

HAYNES® Ti-3Al-2.5V alloy

Principal Features

Lightweight, High Strength

HAYNES® Ti-3Al-2.5V alloy (UNS R56320) is both lightweight and strong. It has a high strength-to-weight ratio which provides a major design advantage – saving weight. Ti-3Al-2.5V alloy is about 43 percent lighter than 21-6-9 stainless steel. Comparative typical weights per foot for 1 in (25.4 mm) x 0.035 in (0.89 mm) wall tubing are as follows:

21-6-9	0.36 lb (0.16 kg)
Ti-3Al-2.5V	0.21 lb (0.09 kg)

Developed as Tubing Alloy

In the initial examination of titanium alloys for specific aircraft/aerospace tasks, commercially pure titanium was alloyed with selected elements to improve the performance characteristics and to obtain higher strength levels. Specific alloying additives, notably aluminum, raise the temperature at which the alloy transforms completely to the beta phase. This point on the temperature scale is known as the beta transus temperature. The addition of vanadium, on the other hand, lowers the temperature of transformation of alpha to beta phases.

Titanium 6% aluminum 4% vanadium (Ti-6Al-4V) was chosen as an ideal aircraft/aerospace alloy because it had a good strength-to-weight ratio as annealed combined with resistance to cracking during forging, fair to good weldability, and was heat treatable to higher strengths.

But, because Ti-6Al-4V alloy did not have good cold forming characteristics, the titanium alloy with 3% aluminum and 2.5% vanadium (Ti-3Al-2.5V) was developed for tubing and foil applications. This alloy is intermediate in strength between commercially pure titanium and Ti-6Al-4V. It has properties 30 to 50 percent higher than pure titanium, but more importantly, has the excellent cold formability needed to make seamless tubing.

Readily Formed

Seamless tubing of HAYNES Ti-3Al-2.5V alloy is readily formed cold on conventional tube bending equipment of the same type used for stainless steel. Tubing can be bent 180 degrees around a suitable bend die with a centering radius equal to 3 to 5 times the nominal outside diameter of the tubing. Relatively thin wall tubing should be bent using tubing fillers or other inside diameter constraints.

Good Weldability

HAYNES Ti-3Al-2.5V alloy tubing is readily welded by the standard gas tungsten arc process with inert gas shielding and by the use of automatic welding tools with built-in gas purge chambers.

Machine settings similar to those used for stainless steels are used when welding Ti-3Al-2.5V tubing.

Principal Features Continued

Applications

Seamless tubing of HAYNES Ti-3Al-2.5V alloy was developed for aircraft hydraulic and fuel systems. Its performance has been proven in high technology military aircraft and spacecraft as well as in commercial aircraft. Another application for HAYNES Ti-3Al-2.5V alloy is tubing for bicycle frames. The high strength and light weight characteristics are ideal for this product.

Strict Quality Controls

The latest in quality control equipment is available at Haynes International, Inc. To provide maximum product integrity. Tubing lots are 100% visually, dimensionally and ultrasonically tested. Samples also are examined metallographically as well as tested for conformance to the chemical composition and mechanical property requirements of the applicable specification.

Heat-Treatment

HAYNES Ti-3Al-2.5V alloy seamless tubing is normally supplied in either the annealed or cold worked and stress received condition. Temperatures used generally range from 700°F to 1450°F (371°C 790°C) depending on the degree of re-crystallization or stress relief that is required for a given end use.

Heat-treatment is done in vertical vacuum annealing furnaces. Vertical annealing has two advantages over horizontal annealing. Tubes hung vertically can be arranged so that each tube receives uniform furnace heat. Also, tubes annealed vertically tend to remain straight and round.

Nominal Composition

Weight %

Titanium:	94 Balance
Aluminum:	3
Vanadium:	2.5
Iron:	0.25 max.
Carbon:	0.05 max.
Hydrogen:	**
Oxygen:	0.12 max.
Nitrogen:	0.02 max.

** Varies with specification

Physical Properties

Physical Property	Metric Units		British Units	
	Density	RT	4.48 g/cm ³	RT
Melting Temperature	Approx. 1705 °C	-	Approx. 3100 °F	-

*RT= Room Temperature

Minimal Mechanical Properties

Condition	Specification	0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation*	
		MPa	ksi	MPa	ksi	%	-
Annealed	AMS 4943	517	75	621	90	15	-
CWSR	AMS 4944/4945	724	105	862	125	8	0.016 in. Wall & Bellow
CWSR	AMS 4944/4945	724	105	862	125	10	Above 0.016 in. Wall
CWSR	DAN 2700.9	655	95	690-920	100.0-133.0	14	¼ in. Diameter
		730	106	870-1030	126.0-149.0	14	3/8 in Diameter
		730	106	870-1030	126.0-149.0	16	½ to 1 in. Diameter

*2in (50.8 mm) gage length for AMS 4944 and AMS 4945. 1.969 in (50.0 mm) gage length for DAN 2700.9

Common Tubing Sizes

Listed in the following table are some of the common sizes produced for major aircraft companies. Sizes other than those shown can be produced depending on the quantity required.

Outside Diameter		Wall Thickness		Outside Diameter		Wall Thickness	
in	mm	in	mm	in	mm	in	mm
1/4	6.4	0.016	0.41	3/4	19.1	0.02	0.51
		0.02	0.51			0.028	0.71
		0.028	0.71			-	-
		-	-			0.039	0.99
		-	-			0.054	1.37
		-	-			0.081	2.06
3/8	9.5	0.019	0.48	7/8	22.2	0.028	0.53
		0.022	0.56			0.032	0.71
		0.028	0.71			0.035	0.89
		0.035	0.89			0.049	1.24
		0.042	1.07			0.061	1.55
1/2	12.7	0.023	0.58	1	25.4	0.021	0.53
		0.026	0.66			0.028	0.71
		0.028	0.71			0.035	0.89
		0.036	0.91			0.051	1.3
		0.056	1.42			0.07	1.78
		-	-			0.073	1.85
5/8	15.9	0.023	0.58	1 1/4	31.8	0.028	0.71
		0.028	0.71			0.032	0.81
		0.032	0.81			0.035	0.89
		0.035	0.89			0.04	1.02
		0.044	1.12			0.065	1.65
		0.049	1.24			0.087	2.21
-	-	-	-	1 1/2	38.1	0.035	0.89
		-	-	-	-	0.054	1.37

Dimensional Tolerances

Commercial OD/Wall (ASTM B-338)

Nominal Outside Diameter		Diameter Tolerance		Ovality Tolerance	Wall Tolerance
mm	in	mm	in	Tolerance* Included in Diameter Tolerances	+/- 10% Nominal Wall Thickness
25.4 excl.	Under 1.	0.102	+/-0.004		
25.4 to 38.1 excl.	1 to 1.5	0.127	+/-0.005		
38.1 to 50.8 excl.	1.5 to 2	0.152	+/-0.006		
50.8 to 63.5 excl.	2 to 2.5	0.178	+/-0.007		
63.5 to 88.9 excl.	2.5 to 3.5	0.254	+/-0.010		

Aerospace OD/Wall (AMS)

Nominal Outside Diameter, in.	Diameter Tolerance, in.	Ovality Tolerance	Wall Tolerance
Over 0.093 to 0.188, incl.	+0.002/-0.000	Tolerance Included in Diameter Tolerances	+ 10%, - 5% Nominal Wall Thickness For Tubing under 1.500 in. (38.1 mm) Nominal OD +/- 10% Nominal Wall Thickness for Tubing over 1.500 in (38.1 mm) Nominal OD
Over 0.188 to 0.500, incl.	+0.003/-0.000		
Over 0.500 to 1.000, incl.	+0.004/-0.000		
Over 1.000 to 1.500, incl.	+0.004/-0.001		
Over 1.500 to 2.000, incl.	+0.005/-0.001		
Diameter, mm	Tolerance, mm		
Over 2.3 to 4.70, incl.	+0.05/-0.00		
Over 4.7 to 12.50, incl.	+0.08/-0.00		
Over 12.5 to 25.00, incl.	+0.10/-0.00		
Over 25.0 to 37.50, incl.	+0.10/-0.02		
Over 37.5 to 50.0, incl.	+0.12/-0.02		

Dimensional Tolerances Continued

Aerospace OD/ID (AMS/DAN)

Nominal Outside Diameter, in.	Diameter Tolerance, in.	Ovality Tolerance	Wall Tolerance
Over 0.093 to 0.187, incl.	+0.002/-0.000	Tolerance Included in Diameter Tolerances	All Tubing 1.500 in. (38.1 mm) And Under in Nominal O.D. Shall Have a Wall Thickness Not Less Than 95% of Nominal
Over 0.187 to 0.499, incl.	+0.003/-0.000		
Over 0.499 to 0.749, incl.	+0.004/-0.000		
Over 0.749 to 0.999, incl.	+0.004/-0.001		
Over 0.999 to 1.499, incl.	+0.004/-0.002		
Over 1.499 to 1.999, incl.	+0.005/-0.002		
Diameter, mm	Tolerance, mm		
Over 2.36 to 4.75, incl.	+0.05/-0.00		
Over 4.75 to 12.67, incl.	+0.08/-0.00		
Over 12.67 to 19.02, incl.	+0.10/-0.00		
Over 19.02 to 25.37, incl.	+0.10/-0.025		
Over 25.37 to 38.07, incl.	+0.10/-0.05		
Over 38.07 to 50.77, incl.	+0.13/-0.05		
Nominal Inside Diameter, in.	Diameter Tolerance, in.		
Up to 0.338, incl.	+0.0015/-0.0015		
Over 0.338 to 0.499, incl.	+0.002/-0.002		
Over 0.499 to 0.637, incl.	+0.0025/-0.0025		
Over 0.637 to 0.900, incl.	+0.003/-0.003		
Over 0.900 and over	+0.004/-0.004		
Diameter, mm	Tolerance, mm		
Up to 8.59, incl.	+0.038/-0.038		
Over 8.59 to 11.40, incl.	+0.05/-0.05		
Over 11.40 to 17.09, incl.	+0.064/-0.064		
Over 17.09 to 22.86, incl.	+0.08/-0.08		
Over 22.86 and above	+0.10/-0.10		

Inside diameter is equal to the nominal OD minus twice the nominal wall

Specifications

Specifications

HAYNES® Ti-3Al-2.5V alloy (R56320)	
Sheet Plate and Strip	-
Biller Rod/Bar	-
Coated Electrodes	-
Bar Welding Rods	-
Seamless Pipe & Tube	AMS 4943, AMS 4944 AMS 4945 AMS 4946 AS5620 D210-12096-1 DMS 2241 MMS 1205 MS 330 SB 338/ B 338Gr9
Weld Pipe & Tube	-
Fittings	-
Forgings	-
DIN	-
TÜV	-
Others	-