MATERION

Data Sheet

Niobium C-103 Alloy for Space Exploration

Composed of niobium, hafnium and titanium, niobium C-103 provides a high-performance alloy solution for aerospace, spacecraft, missiles and launch vehicles. C-103 has high temperature and load-bearing characteristics while still being relatively easy to work with when compared to other materials. Niobium has the lowest density of the refractory metals and exhibits excellent thermal conductivity, high room-temperature ductility, low ductile-to-brittle transition temperature (giving it resistance to high frequency vibrations at cryogenic temperatures), and good weldability.

C-103 Applications:

- High-thrust rocket nozzles
- Steering (vectoring) nozzles for missiles
- Rockets
- Satellites
- Jet engine afterburner flap sections
- Burst disks for jet engine test stands

C-103 Benefits:

- Capable of withstanding high stresses at elevated temperatures
- Low ductile-to-brittle transition temperature for cryogenic applications (-150°C)
- Formed after TIG welding
- Excellent fabricability
- Readily weldable

Material Thickness and Tolerances (Imperial)

Thickness of Material (in excl.)	Tolerance on Thickness Width Under 6"	Plus/Minus (in) Width 6-24"	Tolerance on Width (slit) Width Under 6"	Plus/Minus (in) Width 6-24"	Tolerance on Sheared Length 12" and Under Plus/Minus	Tolerance on Sheared Length Over 12" Plus/Minus
0.005 - 0.010	0.0005	0.001	0.012	—	⅙ / 0	$^{3}/_{32}$ / 0
0.010 - 0.015	0.0007	0.001	0.015	0.015	⅙ / 0	$^{3}/_{32}$ / 0
0.015 - 0.020	0.0008	0.0015	0.015	0.015	⅙ / 0	$^{3}/_{32}$ / 0
0.020 - 0.030	0.0015	0.0025	0.020	0.015	⅙ / 0	$^{3}/_{32}$ / 0
0.030 - 0.060	0.0025	0.0035	0.025	0.030	⅙ / 0	$^{3}/_{32}$ / 0
0.060 - 0.090	0.004	0.005	0.025	0.035	⅙ / 0	$^{3}/_{32}$ / 0
0.090 - 0.125	0.006	0.007	—	—	⅙ / 0	$^{3}/_{32}$ / 0
0.125 - 0.187	0.010	0.010	—	—	⅙ / 0	$^{3}/_{32}$ / 0
0.187 - 0.250	0.015	0.015	—	—	⅛ / 0	$^{5}/_{32}$ / 0
0.250 - 0.312	0.020	0.020	—	—	⅛ / 0	$^{5}/_{32}$ / 0
0.312 - 0.375	0.025	0.025	—	—	$^{3}/_{16}$ / 0	$^{7}/_{32}$ / 0

Material Thickness and Tolerances (Metric)

Thickness of Material (mm excl.)	Tolerance on Thickness Width Under 150 mm	Plus/Minus (mm) Width 150 - 610 mm	Tolerance on Width (slit) Width Under 150 mm	Plus/Minus (mm) Width 150 - 610 mm	Tolerance on Sheared Length 305 mm and Under Plus/Minus	Tolerance on Sheared Length Over 305 mm Plus/Minus
0.13 - 0.25	0.013	0.025	0.30	—	1.60 / 0	2.40 / 0
0.25 - 0.40	0.018	0.025	0.40	0.40	1.60 / 0	2.40 / 0
0.40 - 0.50	0.020	0.040	0.40	0.40	1.60 / 0	2.40 / 0
0.50 - 0.80	0.040	0.060	0.50	0.60	1.60 / 0	2.40 / 0
0.80 - 1.50	0.060	0.090	0.60	0.80	1.60 / 0	2.40 / 0
1.50 - 2.30	0.010	0.013	0.60	0.90	1.60 / 0	2.40 / 0
2.30 - 3.20	0.015	0.018	—	—	1.60 / 0	2.40 / 0
3.20 - 4.80	0.025	0.250	—	—	1.60 / 0	2.40 / 0
4.80 - 6.40	0.040	0.40	—	—	3.20 / 0	4.0 / 0
6.40 - 8.0	0.050	0.50	—	—	3.20 / 0	4.0 / 0
8.0 - 9.50	0.060	0.60	—	—	4.80 / 0	5.60 / 0

Physical Properties

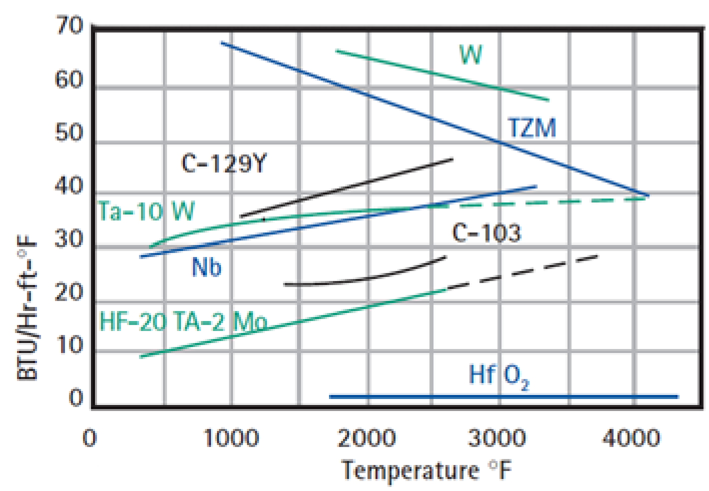
Density	Melting Point
0.320 lb./cubic in	4260 ± 90˚F
8.850 gm/cubic cm	2350 ± 50˚C

Thermal Conductivity

Temperature	Thermal Conductivity K*
1600˚F (811˚C)	22.0 (38.1)
2035˚F (1113˚C)	23.5 (40.7)
2380˚F (1304˚C)	25.8 (44.7)

*K = Btu/hr - ft^2 - ˚F/ft (W/m˚C)

Thermal Conductivity of Refractory Metals



Thermal Expansion

Temperature	Expansion, in/in/˚F (m/m˚C)
200˚F (93˚C)	3.8 x 10-6 (6.8 x 10-6)
400˚F (204˚C)	3.9 (7.0)
600˚F (316˚C)	3.9 (7.0)
800˚F (427˚C)	4.0 (7.2)
1000˚F (538˚C)	4.0 (7.2)
1200˚F (649˚C)	4.1 (7.4)
1400˚F (760˚C)	4.1 (7.4)
1600˚F (871˚C)	4.2 (7.6
1800˚F (982˚C)	4.3 (7.7)
2000˚F (1093˚C)	4.4 (7.9)
2200˚F (1204˚C)	4.5 (8.1)

Niobium C-103 alloy has a linear coefficient of thermal expansion from room temperatures to 2200°F (1204°C).

Minimum Mechanical Properties

Room and elevated temperatures for tensile testing, when fully recrystallized.

Type	Atmosphere	UTS, ksi (MPa)	YS, ksi (MPa)	Elongation, %
RT	Air	56 (386)	40 (276)	20
1000˚F (538˚C)	Vacuum	41 (283)	25 (172)	19
1200˚F (649˚C)	Vacuum	41 (283)	23 (159)	15
1400˚F (760˚C)	Vacuum	41 (283)	21 (145)	16
1600˚F (871˚C)	Vacuum	41 (283)	19 (131)	30
2000˚F (1093˚C)	Vacuum	25 (172)	18 (124)	30
2500˚F (1371˚C)	Vacuum	11 (76)	8 (55)	50

Elastic Modulus GPa (Mpsi) for Common Niobium Alloys

Elastic modulus, thermal conductivity and total hemispherical emissivity are listed in the tables. The emissivity data are for smooth and non-oxidized surfaces, which exhibit much lower emissivity values than oxidized material.

Alloy	68˚F / 20˚C	2192˚F / 1200˚C
C-103	90 (13.0)	64 (9.3)
Nb-IZR	80 (11.6)	28 (4.1)
C-3009	123 (17.8)	
FS-85	140 (20.3)	110 (16.0)

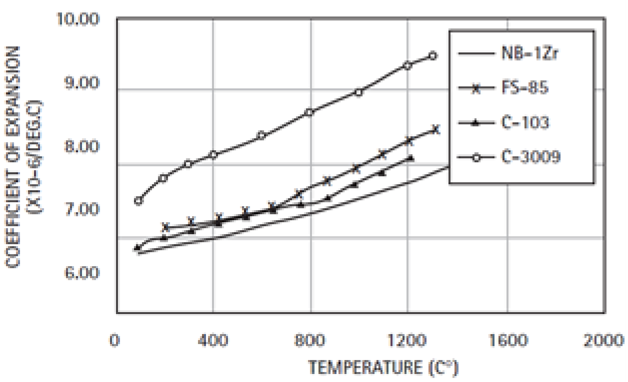
Thermal Conductivity W/m˚C (Btu/hr – ft^2 – ˚F/ft) of Niobium Alloys

Alloy	800˚C	1200˚C
C-103	37.4 (21.6)	42.4 (24.5)
Nb-IZR	59.0 (34.1)	63.1 (36.5)
FS-85	52.8 (30.6)	56.7 (32.8)

Total Hemispherical Emissivity for Common Niobium Alloys

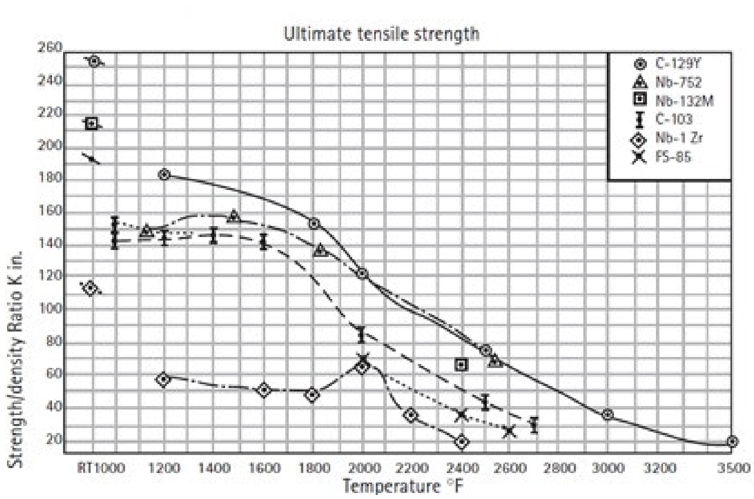
Alloy	1472˚F / 800˚C	2192˚F / 1200˚C
C-103	0.28	0.40
Nb-IZR	0.14	0.18
C-103 (silicide coated)	0.70	0.82

Coefficient of Expansion Versus Temperature



Thermal Expansion Coefficient for Various Niobium Alloys at Elevated Temperature

Strength/Density Comparison of Niobium Alloys at Elevated Temperatures



Forms Available

Niobium C-103 is available in plate, sheet, bar and rod. Wire and powder feedstock are available for additive manufacturing applications. For specialized use cases, we can help address specific issues by collaborating with customers to fabricate and machine components for the aerospace industry, including build-to-print and design.

Sizes Available for Specified Forms

Niobium C-103 Material	Dimensions (inches)	Dimensions (centimeters)
Bar and Rod	1.50” - 6.50” diameter	3.81 – 16.51 cm
Sheet	0.024” - 0.1875” thick, up to 24” width	0.60 – 0.48 cm, up to 61 cm width
Plate	0.1875” - 1” thick, common widths	0.60 - 2.54 cm
Ingots	Up to 9.50” diameter	Up to 24.10 cm
Slabs	As requested	
Niobium C-103 Powder	Additive manufacturing	
Fabricated Parts	Per customer specifications	

Niobium C-103 alloy meets ASTM B652, B654 and B655; as well as AMS7852 and AMS7857 specifications.

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