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

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

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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.

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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 6A718)	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.