Metallic Material Limits for API Equipment Used in High Temperature Applications

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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.

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Introduction

The First Edition of this document was based on 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 11 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. The First Edition covered Phases I-III.

The Second Edition of this document incorporated the results of testing performed 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. An API-funded project was conducted by a task group operating under the direction of API Subcommittee 21and this work is described as Phase IV.

The Third Edition incorporates the results of an API-funded project initiated in 20[illegible]. This work is described as Phase V and was established through laboratory testing:

— tensile yield properties, tensile modulus at room, elevated temperature in both longitudinal and transverse directions;

— compression yield properties, compression modulus at room, elevated temperature in both longitudinal and transverse directions.

UNS N07718 was selected as the first alloy to be tested to demonstrate the feasibility of obtaining the desired material properties. Due to personnel changes over time and laboratory testing issues, the project took longer than anticipated, and only UNS N07718 was tested. The results of the testing have been used to update the recommended yield strength reduction ratios for UNS N07718 in Table 6, add recommended compression yield strength reduction ratios for UNS N07718 in Table 8, add recommended chord modulus values for UNS N07718 from tension testing in Table 9, and add recommended chord modulus for UNS N07718 from compression testing in Table 10. Analysis of test data indicated UNS N07718 had little anisotropy between longitudinal and transverse directions for tensile yield. Similarly, the anisotropy in the compression yield strength, while slightly higher than tensile yield strength anisotropy, was still quite low. Also, the compression yield strength at a given temperature in either direction was higher than corresponding tensile yield strength consistently.

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1 Scope

This document covers testing performed to develop recommended yield strength reduction ratios and elevated temperature properties for several steels, stainless steels, and nickel alloys used in oil and gas drilling and production equipment.

2 Normative References

There are no normative references in this document.

3 Abbreviations

For the purpose of this document, the following abbreviated terms apply.

AWHEM	Association of Well Head Equipment Manufacturers
ER	equivalent round
RT	room temperature
YS	yield strength

4 Testing Criteria

Testing was performed in five phases, presented herein in chronological order as Phase I, Phase II, Phase III, Phase IV, and Phase V. 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. Phase V was a separate test program intended to develop both tensile and compression yield data on one alloy.

For Phases I-III, 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