Metallic Material Limits for Wellhead Equipment Used in High Temperature for API 6A and API 17D Applications

API TECHNICAL REPORT 6MET
SECOND EDITION, AUGUST 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.

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

Users of this Technical Report 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.

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

Contents

Introduction

The initial basis for this document was an API-funded project that was conducted by a task group charged by the Association of Well Head Equipment Manufacturers (AWHEM). The task group examined mechanical properties of metallic materials used for API 6A and API 17D wellhead equipment for service above 250 °F. A total of eleven different alloys meeting API 6A, PSL 3 conditions were supplied “in condition” by a variety of suppliers. Materials in this test program included alloys common to the oil and gas industry. The alloys tested included low-alloy steels, martensitic, precipitation-hardened and duplex stainless steels, and nickel alloys. Yield strength reduction ratios at temperatures of 300 °F, 350 °F, 400 °F, and 450 °F are reported. As a result of testing, yield strength reduction ratios at 300 °F to 450 °F ranged from 92 % to 87 % for the low-alloy steels, 92 % to 88 % for the martensitic stainless steels, 81 % to 73 % for super duplex, 99 % to 89 % for the precipitation-hardened stainless steel, and 94 % to 89 % for the nickel alloys. The reported results represent an average over the different heats for each type of material. These results are intended to expand the data shown in API 6A for design and rating of equipment for use at elevated temperatures.

After the accuracy of the derating factors for the precipitation-hardened stainless steel as published in the First Edition and in API 6A, 19th Edition, Annex G was questioned, another API-funded project was conducted by a task group operating under the direction of API Subcommittee 21. The results of this project have been added in the Second Edition.

Metallic Material Limits for Wellhead Equipment Used in High Temperature for API 6A and 17D Applications

1 Scope

Testing was performed in four phases, presented herein in chronological order as Phase I, Phase II, Phase III, and Phase IV. Initially, all testing was to be completed in two phases, but testing anomalies in Phase II prompted re-testing of some alloys in Phase III and later in Phase IV.

Alloy candidates were recommended by AWHEM membership for analysis and confirmed by API's approval of New Work Item No. 2003-100786 in June 2002. Several material suppliers and several AWHEM member companies donated material for testing. Metallurgists on the task group screened material certificates to ensure a "normal" chemistry without enhancements for the material candidates listed in Table 1, Table 2, and Table 3.

Table 1—List of Alloys Included in Phase I Testing

Material	Yield Strength Class	Bar Size
AISI 4130	75K	5 in. ER
AISI 8630M	75K	5 in. ER
$2^1/_4$ Cr 1 Mo	75K	5 in. ER
AISI 4140	75K	5 in. ER
AISI 410 SS	75K	5 in. ER
F6NM	75K	5 in. ER

Table 2—List of Alloys Included in Phase II Testing

Material	Yield Strength Class	Material Size
25 Cr Super Duplex [a]	110K	2.4 in. to 5.5 in. OD
ASTM A453 Gr 660	100K	0.75 in. to 1.5 in. OD
718 (per Spec 6A-718)	130K	1.25 in. to 8.5 in. OD x 5.5 in.
725/625 Plus	130K	0.63 in. to 6.5 in. OD data, 9 in. OD test
925	110K	1 in. to 6.5 in. OD

[a] Pitting resistance equivalence number, PREN >40.

Table 3—List of Alloys Included in Phase III Testing

Material	Yield Strength Class	Material Size
Nickel Alloy 725/625 Plus	120K	1.25 in. to 6.0 in. OD
Nickel Alloy 925	110K	1.0 in. to 8.7 in. OD

Another API New Work Item approved in 2014 covered a new round of testing of austenitic precipitation-hardened stainless steel ASTM A453 Grade 660 Class D (see Table 4). Three mills donated the material for testing.

A summary of the yield strength derating factors from testing of the 11 alloys is provided in Table 5 and compares favorably with the available data from literature, as provided in Table 6.