

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

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## Contents

	Page
<b>1</b>	<b>Scope</b> . . . . . <b>1</b>
<b>2</b>	<b>Procedure</b> . . . . . <b>3</b>
<b>2.1</b>	<b>Phase I, Phase II, and Phase III Procedure</b> . . . . . <b>3</b>
<b>2.2</b>	<b>Phase IV Procedure</b> . . . . . <b>3</b>
<b>3</b>	<b>Results</b> . . . . . <b>4</b>
<b>3.1</b>	<b>Phase I Results</b> . . . . . <b>4</b>
<b>3.2</b>	<b>Phase II Results</b> . . . . . <b>5</b>
<b>3.3</b>	<b>Phase III Results</b> . . . . . <b>5</b>
<b>3.4</b>	<b>Phase IV Results</b> . . . . . <b>5</b>
<b>4</b>	<b>Conclusions</b> . . . . . <b>6</b>
<b>5</b>	<b>Recommendations</b> . . . . . <b>6</b>
<b>Annex A</b>	<b>(informative) AISI 4130 Test Results</b> . . . . . <b>11</b>
<b>Annex B</b>	<b>(informative) AISI 8630M Test Results</b> . . . . . <b>14</b>
<b>Annex C</b>	<b>(informative) 2<sup>1</sup>/<sub>4</sub> Cr 1 Mo Test Results</b> . . . . . <b>17</b>
<b>Annex D</b>	<b>(informative) AISI 4140 Test Results</b> . . . . . <b>20</b>
<b>Annex E</b>	<b>(informative) 410 Stainless Steel Test Results</b> . . . . . <b>23</b>
<b>Annex F</b>	<b>(informative) F6NM Test Results</b> . . . . . <b>26</b>
<b>Annex G</b>	<b>(informative) 25 Chrome Super Duplex Test Results</b> . . . . . <b>29</b>
<b>Annex H</b>	<b>(informative) ASTM A453 Gr. 660 Test Results from Phase II</b> . . . . . <b>32</b>
	<b>ASTM A453 Gr. 660 Test Results from Phase IV</b> . . . . . <b>34</b>
<b>Annex I</b>	<b>(informative) 718 (per Spec 6A718) Test Results</b> . . . . . <b>40</b>
<b>Annex J</b>	<b>(informative) 725/625 Plus Test Results</b> . . . . . <b>43</b>
<b>Annex K</b>	<b>(informative) 925 Test Results</b> . . . . . <b>45</b>
<b>Bibliography</b>	. . . . . <b>47</b>
<b>Figures</b>	
<b>1</b>	<b>AISI 8630M Strength Reduction with Temperature</b> . . . . . <b>4</b>
<b>A.1</b>	<b>Plot of 4130 Test Results</b> . . . . . <b>13</b>
<b>B.1</b>	<b>Plot of 8630M Test Results</b> . . . . . <b>16</b>
<b>C.1</b>	<b>Plot of 2<sup>1</sup>/<sub>4</sub> Cr 1 Mo Test Results</b> . . . . . <b>19</b>
<b>D.1</b>	<b>Plot of AISI 4140 Test Results</b> . . . . . <b>22</b>
<b>E.1</b>	<b>Plot of AISI 410 Stainless Steel Test Results</b> . . . . . <b>25</b>
<b>F.1</b>	<b>Plot of F6NM Test Results</b> . . . . . <b>28</b>
<b>G.1</b>	<b>Plot of 25 Chrome Super Duplex Test Results</b> . . . . . <b>31</b>
<b>H.1</b>	<b>Plot of ASTM A453 Gr. 660 Test Results</b> . . . . . <b>34</b>
<b>I.1</b>	<b>Plot of 718 (per Spec 6A718) Test Results</b> . . . . . <b>42</b>
<b>J.1</b>	<b>Plot of 725/625 Plus Test Results</b> . . . . . <b>44</b>
<b>K.1</b>	<b>Plot of 925 Test Results</b> . . . . . <b>46</b>

# Contents

Page

## Tables

1	List of Alloys Included in Phase I Testing . . . . .	1
2	List of Alloys Included in Phase II Testing . . . . .	1
3	List of Alloys Included in Phase III Testing . . . . .	1
4	List of Alloys Included in Phase IV Testing . . . . .	2
5	Recommended Yield Strength Reduction Ratios in Percent by Temperature . . . . .	2
6	Yield Strength Reduction Factors in Percent by Temperature (from Literature) . . . . .	2
7	Alloy Composition for AISI 4130 Test Material . . . . .	6
8	Alloy Composition for 8630M Test Material . . . . .	6
9	Alloy Composition for 2 <sup>1</sup> / <sub>4</sub> Cr-1Mo (F22) Test Material . . . . .	7
10	Alloy Composition for AISI 4140 Test Material . . . . .	7
11	Alloy Composition for 410 Stainless Steel Test Material . . . . .	7
12	Alloy Composition for F6NM Stainless Steel Test Material . . . . .	8
13	Alloy Composition for 25Cr Super Duplex Test Material . . . . .	8
14	Alloy Composition for ASTM A453 Gr 660 Precipitation-Hardened Austenitic Stainless Steel (Phase II) Test Material . . . . .	8
15	Alloy Composition for ASTM A453 Gr 660 Precipitation-Hardened Austenitic Stainless Steel (Phase IV) Test Material . . . . .	9
16	Alloy Composition for Nickel Alloy 718 (per Spec 6A718) Test Material . . . . .	9
17	Alloy Composition for Nickel Alloys 725 and 625 Test Material . . . . .	10
18	Alloy Composition for Nickel Alloy 925 Test Material . . . . .	10
A.1	AISI 4130 Test Results . . . . .	11
B.1	AISI 8630M Test Results . . . . .	14
C.1	2 <sup>1</sup> / <sub>4</sub> Cr 1 Mo Test Results . . . . .	17
D.1	AISI 4140 Test Results . . . . .	20
E.1	AISI 410 Test Results . . . . .	23
F.1	F6NM Test Results . . . . .	26
G.1	25 Chrome Super Duplex Test Results . . . . .	29
H.1	ASTM A453 Gr. 660 Test Results . . . . .	32
H.2	ASTM A453 Gr. 660 Class D Initial Aging Study Results—Using 1800 °F Solution Anneal . . . . .	34
H.3	ASTM A453 Gr. 660 Class D Initial Aging Study Results—Using 1650 °F Solution Anneal . . . . .	34
H.4	ASTM A453 Gr. 660 Class D Test Results . . . . .	35
H.5	ASTM A453 Gr. 660 Class D Second Aging Study Results . . . . .	39
H.6	ASTM A453 Gr. 660 Class D Derating Factors Developed From Linear Regression Analyses . . . . .	39
H.7	ASTM A453 Gr. 660 Class D Recommended Derating Factors . . . . .	39
I.1	718 (per Spec 6A718) Test Results . . . . .	40
J.1	725/625 Plus Test Results . . . . .	43
K.1	925 Test Results . . . . .	45

## 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 <sup>1</sup> / <sub>4</sub> 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 <sup>a</sup>	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

<sup>a</sup> 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.