

ASTM A453 Grade 660 Stud Bolt Specification

ASTM A453 Grade 660 Bolts

Material Chemical Composition Requirements

ELEMENT	Grade 660	Grade 651	Grade 662	Grade 665	Grade 668
	%	%	%	%	%
Carbon	0.08 max	0.28-0.35	0.08 max	0.08 max	0.08 max
Manganese	2.00 max	0.75-1.5	0.40-1.00	1.25-2.00	2.00 max
Phosphorus, max	0.040 max	0.040 max	0.040 max	0.040 max	0.040 max
Sulfur, max	0.030 max	0.030 max	0.030 max	0.030 max	0.030 max
Silicon	1.00 max	0.30-0.80	0.40-1.00	0.1-0.80	1.00 max
Nickel	24.0-27.0	8.0-11.0	24.0-28.0	24.0-28.0	17.5-21.5
Chromium	13.5-16.0	18.0-21.0	12.0-15.0	12.0-15.0	13.5-16.0
Molybdenum	1.00-1.50	1.00-1.75	2.0-3.50	1.25-2.25	1.50 max
Tungsten	...	1.00-1.75
Titanium	1.9-2.35	0.1-0.35	1.80-2.10	2.70-3.30	2.20-2.80
Columbium *	...	0.25-0.6
Aluminum	0.35 max		0.35 max	0.25 max	0.50 max
Vanadium	0.10-0.50		0.50 max
Boron	0.001-0.010		0.001-0.010	0.01-0.07	0.001-0.010
Copper		0.50 max	0.50 max	0.25 max	...

Mechanical Properties Requirements

Size	Class	Tensile, Mpa	Yield, Mpa	Elong. %, min	RA %, min
Grade 660	A, B, & C	895 min	585 min	15	18
	D	895 min	725 min	15	18
Grade 651	A	690 min	485 min	18	35
			415 min		
	B	655 min	415 min	18	35
			345 min		
Grade 662	A	895 min	585 min	15	18
	B	860 min	550 min	15	18
Grade 665	A	1170 min	830 min	12	15
	B	1070 min	830 min	12	15
Grade 665	A & B	895 min	858 min	15	18

Heat Treatment Requirements

Grade	Class	Solution Treatment	Hardening Treatment
660	A	1650 +/- 25 °F [900 +/-14 °C], hold 2 h, min and liquid quench	1325 +/- 25 °F [720 +/- 14 °C] 16h, air cool
	B	1800 +/- 25 °F [980 +/-14 °C], hold 1 h, min and liquid quench	1325 +/- 25 °F [720 +/- 14 °C] 16h, air cool
	C	1800 +/- 25 °F [980 +/-14 °C], hold 1 h, min and oil quench	1425 +/- 25 °F [775 +/- 14 °C] hold 16h, air cool followed by 1200 +/- 25 °F [650 +/- 14 °C], hold 16h, air cool
	D	1650 +/- 25 °F [900 +/-14 °C], hold 2 h, min and liquid quench OR	1325 +/- 25 °F [720 +/- 14 °C] hold 16h, air cool followed by 1200 +/- 25 °F [650 +/- 14 °C], hold 16h, air cool

		1800 +/- 25 °F [980 +/-14 °C], hold 1 h, min and liquid quench	if necessary to achieve properties, second age : 1200 +/- 25 °F [650 +/- 14 °C] hold 16h, air cool
651	A		hot-cold worked at 1200 °F[650] min with 15% min reduction in cross sectional area, stress-relief anneal at 1200 °F [650 °C] min or 4h, min
	B		hot-cold worked at 1200 °F[650] min with 15% min reduction in cross sectional area, stress-relief anneal at 1350 °F [730 °C] min or 4h, min
662	A	1800 +/- 25 °F [980 +/-14 °C], hold 1 h, min and liquid quench	1350 to 1400 °F [730 to 760 °C], hold 20h, furnace cool to 1200 +/- 25 °F [650 +/- 14 °C], hold 20h, air cool
	B	1950 +/- 25 °F [1065 +/-14 °C], hold 2 h, min and liquid quench	1350 to 1400 °F [730 to 760 °C], hold 20h, furnace cool to 1200 +/- 25 °F [650 +/- 14 °C], hold 20h, air cool
665	A	1800 +/- 25 °F [980 +/-14 °C], hold 3 h, min and liquid quench	1350 to 1400 °F [730 to 760 °C], hold 20h, furnace cool to 1200 +/- 25 °F [650 +/- 14 °C], hold 20h, air cool
	B	2000 +/- 25 °F [1095 +/-14 °C], hold 3 h, min and liquid quench	1350 to 1400 °F [730 to 760 °C], hold 20h, furnace cool to 1200 +/- 25 °F [650 +/- 14 °C], hold 20h, air cool
668	A	1650 +/- 25 °F [900 +/-14 °C], hold 2 h, min and liquid quench	1325 +/- 25 °F [720 +/- 14 °C] 16h, air cool
	B	1800 +/- 25 °F [980 +/-14 °C], hold 1 h, min and liquid quench	1325 +/- 25 °F [720 +/- 14 °C] 16h, air cool

Stree Rupture Requirements

Grade	Class	Test Temperature	Stress, Min		Time to Rupture	Elongation
		Deg F [Deg C]	Ksi	Mpa	Min, h*	Min %
660	A, B & C	1200 [650]	56	385	100	5
651	A & B	1200 [650]	40	275	100	5
662	A & B	1200 [650]	55	380	100	5
665	A	1200 [650]	75	515	100	3
	B	1200 [650]	70	485	100	5