



Designation: B 862 – 05^{ε1}

Standard Specification for Titanium and Titanium Alloy Welded Pipe¹

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 approval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

^{ε1} NOTE—Tensile strength for Grade 3 in Table 4 was corrected editorially in January 2006.

1. Scope

1.1 This specification covers the requirements for 28 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,
- 1.1.3 *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,
- 1.1.6 *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,
- 1.1.13 *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,
- 1.1.22 *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), and
- 1.1.28 *Grade 37*—Titanium alloy (1.5 % aluminum).

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

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.

Current edition approved Jan. 1, 2005. Published February 2005. Originally approved in 1995. Last previous edition approved in 2002 as B 862 – 02.

TABLE 1 Dimensions of Pipe

NOTE 1—Schedule sizes conform to ANSI/ASME B 36.19 (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 | | | | | | | | | | | | | | | | |
|---------------|--------------|--------|--------------------------|------|-------------------------|------|---------------------------|------|--------------------------|------|--------------|------|-------------|-------|--------------|-------|-------------|-------|---|
| | in | mm | 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 | |
| 1/8 | 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 | |
| 1/4 | 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 | |
| 3/8 | 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 | |
| 1/2 | 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 | |
| 3/4 | 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 | |
| 1-1/4 | 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 | |
| 1-1/2 | 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 | |
| 2-1/2 | 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 | |
| 3-1/2 | 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 | x |
| 28 | 28.00 | 711.20 | x | x | x | x | x | x | 0.312 | 7.92 | x | 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 | 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 | 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 | 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 | x |

^A Threading not permitted in accordance with ANSI B.1.20.1

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 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.

1.4 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.

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 120** Test Methods for Chemical Analysis of Titanium and Titanium Alloys³
- 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 the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

2.2 ANSI/ASME Standards:

B 36.19M-1985 Stainless Steel Pipe⁴

ASME Boiler and Pressure Vessel Code, Section VIII

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),

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 Withdrawn.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

TABLE 2 Chemical Requirements^A

| Element | Composition, % | | | | | | | | |
|---------------------------------------|----------------|---------|---------|----------|-----------|---------|-----------|----------|--|
| | Grade 1 | Grade 2 | Grade 3 | Grade 5 | Grade 7 | Grade 9 | Grade 11 | Grade 12 | |
| Nitrogen, max | 0.03 | 0.03 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | |
| Carbon, max | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | |
| Hydrogen, ^{B,C} max | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | |
| Iron, max | 0.20 | 0.30 | 0.30 | 0.40 | 0.30 | 0.25 | 0.20 | 0.30 | |
| Oxygen, max | 0.18 | 0.25 | 0.35 | 0.20 | 0.25 | 0.15 | 0.18 | 0.25 | |
| Aluminum | ... | ... | ... | 5.5–6.75 | ... | 2.5–3.5 | ... | ... | |
| Vanadium | ... | ... | ... | 3.5–4.5 | ... | 2.0–3.0 | ... | ... | |
| Tin | ... | ... | ... | ... | ... | ... | ... | ... | |
| Ruthenium | ... | ... | ... | ... | ... | ... | ... | ... | |
| Palladium | ... | ... | ... | ... | 0.12–0.25 | ... | 0.12–0.25 | ... | |
| Cobalt | ... | ... | ... | ... | ... | ... | ... | ... | |
| Molybdenum | ... | ... | ... | ... | ... | ... | ... | 0.2–0.4 | |
| Chromium | ... | ... | ... | ... | ... | ... | ... | ... | |
| Nickel | ... | ... | ... | ... | ... | ... | ... | 0.6–0.9 | |
| Niobium | ... | ... | ... | ... | ... | ... | ... | ... | |
| Zirconium | ... | ... | ... | ... | ... | ... | ... | ... | |
| Silicon | ... | ... | ... | ... | ... | ... | ... | ... | |
| Residuals, ^{D,E,F} max each | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | |
| Residuals, ^{D,E,F} max total | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Titanium ^G | balance | balance | balance | balance | balance | balance | balance | balance | |



TABLE 2 *Continued*

| Element | Composition, % | | | | | | | | | |
|---------------------------------------|----------------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|----------|
| | Grade 13 | Grade 14 | Grade 15 | Grade 16 | Grade 17 | Grade 18 | Grade 19 | Grade 20 | Grade 21 | Grade 23 |
| Nitrogen, max | 0.03 | 0.03 | 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 | 0.05 | 0.05 | 0.05 | 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 |
| Iron, max | 0.20 | 0.30 | 0.30 | 0.30 | 0.20 | 0.25 | 0.30 | 0.30 | 0.40 | 0.25 |
| Oxygen, max | 0.10 | 0.15 | 0.25 | 0.25 | 0.18 | 0.15 | 0.12 | 0.12 | 0.17 | 0.13 |
| Aluminum | ... | ... | ... | ... | ... | 2.5–3.5 | 3.0–4.0 | 3.0–4.0 | 2.5–3.5 | 5.5–6.5 |
| Vanadium | ... | ... | ... | ... | ... | 2.0–3.0 | 7.5–8.5 | 7.5–8.5 | ... | 3.5–4.5 |
| Tin | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Ruthenium | 0.04–0.06 | 0.04–0.06 | 0.04–0.06 | ... | ... | ... | ... | ... | ... | ... |
| Palladium | ... | ... | ... | 0.04–0.08 | 0.04–0.08 | 0.04–0.08 | ... | 0.04–0.08 | ... | ... |
| Cobalt | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Molybdenum | ... | ... | ... | ... | ... | ... | 3.5–4.5 | 3.5–4.5 | 14.0–16.0 | ... |
| Chromium | ... | ... | ... | ... | ... | ... | 5.5–6.5 | 5.5–6.5 | ... | ... |
| Nickel | 0.4–0.6 | 0.4–0.6 | 0.4–0.6 | ... | ... | ... | ... | ... | ... | ... |
| Niobium | ... | ... | ... | ... | ... | ... | ... | ... | 2.2–3.2 | ... |
| Zirconium | ... | ... | ... | ... | ... | ... | 3.5–4.5 | 3.5–4.5 | ... | ... |
| Silicon | ... | ... | ... | ... | ... | ... | ... | ... | 0.15–0.25 | ... |
| Residuals, ^{D,E,F} max each | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.15 | 0.15 | 0.1 | 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 |
| Titanium ^G | balance | balance | balance | balance | balance | balance | balance | balance | balance | balance |

| Element | Composition, % | | | | | | | | | |
|---------------------------------------|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | Grade 24 | Grade 25 | Grade 26 | Grade 27 | Grade 28 | Grade 29 | Grade 33 | Grade 34 | Grade 35 | Grade 37 |
| Nitrogen, max | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.05 | 0.03 |
| Carbon, max | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Hydrogen, ^{B,C} max | 0.015 | 0.0125 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| Iron, max or range | 0.40 | 0.40 | 0.30 | 0.20 | 0.25 | 0.25 | 0.30 | 0.30 | 0.20–0.80 | 0.30 |
| Oxygen, max | 0.20 | 0.20 | 0.25 | 0.18 | 0.15 | 0.13 | 0.25 | 0.35 | 0.25 | 0.25 |
| Aluminum | 5.5–6.75 | 5.5–6.75 | ... | ... | 2.5–3.5 | 5.5–6.5 | ... | ... | 4.0–5.0 | 1.0–2.0 |
| Vanadium | 3.5–4.5 | 3.5–4.5 | ... | ... | 2.0–3.0 | 3.5–4.5 | ... | ... | 1.1–2.1 | ... |
| Tin | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Ruthenium | ... | ... | 0.08–0.14 | 0.08–0.14 | 0.08–0.14 | 0.08–0.14 | 0.02–0.04 | 0.02–0.04 | ... | ... |
| Palladium | 0.04–0.08 | 0.04–0.08 | ... | ... | ... | ... | 0.01–0.02 | 0.01–0.02 | ... | ... |
| Cobalt | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Molybdenum | ... | ... | ... | ... | ... | ... | ... | ... | 1.5–2.5 | ... |
| Chromium | ... | ... | ... | ... | ... | ... | 0.1–0.2 | 0.1–0.2 | ... | ... |
| Nickel | ... | 0.3–0.8 | ... | ... | ... | ... | 0.35–0.55 | 0.35–0.55 | ... | ... |
| Niobium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Zirconium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Silicon | ... | ... | ... | ... | ... | ... | ... | ... | 0.20–0.40 | ... |
| Residuals, ^{D,E,F} max each | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 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 |
| Titanium ^G | balance | balance | balance | balance | balance | balance | Remainder | Remainder | Remainder | Remainder |

^A Analysis shall be completed for all elements listed in this table for each grade. The analysis results for the elements not quantified in the table need not be reported unless the concentration level is greater than 0.1 % each or 0.4 % total.

^B Lower hydrogen may be obtained by negotiation with the manufacturer.

^C Final product analysis.

^D Need not be reported.

^E A residual is an element present in a metal or an alloy in small quantities and is inherent to the manufacturing process but not added intentionally. In titanium these elements include aluminum, vanadium, tin, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten.

^F The purchaser may, in his written purchase order, request analysis for specific residual elements not listed in this specification.

^G The percentage of titanium is determined by difference.

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 2 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