FORT WAYNE METALS

Technical capabilities guide

Custom material solutions

fwmetals.com

Our mission

Our company was founded and continues to grow because of our dedication to the manufacturing of medical grade wire. Our mission is to continually improve the quality of our products, the speed with which we respond to customers' requests, and our level of understanding of the materials we work with and recommend.

This document was updated on 1/2024. For the latest information, please visit **fwmetals.com** or contact your Fort Wayne Metals Sales Representative.

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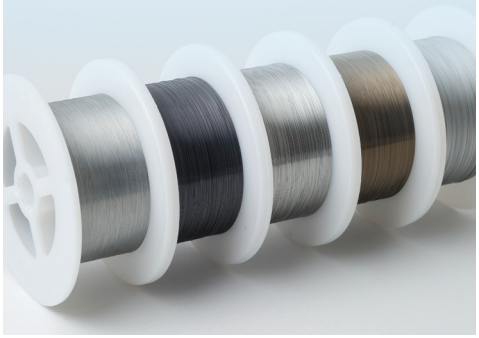

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About this information

The data and information provided are based on work conducted principally by Fort Wayne Metals Research Products, LLC and occasionally supplemented by information from the open literature, and are believed to be reliable. However, we do not make any warranty or assume any legal liability or responsibility for its accuracy, completeness, or usefulness, nor do we represent that its use would not infringe upon private rights. Any suggestions as to uses and applications for specific alloys are opinions only and Fort Wayne Metals Research Products, LLC makes no warranty of results to be obtained in any particular situation. For specific concentrations of elements present in a particular product and a discussion of the potential health effects thereof, refer to the Material Safety Data Sheet supplied by Fort Wayne Metals Research Products, LLC

Alloys

Stainless steel

A versatile industry favorite for applications requiring strength and corrosion resistance, stainless steel can be tailored to fit a variety of medical and industrial uses. With grades ranging from hard 302 to reduced carbon 316LVM, this alloy is the workhorse of the medical device industry. Even as novel materials open up new possibilities, stainless steel remains the backbone of many critical applications.

Understanding stainless steel

To be considered a stainless steel, an alloy must have at least 10.5% chromium and no more than 1.2% carbon. Generally speaking, higher chromium content means greater corrosion resistance. Austenitic stainless steels are characterized by their microstructure, and are not susceptible to hardening during heat treatment, which offers greater versatility for processing and end applications.

Alloys we produce

At Fort Wayne Metals, we routinely process a number of stainless steel alloys.

- 302
- 304V
- 304LV
- 316LVM
- Custom 455® alloy

Typical end uses

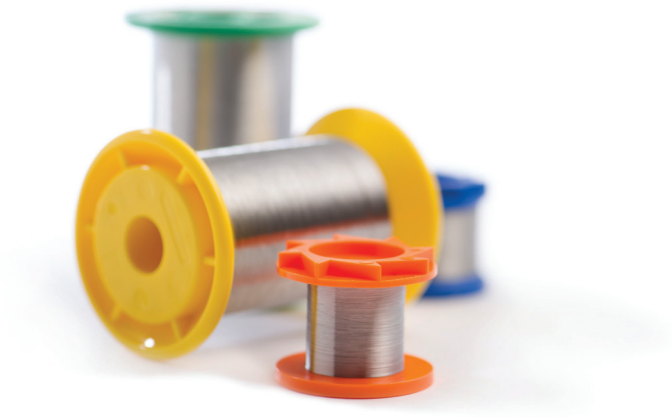
Once stainless steel is in your chosen product form, you can do just about anything with it. We've seen customers use our stainless steel products in:

- Stylets
- Catheters
- Guidewires
- Springs
- Needles
- Orthodontics
- Bone pins
- Skin closure staples
- Orthopaedic cables

Surface finishes & material conditions

While the exact finish and condition of your stainless steel depends on the alloy, product form, and other important factors, generally it will have a highly polished appearance, especially at small diameters. The condition, or temper, relates to the tensile strength of the material. Hyten condition usually provides the highest tensile strength, while annealed typically offers the lowest.

- Hyten
- Ultra spring
- Double spring
- Spring
- Full hard
- ¾ Hard
- ½ Hard
- ¼ Hard
- Annealed



Enhanced solutions

If you need stainless steel wire that performs beyond what is expected of typical alloys, explore our NDR® wire. Using certain grades of stainless steel, NDR® wire is produced using a thermal-mechanical treatment to refine the microstructure, which means you get better fatigue life without altering the physical properties of the material.

302 stainless steel

302 stainless steel has increased carbon content for higher tensile strength. This material is produced using an electric-arc melt process, resulting in a high-quality austenitic stainless steel.

Chemical composition

Element	ASTM A313 Composition, % (mass/mass)
Carbon	0.12
Manganese	2.00
Phosphorus	0.045
Sulfur	0.030
Silicon	1.00
Chromium	17.0 - 19.0
Nickel	8.0 - 10.0
Nitrogen	0.10
Iron	Balance

Maximum unless range or minimum is indicated

Physical properties

	Metric	English
Density	7.92 g/cm^3	0.286 lbs/in^3
Modulus of elasticity	193 GPa	28 Mpsi
Electrical resistivity	720 μΩ/mm	28.4 μΩ/in
Thermal conductivity*	16.3 W/m-K	9.05 BTU-in/hr-ft^2-°F

**Values calculated at 100°C [212°F]*

Mechanical properties

Cold worked	Yield Strength		Ultimate tensile strength		Elongation
%	MPa	ksi	MPa	ksi	%
0	338	49	731	106	48
20	862	125	1014	147	9.8
37	1165	169	1303	189	3.2
50	1351	196	1517	220	2.6
60	1531	222	1682	244	2.2
68	1675	243	1882	273	2.1
75	1731	251	1993	289	2.4
80	1944	282	2130	309	2.2
84	2034	295	2255	327	2.2
87	2068	300	2289	332	2.3
90	2199	319	2379	345	2.2
92	2220	322	2558	371	2.5

Localized variations in final melt chemistry can cause slight changes in ultimate tensile strength when 302 stainless steel is drawn to fine wire.

304V stainless steel

304V stainless steel has more uniform chemistry and increased carbon content for higher tensile strength.

Chemical composition

Element	ASTM A313 Composition, % (mass/mass)
Carbon	0.08
Manganese	2.00
Phosphorus	0.045
Sulfur	0.030
Silicon	1.00
Chromium	18.0 - 20.0
Nickel	8.0 - 10.5
Nitrogen	0.10

Maximum unless range or minimum is indicated

Physical properties

	Metric	English
Density	7.92 g/cm^3	0.286 lbs/in^3
Modulus of elasticity	196 GPa	28 Mpsi
Electrical resistivity	720 μΩ/mm	28.4 μΩ/in
Thermal conductivity*	16.3 W/m-K	9.08 BTU-in/hr-ft^2-°F

**Values calculated at 100°C [212°F]*

Mechanical properties

Cold worked	Yield Strength		Ultimate tensile strength		Elongation
%	MPa	ksi	MPa	ksi	%
0	345	50	738	107	41
20	483	70	965	140	14
37	621	90	1269	184	4
50	965	140	1434	208	3
60	1103	160	1579	229	2.6
68	1241	180	1703	247	2.7
75	1379	200	1827	265	2.6
80	1482	215	1875	272	2.9
84	1586	230	1993	289	2.5
90	1689	245	2110	306	2.6
93	1724	250	2179	316	2.7
95	1931	280	2303	334	2.6

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

304LV stainless steel

304LV stainless steel has reduced carbon content for better corrosion resistance in place of tensile strength.

Chemical composition

Element	ASTM A276 Composition, % (mass/mass)
Carbon	0.030
Manganese	2.00
Phosphorus	0.045
Sulfur	0.030
Silicon	1.00
Chromium	18.0 - 20.0
Nickel	8.0 - 12.0

Maximum unless range or minimum is indicated

Physical properties

	Metric	English
Density	7.92 g/cm^3	0.286 lbs/in^3
Modulus of elasticity	193 GPa	28 Mpsi
Electrical resistivity	720 μΩ/mm	28.4 μΩ/in
Thermal conductivity*	16.3 W/m-K	9.05 BTU-in/hr-ft^2-°F

**Values calculated at 100°C [212°F]*

Mechanical properties

Cold worked	Yield Strength		Ultimate tensile strength		Elongation
%	MPa	ksi	MPa	ksi	%
0	331	48	621	90	40
20	562	81.5	731	106	27
37	800	116	1014	147	5.9
50	1014	147	1193	173	3.2
60	1151	167	1317	191	2.8
68	1089	158	1420	206	2.8
75	1262	183	1496	217	2.7
80	1400	203	1538	223	2.6
84	1455	211	1600	232	2.5
90	1517	220	1655	240	2.5
93	1710	248	1862	270	2.5
95	1779	258	1937	281	3.1

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

316LVM stainless steel

316LVM stainless steel has uniform chemistry and improved microcleanliness and can be processed to improve ductility or corrosion resistance.

Chemical composition

Element	ASTM F138 Composition, % (mass/mass)
Carbon	0.030 max
Manganese	2.00 max
Phosphorus	0.025 max
Sulfur	0.010 max
Silicon	0.75 max
Chromium	17.00 - 19.00
Nickel	13.00 - 15.00
Molybdenum	2.25 - 3.00
Nitrogen	0.10 max
Copper	0.50 max
Iron	Balance

The compositional requirement should meet the following:
% Cr + 3.3x % Mo ≥ 26.0

Physical properties

	Metric	English
Density	7.94 g/cm^3	0.287 lbs/in^3
Modulus of elasticity	195 GPa	28 Mpsi
Electrical resistivity	720 μΩ/mm	29.2 μΩ/in
Thermal conductivity*	16.3 W/m-K (100 °C)	9.08 BTU-in/hr-ft^2-° F

**Values calculated at 100 °C [212 °F]*

Mechanical properties

Cold worked	Yield Strength		Ultimate tensile strength		Elongation
%	MPa	ksi	MPa	ksi	%
0	310	45	627	91	42
20	758	110	848	123	8
37	1000	145	1103	160	2.5
50	1110	161	1213	176	2.2
60	1172	170	1317	191	2.1
68	1213	176	1400	203	2.5
75	1317	191	1503	218	2.6
80	1282	186	1496	217	2.6
84	1393	202	1565	227	2.6
90	1413	205	1641	238	2.6
93	1462	212	1648	239	2.6
95	1469	213	1696	246	2.8

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

Custom 455® alloy

Custom 455® alloy offers a soft, formable material that hardens with heat treatment for increased tensile strength. This material is double vacuum-melted using a vacuum induction melt followed by a vacuum arc remelt, creating a martensitic age-hardenable stainless steel.

Chemical composition

Element	AMS5617 grade 1 Composition, % (mass/mass)
Carbon	0.03 max
Manganese	0.50 max
Silicon	0.50 max
Phosphorus	0.015 max
Sulfur	0.015 max
Chromium	11.00 - 12.50
Nickel	7.50 - 9.50
Titanium	0.90 - 1.40
Copper	1.50 - 2.50
Molybdenum	0.50 max
Columbium	0.50 max
Nitrogen	0.015 max

Physical properties

	Metric	English
Density	7.75 g/cm^3	0.280 lbs/in^3
Modulus of elasticity	200 GPa	29 Mpsi
Electrical resistivity	758 μΩ/mm	29.9 μΩ/in
Thermal conductivity*	18.0 W/m-°C	10.0 BTU-in/hr-ft^2-°F

**Values calculated at 100°C [212°F]*

Mechanical properties

Cold worked	Yield Strength		Elongation
%	MPa	ksi	%
0	1000	145	6.3
20	1055	153	5.7
37	1110	161	3.8
50	1138	165	3.5
60	1193	173	4.6
68	1275	185	2.4
75	1310	190	2.5
80	1331	193	2.6
84	1372	199	2.6
87	1448	210	2.2
90	1517	220	2.5
92	1586	230	2.4

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

High-performance alloys

High-performance alloys are designed to take on the challenges of an ever-changing world. These exactingly engineered materials offer strength, fatigue resistance, ductility, good biocompatibility, and corrosion resistance to withstand the pressures of critical applications. Whatever the challenge, high-performance alloys are up to the task.

Understanding high-performance alloys

There is no basic definition for what makes a high-performance alloy, sometimes called a superalloy. Many of the most common high-performance alloys are nickel or cobalt-based. They can usually operate in high-heat environments for extended periods of time and offer high strength and corrosion resistance.

Alloys we produce

At Fort Wayne Metals, we routinely process a number of high-performance alloys.

- 35N LT™ alloy
- MP35N® alloy
- L-605 alloy
- FWM™ 1058 alloy
- FWM™ 1537 alloy

Surface finishes and material conditions

Cobalt-based alloys develop a highly polished appearance as they are drawn to fine diameters.

Enhanced solutions

If your application requires more than high-performance alloys typically offer, explore our NDR® wire. Several high-performance alloys can be used in NDR® wire, which is produced using a thermal-mechanical treatment to refine the microstructure, which means you get better fatigue life without altering the physical properties of the material.

Typical end uses

Our customers use high-performance alloys in their most challenging applications, such as implantable devices that need to perform even with rigorous use. Some of the most common include:

- Hip and knee replacements
- Spinal rods and screws
- Stents
- Vena cava filters
- Surgical clips
- Orthodontic appliances

35N LT™ alloy

35N LT™ alloy provides an excellent combination of strength, fatigue resistance, corrosion resistance, and good biocompatibility.

Chemical composition

Element	ASTM F562 Composition, % (mass/mass)
Carbon	0.025 max
Manganese	0.15 max
Silicon	0.15 max
Phosphorus	0.015 max
Sulfur	0.010 max
Chromium	19.0 - 21.0
Nickel	33.0 - 37.0
Molybdenum	9.0 - 10.5
Iron	1.0 max
Titanium	0.01 max
Boron	0.015 max
Cobalt	Balance

Physical properties

	Metric	English
Density	8.41 g/cm^3	0.304 lbs/in^3
Modulus of elasticity @ 26°C	233 GPa	33.8 x 10^6 psi
Electrical resistivity @ 21°C	1033 μΩ/mm	40.7 μΩ/in
Thermal conductivity @ 21°C	11.2 W/m -°C	77.7 BTU-in/hr-ft^2-°F
Coefficient of thermal expansion @ 21 - 93°C	12.8 μm/m -°C	7.11 μin/in -°F

Mechanical properties

Cold worked	Ultimate tensile strength		Elongation
%	MPa	ksi	%
0	1317	191	33.0
20	1669	242	6.4
37	1959	284	3.9
50	2082	302	3.5
60	2206	320	3.5
68	2317	336	2.6
75	2372	344	2.5
80	2372	344	2.3
84	2413	350	2.8
90	2427	352	2.4
93	2482	360	2.3

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

MP35N® alloy

MP35N® alloy provides a combination of strength, good biocompatibility, and corrosion resistance.

Chemical composition

Element	ASTM F562 Composition, % (mass/mass)
Carbon	0.025 max
Manganese	0.15 max
Silicon	0.15 max
Phosphorus	0.015 max
Sulfur	0.01 max
Chromium	19.0 - 21.0
Nickel	33.0 - 37.0
Molybdenum	9.0 - 10.5
Iron	1.0 max
Titanium	1.0 max
Boron	0.015 max
Cobalt	Balance

Physical properties

	Metric	English
Density	8.41 g/cm^3	0.304 lbs/in^3
Modulus of elasticity @ 26 °C	233 GPa	33.8 x 10^6 psi
Electrical resistivity @ 21 °C	1033 μΩ/mm	40.7 μΩ/in
Thermal conductivity @ 21 °C	11.2 W/m - °C	77.7 BTU-in/hr-ft^2-°F

Mechanical properties

Cold worked	Ultimate tensile strength		Elongation
%	MPa	ksi	%
0	1310	191	33.3
20	165	240	6.4
37	1931	280	3.9
50	2268	329	3.5
60	2206	320	3.5
68	2275	330	2.6
75	2344	340	2.5
80	2413	350	2.3
84	2482	360	2.8
90	2551	370	2.4
93	2482	360	2.3

All data represent results from a 25.4 cm [10 in] test gauge length. Values are typical and may not represent all diameters. Test method will affect results.

L-605 alloy

L-605 alloy is a cobalt-chromium-tungsten-nickel, nonmagnetic alloy that possesses high strength properties at elevated temperatures along with good oxidation and corrosion resistance.

Chemical composition

Element	ASTM F90 Composition, % (mass/mass)
Carbon	0.05 - 0.15
Manganese	1.00 - 2.00
Silicon	0.40 max
Phosphorus	0.040 max
Sulfur	0.030 max
Chromium	19.00 - 21.00
Nickel	9.00 - 11.00
Tungsten	14.00 - 16.00
Iron	3.00 max
Cobalt	Balance

Mechanical properties

Cold worked	Ultimate tensile strength		Elongation
%	MPa	ksi	%
0	1138	165	50
20	1655	240	9
37	1999	290	6
50	2241	325	3.6

Mechanical properties - straight and cut bar

	Ultimate tensile strength		Yield strength		Elongation
Condition	MPa	ksi	MPa	ksi	% (2 in gauge length)
Annealed	1034	150	517	75	40
Cold worked	1379	200	1034	150	25

FWM™ 1058 alloy

FWM™ 1058 alloy offers excellent corrosion resistance, mechanical strength, fatigue resistance, and a high elastic modulus.

Chemical composition

Element	ASTM F1058 grade 2 Composition, % (mass/mass)
Carbon	0.15 max
Manganese	1.0 - 2.0
Silicon	1.20 max
Phosphorus	0.015 max
Sulfur	0.015 max
Cobalt	39.0 - 42.0
Chromium	18.5 - 21.5
Nickel	15.0 - 18.0
Molybdenum	6.5 - 7.5
Beryllium	0.001 max
Iron	Balance

Physical properties

	Metric	English
Density	8.30 g/cm^3	0.300 lbs/in^3
Modulus of elasticity @ 26°C	200 MPa	29 x 10^6 psi
Electrical resistivity @ 21°C	996 μΩ/mm	39.2 μΩ/in
Thermal conductivity @ 21°C	12.5 W/m - K (0 - 100°C)	86.7 BTU-in/hr-ft^2-°F (0 - 100°C)

Mechanical properties

Cold worked	Ultimate tensile strength		Elongation
%	MPa	ksi	%
0	1034	150	55
20	1413	205	9
37	1689	245	5
50	1896	275	3.9
60	2034	295	3.8
68	2151	312	3.8
75	2241	325	3.9

Values are typical and may not represent all diameters. Test methods will affect results.

FWM™ 1537 alloy

FWM™ 1537 alloy is a low carbon wrought cobalt-chromium-molybdenum alloy that features high strength, ductility, wear resistance, corrosion resistance, and good biocompatibility.

Chemical composition

Element	ASTM F1537 alloy 1 Composition, % (mass/mass)
Carbon	0.14 max
Chromium	26.0 - 30.0
Molybdenum	5.0 - 7.0
Nickel	1.0 max
Iron	0.75 max
Silicon	1.0 max
Manganese	1.0 max
Nitrogen	0.25 max
Cobalt	Balance

Physical properties

	Metric	English
Density	8.28 g/cm^3	0.299 lbs/in^3
Modulus of elasticity	241 GPa	35 x 10^6 psi
Thermal conductivity	12.6 W/m - K	87.4 BTU-in/hr-ft^2-°F
Coefficient of thermal expansion (20 - 100°C)	13.2 x 10 - 6 m/m/°C	7.3 x 10 - 6 in/in/°F

Mechanical properties

	Ultimate tensile strength		Yield strength		Hardness	Elongation
Condition	MPa	ksi	MPa	ksi	Rockwell C	%
Annealed	1034 - 1172	150 - 170	552 - 758	80 - 110	30 - 35	> 25
Hard*	1172 - 1344	170 - 195	758 - 896	110 - 130	~40	> 30

Values are typical and may not represent all diameters. Test methods will affect results.

**This material condition is similar to the ASTM condition "warm worked." The properties are similar, but the material is cold worked only. No thermal processing is used to achieve these properties.*

Titanium

Stronger, lighter, and more corrosion-resistant than standard stainless steel, titanium is a powerful component in applications requiring materials that go the extra mile. In addition to its strength-related properties, titanium offers a distinct advantage over other alloys – impressive biocompatibility. Titanium promotes osseointegration, meaning that bone can grow into the material, further helping to anchor implants in the body.

Understanding titanium

Titanium comes either as a commercially pure material or alloyed with a secondary element to customize its properties.

Commercially pure titanium is available in four distinct grades to suit a variety of needs: 1, 2, 3, and 4. These grades are ordered in relation to corrosion resistance, ductility, and strength requirements.

Alloyed titanium is made by combining titanium with other materials, allowing you to customize the alloy for specific performance requirements. The alloyed titanium we most commonly work with is Ti 6Al-4V ELI.

Typical end uses

Our customers use high-performance alloys in their most challenging applications, such as implantable devices that need to perform even with rigorous use. Some of the most common include:

- Pacing leads
- Needles
- Orthopaedics
- Dental implants

Surface finishes

Processing titanium is no easy feat, as it has a tendency to stick, fret or cold weld with drawing dies. To offer you the best surface condition possible, we have developed processing techniques to require minimal etching at finish size, yielding a cleaner and smoother surface finish without the heavy etching that is common practice with many manufacturers.

Enhanced solutions

When you need the strength of alloyed titanium but can't sacrifice the properties of commercially pure titanium, you need 4TiTUDE® bar. Equivalent to grade 4 titanium in promoting osseointegration, but with the strength of alloyed titanium such as TiZr or Ti 6Al-4V ELI, 4TiTUDE® bar offers the best of both worlds.

Commercially pure titanium

Unalloyed commercially pure titanium is divided into four distinct grades, numbered 1 through 4. The grade is related to the required corrosion resistance, ductility, and strength. Properties range from grade 1, with the highest corrosion resistance and formability but the lowest strength, through grade 4, which offers the highest strength with moderate ductility.

Chemical composition

ASTM F67
Composition, % (mass/mass)

Element	Grade 1	Grade 2	Grade 3	Grade 4
Nitrogen, max	0.03	0.03	0.05	0.05
Carbon, max	0.08	0.08	0.08	0.08
Hydrogen, max	0.015	0.015	0.015	0.015
Iron, max	0.20	0.30	0.30	0.50
Oxygen, max	0.18	0.25	0.35	0.40
Titanium	Balance	Balance	Balance	Balance

Mechanical properties

Grade	Ultimate tensile strength (min.)		Yield strength* (min.)		Elongation** (min.)
	MPa	ksi	MPa	ksi	%
1	240	35	170	25	24
2	345	50	275	40	20
3	450	65	380	55	18
4	550	80	483	70	15

**2% offset*

***51 mm [2 in] gauge length*

Fort Wayne Metals mechanical properties

Grade	Condition	Ultimate tensile strength	
		MPa	ksi
1	Cold worked	586 - 793	85 - 115
1	Annealed	310 - 517	45 - 75
2	Cold worked	1758 - 965	110 - 140
2	Annealed	448 - 621	65 - 90
4	Cold worked	931 - 1138	135 - 165
4	Annealed	655 - 827	92 - 120

Ti 6Al-4V ELI alloyed titanium

Ti 6Al-4V ELI, one of the most commonly used titanium alloys, is an alpha-beta alloy containing 6% Aluminum, 4% Vanadium, and extra low interstitials (ELI). Interstitial elements such as iron and oxygen are tightly controlled during the melt process in order to improve the ductility and fracture toughness.

Chemical composition

Element	ASTM F136 Composition, % (mass/mass)
Nitrogen, max	0.05
Carbon, max	0.08
Hydrogen, max	0.012*
Iron, max	0.25
Oxygen, max	0.13
Aluminum	5.5 - 6.50
Vanadium	3.5 - 4.5
Titanium	Balance

**Material 0.813 mm [0.032 in] and under may have hydrogen content up to 0.0150%.*

Fort Wayne Metals mechanical properties

Condition	Ultimate tensile strength MPa	 ksi	4D elongation* %
Cold worked	1310 - 1448	185 - 200	0.05
Cold worked and stress relieved	1172 - 1310	165 - 180	0.08
Annealed	1000 - 1172	140 - 155	0.012*

**51 mm [2 in] gauge length*

Mechanical properties

Size mm	 in	Ultimate tensile strength (min.) MPa	 ksi	Yield strength* (min.) MPa	 ksi	4D Elongation**(min.) %
< 4.75	< 0.187	860	125	795	115	10
4.75 - 6.35	0.187 - 0.250	860	125	795	115	10

**2% offset*

***51 mm [2 in] gauge length*

Nitinol

When combined in just the right amounts, nickel and titanium create Nitinol. Known for its unique superelastic and shape memory properties - the ability to remember and return to a specified shape after deformation when exposed to a predetermined temperature - this alloy is revolutionizing the way the medical device and other high-performance industries manufacture next-generation solutions.

Understanding Nitinol

There are two primary types of Nitinol: superelastic and shape memory, which are determined by transformation temperature. Superelastic Nitinol is cooler, and shape memory Nitinol is warmer. Don't let the description fool you - the same superelastic and shape memory effect is taking place regardless of category.

To help you pick the Nitinol that is best for your application, at Fort Wayne Metals, we divide the categories of superelastic and shape memory into grades with stricter temperature ranges.

SUPERELASTIC NITINOL is commonly used in medical devices. Transformation temperatures for superelastic grades are between -20 °C and 22 °C [-4 °F and 71.6 °F].

SHAPE MEMORY NITINOL is commonly used for actuators and other industrial applications. Transformation temperatures for shape memory grades are between 22 °C and 80 °C [71.6 °F and 176 °F], with some grades offering temperatures greater than 85 °C [185 °F].

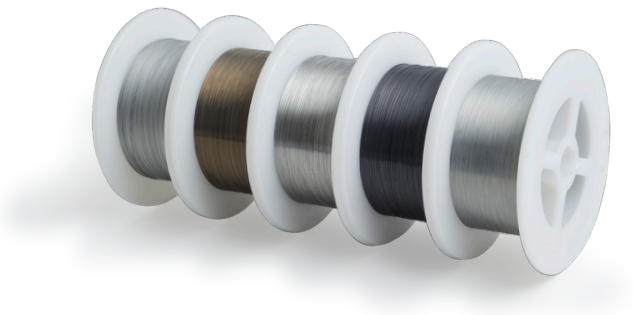
Precision Nitinol melting

We believe in ensuring quality at the source. As a trusted melt-to-finish supplier for Nitinol to the medical device industry, we carefully control our process to ensure the Nitinol you use for critical applications is of the highest quality.

Surface finishes & material conditions

We offer a variety of surface finishes so you can tailor our Nitinol to your exact needs.

- **Light oxide:** diamond drawn surface
- **Dark oxide:** diamond drawn surface
- **Etched:** chemical removal of oxide layer while maintaining smooth surface
- **Pickled:** chemical removal of oxide layer along with a slight amount of base metal - surface will have a rough texture
- **Etched and mechanically polished:** chemical removal of oxide layer followed by mechanical polish - surface will have stainless steel appearance although at > 40x magnification micro scratches are present



Superelastic Nitinol

Superelastic Nitinol's phase transformation in environments as cool as body or room temperatures, makes these cooler grades more common in medical devices or other lower temperature applications.

Examples of uses for superelastic Nitinol

NiTi #1 is commonly used for applications requiring superelasticity at room and body temperatures. Typical applications include guidewires, stents, stylets, forming mandrels, stone retrieval baskets, and orthodontic files.

NiTi #2 is a ternary grade of Nitinol containing additions of chromium (0.2 to 0.3% Cr by weight) and is often used in applications requiring increased loading and unloading plateau stresses and decreased transformation temperatures.

NiTi #3 is a ternary grade of Nitinol containing additions of cobalt (1.0 to 2.0% Co by weight) and is often used to maximize loading and unloading plateau stresses over other Nitinol grades. Decreased transformation temperatures also allow this grade of Nitinol to remain superelastic in colder temperature applications.

NiTi #4 has the warmest transformation temperatures of our superelastic grades, resulting in decreased modulus and plateau stresses and improved fatigue performance at room and body temperatures when compared to other superelastic Nitinol grades with equivalent previous cold work and heat treatments.

NiTi #9 is the coldest grade of binary Nitinol that we offer and is used for applications requiring superelasticity at colder temperatures.

After an appropriate heat treatment, superelastic Nitinol will accommodate strain of up to 8% in tension without significant permanent deformation, when tested at room temperature which is above the transformation temperature of the material.

All binary Nitinol grades meet the chemistry requirements set forth by ASTM F2063 for use in surgical implants.

Superelastic thermal and mechanical properties table

		Cold worked		Superelastic				
Product	Ingot A_s (°C)	UTS (MPa) [ksi]	Elongation (%)	UTS (MPa) [ksi]	Elongation (%)	Upper plateau (MPa) [ksi]	Lower plateau (MPa) [ksi]	Active A_f (°C)
NiTi #1	-35 to -10	1379 [200]	> 4%	1241 [180]	> 10%	> 483 [> 70]	> 138 [> 20]	10 to 18
NiTi #2	-65 to 5	1655 [240]	> 4%	1378 [200]	> 10%	> 552 [> 80]	>207 [> 30]	0 to 18
NiTi #3	-95 to -65	1379 [200]	> 4%	1241 [180]	> 10%	> 689 [> 100]	> 414 [> 60]	-20 to -10
NiTi #4	-10 to 10	1379 [200]	> 4%	1241 [180]	> 10%	> 448 [> 65]	> 48 [> 7]	14 to 22
NiTi #9	≤ -35	1379 [200]	> 4%	1103 [160]	> 10%	> 517 [> 75]	> 172 [> 25]	-10 to 5

Permanent set < 0.5% after strained to 8%. Results are typical for round wire diameters from 0.03 mm to 1.02 mm [0.001 in to 0.04 in]. All mechanical testing conducted at 22°C ± 2°C [71.6°F ± 3.6°F].

Shape memory Nitinol

Categorized as warmer grades of Nitinol, shape memory is more appropriate for use in high temperature industrial applications. Shape memory grades are also about to take the spotlight for their use in Nitinol actuators.
Shape memory isn't limited to use in industrial applications. Designs often leverage phase transformation at body temperature (37 °C [98.6 °F]), making shape memory Nitinol useful for medical devices.

Examples of uses for shape memory grades

NiTi #5 AND NiTi #6 are commonly used in high temperature actuators.

NiTi #8 is typically used in applications that require a phase transformation at body temperature.

All binary Nitinol grades meet the chemistry requirements set forth by ASTM F2063 for use in surgical implants.

Shape memory thermal and mechanical properties table

		Cold worked		Straight annealed		
Product	Ingot A_s (°C)	UTS (MPa) [ksi]	Elongation (%)	UTS (MPa) [ksi]	Elongation (%)	Active A_f (°C)
NiTi #5	≥ 85	1310 [190]	> 3%	1069 [155]	> 10%	≥ 85
NiTi #6	35 to 85	1310 [190]	> 3%	1069 [155]	> 10%	40 to 80
NiTi #8	10 to 35	1517 [200]	> 3%	1103 [160]	> 10%	22 to 40

All mechanical testing is conducted at 22 °C ± 2 °C [71.6 °F ± 3.6 °F].

Less is more with Nitinol actuators

Actuator wire can perform work through a phase transformation. Simply put, a bias load or force will elongate the wire, and a phase change induced using heat or electricity will cause the wire to contract. As the material cycles, contracting as heat is applied and elongating as it cools, the actuator performs work, which could include pulling a release valve, lifting loads, or otherwise applying force. Using a wire to perform work has several advantages. At the forefront is its high work density, meaning it can generate a large amount of work for a relatively small footprint. Another benefit is its comparative silence by eliminating the need for noisy motors.

*To learn more about acuators, please refer to **page 36**.*

Wire footage conversion charts

Stainless steel conversion chart - UNS 30400 (type 304)

Diameter in	Area in²	ft/lb
0.0005	**0.00000020**	**1483962**
0.0006	**0.00000028**	**1030529**
0.0007	**0.00000038**	**757124**
0.0008	**0.00000050**	**579673**
0.0009	**0.00000064**	**458013**
0.0010	**0.00000079**	**370991**
0.0011	**0.00000095**	**306604**
0.0012	**0.00000113**	**257632**
0.0013	0.00000133	219521
0.0014	**0.00000154**	**189281**
0.0015	0.00000177	164885
0.0016	**0.00000201**	**144918**
0.0017	0.00000227	128370
0.0018	**0.00000254**	**114503**
0.0019	0.00000284	102767
0.0020	**0.00000314**	**92748**
0.0021	0.00000346	84125
0.0022	**0.00000380**	**76651**
0.0023	0.00000415	70131
0.0024	0.00000452	64408
0.0025	**0.00000491**	**59358**
0.0026	0.00000531	54880
0.0027	0.00000573	50890
0.0028	**0.00000616**	**47320**
0.0029	0.00000661	44113
0.0030	0.00000707	41221
0.0031	**0.00000755**	**38605**
0.0032	0.00000804	36230
0.0033	0.00000855	34067
0.0034	0.00000908	32093
0.0035	**0.00000962**	**30285**
0.0036	0.00001018	28626
0.0037	0.00001075	27099
0.0038	0.00001134	25692
0.0039	0.00001195	24391
0.0040	**0.00001257**	**23187**
0.0041	0.00001320	22070
0.0042	0.00001385	21031
0.0043	0.00001452	20064
0.0044	0.00001521	19163
0.0045	**0.00001590**	**18321**
0.0046	0.00001662	17533
0.0047	0.00001735	16795
0.0048	0.00001810	16102
0.0049	0.00001886	15452
0.0050	**0.00001963**	**14840**
0.0051	0.00002043	14263
0.0052	0.00002124	13720
0.0053	0.00002206	13207
0.0054	0.00002290	12723
0.0055	0.00002376	12264
0.0056	**0.00002463**	**11830**
0.0057	0.00002552	11419
0.0058	0.00002642	11028
0.0059	0.00002734	10658
0.0060	0.00002827	10305
0.0061	0.00002922	9970
0.0062	0.00003019	9651
0.0063	**0.00003117**	**9347**
0.0064	0.00003217	9057
0.0065	0.00003318	8781
0.0066	0.00003421	8517
0.0067	0.00003526	8264
0.0068	0.00003632	8023
0.0069	0.00003739	7792
0.0070	**0.00003848**	**7571**
0.0071	0.00003959	7359
0.0072	0.00004072	7156
0.0073	0.00004185	6962
0.0074	0.00004301	6775
0.0075	0.00004418	6595
0.0076	0.00004536	6423
0.0077	0.00004657	6257
0.0078	0.00004778	6098
0.0079	**0.00004902**	**5944**
0.0080	0.00005027	5797
0.0081	0.00005153	5654
0.0082	0.00005281	5517
0.0083	0.00005411	5385
0.0084	0.00005542	5258
0.0085	0.00005675	5135
0.0086	0.00005809	5016
0.0087	0.00005945	4901
0.0088	0.00006082	4791
0.0089	**0.00006221**	**4684**
0.0090	0.00006362	4580
0.0091	0.00006504	4480
0.0092	0.00006648	4383
0.0093	0.00006793	4289
0.0094	0.00006940	4199
0.0095	0.00007088	4111
0.0096	0.00007238	4026
0.0097	0.00007390	3943
0.0098	0.00007543	3863
0.0099	0.00007698	3785
0.0100	**0.00007854**	**3710**
0.0101	0.00008012	3637
0.0102	0.00008171	3566
0.0103	0.00008332	3497
0.0104	0.00008495	3430
0.0105	0.00008659	3365
0.0106	0.00008825	3302
0.0107	0.00008992	3240
0.0108	0.00009161	3181
0.0109	0.00009331	3123
0.0110	0.00009503	3066
0.0111	0.00009677	3011
0.0112	0.00009852	2958
0.0113	**0.00010029**	**2905**
0.0114	0.00010207	2855
0.0115	0.00010387	2805
0.0116	0.00010568	2757
0.0117	0.00010751	2710
0.0118	0.00010936	2664
0.0119	0.00011122	2620
0.0120	0.00011310	2576
0.0121	0.00011499	2534
0.0122	0.00011690	2493
0.0123	0.00011882	2452
0.0124	0.00012076	2413
0.0125	0.00012272	2374
0.0126	**0.00012469**	**2337**
0.0127	0.00012668	2300
0.0128	0.00012868	2264
0.0129	0.00013070	2229
0.0130	0.00013273	2195
0.0131	0.00013478	2162
0.0132	0.00013685	2129
0.0133	0.00013893	2097
0.0134	0.00014103	2066
0.0135	0.00014314	2036
0.0136	0.00014527	2006
0.0137	0.00014741	1977
0.0138	0.00014957	1948
0.0139	0.00015175	1920
0.0140	0.00015394	1893
0.0141	0.00015615	1866
0.0142	**0.00015837**	**1840**
0.0143	0.00016061	1814
0.0144	0.00016286	1789
0.0145	0.00016513	1765
0.0146	0.00016742	1740
0.0147	0.00016972	1717
0.0148	0.00017203	1694
0.0149	0.00017437	1671
0.0150	0.00017671	1649
0.0151	0.00017908	1627
0.0152	0.00018146	1606
0.0153	0.00018385	1585
0.0154	0.00018627	1564
0.0155	0.00018869	1544
0.0156	0.00019113	1524
0.0157	0.00019359	1505
0.0158	0.00019607	1486
0.0159	**0.00019856**	**1467**
0.0160	0.00020106	1449
0.0161	0.00020358	1431
0.0162	0.00020612	1414
0.0163	0.00020867	1396
0.0164	0.00021124	1379
0.0165	0.00021382	1363
0.0166	0.00021642	1346
0.0167	0.00021904	1330
0.0168	0.00022167	1314
0.0169	0.00022432	1299
0.0170	0.00022698	1284
0.0171	0.00022966	1269
0.0172	0.00023235	1254
0.0173	0.00023506	1240
0.0174	0.00023779	1225
0.0175	0.00024053	1211
0.0176	0.00024328	1198
0.0177	0.00024606	1184
0.0178	0.00024885	1171
0.0179	**0.00025165**	**1158**
0.0180	0.00025447	1145
0.0181	0.00025730	1132
0.0182	0.00026016	1120
0.0183	0.00026302	1108
0.0184	0.00026590	1096
0.0185	0.00026880	1084
0.0186	0.00027172	1072
0.0187	0.00027465	1061
0.0188	0.00027759	1050
0.0189	0.00028055	1039
0.0190	0.00028353	1028
0.0191	0.00028652	1017
0.0192	0.00028953	1006
0.0193	0.00029255	996
0.0194	0.00029559	986
0.0195	0.00029865	976
0.0196	0.00030172	966
0.0197	0.00030481	956
0.0198	0.00030791	946
0.0199	0.00031103	937
0.0200	0.00031416	927
0.0201	**0.00031731**	**918**
0.0202	0.00032047	909
0.0203	0.00032365	900
0.0204	0.00032685	891
0.0205	0.00033006	883
0.0206	0.00033329	874
0.0207	0.00033654	866
0.0208	0.00033979	858
0.0209	0.00034307	849
0.0210	0.00034636	841
0.0211	0.00034967	833
0.0212	0.00035299	825
0.0213	0.00035633	818
0.0214	0.00035968	810
0.0215	0.00036305	803
0.0216	0.00036644	795
0.0217	0.00036984	788
0.0218	0.00037325	781
0.0219	0.00037668	774
0.0220	0.00038013	767
0.0221	0.00038360	760
0.0222	0.00038708	753
0.0223	0.00039057	746
0.0224	0.00039408	739
0.0225	0.00039761	733
0.0226	**0.00040115**	**726**
0.0227	0.00040471	720
0.0228	0.00040828	714
0.0229	0.00041187	707
0.0230	0.00041548	701
0.0231	0.00041910	695
0.0232	0.00042273	689
0.0233	0.00042638	683
0.0234	0.00043005	678
0.0235	0.00043374	672
0.0240	0.00045239	644
0.0245	0.00047144	618
0.0250	0.00049087	594
0.0253	**0.00050273**	**580**
0.0255	0.00051071	571
0.0260	0.00053093	549
0.0265	0.00055155	528
0.0270	0.00057256	509
0.0275	0.00059396	491
0.0280	0.00061575	473
0.0285	**0.00063794**	**457**
0.0290	0.00066052	441
0.0295	0.00068349	426
0.0300	0.00070686	412
0.0305	0.00073062	399
0.0310	0.00075477	386
0.0315	0.00077931	374
0.0320	**0.00080425**	**362**
0.0325	0.00082958	351
0.0330	0.00085530	341
0.0335	0.00088141	331
0.0340	0.00090792	321
0.0350	0.00096211	303
0.0359	**0.00101223**	**288**
0.0360	0.00101788	286
0.0370	0.00107521	271
0.0380	0.00113411	257
0.0390	0.00119459	244
0.0400	0.00125664	232
0.0403	**0.00127556**	**228**
0.0410	0.00132025	221
0.0420	0.00138544	210
0.0430	0.00145220	201
0.0440	0.00152053	192
0.0450	0.00159043	183
0.0453	**0.00161171**	**181**
0.0460	0.00166190	175
0.0470	0.00173494	168
0.0480	0.00180956	161
0.0490	0.00188574	155
0.0500	0.00196350	148
0.0508	**0.00202683**	**144**
0.0510	0.00204282	143
0.0520	0.00212372	137
0.0530	0.00220618	132
0.0540	0.00229022	127
0.0550	0.00237583	123
0.0560	0.00246301	118
0.0570	**0.00255176**	**114**
0.0580	0.00264208	110
0.0590	0.00273397	107
0.0600	0.00282743	103
0.0610	0.00292247	100
0.0620	0.00301907	97
0.0630	0.00311725	93
0.0640	**0.00321699**	**91**
0.0650	0.00331831	88
0.0660	0.00342119	85
0.0670	0.00352565	83
0.0680	0.00363168	80
0.0690	0.00373928	78
0.0700	0.00384845	76
0.0710	0.00395919	74
0.0720	**0.00407150**	**72**
0.0730	0.00418539	70
0.0740	0.00430084	68
0.0750	0.00441786	66
0.0760	0.00453646	64
0.0770	0.00465663	63
0.0780	0.00477836	61
0.0790	0.00490167	59
0.0800	0.00502655	58
0.0810	**0.00515300**	**57**
0.0850	0.00567450	51
0.0900	0.00636173	46
0.0910	**0.00650388**	**45**
0.0950	0.00708822	41
0.1020	**0.00817128**	**36**
0.1140	**0.01020703**	**29**
0.1280	**0.01286796**	**23**
0.1440	**0.01628602**	**18**
0.1620	**0.02061199**	**14**
0.1820	**0.02601553**	**11**
0.2040	**0.03268513**	**9**

Density for 304 stainless steel is 0.286 lbs/in³

Bold face indicates AWG sizes.

Wire footage conversion charts

Multiplying factors for 304 footage conversion charts

Alloys		
Factor	Type	Density
1.000	302, 304 stainless steel	0.286
0.997	316, 316LVM stainless steel	0.287
1.025	420 stainless steel	0.279
1.021	455 stainless steel	0.280
1.021	17-4-PH® stainless steel	0.280
1.014	17-7 PH® stainless steel	0.282
1.021	18Cr-2Ni-12Mn	0.280
1.004	22Cr-13Ni-5Mn	0.285
0.941	35N LT™	0.304
0.957	Inconel® Alloy X-750	0.299
0.960	Alloy 41	0.298
0.938	Inconel® Alloy 625	0.305
0.941	Alloy 650	0.304
0.976	Alloy 902	0.293
0.891	Hastelloy® Alloy C276	0.321
0.891	CBX Cupron®	0.321
1.014	Custom 470®	0.282
1.007	Custom 475®	0.284
0.976	Evanohm® R	0.293
0.953	FWM™ 1058	0.300
0.957	FWM™ 1537	0.299
0.905	HyMu 80™	0.316
0.859	L-605	0.333
0.941	MP35N®	0.304
0.935	NiAl® II	0.306
0.905	Niclal 47	0.316
1.227	Nitinol	0.233
0.477	Ta-R05400	0.600
1.765	Ti-3Al-2.5V	0.162
1.788	Ti 6Al-4V ELI	0.160
1.788	Ti 6Al-7Nb	0.160
1.563	Ti-Beta 3	0.183
0.941	Tophet® A	0.304
0.960	Tophet® C	0.298
1.021	Trimrite®	0.280

Metals		
Factor	Type	Density
0.885	Copper (Cu)	0.323
1.755	CP Titanium (CP Ti)	0.163
0.410	Gold (Au)	0.698
1.007	Iron (Fe)	0.284
0.891	Nickel (Ni)	0.321
0.369	Platinum (Pt)	0.775
0.755	Silver (Ag)	0.379
0.477	Tantalum (Ta)	0.600
0.410	Tungsten (W)	0.697
1.212	Zirconium (Zr)	0.236

Composites		
Factor	Type	Density
0.940	22Cr-13Ni-5Mn-DBS®(7)-Ag	0.304
0.935	316L-DBS®(7)-Ag	0.306
0.907	35N LT®-DFT®-15%Ag	0.315
0.886	35N LT®-DFT®-25%Ag	0.323
0.880	35N LT®-DFT®-28%Ag	0.325
0.656	35N LT®-DFT®-28%Pt	0.436
0.870	35N LT®-DFT®-33%Ag	0.329
0.854	35N LT®-DFT®-41%Ag	0.335
0.575	35N LT®-DFT®-41%Pt	0.497
0.763	FWM® 1058-DFT®-25%Ta	0.375
0.996	NiTi 1-DFT®-10%Pt	0.287
0.838	NiTi 1-DFT®-20%Pt	0.341
0.722	NiTi 1-DFT®-30%Pt	0.396
0.636	NiTi 1-DFT®-40%Pt	0.450
1.059	NiTi 1-DFT®-10%Ta	0.270
0.834	NiTi 1-DFT®-30%Ta	0.343


flexible design
looped end fitting
X + X = ?
rotational control
tight tolerances
flexible design
X + X = ?
flexible design
rotational control

Products

Round wire

Round wire's shape might be simple, but the materials and processes used to make it can yield a surprisingly complex product. It isn't just wire in its most basic form—it's the foundation for nearly all our other products, ranging from flat wire to complex strands and cable constructions.

Understanding round wire

Round wire starts at a larger diameter and is expertly drawn down to customer specifications, all the way to ultra-fine diameters smaller than a human hair. It comes in standard stainless steel, Nitinol, titanium, and other high-performance alloys that are customized to serve almost any application.

Typical end uses

Round wire can be used on its own, or as a component in strands, cables, mechanical assemblies, or other constructions that contribute to customer end uses such as:

- Pacing leads
- Articulation devices
- Endoscopic devices
- Minimally invasive surgical instruments

Design specifications

The first step to creating custom round wire is choosing the right material.

AVAILABLE ALLOYS

- **Stainless steel:** for strength and corrosion resistance
- **High-performance alloys:** for fatigue life, strength, and corrosion resistance
- **Nitinol:** for shape memory and superelastic performance
- **Titanium:** for strength and biocompatibility

SIZE RANGE

- Round wire can be manufactured in diameters ranging from 0.0127 mm to 13.97 mm [0.0005 in to 0.550 in].

Flat wire

Flat wire has a rectangular cross section and a smooth, bright surface. That's why it is often called ribbon wire. When you need to reduce a wire profile without sacrificing performance, you can leverage the unusual rectangular cross section of flat wire, which may provide an advantage over traditional round wire.

Understanding flat wire

The two methods used to produce flat wire are drawing and rolling, each of which provide different benefits. You can use the information below to compare rolled and drawn flat wire to find the right product for your application.

Typical end uses

Our customers use flat wire for many different applications, including:

- Percutaneous catheters
- Neurovascular devices
- Endovascular devices
- Self-expanding stents and delivery systems
- Coronary stents
- Stone retrieval baskets
- Catheter-based heart pumps
- Orthodontic clips
- Suture passers

Product forms and capabilities

Flat wire can be utilized in different product forms, or used in custom component assemblies, to create even more customized solutions. Flat wire can be ordered on a spool or in cut lengths to streamline your production processes. Additional processing for flat wire includes:

CUSTOM ASSEMBLY of crimps, fittings, and specialized parts

SHAPE SETTING custom Nitinol wire constructions that can deform and return to a set shape

COATING carefully applied to provide electrical insulation or chemical separation

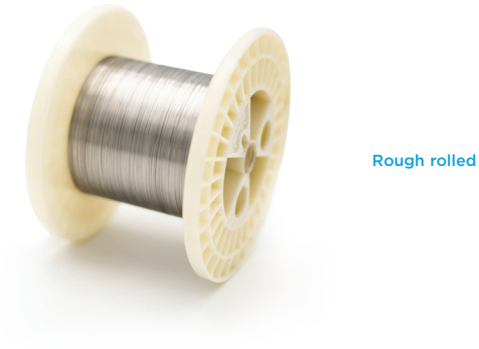
Surface finishes

Rolled wire is available in three surface finishes:

ROUGH ROLLED duller, rougher appearance

SEMI-BRIGHT slightly less mirror-like appearance, more consistent surface finish

BRIGHT clear, mirror-like appearance



Rough rolled

Semi-bright

Bright

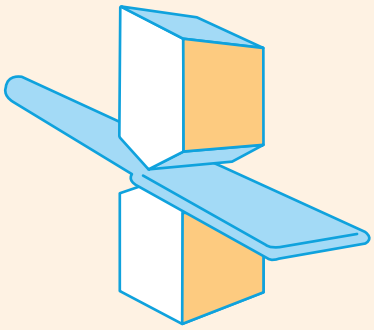
Information continued on next page.

Flat wire

Drawn flat wire

The process to produce drawn flat wire results in a more precise product, offering benefits such as:

- Improved size tolerances
- More consistent dimensions



Drawn flat wire

AVAILABLE ALLOYS

- **Stainless steel:** for strength and corrosion resistance
- **High-performance alloys:** for fatigue life, strength, and corrosion resistance
- **Nitinol:** for shape memory and superelastic performance
- **Titanium:** for strength and biocompatibility

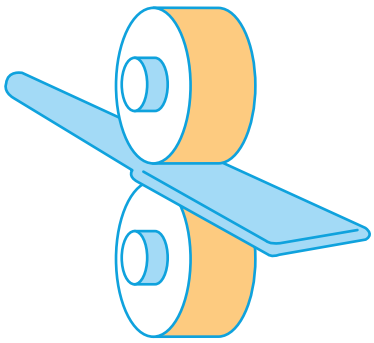
DESIGN PARAMETERS

- Drawn flat wire should be stress relieved after the initial drawing to help improve its cast and camber.
- Drawn flat wire can be produced as thin as 0.0635 mm [0.0025 in]
- Typical thickness tolerance for drawn flat wire is ±10% of the thickness rounded up to the next 0.0025 mm [0.0001 in], with a minimum of ±0.0025 mm [±0.0001 in]
- Typical width tolerance is ±10% of the width rounded up to the next 0.0025 mm [0.0001 in], with a minimum of ±0.0076 mm [±0.0003 in]

Rolled flat wire

Rolled flat wire has a larger cast, less camber, and less stress induced in the wire when compared with drawn flat wire of the same width to thickness ratio. Additional benefits include:

- If straightness is critical to the application, rolled flat wire can be stress relieved to improve overall straightness
- Options for tighter packaging of spools
- Optional textured surfaces



Rolled flat wire

AVAILABLE ALLOYS

- **Stainless steel:** for strength and corrosion resistance
- **High-performance alloys:** for fatigue life, strength, and corrosion resistance
- **Nitinol:** for shape memory and superelastic performance
- **Titanium:** for strength and biocompatibility

DESIGN PARAMETERS

- Typical width/thickness ratio is 3:1 minimum to a 10:1 maximum
- Minimum thickness is 0.0127 mm [0.0005 in]
- Typical thickness tolerance for rolled flat wire is ±10% of the thickness rounded up to the next 0.0025 mm [0.0001 in], with a minimum of ±0.005 mm [±0.0002 in]
- Typical width tolerance is ±10% of the width rounded up to the next 0.0025 mm [0.0001 in], with a minimum of ±0.0076mm [±0.0003in]

Shaped wire

Shaped wire allows you to leverage the versatility of nonstandard profiles. From triangles to crescent shapes, or wire with a continuous helical groove, we manufacture shaped wire in a variety of alloys. To do this, we use specialized tooling and processing, creating a unique construction that decreases the overall cross-sectional area.

Finding the right shape

We make a number of standard shapes, but we're always willing to push the boundaries. Explore our shaped wire offerings to find just the right fit for your applications.

Product forms and capabilities

We can supply shaped wire in cut lengths. We can also perform a number of other assembly operations to help you reduce process steps or eliminate in-house assembly needs.

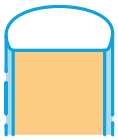
Typical end uses

With so many different constructions, shaped wire finds use in a variety of end applications. We often see our customers use shaped wire in catheter wires where the unique shapes allow them to fit multiple wires for a single entry point within the same overall diameter.

- Catheters
- Staples
- Coiling applications
- Shaped guidewires
- Tooling
- Needles
- Deployment mechanisms

Designing with shaped wire

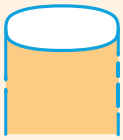
Shaped wire can be manufactured to fit a variety of applications, making it a versatile design component. Given the unusual profiles of shaped wire, our Engineering teams use specific terminology and measurements to tailor products to your specifications. The illustrations to the right can help guide your conversation with your Sales Representative about what shaped wire can do for your application.



D-WIRE

0.0762 mm x 0.127 mm to 1.016 mm x 2.032 mm
[0.003 in x 0.005 in to 0.040 in x 0.080 in]

- Half-round, over half-round, under half-round



ELLIPTICAL WIRE

0.0762 mm x 0.127 mm to 0.508 mm x 1.524 mm
[0.003 in x 0.005 in to 0.020 in x 0.060 in]

TRIANGLE WIRE

0.1143 mm x 0.216 mm to 1.016 mm x 1.143 mm
[0.0045 in x 0.0085 in to 0.040 in x 0.045 in]

GROOVED WIRE

0.254 mm to 0.762 mm [0.010 in to 0.030 in]

- Groove size can range from 4 to 20% of the cross-sectional area

Manufactured with Nitinol, 304V stainless steel, 316LVM stainless steel, and 35N LT™ alloy

TURKSHEAD WIRE

0.152 mm x 0.152 mm to 0.889 mm x 0.889 mm
[0.006 in x 0.006 in to 0.035 in x 0.035 in]

- Max width/thickness ratio of 2:1

CRESCENT WIRE

0.147 mm x 0.254 mm to 1.016 mm x 1.524 mm
[0.0058 in x 0.010 in to 0.040 in x 0.060 in]

PIE WIRE

0.142 mm x 0.177 mm to 0.762 mm x 1.143 mm
[0.0056 in x 0.007 in to 0.030 in x 0.045 in]

- Wire angle: 45° to 120°

Bar products

Strong, straight, and smooth. Despite their deceptively simple appearance, bar products are used in a variety of demanding applications, and you need your bar to withstand whatever you throw at it. That's why our products are made to tight tolerances and custom specifications, ensuring that you get exactly what you need.

Understanding bar products

Bar is typically produced as centerless ground, offering a straight product with tight tolerances and a smooth, polished surface. Bar products are manufactured to meet your specifications for tensile strength, yield strength, diameter tolerance, and length. Depending on the alloy, bar can offer strength, corrosion resistance, and good biocompatibility, making this product remarkably adaptable.

Typical end uses

Our customers have used bar products to make:

- Orthopaedic screws
- Orthopaedic guidewires
- Pins
- Spinal rods
- Dental implants

Surface finishes

Bar is available in two surface finishes, allowing you to select the right bar for your application, whether that means a premium, ready-to-go finish, or a rougher, more economical surface primed for additional processing.

CENTERLESS GROUND AND POLISHED BAR

- Bright, smooth surface
- Consistent diameter and surface
- Often used in applications that require premium bar surface

Design specifications

- 1 mm to 12 mm [0.040 in to 0.500 in]
- Standard diameter tolerance: ± 0.0127 mm [0.0005 in]
- Surface Ra
  - Stainless steel: <0.4 µm [16 µin]
  - High-performance alloys: <0.4 µm [16 µin]
  - Titanium: <0.8 µm [32 µin]

MILL FINISH

- Rough, matte surface
- More economical than centerless ground and polished
- Less uniform diameter and surface
- Often used in manufacturing steps that require removal of material

Design specifications

- 1.59 mm to 12 mm [0.0625 in to 0.500 in]
- Standard diameter tolerance: ± 0.0254 mm [0.001 in]
- Surface Ra: <1.6 µm [64 µin]
  - Surface Ra does not vary with alloy

Design specifications

The first step to creating custom bar products is choosing the right material. Below is a list of our wide selection of alloys.

AVAILABLE ALLOYS

- **Stainless steel:** for strength and corrosion resistance
- **High-performance alloys:** for fatigue life, strength, and corrosion resistance
- **Nitinol:** for shape memory and superelastic performance
- **Titanium:** for strength and biocompatibility

SLT® wire

SLT® wire is straight wire right off the spool with no need for additional processing. Carefully engineered to eliminate process steps and reduce machine downtime, SLT® wire offers the ability to streamline production without sacrificing performance.

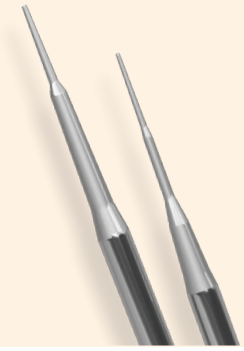
Understanding SLT® wire

You can customize SLT® wire for your intended application by selecting one of the four distinct types. You can use the information below to compare all four or read on to learn more about each type. The surface finish for all SLT® wire is bright.

Alloys

SLT® wire is available in the following alloys:

- 304V
- 316LVM
- FWM™ 1058 alloy
- 35N LT™ alloy
- MP35N® alloy
- Ti 6Al-4V ELI
- Ti 3Al-2.5V



Additional processing capabilities

No matter how you need your SLT® wire, we're here to make sure you get exactly what you need. We can supply SLT® wire in cut lengths or on a spool, and provide additional processing, such as:

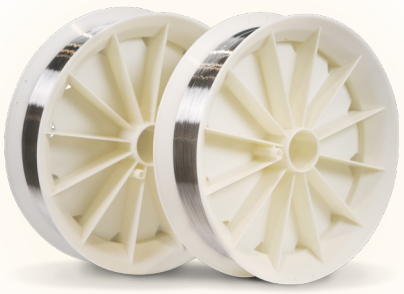
COATING to provide electrical insulation or chemical separation

LASER ABLATION for adjustable coating coverage

TAPER GRINDING for additional flexibility

MECHANICAL ASSEMBLY of crimps, fittings, and specialized parts

Information continued on next page.



Design specifications

The chart below details the material condition, surface finish, and diameter possibilities for each type of SLT® wire.

Types of SLT® wire	Condition	Size range	
		Millimeters (mm)	Inches (in)
Type 1	Half hard	0.0381 – 1.3716	0.0015 – 0.0540
	3/4 hard		
	Hard		
	Spring		
	Ultra spring		
	Hyten	0.0508 – 0.8890	0.0020 – 0.0350
Type 2	Hard	0.0508 – 1.0033	0.0020 – 0.0395
	Spring		
	Ultra spring		
	Hyten	0.0508 – 0.8890	0.0020 – 0.0350
Type 3	Hard	0.0508 – 1.0033	0.0020 – 0.0395
	Spring		
	Double spring		
	Ultra spring	0.0508 – 0.9398	0.0020 – 0.0370
	Hyten	0.0508 – 0.8890	0.0020 – 0.0350
Type 4	Spring	0.1981 – 0.8712	0.0078 – 0.0343
	Ultra spring		
	Hyten	0.1981 – 0.7620	0.0078 – 0.0300

The sizes and conditions above reflect SLT® wire made with 304V. If your product need falls outside of the above parameters, please contact your Sales Representative to see how we can meet your specific requirements.

SLT® wire

Type 1

Eliminate manufacturing process steps and the need for additional equipment with already straight wire.
Typical end uses:

› Staples
› Braiding mandrels
› Dental probes

STRAIGHTNESS VARIANCE 25.4 mm per 304.8 mm [1.00 in per 12.00 in]
PACKING SPECIFICATIONS wire on a spool
MIN HUB SIZE 220x wire diameter

Type 2

Eliminate the need for mechanical straightening and leverage rotary-mark-free surface with no need for further polishing. Typical end uses:

› Needles
› Staples
› Point coiling
› Micro-needles

STRAIGHTNESS VARIANCE 2.997 mm per 304.8 mm [0.118 in per 12.00 in]
PACKING SPECIFICATIONS wire on a spool or cut to length
MIN HUB SIZE 300x wire diameter

Type 3

Eliminate the need to straighten and remove up to 90% of the cross-sectional area by taper grinding without requiring heat treatment. Meets ASTM F2819 standards. Typical end uses:

› Orthodontics
› Suture needles
› Guidewires
› Endoscopes
› Embolic filters

STRAIGHTNESS VARIANCE 0.508 mm per 304.8 mm [0.02 in per 12.00 in]
PACKING SPECIFICATIONS wire on a spool or cut to length
MIN HUB SIZE 400x wire diameter

Type 4

Leverage 1:1 torque transmission and remove up to 95% of the cross-sectional area by deep taper grinding without requiring additional heat treatment or resulting in pigtailing. Meets ASTM F2819 standards. Typical end uses:

› Steerable PTCA
› Endoscopes
› Guidewires
› Other precision applications

STRAIGHTNESS VARIANCE 0.254 mm per 304.8 mm [0.01 in per 12.00 in]
PACKING SPECIFICATIONS cut to length only

NDR® wire

Some applications require better performance under stressful conditions than typical materials can provide. That's why we make NDR® wire. Specially manufactured to increase performance without compromising the chemical properties of your chosen material, you can achieve improved fatigue life in challenging applications.

Understanding NDR® wire

NDR® wire offers greater fatigue life without altering the chemical properties of the material. Using a proprietary thermal-mechanical treatment designed to produce nanoscale microstructure refinement, NDR® wire provides increased performance under repeated use while maintaining the properties of conventional wire.

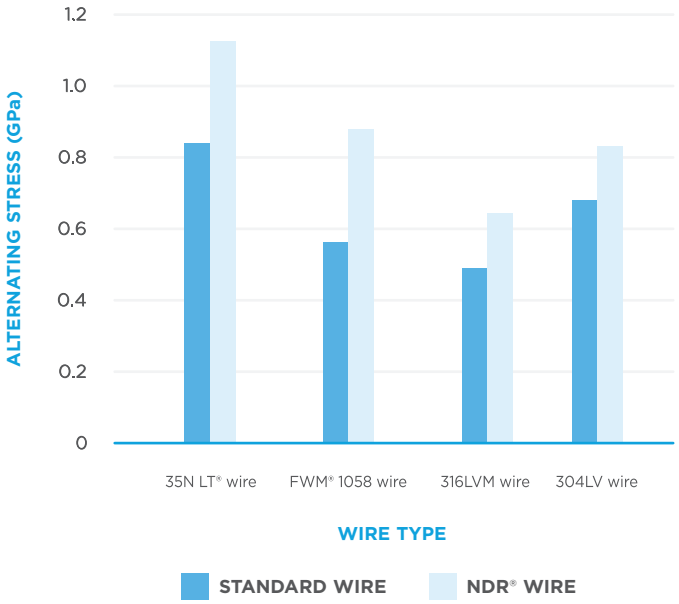
Design specifications

NDR® wire can be manufactured with the following materials, with size range dependent on processing parameters:

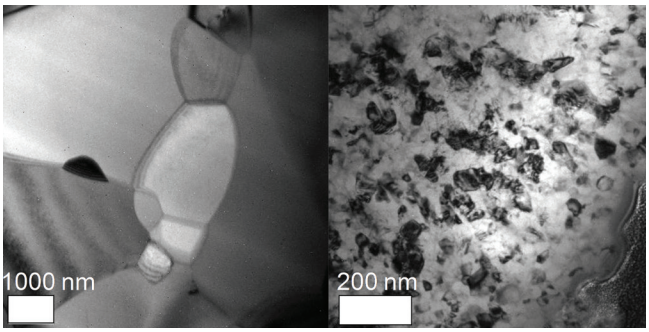
- **35N LT™ alloy:** enhanced fatigue life, strength, and corrosion resistance
- **MP35N® alloy:** high fatigue life, strength, and corrosion resistance
- **FWM™ 1058 alloy:** high strength and corrosion resistance
- **316LVM stainless steel:** improved microcleanliness, ductility, and corrosion resistance

Fatigue strength

You can use the chart below as a reference point for fatigue life and microstructure for NDR® wire.



Grain structure



Silk® Nitinol wire

Our Silk® Nitinol wire is an ultra-smooth oxide-free Nitinol wire. Engineered to eliminate the need for electropolishing your oxide-free Nitinol to achieve a smooth surface, Silk® Nitinol wire features a surface roughness of 3 µin (0.0762 µm) RMS or less. By avoiding the traditional methods for achieving oxide-free Nitinol, like etching, you get a smooth, bright surface without comprising surface roughness.

Understanding Silk® Nitinol wire

The ultra-smooth surface of Silk® Nitinol wire has been found to reduce snags in braiding operations by reducing the friction between filars of wire. In addition to eliminating the need for mechanical or electropolishing, Silk® Nitinol wire has a bright, smooth surface, offers slightly increased fatigue strength, and is otherwise equivalent to our etched bright Nitinol.

Design specifications

Silk® Nitinol wire is available as round wire in diameters ranging from 0.020 mm to 1.01 mm [0.0008 in to 0.040 in], and can be manufactured in the following grades of Nitinol:

- **NiTi #1** is commonly used for applications requiring superelasticity at room and body temperature. Typical applications include guidewires, stents, stylets, forming mandrels, stone retrieval baskets, and orthodontic files.
- **NiTi #2** is a ternary grade of Nitinol containing additions of chromium and is often used in applications requiring increased loading and unloading plateau stresses and decreased transformation temperatures.
- **NiTi #4** has the warmest transformation temperatures of our superelastic grades, resulting in decreased plateau stresses and improved fatigue performance at room and body temperature.
- **NiTi #8** is typically used in applications that require a phase transformation at body temperature.

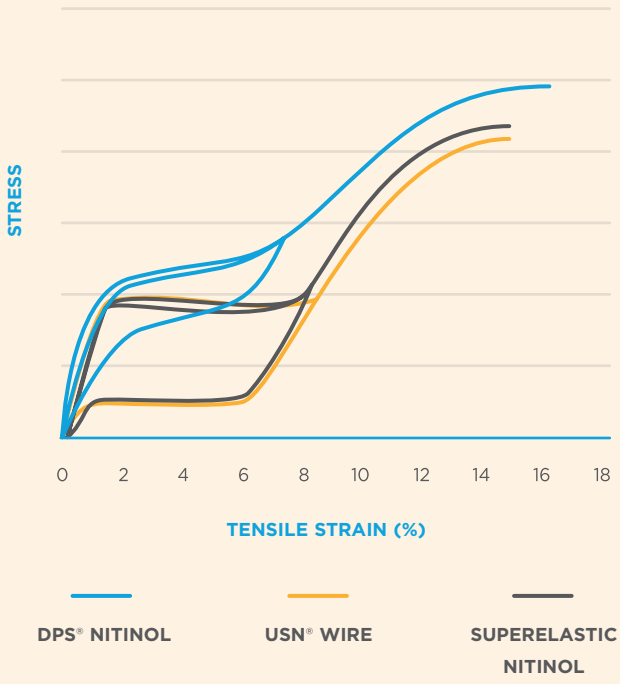
DPS® Nitinol wire

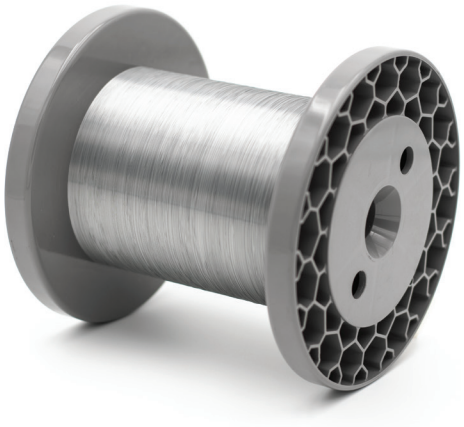
DPS® Nitinol wire offers high stiffness in applications requiring between a 1.5% and 8% strain, where the material enters the plateau region on a stress-strain curve. Guidewire made from DPS® Nitinol that has undergone a slight initial bend will exhibit greater resistance to being bent further than standard Nitinol of the same grade and diameter.

Design specifications

Available in diameters from 0.228 mm to 0.762 mm [0.0090 in to 0.0300 in] and in discrete lengths ranging from 12.7 mm to 3.657 m [0.5 in to 12 ft].

Stress/strain curve





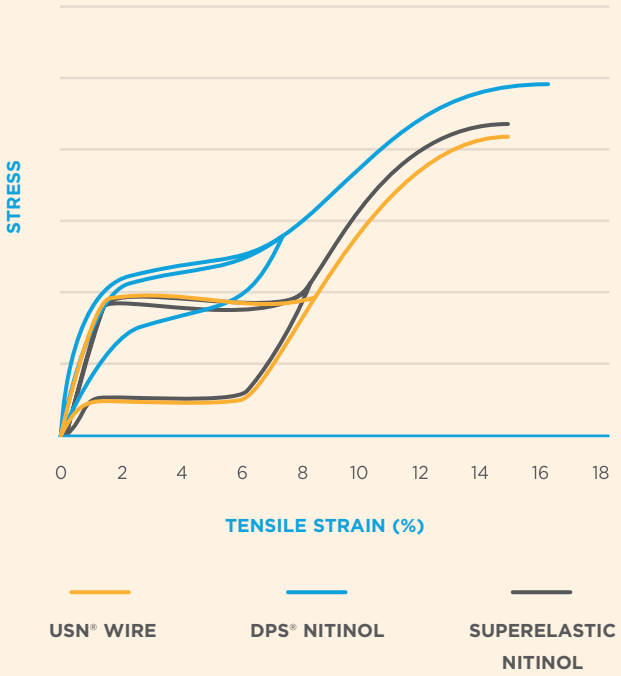
USN® wire

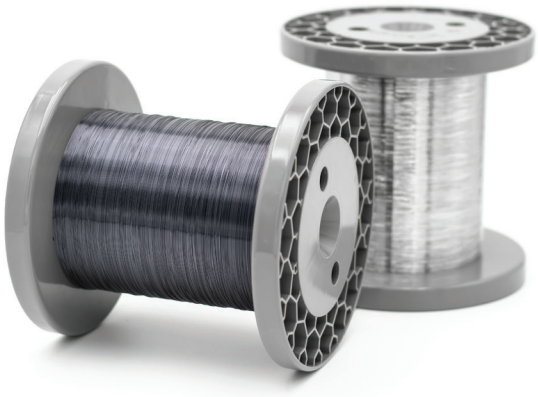
In applications where the gradual bend of the wire causes less than 1.5% strain, and only enters into the modulus region of the stress-strain curve, USN® wire exhibits increased stiffness when compared to our standard straight annealed Nitinol. Guidewire made from USN® wire that is straight will exhibit greater resistance to initial bend than standard Nitinol of the same grade and diameter.

Design specifications

Available in diameters from 0.228 mm to 0.762 mm [0.009 in to 0.030 in] on spools containing up to 2,438 m [8,000 ft] of wire.

Stress/strain curve





Actuator wire

Actuator wire is made with shape memory Nitinol, utilizing the material's ability to cycle between two different material phases. At room temperature, the wire is in its martensitic phase. By applying a load, the wire is elongated and can then actuate by applying an electrical current or other means of heat to achieve a phase transformation. When heated beyond the transformation temperature, the material recovers, transforming to the austenitic phase, and the wire performs work — meaning that it returns to its original length - lifting or otherwise pulling on the load. As the material cools, it returns to the martensitic phase and the load causes the wire to elongate again, ready to repeat the cycle.

Understanding the benefits

Nitinol's unique properties allow it to perform a surprising amount of work for its size. This means that actuator wire is smaller, lighter, quieter, and can be longer-lasting than more traditional actuators. Additionally, you can choose to have your actuator wire arrive in cut lengths or on a spool for easier processing.

Typical end uses

Actuator wire is often used in industries with small spaces and where lightweight devices are required, such as:

- Automotive
- Aerospace
- Active textiles
- Consumer electronics

Product forms and capabilities

In addition to actuator wire, you can take advantage of our additional processing and testing capabilities. Since actuator wire is tailored to your application, additional processing and testing are evaluated on a case-by-case basis. Reach out to your Sales Representative for more information.

MECHANICAL ASSEMBLY consists of crimps, fittings, and specialized parts

THERMOMECHANICAL TESTING

- ASTM E3097 compliant thermal characterization under stress
- Variable load with spring simulation thermal characterization
- Material electrical response in various environmental temperatures

Size ranges and operating parameters

Product	Size range	A_s	Recommended application stress	Hysteresis width
Actuator wire on a spool	0.0762 - 0.5842 mm [0.003 - 0.023 in]	70 - 90 °C [158 - 194 °F]	100 - 150 MPa [14.5 - 21.75 ksi]	30 +/- 5 °C [54 +/- 9 °F]

A_s and hysteresis width based on 150 MPa application stress. Recommended application stress values are for maximized stroke performance and fatigue life. Application stresses outside of this range can also be used depending on the design requirements of the actuator.

While we provide standard size ranges and operating parameters as a starting point, we're always looking for new ways to innovate. If you are interested in something outside what is listed, please contact your Sales Representative to discuss possibilities.

Helical Turkshead Nitinol

Helical Turkshead Nitinol wire possesses a unique geometry that can significantly reduce friction while at the same time potentially improving torqueability to help medical devices better navigate vasculature.

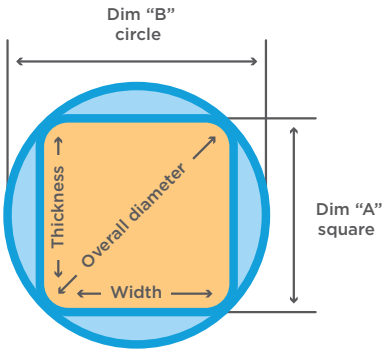
Understanding the benefits

This new material technology leverages a variety of mechanical properties, including torque, whip, flexibility, strength, shape memory, and superelasticity, that can help users to better control and guide medical devices inside the human body.

The turkshead shape reduces the contact surface area of the wire by approximately 60% when compared to a traditional round configuration. Less surface area means less friction, increasing operational efficiency and improving steerability of the wire, and potentially decreasing the need for expensive coatings. Additionally, the helical geometry results in excellent 1:1 torque transmission, providing users with a more tactile feel for maximizing wire handling and placement while navigating complex anatomies.

Typical end use

› Guidewires



Design specifications

SIZE RANGE

Round wire can be manufactured in diameters ranging from 0.0254 mm to 0.762 mm [0.010 in to 0.030 in].

SURFACE FINISHES

› Light oxide

› Dark oxide

› Oxide free

CONDITION

Straight annealed

MATERIALS

NiTi #1, #2, #3, #4, and #9

DELIVERY

Cut lengths

Linear Elastic Nitinol

When Linear Elastic Nitinol is subjected to strain, the stress increase is nearly proportional. This linear performance sets it apart from standard superelastic or shape memory Nitinol, which would deform more easily upon reaching its plateau stress. This product features a stiffer wire that offers greater pushability, primarily required by guidewire applications, along with greater strength without sacrificing 1:1 torque transmission. Linear Elastic Nitinol will recover up to 4% strain, which is not dependent on a temperature induced phase change.

Design specifications

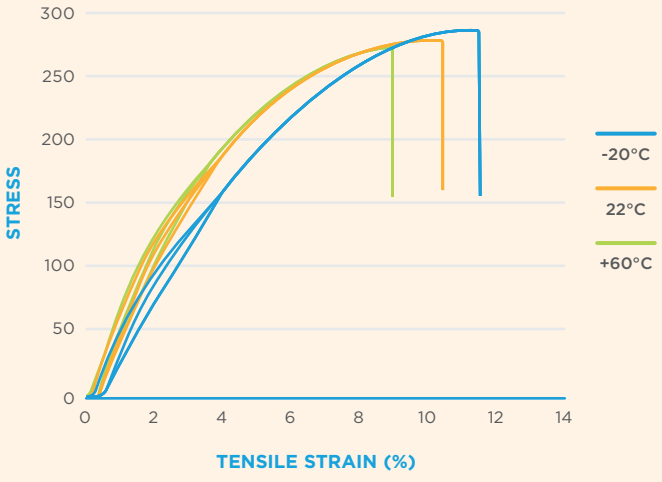
- Size range: 0.0762 mm [0.003 in] to 0.635 mm [0.025 in]
- Linear Elastic Nitinol is available in discrete lengths ranging from 51 mm [2.0 in] to 5 m [197.0 in].
- Available in all superelastic alloys with NiTi #1 and NiTi #9 being most common.

SURFACE FINISHES

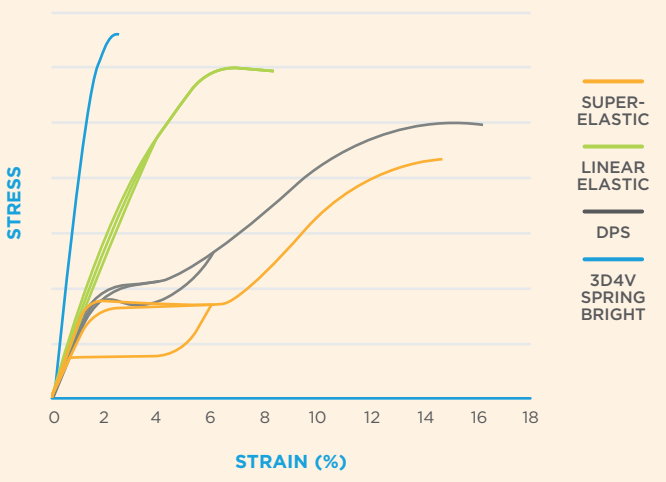
- Light oxide
- Dark oxide
- Etched
- Pickled
- Mechanically polished
- Silk® Nitinol wire

Bend moment comparison

Axial tension



Axial tension vs. stainless steel



Typical end uses

We often see our customers put Linear Elastic Nitinol to use in guidewire applications.

Exposure to temperatures above 250 °C may alter the mechanical properties of Linear Elastic Nitinol products.

DFT® wire

DFT® wires combine the properties of dissimilar materials in a single wire system. The outer sheath provides strength and a degree of biocompatibility while protecting the core material, which can provide key properties, such as superelasticity, conductivity, radiopacity, resiliency, or MRI enhancement.

Understanding the benefits

Complex applications often require more than any one material can offer. By leveraging the strength and good biocompability of a sheath material, engineers can take full advantage of the desired properties of another material, without expanding the overall diameter. An enormous amount of force is imparted during process, which forms a mechanical bond between the two materials. This means the material is metallurgically sound — two materials in one.

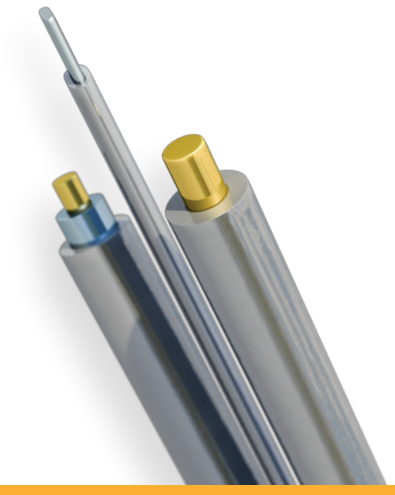
DFT® wire is made of a core wire fully enclosed in a tube of a different material and drawn together in a single wire system.

Typical end uses

DFT® wires find uses in a variety of applications, including:

- Pacing leads
- Shock coils
- Neurovascular stents
- LVAD driveline cables
- Vascular stents
- Retrieval baskets
- Aneurysm coils

Information continued on next page.



Design specifications

To build a DFT® wire you select a sheath material based on your desired properties, then pair it with a core material.

The naming convention for DFT® wire follows this logic: you'll see the tube material listed first, followed by the DFT® wire designation, and lastly the fill ratio and core material. For example: 35N LT®-DFT® 28%Pt.

SHEATH MATERIALS

- **35N LT™ alloy:** enhanced fatigue life, strength, and corrosion resistance
- **FWM™ 1058 alloy:** high strength and corrosion resistance
- **MP35N® alloy:** high fatigue life, strength, and corrosion resistance
- **Nitinol:** superelastic and shape memory alloy
- **Platinum:** oxidation-corrosion resistance and bonding to platinum pins for assembly
- **Platinum alloys:** oxidation-corrosion resistance and bonding to platinum pins for assembly
- **Titanium alloys:** high strength, high corrosion resistance and good biocompatibility

CORE MATERIALS

- **Gold:** electrical conductivity, radiopacity
- **Nitinol:** guidewire tip flexibility and steerability
- **Platinum:** radiopacity, other imaging contrast, moderate electrical conductivity
- **Silver:** electrical conductivity
- **Tantalum:** radiopacity, moderate electrical conductivity
- **Titanium-Beta:** guidewire tip flexibility

SIZE RANGES

- DFT® wires can be constructed in sizes ranging from 0.017 mm to 3.175 mm [0.0007 in to 0.125 in] or smaller depending on the constituents.

DFT® wire

Tensile values for 35N LT™ alloy DFT® wire with silver core

Since DFT® wires are highly customizable, exact mechanical properties vary based on construction, primarily influenced by coldwork percentages and fill ratio. You can use the chart below to compare properties for 35N LT™ alloy DFT® wire with a variety of coldwork percentages and silver fill ratios.

Cold worked	35N LT™-DFT®-25% Ag wire		35N LT™-DFT®-28% Ag wire		35N LT™-DFT®-33% Ag wire		35N LT™-DFT®-41% Ag wire	
%	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi
0	1091	158.2	1026	148.8	1031	149.6	856	124.1
20	1388	201.3	1318	191.2	1328	192.6	1122	162.8
37	1555	225.6	1493	216.5	1474	213.8	1143	165.8
50	1636	237.3	1567	227.3	1549	224.7	1327	192.4
61	1696	246.0	1627	236.0	1602	232.4	1379	200.0
69	1770	256.7	1682	244.0	1650	239.3	1423	206.4
75	1801	261.2	1711	248.1	1671	242.3	1444	209.5
80	1846	267.8	1755	254.5	1719	249.3	1482	214.9
84	1903	276.0	1820	264.0	1804	261.6	1496	217.0
87	1918	278.2	1822	264.3	1808	262.3	1551	225.0
90	1912	277.3	1822	264.3	1782	258.4	1540	223.3
92	1944	281.9	1840	266.9	1756	254.7	1601	232.2

Electrical resistance

Since DFT® wires are commonly used as conductors, you can use the table below to compare 35N LT® wire DFT® wire with a silver core to solid 35N LT® wire.

Wire size		35N LT®-DFT®-25% Ag wire		35N LT®-DFT®-28% Ag wire		35N LT®-DFT®-33% Ag wire		35N LT®-DFT®-41% Ag wire		Solid 35N LT® wire	
mm	in	Ω/m	Ω/ft	Ω/m	Ω/ft	Ω/m	Ω/ft	Ω/m	Ω/ft	Ω/m	Ω/ft
0.152	0.006	3.324	1.013	2.987	0.91	2.555	0.779	2.075	0.632	56.63	17.26
0.102	0.004	7.479	2.280	6.722	2.049	5.748	1.752	4.668	1.423	127.4	38.84
0.051	0.002	29.90	9.113	26.87	8.191	22.99	7.006	18.67	5.691	509.6	155.3
0.025	0.001	119.9	36.53	107.5	37.76	94.36	28.76	74.69	22.77	2039	621.4

Fill ratios

When designing DFT® wires, the fill ratio refers to the amount of core material in a construction. If the fill ratio is 10%Pt this means that the DFT® wire is 90% sheath material and the platinum core makes up 10% of the construction's cross-sectional area.

Information continued on next page.

DFT® wire

Designing with Nitinol DFT® wire

Nitinol DFT® wires are offered in a number of standard materials and fill ratios to provide maximum design flexibility while offering the convenience of established production processes. The fill ratio of DFT® wire impacts other mechanical properties. Our engineering team can help you determine which materials and fill ratio are best suited for your application. Standard fill ratios include:

- NiTi #1-DFT®-10%Pt
- NiTi #1-DFT®-20%Pt
- NiTi #1-DFT®-30%Pt
- NiTi #1 ELI-DFT®-10%Pt
- NiTi #1 ELI-DFT®-20%Pt
- NiTi #1 ELI-DFT®-30%Pt
- NiTi #1 ELI-DFT®-40%Pt
- NiTi #1-DFT®-10%Ta
- NiTi #1-DFT®-30%Ta
- NiTi #2-DFT®-20%Pt
- NiTi #2-DFT®-30%Pt

If you'd like to explore options for other combinations, reach out to your Sales Representative.

Nitinol DFT® wire

One of the many benefits of using DFT® wire in your application is the ability to utilize Nitinol's superelastic properties combined with an alternate core material, such as platinum or tantalum. One of the primary benefits of using Nitinol DFT® wire is the ability to increase the radiopacity of the wire under X-ray by customizing the fill ratio. Higher fill ratios of radiopaque materials yield better visibility.

Product forms and capabilities

You can further customize your DFT® wire by taking advantage of our additional processing capabilities.

WIRES for coiling or shapes

STRANDS AND CABLES in complex constructions for advanced applications

COATINGS carefully applied to provide electrical insulation or chemical separation

MECHANICAL ASSEMBLY of crimps, fittings, and specialized parts

SHAPE SETTING custom Nitinol wire constructions that can deform and return to a set shape

Typical applications for Nitinol DFT® wires

Leveraging the ability to increase radiopacity, Nitinol DFT® wires are often used in:

- Braided stents
- Embolic coils

DBS® wire

DBS® wire is made by stranding wires of one alloy around a core of a different material. The outer stranded wire provides strength while the core material typically offers greater flexibility and conductivity.

Understanding the benefits

When you pair the strength of one alloy with the conductivity of another you get the best of both worlds. Among the benefits of using DBS® wires are high conductivity, solderability, strength, and resistance to stresses in strand and cable applications. When we draw DBS® wire, the pressure causes the core material to integrate with the stranded outer wire, meaning parts of the core material will be exposed. Coated DBS® wires can be used to provide insulation for good biocompatibility.

Design specifications

To build a DBS® wire, you first select a core material based on your desired properties, then pair it with an outer material.

CORE MATERIALS

- **Platinum:** radiopacity, other imaging contrast, moderate electrical conductivity
- **Silver:** electrical conductivity

OUTER WIRE MATERIALS

- **316LVM**
- **35N LT™ alloy:** enhanced fatigue life, strength, and corrosion resistance
- **MP35N® alloy:** high fatigue life, strength, and corrosion resistance
- **FWM™ 1058 alloy:** high strength and corrosion resistance

SIZE RANGES

DBS® wires can be constructed in sizes ranging from 0.025 mm to 3.175 mm [0.001 in to 0.125 in]

Product forms and capabilities

DBS® wires can be put to work in the following product forms or leverage additional processing to adapt to your application.

WIRE individual segments for flexible simple applications

STRANDS AND CABLES in complex constructions for advanced applications

MECHANICAL ASSEMBLY of crimps, fittings, and specialized parts

COATINGS to provide electrical insulation or chemical separation

Fill ratios

Our core wire sizes allow for adjustments in the final core content between 20% and 25%. This means that if you were to look at a cross section of a DBS® wire the core content, for example silver, would be between 20% and 25% of the overall cross-sectional area, with the remaining 75% to 80% being composed of the outer wire material.

Typical end uses

Our DBS® wires have helped our customers to pioneer new advances. We see them used in:

- Pacemaker leads
- Electrocautery conductors
- High frequency conductors
- Conductors subject to cyclic bending
- High fatigue conductor applications
- Applications requiring solderability
- Applications requiring strength and conductivity

HHS® tube

Precise control and flexibility, coupled with an open working channel, makes HHS® tube a top performer in applications requiring torque transmission and pushing forces without whip or kinks. Manufactured in single, double, or triple layers, HHS® tube can be customized to provide the flexibility and control your application requires.

Understanding the benefits

Certain applications require higher performance than unifilar or even multi-filar coils can provide. By selecting single, double, or triple layer and by adjusting filars per layer, filar diameters, and pitch direction, HHS® tube can be customized for flexibility, torque, and rotational control.

Typical end uses

While HHS® tube's exceptional characteristics allow it to serve any number of applications, we've seen our customers use it in:

- Endovascular devices
- Minimally invasive tools
- Catheter devices
- Delivery devices
- Urological tools
- Neurological components
- Bioconductors

Additional capabilities

Your custom-made HHS® tube can undergo a number of additional processing steps to further tailor it to your needs:

SQUARE CUT ENDS for a flush, ready to assemble end

LASER WELDING with a no-additive welding process

TAPER GRINDING/OUTSIDE DIAMETER STEP GRINDING to remove material from the outer surface for easier assembly and customized flexibility

COATING to provide electrical insulation or chemical separation

MECHANICAL ASSEMBLY of crimps, fitting, and specialized parts

SHAPE-SET Nitinol parts

Design specifications

What makes HHS® tube so versatile is its ability to be customized to your specifications. Below are the standard parameters for design, but we're always open to conversations about products that push the current limits.

SIZE RANGE

- **Inside diameter:** 0.0762 mm to 2.2098 mm [0.003 in to 0.087 in]
- **Outside diameter:** 0.1524 mm to 4.064 mm [0.006 in to 0.160 in]
- **Filars**: 3 to 18
- **Layers:** 1 to 3
- **Pitch direction:** Left, right (pitch direction alternates each layer)

HHS® tube can be customized to meet your design specifications. Changing one specification can impact others. For example, filar size must decrease to accommodate more layers without increasing the overall diameter but allows for more filars to be stranded. Talk to our Engineering team to explore the possibilities.

MATERIALS

We can leverage our knowledge of materials and wire drawing processes to create custom HHS® tube. The most commonly used materials include:

- **304V stainless steel:** for high strength
- **316LVM stainless steel:** for improved ductility and corrosion resistance
- **35N LT™ alloy:** for fatigue life
- **Nitinol:** for shape-set parts

Strands and cables

Strands and cables are highly engineered products that are ideal for applications requiring strength and flexibility. They are often used in devices in order to enhance fatigue life, flexibility, and torque in certain configurations. Coupled with the unique properties of different alloys, strands and cables can be used to create ground breaking products.

Understanding the benefits

Whether you've been working with strands and cables for years and are looking for the next construction to take your products to new heights or are just beginning the search to discover what you need, we're happy to help, starting with the basics.

Strands are formed by wrapping several filaments of wire together to form a single strand. When several of these strands are wrapped together, they form a cable. Strands and cables can be designed to perform various mechanical and electrical functions based on your specifications.

Customers use our constructions as control cables, robotics microcables, and in other cutting-edge applications. It's not always easy to find the right material for new devices, which is why our engineers are here to help.

Typical end uses

- Actuate tissue anchor devices
- Secure ligaments, tendons, and bone
- Articulate minimally invasive instruments
- Position and release implants
- Enable endoscopic applications
- Serve as permanent and temporary pacing and nerve stimulation

Design specifications

From 35N LT™ alloy for fatigue life, tungsten cable for high tensile strength in small diameters, DFT® wires as blended or hybrid cables, or titanium for corrosion resistance, we utilize complex constructions and processes to enhance strength, flexibility, fatigue life, torque, stiffness, and smoothness. Strands and cables serve a variety of functions, from robotics microcables to custom medical cables.

ALLOYS

- Stainless steel
- Cobalt-chrome
- DFT® wire
- Titanium
- Nitinol
- Tungsten
- Precious metals

PRODUCT FORMS

- Microcables as small as 0.04 mm [0.002 in] in overall diameter
- Cables as large as 4.8 mm [0.1875 in] in overall diameter
- As few as three wires twisted together
- As many as 1,369 wires with a 0.5 mm [0.02 in] overall diameter

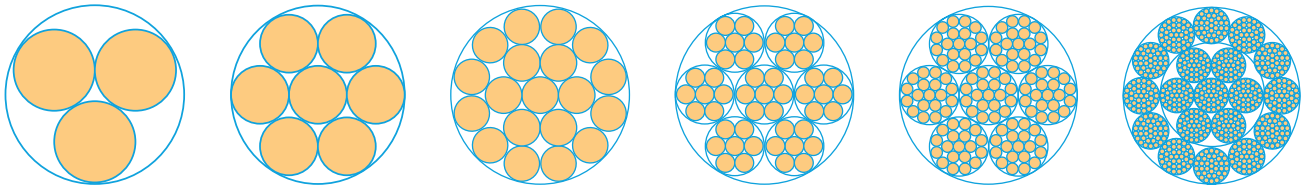
Cables can be provided on a spool to allow for easier processing into components, in discrete lengths,or you can take advantage of our secondary processing capabilities.

PROCESSING CAPABILITIES

- Swaging
- Thermal treatment
- Cleaning

Strands and cables

Examples of cable constructions (cross sections)



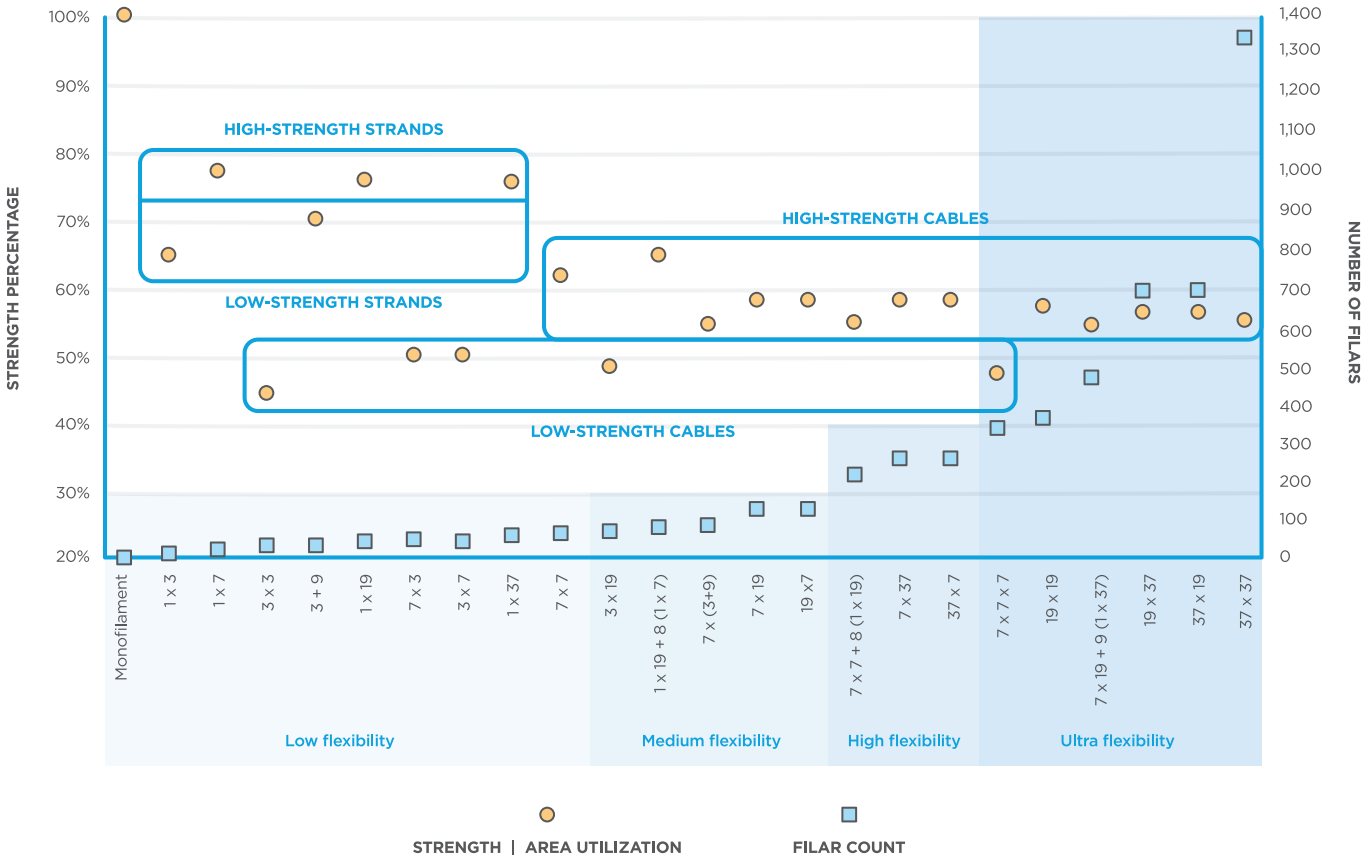
Strength and flexibility

The graph below can be used to compare strength and flexibility for various strand and cable constructions. Typically, gaining strength means compromising flexibility, and vice versa. Strength refers to how much weight the construction can hold, and flexibility refers to how much it can bend without permanent deformation.

Additional capabilities

Your custom-made strands and cables can undergo a number of additional processing steps to further tailor them to your needs:

- Mechanical cable assembly
- Cutting
- Extrusion coating
- Welding/joining
- Laser ablation of coatings



Mechanical assembly

Out-of-the-box solutions won't solve all design challenges. Custom mechanical assemblies open new doors. Working with our Engineering team, you can leverage computer modeling to define concepts and refine design with each iteration until you've found the perfect solution.

Understanding the benefits

From custom crimps and threaded fittings to midsection attachment points and end terminations, mechanical assemblies enable wire-based products to meet the needs of complicated applications. Our integrated operations allow you to streamline your manufacturing process, knowing that your custom parts will arrive just the way you need them.

Typical end uses

When you're designing a custom mechanical assembly, you define the end uses. We've seen our customers put their designs to work in:

- Minimally invasive surgical instruments
- Laparoscopic or robotic surgery devices
- Articulation devices

Additional processing capabilities

Our mechanical assemblies can be further customized with additional processing, such as:

COATING to provide electrical insulation for chemical separation

LASER ABLATION for adjustable coating coverage

We use various techniques to improve the surface quality of our material and ensure that our material is free of any visible debris or foreign particulates. For more information on our cleaning processes, please contact your Sales Representative.

Design specifications

Mechanical assemblies can be as basic as adjusting the ends of cut-to-length strands and cables, or as complicated as custom terminations and midsection fittings.

STRAND AND CABLE END OPTIONS

- Shear
- Fused
- Encapsulated (rounded)
- Square
- Beaded
- Bead and swage

Mechanical assembly components

To make choosing the right components for your assembly easier, you'll find information about different fittings below and to the right to help you prepare for a conversation with our Engineering team. Our custom fittings:

- Provide a secure attachment point
- Can be attached in the middle of a cable if pulling is expected in two directions
- Are configured to yield a breaking load that approaches the breaking load of the cable to which they are attached
- Provide close tolerance on swaged diameter to allow for precision placement into a pocket or bore
- Fittings are normally factory swaged

Mechanical assembly

BALL AND SHANK SPHERICAL FITTINGS

- Provides full breaking load of cable
- Allows for attachment within a spherical pocket
- Allows cable rotation when load is not significant
- Shank provides abrasion protection

BALL SPHERICAL FITTINGS

- Provides 60% of cable breaking load

CLEVIS ENDS

- Are manufactured in a fork or eye configuration
- Provide attachment point using a cross pin where push and pull may be needed

CYLINDRICAL, HEXAGONAL, AND SQUARE END STOPS

- Provide attachment points
- Offer larger dimensions
- Can be provided as an accompaniment to cable assemblies with factory-applied fittings

FLANGED STOPS

- Intended for use at end of cable
- Beneficial when cylindrical end stop does not provide enough shoulder
- Eliminates need for washer to prevent pull-through

LOOPED FITTINGS

- Provide attachment point where loop is secured over a pin

RADIUSED END STOPS

- Centers with a bore or pocket
- Offers holding strength to full breaking load of cable
- Allows for cable rotation and positioning

THREADED FITTINGS

- Allow for secure attachment and adjustability
- Shank and thread diameter customizable
- Can be used to precisely set tension
- Adjustable to remove cable slack

Shape setting

Shape-set parts are Nitinol wire shapes that can flex and return to their original form. Using a number of different product forms, such as round or shaped wire, or strand and cable configurations, shape-set parts can perform work in hard-to-reach places and open up new possibilities for device performance.

Understanding the benefits

Shape setting allows you to take full advantage of Nitinol's unique properties. The first of these is the ability to deform a shape-set part below transformation temperature, allowing it to fit into a smaller space, and return it to the original form by exposing it to the transformation temperature. You can also deform a shape-set part above the transformation temperature and it will return to its original shape immediately upon release.

To create a shape-set part, Nitinol wire is wrapped around a mandrel and heat treated at a closely controlled time and temperature in its desired shape. After the material is quenched and removed from the mandrel, it will remember its shape even after deformation. At Fort Wayne Metals, we use precision fluidized beds as well as other proprietary shape setting methods to meet the requirements of your complex designs. Our Engineering team uses in-house design and tooling to offer rapid prototyping services so you can innovate faster.

Typical end uses

Customizing the specifications of your shape-set part means the possibilities are practically limitless. We've seen our customers utilize shape-set Nitinol for:

- Suture retrievers
- Shaped needles
- Retrieval baskets
- Iris expanders
- Surgical clips

Design specifications

The details of your custom shape-set parts are up to you. Depending on the grade of Nitinol utilized, transformation temperatures for shape-set parts can range from -15 °C to 100 °C [5 °F to 212 °F] We can shape set the following product forms in sizes ranging from 0.0762 mm to 2.000 mm [0.003 in to 0.0787 in].

ROUND WIRE with a circular cross section

SHAPED WIRE with specialty shaped cross sections

FLAT WIRE with a rectangular cross section

STRANDS AND CABLES in complex constructions for advanced applications

HHS® TUBE with an open working channel

You can further customize your shape-set parts with one of the following surface finishes:

- **Oxide:** dark purple or blue in appearance
- **Etched:** by chemical removal of oxide layer for a matte silver appearance
- **Electropolished:** for the smoothest surface and best corrosion resistance
- **Surface conditioned:** for an oxide-free appearance similar to stainless steel

Shape setting

Assembly and testing capabilities

If you need to do more with your shape-set parts, we can help with additional processing such as:

- **Coining/flattening:** for end stops or location specific widening
- **EDM cutting:** for tight tolerances, burr free cuts, and square cut ends
- **Weld beads:** in full radius or large beads greater than wire diameter
- **Custom assembly:** for custom crimps and fittings

You can also count on us for additional inspection steps, such as:

- Finish A_f testing using Differential Scanning Calorimetry (DSC), Bend and Free Recovery (BFR), per ASTM F2082
- Mechanical testing per ASTM F2516
- Dimensional analysis of validation runs and First Article Inspection (FAI)
- Surface roughness testing by non-contact surface profilometer
- Corrosion testing per ASTM F2129

We use various techniques to improve the surface quality of our material and ensure that our material is free of any visible debris or foreign particulates. For more information on our cleaning processes, please contact your Sales Representative.

Examples of shape-set parts

Double diamond - strand

Folded ends - flat wire

U-shaped with beaded end

Twisted hypotube with loop

Crown with crimp


flexible design
looped end fitting
X + X = ?
rotational control
tight tolerances
flexible design
X + X = ?
flexible design
rotational control

Services

Coating

Carefully applied coatings can yield a variety of benefits, from providing electrical insulation to chemical separation or improved lubricity. Whether a wire, strand, or cable, coatings provide the next step to enhance performance in any number of applications.

Understanding the benefits

Coatings are divided into two main categories: dielectric and lubricious. Dielectric coatings are usually used to provide electrical insulation, while lubricous coatings are primarily used for chemical separation and lubricity.

Dielectric coatings

ETFE offers the greatest strength and abrasion resistance and has a continuous service temperature up to 150 °C [302 °F].

MOLDFLON PTFE is a thermoplastic. It retains the properties of pure PTFE, most importantly lubricity, and offers excellent thermal stability with a continuous service temperature of up to 260 °C [500 °F].

PFA is similar to PTFE in chemical and physical behavior but offers a higher service temperature than FEP, at up to 260 °C [500 °F].

FEP is similar in chemical and physical behavior to PFA, but provides a lower service temperature at 200 °C [392 °F] and is slightly less susceptible to water absorption than most other fluoropolymers.

PI offers excellent dielectric strength as well as very good mechanical properties and chemical inertness. Unlike other fluoropolymers, it is applied in multiple thin layers so it bonds directly to the substrate. PI has a high continuous service temperature of up to 240 °C [464 °F], with resistance to short exposures to 400 °C [752 °F] with minimal generation of volatiles.

Typical end uses

Our customers use coated wires for a variety of applications, leveraging different properties to provide chemical separation, electrical insulation, or to reduce relative friction. Examples include:

- Guidewire cores
- Catheter stylets
- Mandrels
- Neurostimulation devices
- Vascular therapy devices

Design specifications

Our extruded coatings can be applied to round, stranded, cabled, and some shaped wires. Coatings may be applied to all alloys that Fort Wayne Metals has to offer, and are available in these colors: brown, gray, blue, white, red, green, purple, yellow, orange, black, and clear. Additional colors available upon request.

SIZE RANGES

- **Round wire sizes:** 0.0380 mm to 0.965 mm [0.0015 in to 0.038 in]
- **Strands and cable sizes:** 0.0760 mm to 1.524 mm [0.0024 in to 0.060 in]
- **Wall thickness:** 0.010 mm to 0.1270 mm [0.0002 in to 0.005 in]

Lubricious coatings

DuraSkin™ COATING offers gamma stable coating with some sensitivity to solvents. Tight control of coating thickness combined with a smooth surface makes DuraSkin™ a popular choice with customers for medical device components.

LubriSkin™ COATING offers a non-gamma stable coating with excellent chemical resistance. Coated prior to coiling, LubriSkin™ coating results in a consistently smooth, non-cracking or flaking coverage.

Information continued on next page.

Coating

Coating properties

You can use the following charts to determine which dielectric or lubricious coating offers the properties you need for your application. If you'd like to speak to an engineer about coating possibilities, please contact us.

Dielectric coatings

Coating type	Density	Tensile strength		Coefficient of friction	Dielectric strength		CTE at 20 °C	Water absorption	Service temp. in air (max)
%	g/cm³	MPa	ksi		kV/mm	V/mil	µm/m/°C	%	°C [°F]
ETFE	1.70	41	6000	0.3	64	1600	130	0.006	150 [302]
PFA	2.15	28	4000	0.2	62	1575	140	0.05	260 [500]
Moldflon PTFE	2.17	36	5260	0.1	60	1525	130	0.01	260 [500]
PI	1.42	138	20000	0.35	192	4800	20	1.8	240 [464]
FEP	2.15	25	3600	0.24	62	1575	140	0.005	200 [392]

Lubricious coatings

	DuraSkin™	LubriSkin™
Coating thickness	Standard: 4 - 10 µm [0.00016 in – 0.00039 in]	Standard: 4 – 10 µm [0.00016 – 0.00039 in]
Uncoated diameter	0.15 mm - 0.965 mm [0.0059 in - 0.038 in]	0.038 mm - 0.70 mm [0.0015 in - 0.0276 in]
Colors	Green, gray, blue*, black, white, clear	Green, other colors on request
Primary uses	Corewires; (PTCA) extrusion mandrel wire	Coiling wire, bonding mandrels, release mandrels
Supplied	Straightened and cut lengths, spooled	Straightened and cut lengths, spooled
Gamma stable	Yes	No
ETO sterilization	Yes	Yes
Biocompatibility	For invasive techniques, excluding permanent human implants	For invasive techniques, excluding permanent human implants
Heat stability	Up to 195 °C [390 °F]	Up to 205 °C [400 °F]
Chemical reistance	Sensitive to some solvents like NMP, acetone, MEK, etc.	Good to excellent

**Blue DuraSkin™ coating uncoated diameter range: 0.20 mm to 0.965 mm [0.0079 in to 0.038 in]*

Laser ablation

Laser ablation is a non-mechanical process for removing coating from select locations on a wire, meaning you get clean, undamaged wire exposed in just the right places.

Understanding the benefits

Using laser ablation to strip coating from a wire allows you to customize the exact amount of exposed material for your application. By stripping coating using a laser instead of mechanical cutting blades, the underlying wire avoids damage. The laser ablation process also provides greater flexibility and accuracy in locating areas of coating removal, allowing you to design more complex components.

When you use laser ablation to strip coating from your wire, instead of a mechanical process, you get:

- Tighter tolerances
- Precise transition zones
- The ability to receive processed wire on a spool or in discrete lengths

Product forms and capabilities

Prior to laser ablation, a wire, strand or cable has to be coated. Learn more about these product forms and our coating capabilities:

ROUND WIRE with a circular cross section

FLAT WIRE with a rectangular cross section

SHAPED WIRE with specialty shaped cross sections

DFT® WIRE that combines two dissimilar materials in a single construction

SLT® WIRE straight-off-the-spool to eliminate process steps

STRANDS AND CABLES in complex constructions for advanced applications

COATINGS carefully applied to provide electrical insulation or chemical separation

Typical end uses

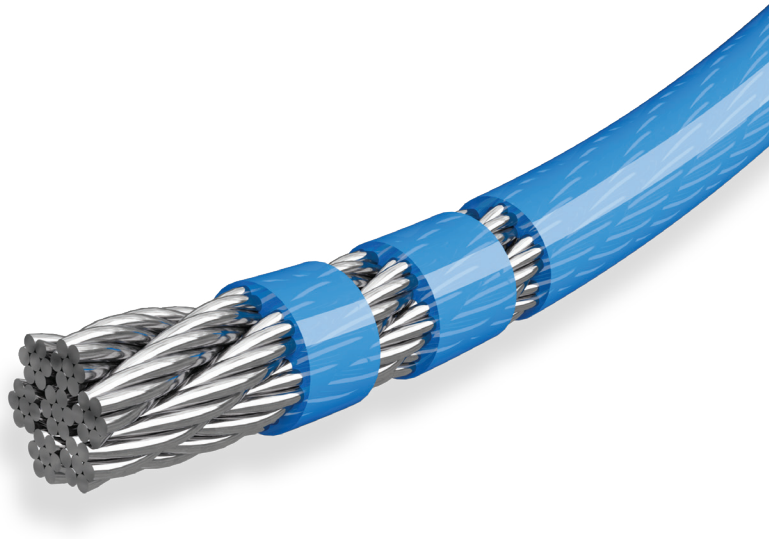
Our customers often use wire that has undergone laser ablation in:

- Cardiac rhythm management devices
- Neurostimulation devices
- Guidewires
- Electrophysiology applications

Design specifications

Laser ablation is customized to your specifications. This information provides a starting point for determining what considerations will impact your design.

- **Wire types:** solid, strand, cable
- **Size range:** 0.05 mm to 1.27 mm [0.002 in to 0.050 in]
- **Coating types:** ETFE, PFA, FEP
- **Coating thickness:** 0.005 mm to 0.127 mm [0.0002 in to 0.0050 in]
- **Lengths:** 2.02 mm [80 in]
- **Ablation locations:** beginning, end, or variable
- **Ablation lengths:** 0.102 mm [0.004 in]



Spools and packaging

Fort Wayne Metals provides a variety of packaging options. You can specify the spool type you want, or let us recommend the one we feel will work best for your specific needs. For additional protection on alloys that are subject to corrosion, spools can be bagged with desiccant packets. Straightened and cut wire is shipped in PVC tubes or wood crates, depending on the quantity.

Use the chart below to determine spooling specifications in U.S. customary units. *The metric equivalents can be found on page 55.*

Spool	Equivalent	Flange (inches)	Hub (inches)	Traverse (inches)	Bore (inches)	Max capacity* (pounds)	Diameter (inches)	Spool composition
22 in x 11 in	--	22	14	11	5	450	0.030 - 0.144	Polystyrene
18 in x 10 in	--	18	11	9.6	5	150	0.030 - 0.144	Polystyrene
12 in x 6 in	--	12	6	6	1.3	60	0.012 - 0.060	ABS
Weld wire	--	11.7	8.3	3.62	2	30	0.004 - 0.050	ABS
8 in x 6 in	--	8	4.6	6	1.2	25	0.012 - 0.060	ABS
6 in x 3.5 in	--	6	3.5	3.5	0.62	10	0.003 - 0.020	ABS
13.62 in x 3.55 in biconical spool	--	13.62	11.16	3.55	2	15	0.002 - 0.030	ABS
4.5 in x 3 in	--	4.5	2.5	3	0.62	2.5	0.003 - 0.010	ABS
2.5 in X 3 in	HK 76-45	2.5	1.7	3	0.62	1	≤ 0.007	ABS
HK 76-45 biconical spool	2.5 in x 3 in	2.5	1.75	2.36	0.62	1	≤ 0.004	ABS
DIN80	--	3.2	2	2.5	0.63	1	≤ 0.003	ABS
DIN100	--	3.9	2.5	3.1	0.63	3	0.001 - 0.005	ABS
DIN125	HKV 125	4.9	3.1	3.9	0.63	5	0.004 - 0.010	ABS
HKV 125 biconical spool	DIN125	4.92	2.8	2.56	0.63	3	0.004 - 0.010	ABS
DIN160	HKV 160	6.3	3.9	5	0.87	10	0.010 - 0.020	ABS
HKV 160 biconical spool	DIN160	6.3	3.54	3.35	0.87	10	0.004 - 0.010	ABS
DIN250	--	9.8	6.3	6.3	0.87	20	0.012 - 0.040	ABS
Wardwell bobbin	--	2.6	1.3	2.8	1.1 spline	0.5	≤ 0.003	Nylon
Medium braider bobbin**	--	1.68	1.015	1.04	0.415	0.25	≤ 0.003	Acetal Copolymer
Large braider bobbin**	--	1.57	1.17	1.04	0.415	0.12	≤ 0.003	Acetal Copolymer
New England #2 braider bobbin	--	1.7	0.62	2.5	0.3	0.75	≤ 0.005	Nylon
Endura® bobbin** biconical spool	--	1.69	1.02	1.4	0.415	0.2	≤ 0.003	Acetal Copolymer

**Actual capacity varies with wire size and alloy type. Please check with your Customer Service Associate for details.*
***Designed for use on Steeger® braiders.*

Spools and packaging

Labeling of spools

Our spools are labeled with information including alloy type, size, lot number, spool net weight, customer purchase order number, date, and spool number on each spool (excluding braiding bobbins). To help ensure accurate information, the statistical average of mechanical properties flows directly from internal data collection to labels.

The label also indicates the average break load, ultimate tensile strength, and percent elongation of the wire, based on our sampling plan. And you also have the option of having your spools 100% inspected and labeled.

Spool return and recycling

In order to minimize our environmental impact, we will reuse any spool returned to us in good condition. We'll also accept any broken or bad spools as a part of our recycling program — please contact us for details.

Custom spooling

We have the ability to custom spool any specific length of wire. In addition, we can adapt our equipment to work in conjunction with any custom spool you supply.

Spool	Equivalent	Flange (centimeters)	Hub (centimeters)	Traverse (centimeters)	Bore (centimeters)	Max capacity* (kilograms)	Diameter (millimeters)	Spool composition
55.88 cm x 27.94 cm	--	55.8	35.56	27.94	12.7	204.1	0.762 - 3.66	Polystyrene
45.72 cm x 25.4 cm	--	45.72	27.94	24.38	12.7	68.03	0.762 - 3.66	Polystyrene
30.48 cm x 15.24 cm	--	30.48	15.24	15.24	3.3	27.21	0.304 - 1.524	ABS
Weld wire	--	29.72	21.08	9.2	5.08	13.60	0.102 - 1.27	ABS
20.32 cm x 8.89 cm	--	20.32	11.68	15.24	3.048	11.33	0.304 - 1.524	ABS
15.24 cm x 8.89 cm	--	15.24	8.89	8.89	1.575	4.54	0.076 - 0.508	ABS
34.59 cm x 9.017 cm biconical spool	--	34.59	28.34	9.017	5.08	6.803	0.0508 - 0.762	ABS
11.43 cm x 7.62 cm	--	11.43	6.35	7.62	1.57	1.133	0.076 - 0.254	ABS
6.35 cm x 7.62 cm	HK 76-45	6.35	4.318	7.62	1.57	0.453	≤ 0.177	ABS
HK 76-45 biconical spool	6.35 cm x 7.62 cm	6.35	4.4	6.0	1.6	0.453	≤ 0.101	ABS
DIN80	--	8.0	5.0	6.4	1.6	0.453	≤ 0.0762	ABS
DIN100	--	10.0	6.3	8.0	1.6	1.360	0.0254 - 0.127	ABS
DIN125	HKV 125	12.5	8.0	10.0	1.6	2.267	0.101 - 0.254	ABS
HKV 125 biconical spool	DIN125	12.5	7.1	6.5	1.6	1.360	0.101 - 0.254	ABS
DIN160	HKV 160	16.0	10.0	12.8	2.2	4.54	0.254 - 0.508	ABS
HKV 160 biconical spool	DIN160	16.0	9.0	13.3	2.2	4.54	0.254 - 0.508	ABS
DIN250	--	25.0	16.0	16.0	2.2	9.071	0.304 - 1.016	ABS
Wardwell bobbin	--	6.604	3.302	7.112	2.794	0.226	≤ 0.0762	Nylon
Medium braider bobbin**	--	4.267	2.578	2.641	1.054	0.113	≤ 0.0762	Acetal Copolymer
Large Braider bobbin**	--	3.987	2.971	2.641	1.054	0.054	≤ 0.0762	Acetal Copolymer
New England #2 braider bobbin		4.318	1.574	6.35	0.762	0.340	≤ 0.127	Nylon
Endura® bobbin** biconical spool		4.292	2.590	3.556	1.054	0.090	≤ 0.0762	Acetal Copolymer

**Actual capacity varies with wire size and alloy type. Please check with your Customer Service Associate for details.*
***Designed for use on Steeger® braiders.*

Research and development

Innovation is at the heart of who we are and what we can do for you. We have scientists, engineers, and technicians who drive research and development from complementary perspectives of theoretical and applied knowledge whether by thought experiment or hands-on iteration. This combination of academic strength, seasoned knowledge, and forward thinking enables our Research & Development team to power ideas from concept to reality for you — whether you're a start-up, a corporation, an academic institution, or a business pushing the boundaries of what's possible.

Understanding the benefits

Our materials experts perform the following custom research and development services for you:

- Integrated manufacturing capabilities to drive effectively from concept iteration to full scale
- Broad range of customized product offerings (alloy design, mechanical properties, unique shapes, and sizes)
- Custom alloy or composite development
- Shape memory and superelastic technology development
- Absorbable magnesium rod and wire technology development
- Access to numerous melt modalities
- Advanced wire processing techniques to push mechanical property boundaries
- Collaboration with leading research universities to expand creative reach and analytical toolbox
- Collaborative peer-reviewed publications and technical conference presentations to share, validate, and expand research findings
- Access to accelerated delivery of customized products for rapid prototyping

Products of innovation

Combining our research, capabilities, and deep understanding of your needs has led us to many advances:

- **DFT® wire:** a monofilament construct that incorporates wire of two or more dissimilar materials that leverage, for example, the strength and corrosion resistance of a sheath material with properties such as conductivity and radiopacity of the core material.
- **Grooved wire:** helically grooved wire possesses a combination of strength, straightness, and dimensional consistency that opens the door to new opportunities for applications.
- **35N LT® wire:** a microstructurally refined iteration of the industry standard MP35N® alloy, this alloy provides an excellent combination of strength, fatigue resistance, corrosion resistance, and a legacy of use in implantable high-fatigue applications.
- **NDR® wire:** nanocrystalline grain refinement for improved fatigue life without change to the chemistry of the material.
- **SLT® wire:** straight wire directly off the spool that eliminates straightening process steps and reduces machine downtime without sacrificing performance.

Trademark information

Notes

LOCATIONS AROUND THE WORLD

Global Headquarters
Fort Wayne, Indiana, U.S.A.

European Headquarters
Castlebar, Co. Mayo, Ireland

Advanced Materials Development
Columbia City, Indiana, U.S.A.

International Sales Support
Shanghai, China
Augsburg, Germany
Tamil Nadu, India
Savyon, Israel
Tokyo, Japan
Seoul, Korea
Miami, Florida, U.S.A.

U.S.A. Sales Support
San Mateo, California
Ridgefield, Connecticut
Chanhassen, Minnesota

Find your Sales Representative at
fwmetals.com/find-your-rep

FORT WAYNE METALS

Turning knowledge into solutions.®

9609 Ardmore Avenue
Fort Wayne, Indiana 46809
PHN 260.747.4154
FAX 260.747.0398
EMAIL info@fwmetals.com

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fwmetals.com

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