

Medical Grade Nitinol Wire

Fort Wayne Metals manufactures numerous medical grades of Nickel-Titanium or Nitinol wire products. All grades are available in either the cold worked (CW) condition ready for heat treatment or as straightened super-elastic (SE) wire.

Fort Wayne Metals offers different grades of Nitinol, which are distinguished by the austenite start temperature of the ingot:

Nitinol #1 (superelastic)	-35 to -10 °C
Nitinol #2 (superelastic)	-45 to -15 °C
Nitinol #4 (superelastic)	-10 to +10 °C
Nitinol #5 (shape memory)	≥ +85 °C
Nitinol #6 (shape memory)	+35 to +85 °C
Nitinol #8 (shape memory)	+10 to + 35 °C
Nitinol #9 (superelastic)	≥ +35 °C

Each medical grade of Nitinol material is comprised of near equal atomic weight percentage of nickel and titanium. With the exception of Nitinol #2 all available grades meet the chemistry requirements set forth by ASTM F2063 for use in surgical implants. Nitinol #2 is chromium doped to lower its transformation temperature, which means that the chromium content of 0.20-0.30 weight% exceeds the 0.01% specified in ASTM F2063.

Fort Wayne Metals inspects all incoming Nitinol raw materials to ensure they meet proprietary internal specifications for chemistry, ingot transformation temperature, material homogeneity, and microstructure. Optimized to promote an exceptionally smooth and uniform surface finish quality, all wire products utilize a proprietary single and multi crystalline diamond drawing die technology. Medical grade Nitinol wire may be purchased in the cold worked (CW) or the super-elastic condition (SE) and after the correct superelastic heat treatment will accommodate strain up to 8% without permanent deformation at body temperature.

Nitinol Wire Applications

Our Nitinol wire is used for many different medical and industrial applications. The table below gives some typical engineering applications for each of our standard Nitinol medical grades:

Grade	Application Examples
Nitinol #1	Guidewires, stents, stylets, forming mandrels, stone retrieval baskets, orthodontic files
Nitinol #2	Applications that require a high loading and unloading plateau stresses at room temperature such as eyeglass frames.
Nitinol #4	Provides the best cycling performances at body temperature (37°C), like orthodontic arch wires.
Nitinol #5	High temperature actuators
Nitinol #6	High temperature actuators
Nitinol #8	Applications that require a phase transformation at body temperature (37°C)
Nitinol #9	Very cold temperature environment applications

Certification Data Package

UTS-Elongation
Upper and lower plateau stress (SE only)
Fully annealed ingot transformation measured by DSC
Wire transformation measured by Bend & Free Recovery (SE only)
Two test temperatures available: 22°C +/- 2°C or 37°C +/- 2°C
Permanent set after straining to 6% or 8% strain (SE only)
Multiple gauge length and crosshead speeds
Chemical analysis

Nitinol Product Forms

Round Wire:	0.0005" to 0.250"
Flat Wire:	Aspect Ratio: W/T ~ 12 Minimum Thickness: 0.0003" Maximum Width: 0.450"
Turkshead:	Square, Rectangular
Custom Shapes:	A wide variety of shaped cross-sectional wire
Stranded Cables:	1x3, 1x7, 1x19, Materials Blends, etc.
DFT®:	Composites manufactured with a Nitinol core or clad jacket

Medical Grade Nitinol Wire

Mechanical Properties for Superelastic Grades

Grade	Cold Worked			Superelastic				
	Ingot A _s (°C)	min UTS (psi)	Elongation (%)	min UTS (psi)	Elongation (%)	Loading Plateau (ksi)	Unloading Plateau (ksi)	Active A _f (°C)
Nitinol #1	-35 to -10	220,000	> 4	180,000	> 10%	> 70,000	> 20,000	+10 to +18
Nitinol #2	-45 to -15	250,000	> 4	210,000	> 10%	> 80,000	> 35,000	0 to +18
Nitinol #4	-10 to +10	220,000	> 4	180,000	> 10%	> 65,000	> 7,000	+14 to +22
Nitinol #9	≥ +35 °C	220,000	> 4	160,000	> 10%	> 75,000	> 25,000	≤ 0

Mechanical Properties for Superelastic Grades

Grade	Cold Worked			Shape Memory				
	Ingot A _s (°C)	min UTS (psi)	Elongation (%)	min UTS (psi)	Elongation (%)	Loading Plateau (ksi)	Unloading Plateau (ksi)	Active A _f (°C)
Nitinol #5	≥ +85	220,000	> 3	160,000	> 10%	N/A	N/A	≥ +85
Nitinol #6	+35 to +85	220,000	> 3	160,000	> 10%	N/A	N/A	+40 to +80
Nitinol #8	+10 to +35	220,000	> 3	160,000	> 10%	N/A	N/A	+22 to +40

Notes:

Permanent Set < 0.5% after strained to 8%

Results are typical for round wire diameters from 0.001" (0.025 mm) to ≤ 0.040" (1.016 mm).

All Mechanical testing conducted at 22°C ± 2°C

Chemical Composition

Nitinol #1, #4, #5, #6, #8, #9

Element	Weight %
Nickel	54.5 to 57.0 (Reference)
Carbon	< 0.050 (500 ppm maximum)
Cobalt	< 0.050 (500 ppm maximum)
Copper	< 0.010 (100 ppm maximum)
Chromium	< 0.010 (100 ppm maximum)
Hydrogen	< 0.005 (50 ppm maximum)
Iron	< 0.050 (500 ppm maximum)
Niobium	< 0.025 (250 ppm maximum)
Nitrogen plus Oxygen	< 0.050 (500 ppm maximum)
Any Single Trace Element	< 0.1
Total Trace Elements	< 0.25
Titanium	balance

Nitinol #2

Element	Weight %
Nickel	55.8 (Reference)
Carbon	< 0.050 (500 ppm maximum)
Cobalt	< 0.050 (500 ppm maximum)
Copper	< 0.010 (100 ppm maximum)
Chromium	0.20 to 0.30
Hydrogen	< 0.005 (50 ppm maximum)
Iron	< 0.050 (500 ppm maximum)
Niobium	< 0.025 (250 ppm maximum)
Nitrogen plus Oxygen	< 0.050 (500 ppm maximum)
Any Single Trace Element	< 0.1 (except Chromium)
Total Trace Elements	< 0.4 (except Chromium)
Titanium	balance

Notes:

Maximum values per ASTM F2063. Chromium content of Nitinol #2 does not meet ASTM F2063 requirements.

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Surface Finishes

Light Oxide (LO) Gold to Brown color - diamond drawn surface

Dark Oxide (DK) Blue to Black color - diamond drawn surface

Black Oxide (BLK) Shiny Black color - diamond drawn surface

Etch (E) Chemical removal of oxide layer - will maintain smooth surface

Pickled (P) Chemical removal of oxide layer along with a slight amount of base metal - surface will have rough texture

Etched and Mechanically Polished (EMP) Chemical removal of oxide layer followed by mechanical polish - surface will have Stainless Steel appearance although at > 40x magnification micro scratches are present



Surface finishes top left to right: Etch, Light Oxide, Etched and Mechanically Polished, Black Oxide, Pickled.

Packaging

You may choose to have your Nitinol wire packaged according to your requirements.

If you do not specify a spool in your order, we will package your wire as follows:

Wire Size	Maximum Weight	Spool Type
0.0005" to 0.003"	0.5 pounds	2.5"x3", DIN80, DIN100, DIN125, Steeger, NE #2, Wardwell Bobbins, ENDURA™ Biconical Bobbin
> 0.003" to < 0.012"	5 pounds	2.5"x3", DIN100, DIN125, Weldwire Reel
> 0.012" to 0.018"	10 pounds	Weldwire Reel
> 0.018" to 0.035"	20 pounds	Weldwire Reel

Note: higher maximum weights may be achieved with multiple wires, strands or cables on one spool. Check with your Fort Wayne Metals representative for details.

Applicable Documents

ASTM A555 Standard Specification for General Requirements for Stainless Steel Wire and Wire Rods

ASTM F2005 Standard Terminology for Nickel-Titanium Shape Memory Alloy

ASTM F2004 Standard Test Method for Transformation Temperature of Nickel-Titanium Alloys by Thermal Analysis

ASTM F2063 Standard Specification for Wrought Nickel-Titanium Shape Memory Alloys for Medical Devices and Surgical Implants

ASTM F2516 Standard Test Method for Tension Testing of Nickel-Titanium Super-Elastic Materials

Nitinol Wire for Super-Elastic Applications with Increased Stiffness Requirements

When your application requires a Nitinol wire with increased stiffness, Fort Wayne Metals offers two options – DPS™ Nitinol wire and USN™ wire. Both options will produce straight wire with 1:1 torque response.

Dynamic Plateau Strength Nitinol

DPS™ Nitinol wire allows device designers to achieve a high stiffness in applications requiring between 1% and 8% strain when the material enters the plateau region on a stress-strain curve. DPS™ Nitinol wire is available in diameters from 0.009" – 0.030" and in discrete lengths from .5" to 144".



Ultra-Stiff Nitinol

In applications where the gradual bend of the wire produces less than 1% strain and only enters into the modulus region of the stress-strain curve, USN™ wire will show an increased stiffness when compared to our superelastic Nitinol #1. USN™ wire is available diameters from 0.009" – 0.030" on spools in lengths up to 8,000'.



Mechanical Properties of DPS Nitinol Wire

UTS	Loading Plateau	Unloading Plateau	Modulus	Af (°C)
~230 ksi	~95 ksi	~50 ksi	~6 MPsi	-5 to 20

Mechanical Properties of USN Wire

UTS	Loading Plateau	Unloading Plateau	Modulus	Af (°C)
~200 ksi	~70 ksi	~20 ksi	~9 MPsi	-15 to 20

Stress-Strain Curves

