup style packers; and requirements for the application, installation, and use of openhole isolation equipment. Equipment and technology that are covered by other API specifications and standards are exempted from this specification, such as:

- production packers,
- liner hanger systems,
- service tools,
- test tool packers.

Repairs, remanufacturing, and redress are excluded from this Specification.

2 Normative References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Spec 5CRA, *Specification for Corrosion Resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock*

API Specification 5CT, *Specification for Casing and Tubing*

API Spec Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

ASNT RP SNT-TC-1A ¹, *Non-Destructive Testing*

ASTM D412 ², *Standard Test Methods for Vulcanized and Thermoplastic Elastomers—Tension*

ASTM D429, *Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates*

ASTM D638, *Standard Test Method of Tensile Properties of Plastics*

ASTM D1414, *Standard Test Methods for Rubber O-Rings*

¹ American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York, 10036.

² American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19427-2959.

ASTM D1415, *Tentative Method of Testing for International Hardness of Vulcanized Natural and Synthetic Rubbers*

ASTM D1708, *Standard Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens*

ASTM D2140, *Standard Practice for Calculating Carbon-Type Composition of Insulating Oils of Petroleum Origin*

ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness*

ISO 37³, *Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties*

ISO 2859-1, *Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3601-1, *Fluid power systems—O-rings—Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 3601-3, *Fluid power systems—O-rings—Part 3: Quality acceptance criteria*

ISO 9712, *Non-destructive testing—Qualification and certification of NDT personnel*

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in API Q1 and the following apply.

3.1

assembly

Product comprised of more than one component.

3.2

base elastomer

An elastomer family of materials with common property limits such as HNBR, FKM, EPDM.

3.3

base elastomer formulation

A base elastomer mixed with additives to achieve physical properties that enhance performance.

3.4

bridge plug

Mechanical device used for blocking fluid (liquid or gas) communication within a conduit when installed (not installed in a design receptacle or conduit).

3.5

component

An individual part of an assembly.

3.6

conduit

Casing, tubing or liner, metallic, or nonmetallic.

3.7

design margin

Ratio of the material yield stress divided by the actual design stress in a given component.

NOTE Design margins account for a level of reduced performance capability to compensate for uncertainties in the loading (applied stress) and intrinsic variation in the mechanical properties such as yield strength, ultimate strength, endurance strength, modulus of elasticity that have distribution about their mean value.

³ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

3.8**design validation**

Process of proving a design by testing to demonstrate conformity of the product to design requirements.

3.9**design verification**

Process of examining the result of design or development output to determine conformity with specified requirements.

3.10**element package**

Series of conformable sealing components, which may include spacers and extrusion controlling components that are utilized as a singular sealing unit.

3.11**expandable packer**

Downhole device designed to isolate fluids in the annular space between a conduit and the openhole that is activated (expanded) by the deformation of an integral structure.

3.12**extrusion controls**

Device engineered to reduce the extrusion gap between sealing surfaces.

3.13**functional test (testing)**

Post-manufacturing evaluation of a product to defined procedures and acceptance criteria.

3.14**heat-traceable**

Traceable to a unique heat treatment (heat) of material.

3.15**inflatable packer**

Downhole device designed to isolate fluids in the annular space between a conduit and the openhole that is activated (expanded) by the selective addition of pressure within a compliant chamber.

3.16**job lot**

Batch of material or components that have undergone the same process or series of processes during the same timeframe.

3.17**job-lot traceable**

Parts identifiable as originating from a job lot that designates the included heat(s).

3.18**material test report**

Traceable records of the measured material properties of a component, derived in a defined manner at a defined point in time.

3.19**non-destructive examination**

Inspection or review activity applied to a component or assembly that compares the results to a defined requirement without damage to the product or component.

3.20**openhole**

A wellbore with no casing or liner in place across the formation surfaces.

3.21**openhole mechanical packer**

Downhole device designed to isolate fluids in the annular space between a conduit and the openhole that is activated (expanded) by the application of force to an integral mechanism.

3.22**operating temperature range**

Specified range of temperature fluctuation over which the product is designed to operate.

3.23**packer**

Device with a packing element, not installed in a designed receptacle, used for blocking fluid (liquid or gas) communication through the annular space between conduits by sealing the space between them.

3.24**packing element**

External compliant sealing device on a packer that provides isolation of fluid communication through the annular space between the conduit and openhole.

3.25**packer mandrel**

Tubular component(s) within a packer that contain the end connections and provide a conduit through the packer.

3.26**product assembly**

The completed device that includes the necessary components to perform the designed functions.

3.27**qualified person**

Individual with characteristics or abilities gained through training, experience, or both, as measured against established requirements, such as standards or tests, that enable the individual to perform a required function effectively.

3.28**scaling**

The ability to validate a design by referencing the design validation conducted on a representative design of the same product type and family.

3.29**setting method**

The design methodology and tools necessary to activate the packer to its fully implemented condition.

3.30**substantive change**

Change to the design or components within the design, identified by the supplier/manufacturer, that may affect the performance of the product in the intended service condition.

3.31**swellable packer**

Downhole device designed to isolate fluids in the annular space between a conduit and the openhole that is activated (expanded) by the contact of a specified fluid.

3.32**temperature range**

Specified range of temperature over which the product is designed to operate.

3.33**Type 1 component**

Component (metallic or nonmetallic and welds) that isolates pressure and/or may be loaded in tension as the result of axial loads applied during run-in, setting, in use, or retrieval.

3.34**Type 2 component**

Components that do not conform to the definition of Type 1 components.

3.35**volume swell****(swell)**

The change in cross-sectional area per unit of length of a swellable element in which the inner diameter of the element (mandrel OD) remains unchanged.

4 Abbreviations and Symbols

AQL	acceptance quality limit
COC	certificate of compliance
DP	differential pressure
EPDM	ethylene-propylene-diene-monomer
FKM	fluoroelastomers
HNBR	hydrogenated nitrile butadiene rubber
ID	inside diameter
L_1	length of validated packer #1
L_2	length of validated packer #2
L_i	scale packer validated length
MTR	material test report
NDE	non-destructive examination
OD	outside diameter
QC	quality control
UNS	unified numbering system
X_1	validated hole size packer #1
X_2	validated hole size packer #2
X_i	scaled packer validated hole size
Y_1	validated differential pressure rating of packer #1
Y_2	validated differential pressure rating of packer #2
Y	scaled packer validation differential pressure rating

5 Functional Requirements

5.1 General

The user/purchaser shall prepare a functional specification for ordering products that conform to this specification and specify the following requirements and operating conditions, as applicable, and/or identify the supplier/manufacturer's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, data sheet, or other suitable documentation.

5.2 Type Description

The user/purchaser shall specify the following device types:

- inflatable packers,
- expandable packers,
- openhole mechanical packers,
- swellable packers (water or oil [hydrocarbon] or both).

5.3 Well Parameters

The user/purchaser should specify, as applicable, the following well parameters:

- anticipated openhole size at projected setting depth;
- dimensions, material, grade of the casing and tubing (conduit);
- end connections and the applicable reference specifications;
- deviations and restrictions device must pass through (dog leg);
- lines (electrical/hydraulic/other) that may pass through or bypass the device;
- representative well schematic;
- expected minimum and maximum values of production/injection pressures, pressure differentials, temperatures, changes in temperatures, and flow rates;
- any relevant well parameter(s), such as expected well ID ovality, inclination, and allowable setting stress.

5.4 Operational Parameters

The user/purchaser should specify, as applicable, the following operational parameters:

- installation method, including conveyance method;
- activation method and/or fluids
- desired time to set;
- setting depth, time duration and temperature exposures to reach that depth;
- retrievable requirement, if applicable;
- anticipated loading conditions/ temperature cycles during the life of the well, including combined loading (pressure, tension/compression) and torque, applied prior to and during setting and use;
- dimensions, type and configuration of devices to be run through (such as, internal profile(s)), or over the packer or bridge plug;
- lost circulation zone(s)
- fluids and their composition which are pumped past the packing element prior to setting
- any other relevant operational parameter(s).

If, due to the operational parameters, material qualifications are required outside of or in addition to NACE MR0175/ ISO 15156 or another specified material standard, the user/purchaser shall specify the following:

- a) test method(s),
- b) design basis/test environment conditions,
- c) test acceptance criteria.

5.5 Environmental Compatibility

5.5.1 General

It is the equipment user/purchaser's responsibility to ensure that any material specified for use is satisfactory in the service environment. If the user/purchaser has access to data of the operating environment based on historical information and/or research, then it should be stated to the supplier/manufacturer which material(s) have the ability to perform as required within the environment. Otherwise, material compatibility shall be specified according to supplier/manufacturers selection criteria. If material qualifications are required outside of or additional to NACE MR0175/ ISO 15156 or other specified material standard, the parameters as defined in 5.4 are required.

5.5.2 Well Environment

The user/purchaser should identify the density, chemical/physical composition, and the condition of the fluid and/or its components, including solids (sand production, scale, salinity, etc.), liquid, and/or gaseous, to which the openhole device is exposed during each portion of its expected life cycle. Fluid exposure durations, temperatures, and pressures should be included. Include chemical stimulations as well as changes in fluid composition over time (acid stimulation, injection water compositions, H₂S and CO₂, etc.)

5.6 Design Validation

The user/purchaser shall specify the required design validation grade. Validation grades V1 OH, V2 OH, and V3 OH are available and the requirements are defined in 6.7.

5.7 Quality Control

The user/purchaser shall specify the required quality grade. Quality grades of Q1 and Q2 are available and the requirements are defined in 7.5.

5.8 Optional Testing

The user/purchaser may select additional validation tests in Annex D to be performed on a product design.

The user/purchaser may select to have the V1 OH test repeated with a commercial purity nitrogen gas as the test medium, see B.5.

6 Technical Specification

6.1 General

The supplier/manufacture shall prepare and provide to the user/purchaser the technical specification that demonstrates that the equipment meets the requirements of the functional specification.

Products conforming to this specification shall be manufactured to drawings and specifications that are substantially the same as those of the same size type and model that has been validated. Products that are validated by design scaling shall also conform to the scaling requirements in Annex B and Annex C. If the technical specification does not fully meet the functional requirements, the supplier/manufacture shall identify the differences to the user/purchaser. The supplier/manufacture shall also provide to the user/purchaser the product data sheet as defined in 7.2.3.

The design of products manufactured to this Specification shall include documentation of those designs. This documentation shall include, as applicable, design requirements, assumptions, analysis methods, comparison with previous designs or operating history of similar products, calculations, manufacturing drawings and specifications, design reviews, and/or physical testing results (such as design validation testing).

6.2 Technical Characteristics

The product shall be designed to perform in accordance with the functional specification and the defined technical characteristics during installation, activation, and operation.

6.3 Design Requirements

Each packer or bridge plug design shall be analyzed and verified to determine the supplier/manufacture's performance ratings. The minimum material condition and minimum material yield strength shall be used in the calculations. Temperature de-rating of material capabilities shall be utilized where applicable as defined by the supplier/manufacture's procedures. Metal mechanical properties de-rating shall be verified and documented by a qualified person.

The following information shall be considered when establishing the design requirements for the tool: fluid density, chemical/physical composition, including solids (sand production, scale, salinity, etc.), liquid, and/or gaseous, to which the openhole device is exposed during each portion of its expected life cycle. Fluid exposure durations, temperatures, and pressures shall be included along with chemical stimulation and changes in composition over time.