INTERNATIONAL

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Standard Specification for Titanium and Titanium Alloy Welded Pipe[1]

This standard is issued under the fixed designation B 862; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers the requirements for 33 grades of titanium and titanium alloy welded pipe intended for general corrosion resisting and elevated temperature service as follows:

1.1.1 *Grade 1*—Unalloyed titanium, low oxygen,

1.1.2 *Grade 2*—Unalloyed titanium, standard oxygen,

1.1.2.1 *Grade 2H*—Unalloyed titanium (Grade 2 with 58 ksi minimum UTS),

1.1.3 *Grade 3*—Unalloyed titanium, medium oxygen,

1.1.4 *Grade 5*—Titanium alloy (6 % aluminum, 4 % vanadium),

1.1.5 *Grade 7*—Unalloyed titanium plus 0.12 to 0.25 % palladium, standard oxygen,

1.1.5.1 *Grade 7H*—Unalloyed titanium plus 0.12 to 0.25 % palladium (Grade 7 with 58 ksi minimum UTS),

1.1.6 *Grade 9*—Titanium alloy (3 % aluminum, 2.5 % vanadium),

1.1.7 *Grade 11*—Unalloyed titanium plus 0.12 to 0.25 % palladium, low oxygen,

1.1.8 *Grade 12*—Titanium alloy (0.3 % molybdenum, 0.8 % nickel),

1.1.9 *Grade 13*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium), low oxygen,

1.1.10 *Grade 14*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium), standard oxygen,

1.1.11 *Grade 15*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium), medium oxygen,

1.1.12 *Grade 16*—Unalloyed titanium plus 0.04 to 0.08 % palladium, standard oxygen,

1.1.12.1 *Grade 16H*—Unalloyed titanium plus 0.04 to 0.08 % palladium (Grade 16 with 58 ksi minimum UTS),

1.1.13 *Grade 17*—Unalloyed titanium plus 0.04 to 0.08 % palladium, low oxygen,

1.1.14 *Grade 18*—Titanium alloy (3 % aluminum, 2.5 % vanadium plus 0.04 to 0.08 % palladium),

1.1.15 *Grade 19*—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum),

1.1.16 *Grade 20*—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum) plus 0.04 to 0.08 % palladium,

1.1.17 *Grade 21*—Titanium alloy (15 % molybdenum, 3 % aluminum, 2.7 % niobium, 0.25 % silicon),

1.1.18 *Grade 23*—Titanium alloy (6 % aluminum, 4 % vanadium, extra low interstitial, ELI),

1.1.19 *Grade 24*—Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.04 to 0.08 % palladium,

1.1.20 *Grade 25*—Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.3 to 0.8 % nickel and 0.04 to 0.08 % palladium,

1.1.21 *Grade 26*—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.21.1 *Grade 26H*—Unalloyed titanium plus 0.08 to 0.14 % ruthenium (Grade 26 with 58 ksi minimum UTS),

1.1.22 *Grade 27*—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.23 *Grade 28*—Titanium alloy (3 % aluminum, 2.5 % vanadium) plus 0.08 to 0.14 % ruthenium,

1.1.24 *Grade 29*—Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements (ELI)) plus 0.08 to 0.14 % ruthenium,

1.1.25 *Grade 33*—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

1.1.26 *Grade 34*—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

1.1.27 *Grade 35*—Titanium alloy (4.5 % aluminum, 2 % molybdenum, 1.6 % vanadium, 0.5 % iron, 0.3 % silicon),

1.1.28 *Grade 37*—Titanium alloy (1.5 % aluminum), and

1.1.29 *Grade 38*—Titanium alloy (4 % aluminum, 2.5 % vanadium, 1.5 % iron).

NOTE 1—H grade material is identical to the corresponding numeric grade (that is, Grade 2H = Grade 2) except for the higher guaranteed minimum UTS, and may always be certified as meeting the requirements of its corresponding numeric grade. Grades 2H, 7H, 16H, and 26H are intended primarily for pressure vessel use.

[1] This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.01 on Titanium.

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***A Summary of Changes section appears at the end of this standard.**

The H grades were added in response to a user association request based on its study of over 5200 commercial Grade 2, 7, 16, and 26 test reports, where over 99 % met the 58 ksi minimum UTS.

1.2 Pipe 8 in. NPS (nominal pipe size) and larger is most frequently custom made for an order. In such cases, the purchaser carefully should consider the applicability of this specification. Since the pipe is custom made, the purchaser may choose a wall thickness other than those in Table 1 to meet specific operating conditions. The purchaser may also be better served to specify only the portions of this specification that are required to meet the operating conditions (for example, annealing, flattening test, chemistry, properties, etc.).

1.3 Optional supplementary requirements are provided for pipe where a greater degree of testing is desired. These supplementary requirements may be invoked by the purchaser, when desired, by specifying in the order.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
B 600 Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces
E 8 Test Methods for Tension Testing of Metallic Materials
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E 539 Test Method for X-Ray Fluorescence Spectrometric Analysis of 6Al-4V Titanium Alloy
E 1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
E 1417 Practice for Liquid Penetrant Testing
E 1447 Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
E 1941 Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys
E 2371 Test Method for Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry
E 2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals

2.2 *ANSI/ASME Standards:* [3]

B.1.20.1 Pipe Threads, General Purpose (Inch)
B 36.10 Carbon, Alloy and Stainless Steel Pipes
B 36.19M-1985 Stainless Steel Pipe
ASME Boiler and Pressure Vessel Code Section VIII

2.3 *AWS Standard:* [4]

AWS A5.16/A5.16M-2007 Specification for Titanium and Titanium Alloy Welding Electrodes and Rods

3. Terminology

3.1 *Definitions:*

3.1.1 *lot*, *n*—a number of pieces of pipe of the same nominal size and wall thickness manufactured by the same process from a single heat of titanium or titanium alloy and heat treated by the same furnace parameters in the same furnace.

3.1.2 *welded pipe*, *n*—a hollow tubular product produced by forming flat-rolled product and seam welding to make a right circular cylinder.

4. Ordering Information

4.1 Orders for materials under this specification shall include the following information as required:

4.1.1 Quantity,
4.1.2 Grade number (Section 1 and Table 2),
4.1.3 Nominal pipe size and schedule (Table 1),
4.1.4 Diameter tolerance (see 9.2),
4.1.5 Method of manufacture and finish (Sections 5 and 10),
4.1.6 Product analysis, if required (Sections 6 and 7; Table 1 and Table 3),
4.1.7 Mechanical properties, (Sections 8, 11, 13, 14, and 15, and Table 4),
4.1.8 Packaging (Section 22),
4.1.9 Inspection and test reports (Sections 18, 19 and 20), and

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.
[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.

TABLE 1 Dimensions of Pipe

NOTE 1—Schedule sizes conform to ANSI/ASME B 36.19M-1985 (for " S" sizes) or B 36.10 (for non-S sizes).
NOTE 2—The decimal thickness listed for the respective pipe sizes represent their nominal wall dimensions.

NPS Desig.	Outside Dia.		Nominal Wall Thickness															
			Schedule 5S[A]		Schedule 5[A]		Schedule 10S[A]		Schedule 10[A]		Schedule 40S		Schedule 40		Schedule 80S		Schedule 80	
	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
⅛	0.405	10.29	x	x	x	x	0.049	1.24	0.049	1.24	0.068	1.73	0.068	1.73	0.095	2.41	0.095	2.41
¼	0.540	13.72	x	x	x	x	0.065	1.65	0.065	1.65	0.088	2.24	0.088	2.24	0.119	3.02	0.119	3.02
⅜	0.675	17.15	x	x	x	x	0.065	1.65	0.065	1.65	0.091	2.31	0.091	2.31	0.126	3.20	0.126	3.20
½	0.840	21.34	0.065	1.65	0.065	1.65	0.083	2.11	0.083	2.11	0.109	2.77	0.109	2.77	0.147	3.73	0.147	3.73
¾	1.050	26.67	0.065	1.65	0.065	1.65	0.083	2.11	0.083	2.11	0.113	2.87	0.113	2.87	0.154	3.91	0.154	3.91
1	1.315	33.40	0.065	1.65	0.065	1.65	0.109	2.77	0.109	2.77	0.133	3.38	0.133	3.38	0.179	4.55	0.179	4.55
1-¼	1.660	42.16	0.065	1.65	0.065	1.65	0.109	2.77	0.109	2.77	0.140	3.56	0.140	3.56	0.191	4.85	0.191	4.85
1-½	1.900	48.26	0.065	1.65	0.065	1.65	0.109	2.77	0.109	2.77	0.145	3.68	0.145	3.68	0.200	5.08	0.200	5.08
2	2.375	60.32	0.065	1.65	0.065	1.65	0.109	2.77	0.109	2.77	0.154	3.91	0.154	3.91	0.218	5.54	0.218	5.54
2-½	2.875	73.02	0.083	2.11	0.083	2.11	0.120	3.05	0.120	3.05	0.203	5.16	0.203	5.16	0.276	7.01	0.276	7.01
3	3.500	88.90	0.083	2.11	0.083	2.11	0.120	3.05	0.120	3.05	0.216	5.49	0.216	5.49	0.300	7.62	0.300	7.62
3-½	4.000	101.60	0.083	2.11	0.083	2.11	0.120	3.05	0.120	3.05	0.226	5.74	0.226	5.74	0.318	8.08	0.318	8.08
4	4.500	114.30	0.083	2.11	0.083	2.11	0.120	3.05	0.120	3.05	0.237	6.02	0.237	6.02	0.337	8.56	0.337	8.56
5	5.563	141.30	0.109	2.77	0.109	2.77	0.134	3.40	0.134	3.40	0.258	6.55	0.258	6.55	0.375	9.53	0.375	9.53
6	6.625	168.27	0.109	2.77	0.109	2.77	0.134	3.40	0.134	3.40	0.280	7.11	0.280	7.11	0.432	10.97	0.432	10.97
8	8.625	219.07	0.109	2.77	0.109	2.77	0.148	3.76	0.148	3.76	0.322	8.18	0.322	8.18	0.500	12.70	0.500	12.70
10	10.75	273.05	0.134	3.40	0.134	3.40	0.165	4.19	0.165	4.19	0.365	9.27	0.365	9.27	0.500	12.70	0.594	15.09
12	12.75	323.85	0.156	3.96	0.156	3.96	0.180	4.57	0.180	4.57	0.375	9.53	0.406	10.31	0.500	12.70	0.688	17.48
14	14.00	355.60	0.156	3.96	0.156	3.96	0.188	4.78	0.250	6.35	x	x	0.438	11.13	x	x	0.750	19.05
16	16.00	406.40	0.165	4.19	0.165	4.19	0.188	4.78	0.250	6.35	x	x	0.500	12.70	x	x	0.844	21.44
18	18.00	457.20	0.165	4.19	0.165	4.19	0.188	4.78	0.250	6.35	x	x	0.562	14.27	x	x	0.938	23.83
20	20.00	508.00	0.188	4.78	0.188	4.78	0.218	5.54	0.250	6.35	x	x	0.594	15.09	x	x	1.031	26.19
22	22.00	558.80	0.188	4.78	0.188	4.78	0.218	5.54	0.250	6.35	x	x	x	x	x	x	1.125	28.58
24	24.00	609.60	0.218	5.54	0.218	5.54	0.250	6.35	0.250	6.35	x	x	0.688	17.48	x	x	1.219	30.96
26	26.00	660.40	x	x	x	x	x	x	0.312	7.92	x	x	x	x	x	x	x	x
28	28.00	711.20	x	x	x	x	x	x	0.312	7.92	x	x	x	x	x	x	x	x
30	30.00	762.00	0.250	6.35	0.250	6.35	0.312	7.92	0.312	7.92	x	x	x	x	x	x	x	x
32	32.00	812.80	x	x	x	x	x	x	0.312	7.92	x	x	0.688	17.48	x	x	x	x
34	34.00	863.60	x	x	x	x	x	x	0.312	7.92	x	x	0.688	17.48	x	x	x	x
36	36.00	914.40	x	x	x	x	x	x	0.312	7.92	x	x	0.750	19.05	x	x	x	x

[A] Threading not permitted in accordance with ANSI B.1.20.1.

TABLE 2 Chemical RequirementsA

~~El~~Grade~~ment~~	Grade 1	G rade 2	Grade 2H	Grade 3	Grade 5	Grade 7	Grade 7H	Grade 9	Grade 11	Grade 12	Molybdenum	Chromium	Cobadlt	Zirconium	Niobium	Tin	Silicon	Othe~~13~~
Composition, % Weight Percent[A,B,C,D,E]																		
	Carbon, max.	Oxygen range or max.	Nitrogen, max.	Hydrogen, max.	Iron range or max.	Aluminum	Vanadium	Palladium	Ruthenium	Nickel	Molybdenum	Chromium	Cobalt	Zirconium	Niobium	Tin	Silicon	Othe~~13~~
						r Elements, max. each						Other Elements, max. total						
~~Nitrogen, max~~	~~0.03~~	~~0.03~~	~~0.03~~	~~0.05~~	~~0.05~~	~~0.03~~	~~0.03~~	~~0.03~~	~~0.03~~	~~0.03~~	~~0.03~~							
											~~0.03~~							
~~Carbon, max~~	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
Carbon, max						- -	0.1	0.4										
~~0.08~~	~~0.08~~	~~0.08~~	~~0.08~~															
1	0.08	0.18	0.08															
~~Hydrogen, max~~	~~0.015~~[F,G]	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	~~0.015~~							
Hydrogen, max3	0.015[F,G]	0.20	- -	- -	- -	- -	- -	- -	- -	- -	~~0.015~~							
~~Iron, max~~	0.20	0.30	0.30	0.30														
Iron, max- -	- -	- -	- -	0.1	0.4													
~~0.40~~	~~0.30~~	~~0.30~~	0.25		0.20	0.30	~~0.20~~											
2	0.08	~~0.30~~	0.25	0.03	0.015	0.30	~~0.20~~											
~~Oxygen, max~~	0.18	0.25	0.25	0.35	0.20	0.25	0.25	0.15	0.18	0.25	- -	0.1	0					
Oxygen, max- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4					
~~Aluminum~~	...	...	...	...	~~5.5–6.75~~	...	...	~~2.5–3.5~~	...	...	...							
2H	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	- -	- -	...							
~~Vanadium~~	...	...	...	...	3.5–4.5	...	...											
Vanadium- -	- -	- -	- -	- -	- -	- -	0.1	0.4										
-																		
~~2.0–3.0~~	...	...	...															
3	0.08	0.35	0....															
~~Tin~~	...	...	...	...	...	...	...	...	...	...	...							
Tin05	0.015	0.30	- -	- -	- -	- -	- -	- -	- -	- -	...							
~~Ruthenium~~	...	...	...	...														
Ruthenium- -		- -	- -	- -	- -													
-																		
...	...	...	...	...	...	~~0.04–0.06~~												
—	—	—	—	—	—	~~0.04–0.06~~												
~~Palladium~~	...	...	...	...	...	0.12–0.25	0.12–0.25	...	0.12–0.25	...	—	0.1	0..					
Palladium—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.4					
~~Cobalt~~	...	...	...	...	...	...	...	...	...	...	...							
5	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	- -	- -	- -	...							
~~Molybdenum~~	...	...	...	...	...	...	...	...- -										
Molybdenum- -	- -	- -	- -	- -	- -	- -	- -	- -										
-																		

ElGradement	Composition, % Weight Percent^{A,B,C,D,E}																		
—	...	0.2–0.4	...																
—	—	—	...																
Chromium	...	...	...	...	...	...	...	...	...	...	—	—	—	—	0.1	0..			
Chromium—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.4			
Nickel	...	...	...	...	...	...	...	...	...	0.6–0.9	—	—	—	—	—	—	—	0.4–1	0.6
7	0.08	0.25	0.03	0.015	0.30	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
Niobium	...	...	...	...	...	...	...	...	...	...	—	—	—	—	—	—	—	0.1	0..
7H	0.08	0.25	0.03	0.015	0.30	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
Zirconium	...	...	...	...	...	...	...	...	...	...	—	—	—	—	—	—	—	0.1	0..
9	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
Silicon	...	...	...	...	...	...	...	...	...	...	...								
11	0.08	0.18	0.03	0.015	0.20	- -	- -	0.12-0.25	- -	- -	...								
Residuals,^{D,E,F} max — each	0.1	0.1	0.1	0.1	- -	- -	0.1												
Residuals,^{D,E,F} max each- -		- -	- -	- -	- -	- -	0.1	0.4											
0.1	0.1	0.1	0.03	0.015	0.1	—	—	—	—	0.1	0.2-0.4	—	—	—	—	—	—	0.1	
12	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	- -	0.6-0.9	0.2-0.4	- -	- -	- -	- -	- -	- -	0.1	0.4
Residuals,^{D,E,F} max total	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	—	—	—	—	—	—	—	0.1	0.4
13	0.08	0.10	0.03	0.015	0.20	- -	- -	- -	0.04-0.06	0.4-0.6	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
Titanium^{G}	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance								
14	0.08	0.15	0.03	0.015	0.30	- -	- -	- -	0.04-0.06	0.4-0.6	balance								

Element	Composition, %											
- -	Grade 14 -	Grade 15 -	Grade 16 -	Grade 16H - -	Grade 17 -	Grade 18 -	Grade0.19	Grade 20Grade 21	Grade 23	Grade 2.4		
Nitrogen, max15	0.038	0.25	0.05	0.0315	0.030	0.03- -	0.03- -	0.03- -	0.034-0.06	0.03	0.03	0.05
Carbon, max	0.08	0.08	0.08	0.08	0.08	0.08	0.05	0.05	0.054			
0.4-0.6	- -	- -	- -	- -	- -	- -	- -	0.1	0.4			
16	0.08	0.08										
Hydrogen,^{B,C} max	0.015	0.015	0.015	0.015	0.015	0.015	0.02	0.02	0.015	0.0125	0.015	
0.25	0.03	0.015	0.30	- -	- -	0.04-0.08	- -	- -	- -	- -	0.015	
Iron, max	0.30	0.30	0.30	0.30	0.20	0.4						
Iron, max- -	- -	- -	- -	- -	0.1	0.4						
16H	0.08	0.25	0.30	0.015	0.30	0.40	0.25	0.40				
16H	0.08	0.25	0.03	0.015	0.30	- -	- -	0.40				
Oxygen, max	0.15	0.25	0.25	0.25	0.18	0.15	0.12	0.12	0.17	0.13	0.20	
0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4	
Aluminum	...	...	...	...	...	2.5–3.5	3.0–4.0	3.0–4.0	2.5–3.5	5.5–6.5	5.5–6.75	
17	0.08	0.18	0.03	0.015	0.20	- -	- -	3.0–4.0	2.5–3.5	5.5–6.5	5.5–6.75	
Vanadium	...	...	...	...	...	2.0–3.0	7.5–8.5	7.5–8.5	...	3.5–4.5	3.5–4.5	
0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4	
Tin	...	...	...	...	...	...	...	...	...	...	...	
18	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	0.04-0.08	- -	- -	...	
Ruthenium	0.04–0.06	0.04–0.06	...	...	...	...	...	...4				
Ruthenium- -	- -	- -	- -	- -	- -	- -	0.1	0.4				
19	...	...	...									
19	0.05	0.12	0...									
Palladium	...	...	0.04–0.08	0.4–0.08	0.04–0.08	0.04–0.08	...	0.04–0.08	...	...	0.04–0.08	
Palladium03	0.02	0.30	3.0-4.0	7.5-8.5	- -	- -	- -	3.5-4.5	5.5-6.5	- -	3.5-4.08	
Cobalt	...	...	...	...	...4							
Cobalt5	- -	- -	- -	0.15	0.4							

TABLE Continued

Element	Grade 14- -	Grade 15- -	Grade 16- -	Grade 16H- -	Grade 17- -	Grade 18- -	Grade0.19	Grade 20Grade 21	Grade 23	Grade 2.4			
	Composition, %												
- -													
Nitrogen, max15	0.038	0.25	0.05	0.0315	0.030	0.03- -	0.03- -	0.03- -	0.034-0.06	0.03	0.03	0.05	
20	...	...	...	...	...	...							
20	0.05	0.12	0.03	0.02	0.30	3.0-4..							
Molybdenum	...	...	...	...	...	...	3.5–4.5	3.5–4.5	14.0–16.0	...	- -	0.15	0..
Molybdenum0	7.5-8.5	0.04-0.08	- -	- -	3.5-4.5	5.5-6.5	- -	3.5-4.5	- -	- -	- -	0.15	0.4
Chromium	...	...	...	...	...	...	5.5–6.5	5.5–6.5	...	...	...		
21	0.05	0.17	0.03	0.015	0.40	2.5-3.5	- -	- -	- -	- -	14.0-16..		
Nickel	0.4–0.6	0.4–0.6	...	...	...	...	...	...4					
Nickel0	- -	- -	- -	2.2-3.2	- -	0.15-0.25	0.1	0.4					
23	...	...	...										
23	0.08	0.13	0..										
Niobium	...	...	...	...	...	...	...	...	2.2–3.2	...	...		
Niobium03	0.0125	0.25	5.5-6.5	3.5-4.5	- -	- -	- -	- -	- -	- -	...		
Zirconium	...	...	...	...	...4								
Zirconium- -	- -	- -	- -	0.1	0.4								
24	...	3.5–4.5	3.5–4.5	...	...	...							
24	0.08	0.20	0.05	0.015	0.40	5.5-6..							
Silicon	...	...	...	...	...	...	...	...	0.15–0.25	...	...		
Silicon75	3.5-4.5	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	...		
Residuals,^{D,E,F} max each	0.1	0.14											
Residuals,^{D,E,F} max each- -	0.1	0.4											
25	0.1	0.1	0.1	0.1	0.15	0.15	0.1	0.1	0.1				
25	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	0.04-0.08	0.1				
Residuals,^{D,E,F} max total	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4		
Residuals,^{D,E,F} max total- -	0.3-0.8	- -	- -	- -	- -	- -	- -	- -	0.1	0.4	0.4		
Titanium^{G}	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance		
26	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	0.08-0.14	- -	balance		

Element	Grade 25- - Grade 350.08	Grade 26- - Grade 370.25	Grade 26H- - Grade0.038	Grade 27- -	Grade 28- -	Grade 29- -	Grade 330.1	Grade 30.4					
	Composition, %												
- - 26H													
Nitrogen, max	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.03	0.03		
Nitrogen, max	0.015	0.30	- -	- -	- -	0.08-0.14	- -	- -	- -	- -	0.03		
Carbon, max	0.08	0.08	0.08	0.08	0.084								
Carbon, max- -	- -	- -	- -	0.1	0.4								
27	0.08	0.08	0.08	0.08	0.08	0.08							
27	0.08	0.18	0.03	0.015	0.20	0.08							
Hydrogen,^{B,C} max	0.0125	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	- -	0.015	
Hydrogen,^{B,C} max- -	- -	- -	0.08-0.14	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
Iron, max or range	0.40	0.30	0.30	0.20	0.25	0.25	0.30	0.30	0.20–0.80	0.30	1.2–1.8		
28	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	- -	0.08-0.14	- -	1.2–1.8		