

Tube and Pipe products

HAYNES
International



HAYNES® Ti-3Al-2.5V Alloy

Lightweight, High Strength

HAYNES® Ti-3Al-2.5V alloy 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 centerline 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 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.

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.

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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 seamless tubing is normally supplied in either the annealed or cold worked and stress relieved condition. Temperatures used generally range from 700 deg. F to 1450 deg. F (371 deg. C to 790 deg. C) depending on the degree of recrystallization 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.

Specifications

Typical specification to which seamless tubing of this alloy can be supplied for Aerospace are AMS 4943, AMS 4944, AMS 4945, and ABS 5004. Commercial specifications are ASTM B-337 and B-338. In addition, many of the aircraft/aerospace companies have their own specifications for this product. For more information on the specifications to which HAYNES Ti-3Al-2.5V tubing can be supplied, contact any of the locations shown on the back cover of this pamphlet.

NOMINAL CHEMICAL COMPOSITION, WEIGHT PERCENT

Ti	Al	V	Fe	C	H	O	N
94 ^a	3	2.5	0.25*	0.05*	**	0.12*	0.02*

* Maximum

** Varies with specification.

^a As balance.

AVERAGE PHYSICAL PROPERTIES

PHYSICAL PROPERTY	TEMPERATURE, °C	METRIC UNITS	TEMPERATURE, °F	BRITISH UNITS
Density	Room	4.48 g/cm ³	Room	0.162 lb./in. ³
Melting Point	Approx. 1705		Approx. 3100	

MINIMUM MECHANICAL PROPERTIES

CONDITIONS	SPECIFICATION	ULTIMATE TENSILE STRENGTH,	YIELD STRENGTH AT 0.2% OFFSET,	ELONGATION
		Ksi (MPa)	Ksi (MPa)	IN PERCENT*
Annealed	AMS 4943	90.0 (621)	75.0 (517)	15
CWSR	AMS 4944/4945	125.0 (862)	105.0 (724)	8
CWSR	AMS 4944/4945	125.0 (862)	105.0 (724)	10
CWSR	DAN 2700.9	100.0-133.0 (690-920)	95.0 (655)	14
		126.0-149.0 (870-1030)	106.0 (730)	14
		126.0-149.0 (870-1030)	106.0 (730)	16

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

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COMMON TUBING SIZES

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

OUTSIDE DIAMETER in. (mm)	WALL THICKNESS in. (mm)	OUTSIDE DIAMETER in. (mm)	WALL THICKNESS in. (mm)
1/4 (6.4)	0.016 (0.41)	3/4 (19.1)	0.020 (0.51)
	0.020 (0.51)		0.028 (0.71)
	0.028 (0.71)		0.035 (0.89)
			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 (0.71)
	0.022 (0.56)		0.032 (0.81)
	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 (1.30)
	0.056 (1.42)		0.070 (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)		0.040 (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, in.(mm)	DIAMETER TOLERANCE, in.(mm)	OVALITY TOLERANCE	WALL TOLERANCE
Under 1 (25.4), excl	+/-0.004 (0.102)		
1 to 1.5 (25.4 to 38.1), excl	+/- 0.005 (0.127)	Tolerance*	+/- 10%
1.5 to 2 (38.1 to 50.8) , exc.	+/- 0.006 (0.152)	Included In	Nominal
2 to 2.5 (50.8 to 63.5), excl	+/- 0.007 (0.178)	Diameter	Wall Thickness
2.5 TO 3.5 (63.5 to 88.9), excl	+/- 0.010 (0.254)	Tolerances	

Minimum wall tolerances are all plus and shall be double the values shown.

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DIMENSIONAL TOLERANCES

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	+10%, -5% Nominal Wall Thickness For
Over 0.188 to 0.500, incl	+0.003/-0.000	Included In	Tubing Under 1.500 in. (38.1 mm) Nominal O.D.
Over 0.500 to 1.000, incl	+0.004 /-0.000	Diameter	
Over 1.000 to 1.500, incl	+0.004/-0.001	Tolerances	+/- 10% Nominal Wall Thickness For
Over 1.500 to 2.000, incl	+0.005/-0.001		Tubing Over 1.500 in. (38.1 mm) Nominal O.D.
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		

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	All Tubing 1.500 in.
Over 0.187 to 0.499, incl	+0.003/-0.000	Included In	(38.1mm) And Under In
Over 0.499 to 0.749, incl	+0.004/-0.000	Diameter	Nominal O.D. Shall Have a
Over 0.749 to 0.999, incl	+0.004/-0.001	Tolerances	Wall Thickness Not Less
Over 0.999 to 1.499, incl	+0.004/-0.002		Than 95% Of Nominal
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 0.449, incl.	+0.002/-0.002		
Over 0.449 to 0.673, incl.	+0.0025/-0.0025		
Over 0.673 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 14.40 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