
World-class solutions
in medical-grade materials.
FORT WAYNE METALS
Turning knowledge into solutions.®

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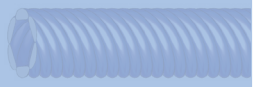

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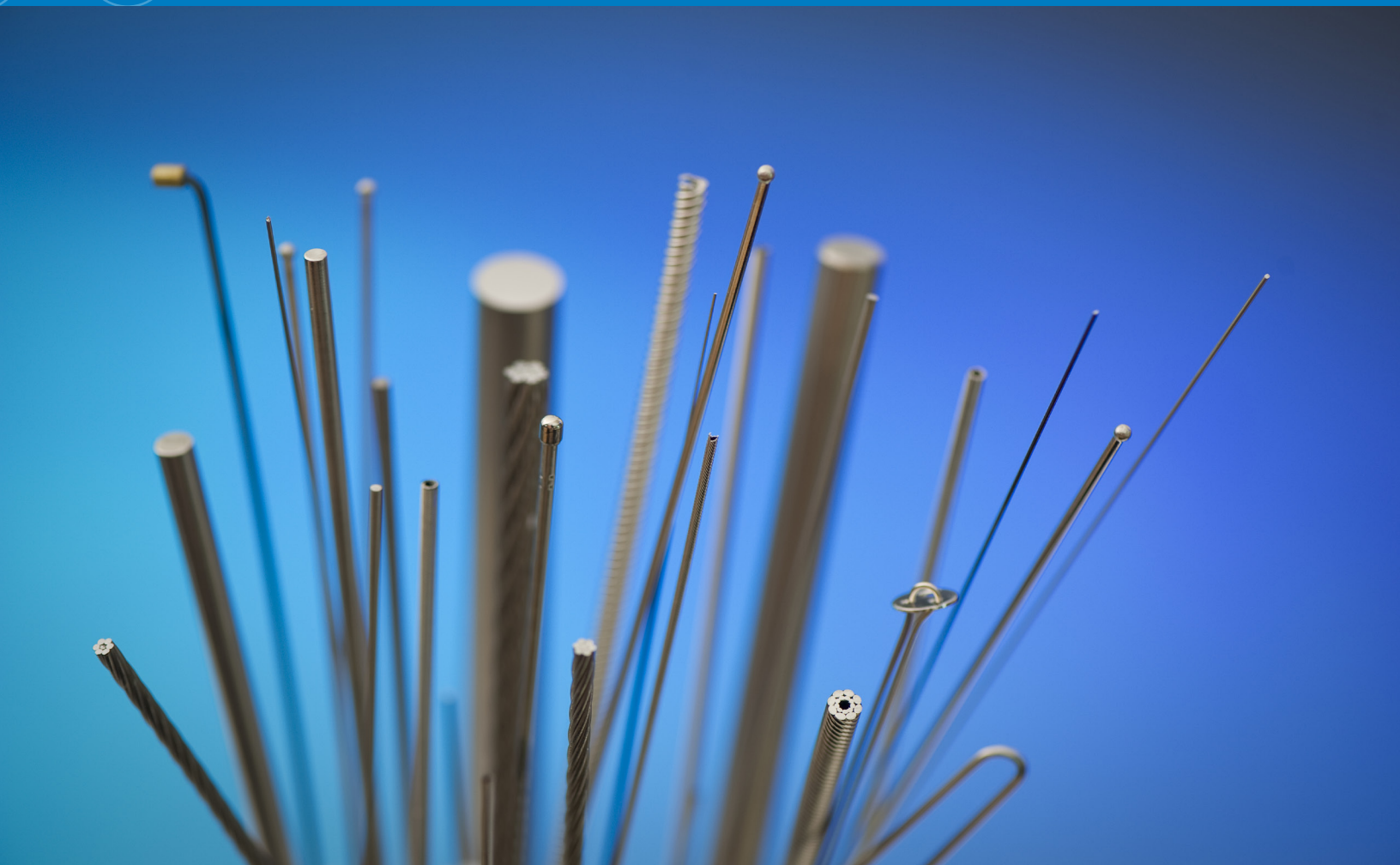
Customer Commitment

As a leading manufacturer of medical-grade materials, we fully support our customers' requirements for quality, service, reliability, dependability and R&D projects. We are FDA registered and ISO 13485, ISO 9001 and AS 9100 certified. We are fully capable of statistical process controls and just-in-time inventory scheduling. At Fort Wayne Metals we're committed to working with each of our customers to ensure that we meet their specific needs as we turn knowledge into solutions.



AVAILABLE ALLOYS

Nitinol (Binary & Ternary)
CP Ti Gr. 1
CP Ti Gr. 2
CP Ti Gr. 3
CP Ti Gr. 4
Ti 6Al-4V ELI
Ti 6Al-7Nb
Ti 3Al-2.5V
Ti-Beta 3
Ti-Beta C
302
304V
304LV
316LVM
DFT® (Composites)
35N LT®
MP35N®
L-605 (HAYNES® 25)
FWM 1058®
FWM 1537
HASTELLOY® C-276 Alloy
HAYNES® 214™
17-7PH®
CUSTOM 455®, 465®, 470®
WASPALOY®
22Cr-13Ni-5Mn

Not all types stocked. Other alloys available.

PRODUCT USES

Bioconductors
Neuro Stimulation
Catheter Reinforcement
Orthopaedics
Orthodontics
Surgical Needles
Surgical Staples & Clips
Suture Wire
Stents
Guidewires & Delivery Systems
Endoscopy

And other demanding medical products

PROCESSING CAPABILITIES

Diamond Drawing
Strand Annealing
Custom Spooling
Flat Drawing
Flat Rolling
Custom Stranding and Cabling
Straightening and Cutting
Centerless Grinding and Polishing
Laser Ablation
Coatings: Dielectric Insulation (ETFE, PFA, FEP)
Lubricious (LubriSkin,™ DuraSkin™)
Custom Assembly
Lab Services (ISO/IEC 17025)
Helical Hollow Strand (HHS® Tube)
Straight Linear Torque (SLT®)
DPS® (Dynamic Plateau Strength Nitinol)
USN™ (Ultra Stiff Nitinol)

PROPERTIES DATA

The data and information provided are based on work conducted principally by Fort Wayne Metals Research Products Corp. 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 Corp. 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 Corp.

302

Melt Practice

We offer this high quality austenitic stainless steel for spring applications. To keep costs at a minimum this alloy is supplied from an electric-arc air melted process. Localized variations in chemistry can cause slight changes in ultimate tensile strength when drawing to fine wire.

Typical Chemistry

	FWM Avg. Wt. %	ASTM A313
Carbon	0.10	0.12
Manganese	1.11	2.00
Phosphorus	0.023	0.045
Sulfur	0.002	0.030
Silicon	0.52	1.00
Chromium	18.60	17.0-19.0
Nickel	8.40	8.0-10.0
Molybdenum	0.32	-
Copper	0.36	-
Nitrogen	0.03	0.10
Cobalt	0.16	-
Iron	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.285 lbs/in^3
Modulus of Elasticity	28.0 x 10^6 psi
Electrical Resistivity	720 µohms-mm
Thermal Conductivity	16.3 W/m K (100°C)

Thermal Treatment

In wire form, cold worked 302 will gain tensile strength when stress relieved at 350-427°C for 4-6 hours. A reducing atmosphere is preferred, but inert gas can be used. 302 will fully anneal at 1010-1121°C in just a few minutes. There is a carbide precipitation phenomenon that occurs between 427 and 899°C that reduces the corrosion resistance of the alloy. American Society for Testing Materials (ASTM) has described a test method to ensure the alloy has not been damaged.

Applications

302 alloy is the same as 304 alloy except for the 0.12% carbon maximum. In 304 the maximum carbon is 0.08%. Technically, all 304 alloy meets the requirements of 302 alloy, but not all 302 can meet 304 chemistry. Practically, this means in general 302 is harder than 304 with the same amount of cold work. End uses for 302 include stylets, catheters, guidewires, springs and needles.

Mechanical Properties

% Cold Work	Y.S. (psi)	U.T.S. (psi)	% Elongation (10″ gauge length)
0%	49,000	106,000	48%
20%	125,000	147,000	9.8%
37%	169,000	189,000	3.2%
50%	196,000	220,000	2.6%
60%	222,000	244,000	2.2%
68%	243,000	273,000	2.1%
75%	251,000	289,000	2.4%
80%	282,000	309,000	2.2%
84%	295,000	327,000	2.2%
87%	300,000	332,000	2.3%
90%	319,000	345,000	2.2%
92%	322,000	371,000	2.5%

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

Surface Conditions

Stainless steels develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies. Additional finish treatments can enhance the surface of the wire.

304LV

Melt Practice

This austenitic stainless steel is initially electric-arc melted. Then as a refinement to the purity and homogeneity of the metal, 304LV is Vacuum Arc Remelted (VAR). This process yields a more uniform chemistry with minimal voids and contaminants. The "L" means low carbon as compared to 304V.

Typical Chemistry

	FWM Avg. Wt. %
Carbon	0.018
Manganese	1.280
Phosphorus	0.018
Sulfur	0.005
Silicon	0.46
Chromium	18.55
Nickel	9.87
Molybdenum	0.24
Copper	0.24
Nitrogen	0.042
Cobalt	0.13
Iron	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.285 lbs/in^3
Modulus of Elasticity	28.0 x 10^6 psi
Electrical Resistivity	720 µohms-mm
Thermal Conductivity	16.3 W/m K (100°C)

Thermal Treatment

A reducing atmosphere is preferred for thermal treatment but inert gas can be used. 304LV will fully anneal at 1010-1121°C in just a few minutes. The precipitation of carbides that decreases corrosion resistance in other 300 series alloys is controlled by a reduced carbon content in 304LV.

Applications

The chemistry of 304LV makes it less susceptible to sensitization. (Sensitization is the reduction in a material's corrosion resistance due to exposure to elevated temperatures.) Because of this feature, 304LV is recommended when exposure to 427-649°C is likely. End uses include catheters, guidewires, small parts made from straightened and cut wire and orthodontic applications.

Mechanical Properties

% Cold Work	Y.S. (psi)	U.T.S. (psi)	% Elongation (10" gauge length)
0%	48,000	90,000	40%
20%	81,500	106,000	27%
37%	116,000	147,000	5.9%
50%	147,000	173,000	3.2%
60%	167,000	191,000	2.8%
68%	158,000	206,000	2.8%
75%	183,000	217,000	2.7%
80%	203,000	223,000	2.6%
84%	211,000	232,000	2.5%
90%	220,000	240,000	2.5%
93%	248,000	270,000	2.5%
95%	258,000	281,000	3.1%

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

Surface Conditions

Stainless steels develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies. Additional finish treatments can enhance the surface of the wire.

304V

Melt Practice

This austenitic stainless steel is initially electric-arc melted. Then as a refinement to the purity and homogeneity of the metal, 304V is Vacuum Arc Remelted (VAR). This process yields a more uniform chemistry with minimal voids and contaminants.

Typical Chemistry

	FWM Avg. Wt. %	ASTM A313
Carbon	0.073	0.08
Manganese	1.310	2.00
Phosphorus	0.021	0.045
Sulfur	0.001	0.030
Silicon	0.700	1.00
Chromium	18.58	18.0-20.0
Nickel	8.65	8.0-10.5
Molybdenum	0.16	-
Copper	0.17	-
Nitrogen	0.034	0.10
Cobalt	0.10	-
Iron	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.286 lbs/in^3
Modulus of Elasticity	28.5 x 10^6 psi
Electrical Resistivity	720 µohms-mm
Thermal Conductivity	16.36 W/m K (100°C)

Thermal Treatment

In wire form, 304V will gain tensile strength when stress relieved at 350-427°C. A reducing atmosphere is preferred but inert gas can be used. 304V will fully anneal at 1010-1121°C in just a few minutes. There is a carbide precipitation phenomenon that occurs between 427 and 899°C that reduces the corrosion resistance of the alloy. The American Society for Testing Materials has described a test method to ensure the alloy has not been damaged.

Applications

This alloy is the most popular for non-implantable medical devices. The ease of joining with solder or welding, combined with excellent strength, makes it desirable. This alloy is also one of the least expensive medical materials. Some examples of end products are stylets, catheters, guidewires, springs and needles. Fort Wayne Metals routinely produces cables, strands, flat wire and shapes from this alloy.

Mechanical Properties

% Cold Work	Y.S. (psi)	U.T.S. (psi)	% Elongation (10" gauge length)
0%	50,000	107,000	41%
20%	70,000	140,000	14%
37%	90,000	184,000	4%
50%	140,000	208,000	3%
60%	160,000	229,000	2.6%
68%	180,000	247,000	2.7%
75%	200,000	265,000	2.6%
80%	215,000	272,000	2.9%
84%	230,000	289,000	2.5%
90%	245,000	306,000	2.6%
93%	250,000	316,000	2.7%
95%	280,000	334,000	2.6%

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

Surface Conditions

Stainless steels develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies.

316LVM

Melt Practice

This austenitic stainless steel is initially electric-arc melted. Then as a refinement to the purity and homogeneity of the metal, 316LVM is Vacuum Arc Remelted (VAR). This process yields a more uniform chemistry with minimal voids and contaminants. 316LVM is unique nomenclature for Fort Wayne Metals. This alloy meets the requirements of 316LS.

Typical Chemistry

	FWM Avg. Wt. %	ASTM F138
Carbon	0.023	0.030
Manganese	1.84	2.00
Phosphorus	0.014	0.025
Sulfur	0.001	0.010
Silicon	0.37	0.75
Chromium	17.57	17.00-19.00
Nickel	14.68	13.00-15.00
Molybdenum	2.79	2.25-3.00
Nitrogen	0.03	0.10
Copper	0.03	0.50
Iron	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.287 lbs/in^3
Modulus of Elasticity	27.9 x 10^6 psi
Electrical Resistivity	740 µohms-mm
Thermal Conductivity	16.3 W/m K (100°C)

Thermal Treatment

A reducing atmosphere is preferred for thermal treatment, but inert gas can be used. 316LVM will fully anneal at 1010-1121°C in just a few minutes. The precipitation of carbides that decreases corrosion resistance in other 300 series alloys is controlled by a reduced carbon content in 316LVM.

Applications

316LVM material has been used for permanent implants for many years. The corrosion resistance in the annealed condition is good. Many studies for new alloys use 316LVM as a reference. This stainless steel has good ductility in the cold worked condition. Applications include suture wire, orthopaedic cables, skin closure staples, catheters, stylets, bone pins and many small machined parts.

Mechanical Properties

% Cold Work	Y.S. (psi)	U.T.S. (psi)	% Elongation (10" gauge length)
0%	45,000	91,000	42%
20%	110,000	123,000	8%
37%	145,000	160,000	2.5%
50%	161,000	176,000	2.2%
60%	170,000	191,000	2.1%
68%	176,000	203,000	2.5%
75%	191,000	218,000	2.6%
80%	186,000	217,000	2.6%
84%	202,000	227,000	2.6%
90%	205,000	238,000	2.6%
93%	212,000	239,000	2.6%
95%	213,000	246,000	2.8%

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

Surface Conditions

Stainless steels develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies. Additional finish treatments can enhance the surface of the wire.

Custom 455®

Melt Practice

Alloy 455 is an alloy melted by several sources. Custom 455 is a trademarked name of Carpenter Specialty Alloys. It is a martensitic age-hardenable stainless steel that offers a unique set of qualities. This alloy is double vacuum-melted using a Vacuum Induction Melt (VIM) followed by a Vacuum Arc Remelt (VAR).

Typical Chemistry

	FWM Avg. Wt. %	AMS 5617 #1
Carbon	0.008	0.03
Manganese	0.05	0.50
Silicon	0.07	0.50
Phosphorus	0.006	0.015
Sulfur	0.003	0.015
Chromium	11.27	11.0-12.5
Nickel	8.22	7.50-9.50
Titanium	1.14	0.90-1.40
Copper	2.13	1.50-2.50
Molybdenum	0.07	0.50
Columbium	0.25	0.50
Nitrogen	0.003	0.015
Iron	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.280 lbs/in^3
Modulus of Elasticity	29.0 x 10^6 psi
Electrical Resistivity	758 µohms-mm
Thermal Conductivity	18.0 W/m K (100°C)

Thermal Treatment

A reducing atmosphere is preferred for thermal treatment, but inert gas can be used. Alloy 455 will fully anneal at 950-980°C in just a few minutes. Alloy 455 can minimally age harden with a loss in ductility when held for prolonged periods at 370-540°C. Original hardness can be restored by heating at 590°C.

Applications

Alloy 455 has the advantage of allowing parts fabrication in the more easily worked as-delivered state, after which heat treatment can develop a much higher ultimate tensile strength. Unlike many other heat treatable alloys, Alloy 455 has good oxidation resistance at room temperature. Primary end applications are needles, stylets, pins and springs.

Mechanical Properties

% Cold Work	U.T.S. (psi)	% Elongation (10" gauge length)
0%	145,000	6.3%
20%	153,000	5.7%
37%	161,000	3.8%
50%	165,000	3.5%
60%	173,000	4.6%
68%	185,000	2.4%
75%	190,000	2.5%
80%	193,000	2.6%
84%	199,000	2.6%
87%	210,000	2.2%
90%	220,000	2.5%
92%	230,000	2.4%

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

Surface Conditions

Stainless steels develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies. Additional finish treatments can enhance the surface of the wire.

FWM® 1058

General

FWM® 1058, Conichrome®, Phynox® and Elgiloy® are trademark names for the cobalt-chromium-nickel-molybdenum-iron alloy specified by ASTM F 1058 and ISO 5832-7. Batelle Laboratories originally developed the alloy for making watch springs, and it was patented in 1950.

As demonstrated in the table below, the current FWM® 1058 melt specification is equivalent to Conichrome, Phynox and Elgiloy. The alloy is first melted using Vacuum Induction Melting (VIM) techniques. A secondary melt operation, Electro Slag Remelt (ESR), is then employed to further remove impurities and improve overall homogeneity.

FWM® 1058 derives its maximum properties from a combination of cold work and thermal processing, and is not a true precipitation-hardening alloy since the response to heat treatment is a function of the degree of cold work.

Typical Chemistry (%)

	FWM 1058	ALTERNATE TRADE NAMES			
		Conichrome/Elgiloy		Phynox	
	average	min	max	min	max
Carbon	0.096	-	0.15	-	0.15
Manganese	1.68	1.5	2.5	1.0	2.0
Silicon	0.015	-	1.20	-	1.20
Phosphorus	0.006	-	0.015	-	0.015
Sulfur	0.001	-	0.015	-	0.015
Cobalt	40.34	39.0	41.0	39.0	42.0
Chromium	20.08	19.0	21.0	18.5	21.5
Nickel	15.28	14.0	16.0	15.0	18.0
Molybdenum	6.80	6.0	8.0	6.5	7.5
Beryllium	<0.001	-	0.1	-	0.001
Iron	balance	bal.	bal.	bal.	bal.

Physical Properties

Density:	0.300 lbs/in^3
Modulus of Elasticity:	29.0 x 10^6 psi
Electrical Resistivity:	996 µohms-mm
Thermal Conductivity:	12.5 W/m K (0-100°C)

Thermal Treatment

After cold working, the mechanical strength of this cobalt based super alloy can be increased by heat treating. In wire form, cold worked FWM® 1058 will gain tensile strength at temperatures from 480-540°C when exposed for approximately 2-5 hours. Reducing or inert atmospheres are typically used for protection during thermal treatment. After annealing with a rapid quench, the alloy has a face-centered cubic structure.

Biocompatibility

Although there is no universally accepted definition for biocompatibility of biomaterials, a medical device should be safe for its intended use. ASTM F1058 has been employed successfully in human implant applications in contact with soft tissue and bone for over a decade.

Long-term clinical experience of the use of this material has shown that an acceptable level of biological response can be expected if the alloy is used in appropriate applications.

Applications

Because of its excellent corrosion resistance, mechanical strength and fatigue resistance combined with high elastic modulus, FWM® 1058 wire and rod is an attractive candidate for surgical implants. It is one of the preferred materials for the fabrication of various stents, pacemaker lead conductors, surgical clips, vena cava filters, orthopaedic cables, and orthodontic appliances. The alloy is also commonly used in the watchmaking industry as a precision spring material.

FWM® 1058

Surface Conditions

Cobalt based alloys develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using single crystal natural diamond dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and therefore exhibit a rougher surface. Wire measuring over 0.100" will have an even rougher surface because it is drawn through carbide dies. However, the surface of the wire can be enhanced with additional finish treatments.

MP35N®

Melt Practice

This superalloy is typically double melted to remove impurities.

Typical Chemistry

	FWM Avg. Wt. %	ASTM F562
Carbon	0.010	0.025
Manganese	0.060	0.15
Silicon	0.030	0.15
Phosphorus	0.002	0.015
Sulfur	0.001	0.010
Chromium	20.580	19.0-21.0
Nickel	34.820	33.0-37.0
Molybdenum	9.510	9.0-10.5
Iron	0.520	1.0
Titanium	0.430	1.0
Boron	0.010	0.015
Cobalt	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.304 lbs/in^3
Modulus of Elasticity	33.76-34.05 x 10^6 psi
Electrical Resistivity	1033 µohms-mm
Thermal Conductivity	11.2 W/m K (100°C)

Thermal Treatment

A reducing atmosphere is preferred for thermal treatment but inert gas can be used. MP35N will fully anneal at 1010-1177°C in just a few minutes. For optimum mechanical properties, cold worked MP35N should be aged at 583-593°C for four hours.

Applications

MP35N is an excellent combination of strength and corrosion resistance. Typically used in the cold-worked condition, tensile strengths are comparable to 304. End uses in the medical field are pacing leads, stylets, catheters and orthopaedic cables.

Mechanical Properties

% Cold Work	U.T.S. (psi)	% Elongation (10" gauge length)
0%	152,000	50%
20%	201,000	7%
37%	253,000	3%
50%	285,000	2.5%
60%	303,000	3.2%
68%	319,000	3.0%
75%	329,000	3.1%
80%	332,000	3.3%
84%	339,000	3.2%
90%	345,000	3.4%
93%	346,000	2.2%
95%	362,000	2.8%

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

Surface Conditions

Cobalt based alloys develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be less than 5 microinches RMS when processed using dies and measured with a profilometer. Diameters over 0.040" are finished with polycrystalline dies and exhibit a rougher surface than natural diamond dies. Diameters over 0.100" have an even rougher surface because they are drawn with carbide dies. Additional finish treatments can enhance the surface of the wire.

35N LT®

Melt Practice

This superalloy is typically double melted to remove impurities. However, this melt practice is an enhancement of the standard melt practice for ASTM F562 material yielding much lower inclusion counts. This results in improved fatigue life of as-drawn wire by as much as 800%.

Typical Chemistry

	FWM Avg. Wt. %	ASTM F562
Carbon	0.010	0.025
Manganese	0.06	0.15
Silicon	0.03	0.15
Phosphorus	0.002	0.015
Sulfur	0.001	0.010
Chromium	20.58	19.0-21.0
Nickel	34.82	33.0-37.0
Molybdenum	9.51	9.0-10.5
Iron	0.52	1.0
Titanium	<=0.01	1.0
Boron	0.010	0.015
Cobalt	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

	English	Metric
Density	0.304 lbs/in³	8.41 g/cc
Modulus Of Elasticity	33.8e6 psi	233 Gpa
Electrical Resistivity	40.7 µohm-in	1033 µohm-mm
Thermal Conductivity	77.7 Btu-in/hr-ft²-°F	11.2 W/m K
Thermal Coefficient of Expansion	7.11 µin/in-°F	12.8 µm/m-°C

Thermal Treatment

A reducing atmosphere is preferred for thermal treatment but inert gas can be used. 35N LT will fully anneal at 1010-1177°C in just a few minutes. For optimum mechanical properties, cold worked 35N LT should be aged at 583-593°C for four hours.

Applications

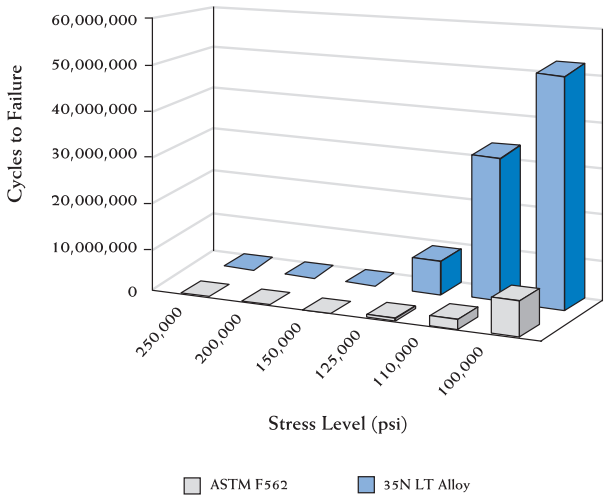
35N LT is an excellent combination of strength and corrosion resistance. Typically used in the cold-worked condition, tensile strengths are comparable to 304. End uses in the medical field are pacing leads, stylets, catheters and orthopaedic cables.

Mechanical Properties

% Cold Work	Y.S. ksi (MPa)	U.T.S. ksi (MPa)	% Elongation (10" gauge length)
0%	130 (896)	190 (1310)	40.0%
20%	190 (1310)	240 (1655)	8.0%
37%	240 (1655)	280 (1931)	3.8%
50%	270 (1862)	300 (2268)	3.8%
60%	290 (1999)	320 (2206)	3.5%
68%	300 (2068)	330 (2275)	3.5%
75%	305 (2103)	340 (2344)	3.3%
80%	315 (2172)	350 (2413)	3.0%
84%	325 (2241)	360 (2482)	3.0%
90%	333 (2296)	370 (2551)	3.0%
93%	338 (2330)	375 (2586)	2.5%
95%	340 (2344)	380 (2620)	2.5%

Values are typical for diameters smaller than .010 in (.254mm).

Rotary Beam Fatigue



L-605

Melt Practice

L-605 is a cobalt-chromium-tungsten-nickel alloy and is typically double melted to remove impurities.

Typical Chemistry

	FWM Avg. Wt. %	ASTM F90
Carbon	0.10	0.05-0.15
Manganese	1.5	1.00-2.00
Silicon	0.40**	0.40**
Phosphorus	0.040**	0.040**
Sulfur	0.030**	0.030**
Chromium	20.0	19.00-21.00
Nickel	10.0	9.00-11.00
Tungsten	15.0	14.00-16.00
Iron	3.0**	3.00**
Cobalt	51.0*	balance

* As balance ** Maximum
FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.333 lbs/in^3
Modulus of Elasticity	32.6 x 10^6 psi (room temp.)
Thermal Conductivity	9.4 W/m K (room temp.)

Description

L-605 alloy is a nonmagnetic, cobalt-chromium-tungsten-nickel alloy. The high strength properties of this alloy may be obtained through work hardening. It remains nonmagnetic in the work-hardened condition.

Thermal Treatment

The alloy is normally solution-treated in the range of 2150ºF-2250ºF (1175ºC-1230ºC), then rapid air cooled or water-quenched to attain optimum properties. Annealing at lower temperatures may cause some precipitation of carbide, which is undesirable for the achievement of many properties.

Applications

L-605 has good oxidation and corrosion resistance as well as excellent high strength properties at elevated temperatures. The alloy is typically used in the cold-worked condition. A modest increase in hardness and strength can be achieved through aging of the cold worked material. End uses in the medical field are stents, bone drill bits, cerclage cables, guide rods, orthopaedic cables, heart valves and various other orthopaedic applications.

Surface Conditions

Cobalt based alloys develop a highly polished appearance as they are drawn to fine diameters. Surface roughness can be reduced when processed using single crystal natural diamond dies. Diameters over 0.040" will not have as smooth a finish because of poly-crystalline dies. Diameters over 0.070" will be carbide drawn and supplied with a more textured surface. Additional finish treatments can enhance the surface of the wire. Material above 0.070" is often centerless ground and polished when supplied as straightened and cut bar. This process yields a lustrous surface finish and maintains a tight tolerance for precision machining applications.

Mechanical Properties - Wire

% Cold Work	U.T.S. (psi)	(10" gauge length)
0%	165,000	50%
20%	240,000	9%
37%	290,000	6%
50%	325,000	3.6%

Mechanical Properties - Straightened and Cut Bar

	U.T.S. (psi)	Y.S. (psi)	% Elongation (2" gauge length)
Annealed	150,000	75,000	40%
Cold worked	200,000	150,000	25%

Values are nominal and may not represent all diameters. Test method will affect results.

Machinability

L-605 is machinable using conventional techniques; however cobalt grades of high-speed steel or carbide tools combined with right machine setups are recommended. L-605 is more difficult to machine than the austenitic stainless steels (e.g. Types 302, 304, 321, and 347 stainless). Generally, lower feed speeds and depths of cut are suggested. A very high work-hardening rate, generation of heat during cutting and a high shear strength complicate machining.

L-605 Specifications

ASTM F90	ASTM F1091	UNSR30605
AMS5796	AMS 5759	ISO 5832-5

FWM® 1537 (ASTM F1537, ISO 5832-12)

FWM® 1537 is a low carbon wrought Cobalt-Chromium-Molybdenum alloy ideal for applications in medical and aerospace industries. It has high strength, ductility, wear resistance, corrosion resistance and biocompatibility.

Typical Chemistry

	FWM™ 1537 (wt%)	ASTM F 1537 Alloy 1 (wt%)
Carbon	0.01-0.04	<0.14
Chromium	27.5	26-30
Molybdenum	5.5	5-7
Nickel	0.05-0.4	<1.0
Iron	<0.5	<0.75
Silicon	<0.6	<1.0
Manganese	<1.0	<1.0
Nitrogen	<0.2	<0.25
Cobalt	balance	balance

FWM® chemistry in this table is for reference only and should not be used for specification purposes.

Physical Properties at Room Temperature

Density:	0.3 lbs/in³
Modulus of Elasticity:	35 Mpsi
Thermal Conductivity:	12.6 W/m K
Coefficient of Thermal Expansion:	13.2×10-6 in/in/°C (20 – 100°C)

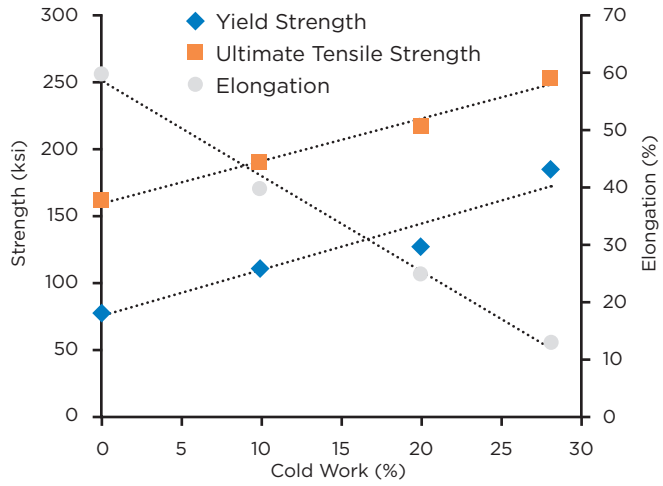
Thermal Treatment

This alloy is normally solution treated at temperatures around 2000°F for one hour, followed by a rapid quench with water or compressed air to ensure optimum properties. Annealing or aging at lower temperatures may cause the precipitation of carbides or phase transformation, which can significantly reduce ductility.

Mechanical Properties

FWM® 1537 can be provided in coil form (typical size range from 0.004" to 0.45") or as straight bars (typical size range from 0.06" to 0.4"). Coiled material can be annealed or cold worked, with the mechanical properties depending on the amount of cold work. The figure below illustrates the influence of cold work on mechanical properties.

Effect of cold work on mechanical properties:



FWM® 1537 bars can be provided in two conditions: annealed and hard. The typical mechanical properties of each condition are listed in the table below.

Typical Mechanical Properties of FWM 1537 bar products:

Condition	U.T.S. (ksi)	Y.S. (ksi)	HRC	Elongation (%)
Annealed	150-170	80-110	30-35	>25
Hard*	170-195	110-130	~40	>30

* 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.

Surface condition

FWM® 1537 develops a highly polished appearance when drawn to fine diameters. Surface roughness can be decreased by using single crystal natural diamond dies. Large diameter wires (>0.05") will be drawn by carbide dies and thus have a more textured surface. Bar products are normally centerless ground and polished, which provides a lustrous surface finish and maintains a tight tolerance for precision machining applications.

FWM® 1537

Applications

FWM® 1537 is currently used in the medical industry to manufacture implants such as hip and knee replacements, spinal rods and screws. Due to its unique properties, FWM® 1537 has great potential in any industrial application that requires high strength, wear and corrosion resistance, for instance in aerospace bushings and bearings.

		Ultimate Tensile Strength (ksi)	0.2 % Yield Strength (ksi)	Elongation (%)	Reduction of Area (%)	Typical HRC Hardness
Annealed	ASTM	130 min	75 min	20 min	20 min	25
	FWM Typical Properties	150-170	80-110	>25	>20	30-35
Hard	ASTM Warm Worked	145 min	101 min	12 min	12 min	28
	FWM Typical Properties	170-195	110-130	>30	>20	40

Unalloyed Commercially Pure Titanium

Unalloyed Commercially Pure (CP) Titanium is represented by four distinct grades, specifically 1, 2, 3 and 4. CP Titanium is ordered in relation to the corrosion resistance, formability (ductility) and strength requirements of a specific application. CP Titanium ranges from grade 1, which has the highest corrosion resistance, formability and lowest strength, to grade 4, which offers the highest strength and moderate formability. CP Titanium end users utilize excellent corrosion resistance, formability and weldable characteristics for many critical applications.

Chemistry **ASTM F67**

	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

FWM chemistry is for reference only, and is not to be used for specification purposes.

Physical Properties

Density	0.163 lbs/in^3
Modulus of Elasticity	14.9 x 10^6 psi
Electrical Resistivity	0.42-0.52 µohms-m
Thermal Conductivity	16-22 W/m K

Surface Conditions

CP Titanium has a tendency to stick, fret or cold weld with drawing dies during processing. Common industry practice to avoid this condition employs heavy etching or pickling at finish size, resulting in a coarse or very textured surface. Fort Wayne Metals has developed processing techniques with enhanced surface treatments that require minimal etching at finish size to remove most residual oxide, yielding a cleaner and smoother surface finish. Material can be purchased with this improved surface finish or with a retained water soluble lubricant for applications where lubricity of the wire is required (e.g. weaving applications).

Diameter Tolerances

Enhanced surface treatments and processing techniques allow Fort Wayne Metals to offer tighter and more controlled tolerances. The chart on the following page details standard diameter tolerances for CP Titanium in wire and coil forms. Most diameters can be produced to tighter tolerances.

Applications

Fort Wayne Metals manufactures CP Titanium in straightened and cut bar, coil, strands and cables, flat wire and wire form to support a variety of critical medical and industrial based applications.

End uses include:

- Orthopaedic applications
- Needles
- Pacing leads
- Woven wire mesh
- Sutures
- Ligature clips
- Orthodontic appliances
- Eye glass frames

Mechanical Properties ASTM F67

Grade	U.T.S. min., ksi (MPa)	Y.S. min., (2% offset) ksi (MPa)	% Elongation (2″ gauge length) minimum
1	35 (240)	25 (170)	24
2	50 (345)	40 (275)	20
3	65 (450)	55 (380)	18
4	80 (550)	70 (483)	15

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

Approximate FWM Tensile Properties

Grade	Condition	U.T.S. ksi (MPa)
1	Cold Worked	85-115 (586-793)
1	Annealed	45-75 (310-517)
2	Cold Worked	110-140 (758-965)
2	Annealed	65-90 (448-621)
4	Cold Worked	135-165 (931-1138)
4	Annealed	95-120 (655-827)

Values are typical and may not represent all diameters. Test method will affect results. CP Titanium in centerless ground bar, coil, and wire can be offered in annealed or cold worked conditions.

Unalloyed Commercially Pure Titanium

Standard Tolerances

Diameter in inches (mm) Including	Under	Standard Tolerance +/-
0.0010 (0.0254)	0.0048 (0.1219)	0.0001 (0.0025)
0.0048 (0.1219)	0.0080 (0.2032)	0.0002 (0.0051)
0.0080 (0.2032)	0.0120 (0.3048)	0.0003 (0.0076)
0.0120 (0.3048)	0.0240 (0.6096)	0.0004 (0.0102)
0.0240 (0.6096)	0.0330 (0.8382)	0.0005 (0.0127)
0.0330 (0.8382)	0.0440 (1.1176)	0.0008 (0.0203)
0.0440 (1.1176)	0.2510 (6.3754)	0.0010 (0.0254)

Product Capability

Wire

Fort Wayne Metals utilizes state-of-the-art equipment and processing techniques to provide precision drawn CP Titanium. Wire is typically provided on standard FWM spools (see packaging and spooling data sheet). Custom packaging or spools will be considered based on our equipment capabilities.

Diameter Range

0.001" (0.0254mm) to 0.062" (1.5748mm)

Coil

Fort Wayne Metals provides precision loose wound coils for many critical applications, coil weights can reach a maximum of 100 pounds, nominal 50 pound weight depending on diameter.

Diameter Range

0.040" (1.016mm) to 0.500" (12.7mm)

Packaging (coil I.D.)

0.040" (1.016mm) to 0.125" (3.175mm) = 20" (508mm) nominal

0.100" (2.54mm) to 0.500"(12.7mm) = 28" (711mm) nominal

Centerless and Precision Ground Bar

Fort Wayne Metals provides straightened and cut bar product in centerless and precision ground conditions. Customers can order discrete lengths, however material is typically manufactured in 10' (3048mm) to 12' (3657mm) random lengths. Available diameters range from 0.0787" (2.0mm) to 0.500" (12.7mm). Standard Tolerances are given below. Most diameters can be produced to tighter tolerances if required.

Diameter Range

	Standard Tolerance	Surface Roughness (RMS)
Centerless Ground Bar	+/- 0.001" (0.0254mm)	24 or better
Precision Ground Bar	+/- 0.0005" (0.0127mm)	16 or better

Other Titanium & Titanium Alloys Available

CP Ti Gr.1	Ti 6Al-4V ELI
CP Ti Gr.2	Ti 6Al-7Nb
CP Ti Gr.3	Ti 3Al-2.5V
CP Ti Gr.4	Ti 3Al-8V-6Cr-4Mo-4Zr (Ti Beta C)

Other titanium and titanium alloys will be considered upon request.

Ti 6Al-4V ELI

One of the most commonly used titanium alloys is an alpha-beta alloy containing 6% Al and 4% V. This alloy, usually referred to as Ti 6Al-4V, exhibits an excellent combination of corrosion resistance, strength and toughness. Typical uses include medical devices or implants, aerospace applications and pressure vessels. In the case of medical applications, stringent user specifications require controlled microstructures and freedom from melt imperfections. The interstitial elements of iron and oxygen are carefully controlled to improve ductility and fracture toughness. Controlled interstitial element levels are designated ELI (extra low interstitials), hence the designation Ti 6Al-4V ELI.

Chemistry

	FWM Avg. Wt. %	ASTM F136
Nitrogen, max.	0.011	0.05
Carbon, max.	0.015	0.08
Hydrogen, max.	0.0058	0.012A
Iron, max.	0.12	0.25
Oxygen, max.	0.11	0.13
Aluminum	6.06	5.5-6.50
Vanadium	3.97	3.5-4.5
Titanium	balance	balance

FWM chemistry is for reference only, and is not to be used for specification purposes.
A Material .032" (0.813mm) and under may have hydrogen content up to .0150%.

Surface Conditions

Ti 6Al-4V ELI has a tendency to stick, fret or cold weld with drawing dies during processing. Common industry practice to avoid this condition employs heavy etching or pickling at finish size resulting in a coarse or very textured surface. Fort Wayne Metals has developed processing techniques with enhanced surface treatments which require minimal etching at finish size to remove residual oxide, yielding a cleaner and smoother surface finish.

Diameter Tolerances

Enhanced surface treatments and processing techniques allow Fort Wayne Metals to offer tighter and more controlled tolerances. The chart in the column to the right details standard diameter tolerances for Ti 6Al-4V ELI in wire and coil forms. Most diameters can be produced to tighter tolerances.

Applications

Fort Wayne Metals manufactures Ti 6Al-4V ELI in straightened and cut bar, coil, strands and cables, and wire form to support a variety of critical medical and industrial based applications. End uses include:

- Orthopaedic pins and screws
- Orthopaedic cables
- Orthodontic appliances
- Springs
- Surgical staples
- Ligature clips

Mechanical Properties per ASTM F136

Size in. (mm)	U.T.S. min., ksi (MPa)	Y.S. min., (2% offset) ksi (MPa)	% Elongation minimum
Under 0.187 (4.75)	125 (860)	115 (795)	10% (2" gauge length)
0.187 to 0.250 (4.75 to 6.35)	125 (860)	115 (795)	10% (4D)

Approximate FWM Mechanical Properties

Condition	U.T.S. ksi (MPa)	% Elongation (2" gauge length)
Cold Worked	190-210 (1310-1448)	3%-7%
Cold Worked/ Stress Relieved	170-190 (1172-1310)	5%-10%
Annealed	145-170 (1000-1172)	10% min.

Values are typical and may not represent all diameters. Test method will affect results.
Ti 6Al-4V ELI centerless ground bar, coil and wire is available in annealed or cold worked condition.

Physical Properties

Density	0.160 lbs/in^3
Modulus of Elasticity	16.5 x 10^6 psi
Electrical Resistivity	1.71 µohms-m
Thermal Conductivity	6.6-6.8 W/m K

Standard Tolerances

Diameter in inches (mm) Including	Under	Standard Tolerance +/-
0.0010 (0.0254)	0.0048 (0.1219)	0.0001 (0.0025)
0.0048 (0.1219)	0.0080 (0.2032)	0.0002 (0.0051)
0.0080 (0.2032)	0.0120 (0.3048)	0.0003 (0.0076)
0.0120 (0.3048)	0.0240 (0.6096)	0.0004 (0.0102)
0.0240 (0.6096)	0.0330 (0.8382)	0.0005 (0.0127)
0.0330 (0.8382)	0.0440 (1.1176)	0.0008 (0.0203)
0.0440 (1.1176)	0.2510 (6.3754)	0.0010 (0.0254)

Ti 6Al-4V ELI

Product Capability

Wire

Fort Wayne Metals utilizes state-of-the-art equipment and processing techniques to provide precision drawn Ti 6Al-4V ELI. Wire is typically provided on standard FWM spools (see packaging and spooling data sheet). Custom packaging or spools will be considered based on our equipment capabilities.

Diameter Range
0.001" (0.0254mm) to 0.062" (1.5748mm)

Coil

Fort Wayne Metals provides precision loose wound coils for many critical applications. Coil weights are a nominal 50 pounds and can reach a maximum of 100 pounds depending on diameter.

Diameter Range
0.040" (1.016mm) to .47244" (12mm)

Packaging (coil I.D.)
0.040" (1.016mm) to 0.125" (3.175mm) = 20" (508mm) nominal
0.100" (2.54mm) to .47244" (12mm) = 28" (711mm) nominal

Centerless and Precision Ground Bar

Fort Wayne Metals provides straightened and cut bar product in centerless and precision ground conditions. Customers can order discrete lengths, however material is typically manufactured in 10' (3048mm) to 12' (3657mm) random lengths. Available diameters range from 0.0787" (2.0mm) to 0.47244" (12mm). Standard Tolerances are given below. Most diameters can be produced to tighter tolerances if required.

Diameter Range

	Standard Tolerance	Surface Roughness (RMS)
Centerless Ground Bar	+/- 0.001" (0.0254mm)	24 or better
Precision Ground Bar	+/- 0.0005" (0.0127mm)	16 or better

Other Titanium & Titanium Alloys Available

CP Ti Gr.1	Ti 6Al-4V ELI
CP Ti Gr.2	Ti 6Al-7Nb
CP Ti Gr.3	Ti 3Al-2.5V
CP Ti Gr.4	Ti 3Al-8V-6Cr-4Mo-4Zr (Ti Beta C)

Other titanium and titanium alloys will be considered upon request.

Nitinol Wire

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

Fort Wayne Metals offers different grades of Nitinol, which are distinguished by the austenite start temperature (A_S) of the ingot per ASTM 2004:

Nitinol #1	-35 to -10 °C
Nitinol #2	-45 to -15 °C
Nitinol #4	-10 to +10 °C
Nitinol #5	≥ +85 °C
Nitinol #6	+35 to +85 °C
Nitinol #8	+10 to + 35 °C
Nitinol #9	≤ +35 °C

Fort Wayne Metals inspects all incoming Nitinol raw materials to ensure they meet proprietary internal specifications for chemistry, ingot transformation temperature, material homogeneity, and microstructure. Optimized to promote an exceptionally smooth and uniform surface finish quality, all wire products utilize a proprietary single and multi crystalline diamond drawing die technology. Each medical grade of Nitinol material is comprised of near equal atomic weight percentage of nickel and titanium.

With the exception of Nitinol #2 all available grades meet the chemistry requirements set forth by ASTM F2063 for use in surgical implants. Nitinol #2 is chromium doped to lower its transformation temperature, which means that the chromium content of 0.20-0.30 weight% exceeds the 0.01% specified in ASTM F2063.

Conditions Available

As Drawn (Hard)	Straight Annealed

Nitinol Wire Applications

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

Grade	Application Examples
Nitinol #1	Superelasticity at room and body temperature.
Nitinol #2	Increased loading and unloading plateau stresses and decreased transformation temperatures.
Nitinol #3	Decreased transformation temperatures that allow this grade of Nitinol to remain superelastic at colder temperatures.
Nitinol #4	Warm transformation temperatures that result in decreased plateau stresses and improved fatigue performance at room and body temperature.
Nitinol #5	High temperature actuators.
Nitinol #6	High temperature actuators.
Nitinol #8	Phase transformation at body temperature.
Nitinol #9	Superelasticity at colder temperatures.

Nitinol Product Forms

Round Wire:	0.0005" to 0.250" (Condition Dependent)
Flat Wire/Strip:	Aspect Ratio:W/T ~ 1-15 Minimum Thickness: 0.0005" Maximum Width: 0.320"
Turkshead:	Square, Rectangular
Custom Shapes:	A wide variety of shaped cross-sectional wire
Stranded Cables:	1x3, 1x7, 1x19, Materials Blends, etc.
DFT® Wire:	Composites manufactured with a Nitinol core or clad jacket
HHS® Tube:	Composites manufactured with a Nitinol core or tube.

Contact Sales Representative for sizes outside these ranges.

Nitinol Wire

Mechanical Properties for Superelastic Grades

	Cold Worked			Superelastic				
Grade	Ingot A_s (°C)	min UTS (psi)	Elongation (%)	min UTS (psi)	Elongation (%)	Loading Plateau (psi)	Unloading Plateau (psi)	Active A_f (°C)
Nitinol #1	-35 to -10	200,000	> 4	180,000	> 10%	> 70,000	> 20,000	+10 to +18
Nitinol #2	-65 to +5	250,000	> 4	210,000	> 10%	> 80,000	> 35,000	0 to +18
Nitinol #3	-95 to -65	200,000	> 5	190,000	> 10%	> 100,000	> 360,000	-20 to -10
Nitinol #4	-10 to +10	220,000	> 4	180,000	> 10%	> 65,000	> 7,000	+14 to +22
Nitinol #9	≤ -35	220,000	> 4	160,000	> 10%	> 75,000	> 25,000	-10 to +5

Notes:

*Typical Target.

Custom mechanical properties customized upon request. Permanent Set < 0.5% after strained to 8%. Results are typical for round wire diameters from 0.001" (0.025 mm) to 0.040" (1.016 mm). All Mechanical testing conducted at 22°C ± 2°C.

Mechanical Properties for Shape Memory Grades

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

Notes:

Permanent Set < 0.5% after strained to 8%

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

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

Chemical Composition

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

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

Nitinol #2 & #3

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

Notes:

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

Cobalt content of Nitinol #3 does not meet ASTM F2063 requirements.

Nitinol Wire

Surface Finishes

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

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

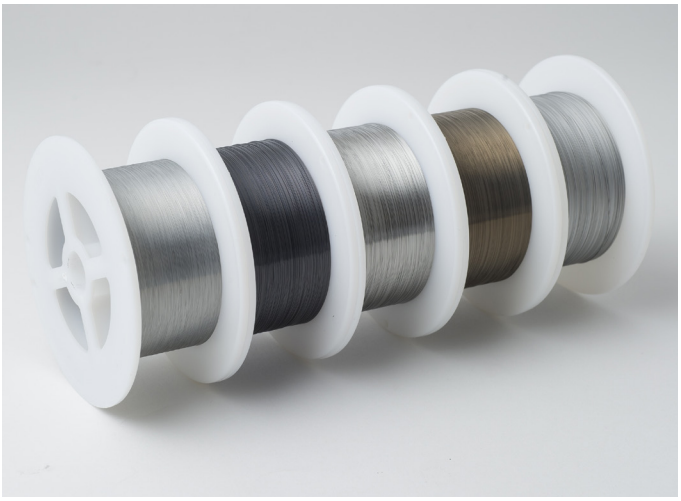
Black Oxide (BLK) Shiny Black color - diamond drawn surface

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

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

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

Sik® NiTi - an ultra-smooth Nitinol wire. Silk® NiTi has a bright, oxide-free surface with a surface roughness of only 0.0762 µm [3 µin] RMS or less.



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

Packaging

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

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

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

Applicable Documents

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

ASTM F2005 Standard Terminology for Nickel-Titanium Shape Memory Alloy

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

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

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

Nitinol Wire for Super-Elastic Applications with Increased Stiffness Requirements

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

Dynamic Plateau Strength Nitinol

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

Mechanical Properties of DPS Nitinol Wire

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

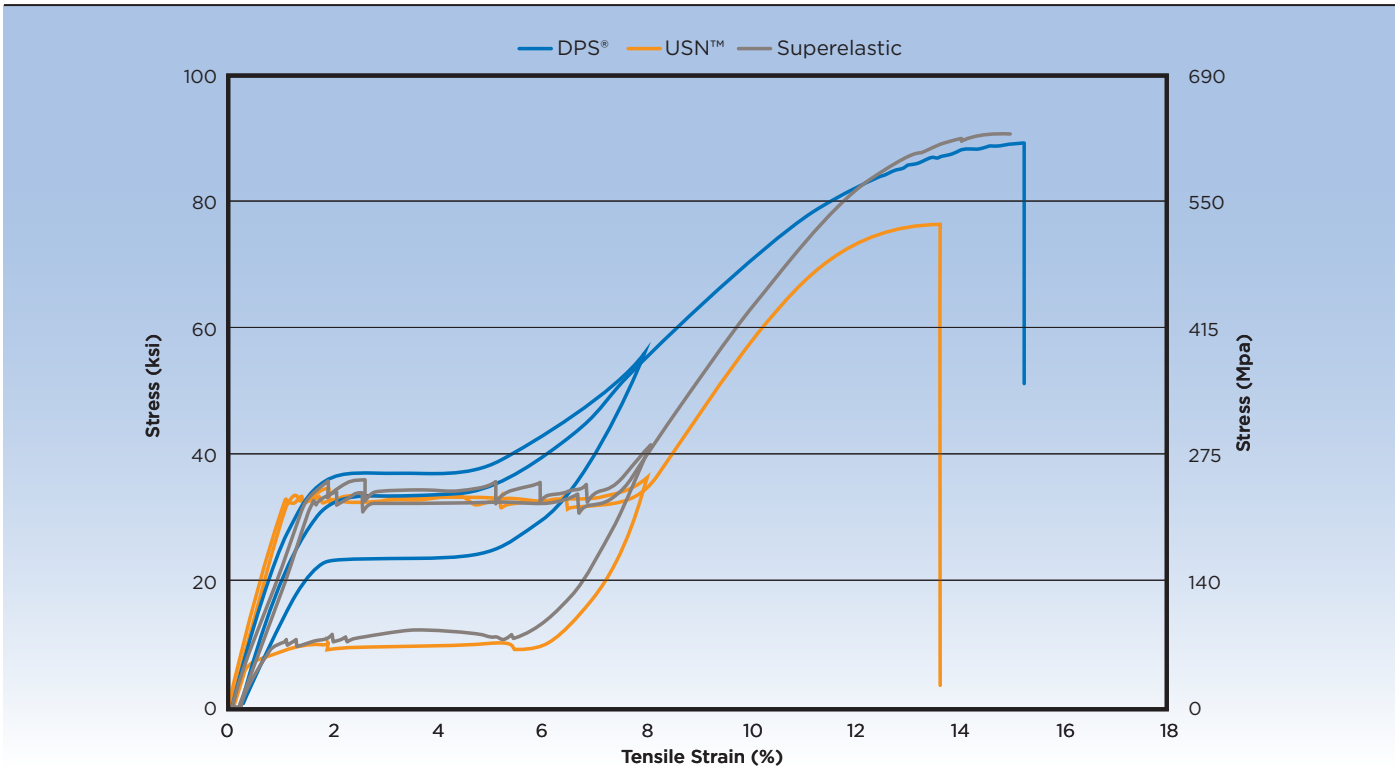
Ultra-Stiff Nitinol

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

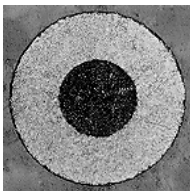
Mechanical Properties of USN Wire

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

Stress-Strain Curves



DFT® Wire



Magnified 200x
0.00894" in Diameter

DFT wire is a metal-to-metal composite developed to combine the desired physical and mechanical attributes of two or more materials into a single wire or ribbon system. As a result of extreme compressive forces imparted during the processing of the dissimilar materials, the mechanical bond formed between surfaces has been found to be metallurgically sound. This feature has given rise to a number of novel applications of DFT wire, cable or ribbon.

One of the more common uses of DFT wire is found in the medical device industry, where designers have integrated the strength and biocompatibility of implant grade alloys with desired properties of other materials. The composite typically uses the outer sheath to impart strength, while the core material is designed to provide conductivity, radiopacity, resiliency or MRI enhancement.

DFT wire enables the unique ability to match dissimilar materials to provide a variety of properties in a single wire system. This technology can be utilized by the engineer to resolve technical issues cost effectively.

Size

Fort Wayne Metals has the capability to create these DFT wire materials in sizes from 0.050" to 0.001" or smaller depending on the constituents.

Values and Compositions

A typical 35N LT®/Silver DFT wire material (35N LT) may have a variety of tensile values depending upon the amount of cold work and core percentages of the individual wires (see Fig. 1). In addition, the table in Fig. 2 is presented to compare the electrical resistivity of various core percentages to that of solid 35N LT wire, a common pacemaker lead material.

35N LT, MP35N®, 316LVM and FWM 1058® tubing is kept in stock for the outer sheath. Core wire options, in wire form, are more abundant in general inventory.

Core Materials	Tubing Material
Gold	35N LT®
Silver	MP35N®
Platinum	316LVM
Titanium Alloys	Nitinol
Nitinol	FWM1058®
Tantalum	Titanium Alloys
Platinum Alloys	

Other materials available upon request.

Fig. 1
Typical tensile values for 35N LT-DFT wire with a silver core (% Ag)

	Pounds per square inch			
% Cold Work	25% Ag	28% Ag	33% Ag	41% Ag
0%	158,200	148,800	149,600	124,100
20%	201,300	191,200	192,600	162,800
37%	225,600	216,500	213,800	165,800
50%	237,300	227,300	224,700	192,400
61%	246,000	236,000	232,400	200,000
69%	256,700	244,000	239,300	206,400
75%	261,200	248,100	242,300	209,500
80%	267,800	254,500	249,300	214,900
84%	276,000	264,000	261,600	217,000
87%	278,200	264,300	262,300	225,000
90%	277,300	264,300	258,400	223,300
92%	281,900	266,900	254,700	232,200

Fig. 2
Theoretical total resistance per foot for 35N LT-DFT wire with a silver core

	Ohms per foot				
Size	25% Ag	28% Ag	33% Ag	41% Ag	Solid 35N LT Wire
0.006	1.0132	0.9104	0.7788	0.6324	17.26
0.004	2.2797	2.0489	1.7521	1.4228	38.84
0.002	9.1126	8.1911	7.0064	5.6914	155.34
0.001	36.5347	32.7598	28.7598	22.7663	621.38

SLT® Wire

SLT® Wire from Fort Wayne Metals has been engineered specifically to reduce production steps in your operation. Whether you just need basic wire that will eliminate the need for straightening and reduce machine downtime, a premium straightened wire that will not deform during deep taper grinding, or anything in between, using SLT® Wire will help streamline your production process.

Type 1

It eliminates manufacturing process steps, reduces set-up time, and often does away with the need for additional equipment. That's why we make Type 1 SLT® Wire. Typically used for staple wire, braiding mandrels, and dental probes, this ready to use product reduces setup time and eliminates the need to rotary or mechanically straighten before additional processes. Now you can streamline your process to get your product out the door faster without compromising quality.

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

Type 2

Type 2 SLT® Wire significantly reduces process time by eliminating the need for mechanical straightening. This wire comes to you free of rotary marks, providing customer-ready surface without the need for later polishing. With no need to adjust for cast or helix in secondary processing, Type 2 SLT® Wire is often used for mandrel wire, needle and staple wire, stylet wire, point coiling, and micro needle applications.

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

Type 3

Straightening and handling ultrafine wire can result in numerous problems such as rippling or pig tailing, but Type 3 SLT® Wire eliminates the need to straighten. In spring and hard conditions, this material is designed for removing up to 90% cross-sectional area by taper grinding without requiring heat treatment. Typical applications for Type 3 SLT® Wire range from micro needles, orthodontics, and suture needles to guide wires, endoscopes and embolic filters.

MEETS ASTM F2819 STANDARDS
STRAIGHTNESS VARIANCE 0.02 in. per 12.00 in. | 0.508 mm per 304.8 mm
PACKING SPECIFICATIONS Wire on a spool or cut to length.
MIN HUB SIZE 400x wire diameter

Type 4

Our premier SLT® Wire features excellent 1:1 torque response, which makes it a popular choice for neurovascular guide wire, steerable PTCA, endoscopes, and other precision applications. Type 4 SLT® Wire is designed for deep taper grinding up to 95% without requiring additional heat treatment, regardless of condition. This superior grindability coupled with its kink resistance means this SLT® Wire is often chosen for the most demanding applications.

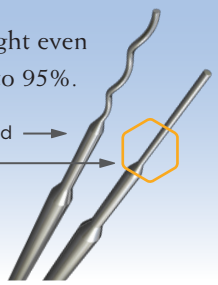
MEETS ASTM F2819 STANDARDS
STRAIGHTNESS VARIANCE 0.01 in. per 12.00 in. | 0.254 mm per 304.8 mm
PACKING SPECIFICATIONS Cut to length only.
MIN HUB SIZE N/A

SLT® Wire

Eliminate ripples

Grinding conventionally straightened wire usually leads to rippling or pig tailing.

TYPE 4 SLT® WIRE will remain straight even after being deep taper-ground up to 95%.



Specifications

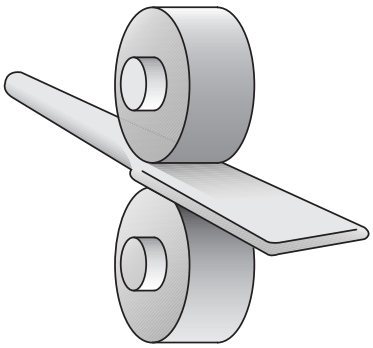
Type	Reduced Set-Up Time	Straightness	Grindability	1:1 Torque Transmission
1	•	•		
2	• •	• •		
3	• • •	• • •	•	•
4	• • •	• • •	• • •	• •

	Condition	Surface Finish	Size(s) Available
Type 1	Half Hard	Light Oxide & Bright	0.0381 mm - 1.3716 mm [0.0015 in - 0.054 in]
	3/4 Hard	Light Oxide & Bright	
	Hard	Light Oxide & Bright	
	Spring	Light Oxide & Bright	
	Ultra Spring	Light Oxide & Bright	
	Hyten	Light Oxide & Bright	0.0381 mm - 0.889 mm [0.0015 in - 0.035 in]
Type 2	Hard	Bright	0.0508 mm - 0.889 mm [0.002 in - 0.035 in]
	Spring	Bright	
	Ultra Spring	Bright	
	Hyten	Bright	0.0508 mm - 0.889 mm [0.002 in - 0.035 in]
Type 3	Hard	Bright	0.0508 mm - 0.889 mm [0.002 in - 0.035 in]
	Spring	Bright	
	Ultra Spring	Bright	
	Hyten	Bright	0.0381 mm - 0.889 mm [0.0015 in - 0.035 in]
Type 4	Spring	Bright	0.2032 mm - 0.8636 mm [0.008 in - 0.034 in]
	Utra Spring	Bright	
	Hyten	Bright	

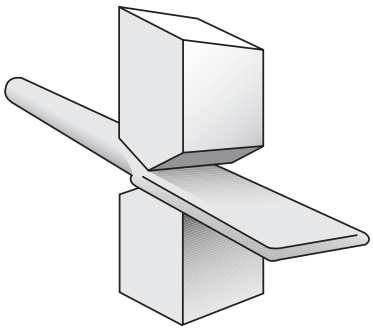
Flat Wire

Manufacturing Techniques

Flat wire, often referred to as ribbon wire, is commonly used in devices designed to reduce catheter profiles or increase available lumen size. Typical applications include safety wires in a catheter guidewire, helical coils in a catheter guidewire and braiding wire. Fort Wayne Metals uses two manufacturing techniques to yield different types of radius edged flat wire: rolled flat wire and drawn flat wire (see illustrations).



Rolled Flat Wire



Drawn Flat Wire

Flat Wire Comparisons

Both products exhibit a smooth bright surface finish and tight size tolerances. However, each has its advantages. Rolled flat wire has a larger cast, less camber (see Straightness), less stress induced in the wire and a lower cost versus drawn flat wire as the width/thickness ratio increases. While drawn flat wire has the advantage of improved size tolerances (see Standard Tolerances), it's often specified for applications requiring more consistent and tighter dimensions.

Size Availability

The maximum available width for both types of flat wire depends on the thickness and the alloy. The maximum width/thickness ratio of rolled flat wire is approximately ten to one, alloy allowing. Rolled flat wire is available as thin as .0003". Drawn flat wire is available as thin as .0015".

Standard tolerances for each wire type are described below. Depending on width, thickness, alloy and width/thickness ratio, both drawn flat wire and rolled flat wire may be offered.

Standard Tolerances

Rolled Flat Wire

Thickness Tolerance

+/- 10% of the thickness rounded up to the next 0.0001", with a minimum of +/- 0.0002".

Width Tolerances

+/- 10% of the width rounded up to the next .0001".

Drawn Flat Wire

Width or Thickness		Tolerance
Over	Including	+/-
0.0000"	0.0080"	0.0002"
0.0080"	0.0120"	0.0003"
0.0120"	0.0240"	0.0004"
0.0240"	0.0330"	0.0005"
0.0330"	0.0440"	0.0008"
0.0440"	—	0.0010"

Tensile Strength

The tensile strength of flat wire is determined by manufacturing techniques. Tensile strength ranges from annealed to spring temper in most alloys. The maximum tensile strength is a function of both the alloy itself and other requirements of the specified wire, such as cast.

Flat Wire

Cross-Sectional Area Calculation

When determining tensile strength, it's necessary to properly calculate the cross-sectional area using the flat wire conversion factors (see chart on the back of this insert). Because both rolled and drawn flat wire have full radius edges (see illustration), necessary adjustments to remove the corners of the rectangle from the area calculation must be determined. Accurate calculation is vital because minute differences in cross-sectional area can make significant differences in tensile strength.

Flat Wire Conversion Factors

The first column is width divided by thickness.
The factor is to be used to calculate cross-sectional area (e.g. 0.010" ÷ 0.003" =3.3; look up 3.3 to get 0.984; 0.003" x 0.010" x 0.984 = 0.0000295; this is the cross-sectional area).

Flat Wire Conversion Factors

Width Thickness	Factor	Width Thickness	Factor
1.1	0.836	3.0	0.981
1.2	0.867	3.1	0.982
1.3	0.890	3.2	0.983
1.4	0.907	3.3	0.984
1.5	0.920	3.4	0.985
1.6	0.930	3.5	0.986
1.7	0.939	3.6	0.987
1.8	0.946	3.7-3.8	0.988
1.9	0.952	3.9-4.0	0.989
2.0	0.957	4.1-4.2	0.990
2.1	0.961	4.3-4.4	0.991
2.2	0.964	4.5-4.7	0.992
2.3	0.968	4.8-5.0	0.993
2.4	0.970	5.1-5.5	0.994
2.5	0.973	5.6-6.0	0.995
2.6	0.975	6.1-6.9	0.996
2.7	0.977	7.0-8.1	0.997
2.8	0.978	8.2-10.0	0.998
2.9	0.980	> 10.0	0.999

Secondary Cleaning Capabilities

Fort Wayne Metals uses various techniques to improve the surface cleanliness of flat wire. These include heat cleaning, solvent wipes and hot alkaline or ultrasonic-cleaning, used on their own or in various combinations.

Straightness: Cast and Camber

If straightness is critical to the flat wire application, then a minimum cast and/or maximum camber may be specified. Cast is measured by cutting a three foot piece off the spool and laying it on its edge on a flat surface so it forms a circle or an arc. The size of the circle or arc is the cast. To determine camber, a short length of flat wire is cut. Next it is placed on its width rather than its edge. Then, by holding the wire in the middle against a straight line, the distance that the free ends extend from the line is measured as camber.

.

Shaped Wire

Shaped Wire

While round and flat wire represent the most commonly produced geometries, they're certainly not the only achievable wire forms. Through our expertise in producing rolled and drawn flat wire, we can also provide you with precision shaped wire in a range of different geometries.

Standard Shapes

D-WIRE
0.0381 x 0.1016 mm [0.0015 x 0.004 in] to
1.016 x 2.032 mm [0.040 x 0.080 in]
Half round, over half round, under half round

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

PIE WIRE
0.142 x 0.177 mm [0.0056 x 0.007 in] to
0.762 x 1.143 mm [0.030 x 0.045 in]
Wire angle: 45° to 120°

ELLIPTICAL WIRE
0.0254 x 0.0635 mm [0.001 x 0.0025 in] to
0.508 x 1.524 mm [0.020 x 0.060 in]

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

GROOVED WIRE
0.254 to 0.762 mm [0.010 to 0.030 in]
Groove size can range from 4 to 20% of the cross-sectional area
Available in 304V, 316LVM, or 35N LT®

TURKSHEAD WIRE
0.152 x 0.152 mm [0.006 x 0.006 in] to
1.778 x 1.778 mm [0.070 x 0.070 in]
Max width/thickness ratio of 2:1

*Sizes are approximate and may not be available in all alloys.

Tolerances:

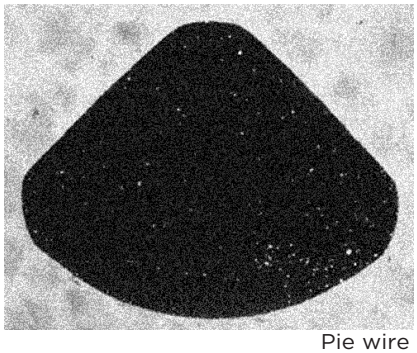
Thickness
+/- 10%

Width
+/- 10%

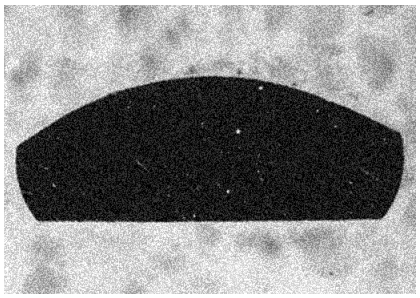
Tighter tolerances may be available on request based on shape and alloy.

Mechanical Properties

Strengths ranging from annealed to spring temper can be achieved in most shapes and alloys.



Pie wire



D-wire

Strands and Cables

Strands and cables are ideal for applications requiring more strength and flexibility than a single wire filament. These highly engineered products often utilize complex constructions or processes to enhance fatigue life, strength, flexibility, torque, stiffness and smoothness. Strands are manufactured by wrapping several filaments of wire together to form a single product. If several strands are wrapped together, they form a single cable.

Applications

Fort Wayne Metals manufactures medical grade multi-filament strands and cables in customized configurations for a variety of critical applications. Strands and cables can be offered on spools, in discrete lengths and fully assembled. End uses include:

- Orthopaedic Cable Systems
- Orthodontic Appliances
- Spinal Cable Systems
- Endoscopic/Laparoscopic Instruments
- Guidewires
- Bioconductors
- Embolic Protection
- Snares

Alloy Selection for Cables

All of the raw materials we work with can be transformed into strands or cables. Biocompatibility, strength, fatigue, flexibility, torqueability and radiopacity are just a few items that might be considered during alloy selection. Our engineering staff can assist you in determining the appropriate alloy for your strand or cable application. Here is a small list of medical grade materials that are commonly used for strand and cable systems:

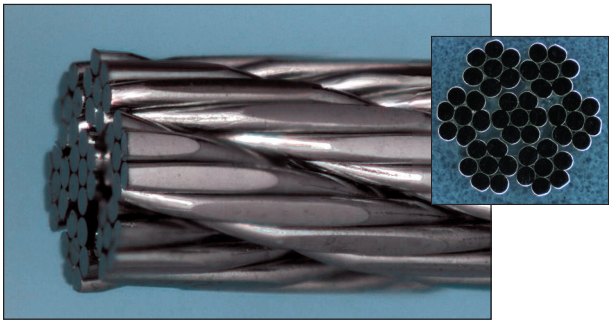
- Ti 6Al-4V ELI
- 35N LT®
- MP35N®
- L-605 (HAYNES® 25)
- 304V
- CP Ti Gr. 2
- FWM 1058® Alloy
- 316LVM (316LS)
- DFT®
- Nitinol (Binary & Ternary)
- 22Cr-13Ni-5Mn
- Ti 6Al-7Nb

DFT® (Drawn Filled Tube) Strands & Cables

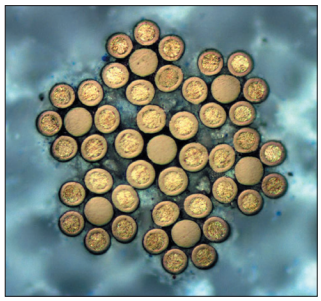
Multi-filament DFT material allows the device maker to match dissimilar materials to provide a variety of unique properties. One of the more common uses of DFT strands and cables is found in the medical device industry where designers have integrated the strength and biocompatibility of implant grade alloys with desired properties of other materials. The composite typically uses the outer sheath to impart strength while the core material is designed to provide conductivity, radiopacity, resiliency or MRI enhancement.

Construction Capabilities

Aside from the typical strand and cables constructions (see illustrations on the following page), we also offer specialty constructions such as swaged, drawn strands and cables with tighter tolerances. We can work with you to create a specialty strand or cable that fits your unique application.

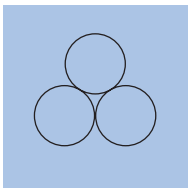


Swaged & Drawn Cable - These strands and cables offer a more tightly compacted structure with smoother surface characteristics. Break strength can also be increased within a drawn or swaged cable by compacting larger filament wires.

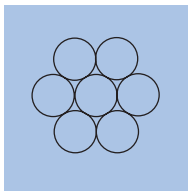


Drawn Filled Tube Cable – This is an example of 7 x 7 cable construction utilizing a combination of DFT and mono-filament wires.

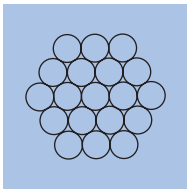
Strands and Cables



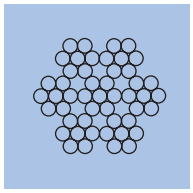
1 x 3 (3 wires)



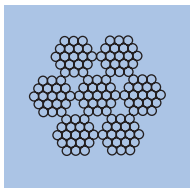
1 x 7 (7 wires)



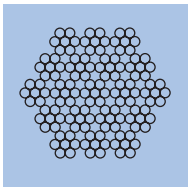
1 x 19 (19 wires)



7 x 7 (49 wires)



7 x 19 (133 wires)



19 x 7 (133 wires)

Size Availability & Tolerances

Fort Wayne Metals has the capability to manufac-ture strands and cables in a variety of sizes and constructions. Ranging from ultra fine or miniature strands with diameters below 0.004" to cables up to 0.125" in diameter. Tolerances can vary depending on diameter, construction, swaging, or drawing, therefore, please contact our technical staff with your requirements.

Assembly

Our assembly room allows our customers the option of one stop shopping. Trained experts can perform a variety of value added manufacturing operations to enhance your strand or cable. Services include:

Beading	Welding	Grinding
Fusing	Swaging	Cutting
Passivation	Crimping	

Breakload & Tensile Strength

Through many years of experience, Fort Wayne Metals has collected and analyzed ultimate tensile strength and breakload (the force required to break the strand or cable under tension) mechanical data from various strand and cable configurations. Understanding both of these mechanical attributes aids in the design of a strand or cable.

Strand and Cable Size and Capability

As a general guideline Fort Wayne Metals can strand wires with filament diameters down to 0.001".

Construction	Finished Diameter	Flexibility	Torque
1 x 3	2.15 x d	Lowest	Greatest
1 x 7	3 x d		
1 x 19	5 x d		
7 x 7	9 x d		
7 x 19	15 x d		
19 x 7	15 x d	Greatest	Lowest

d= diameter of single filament

Coatings

Fort Wayne Metals offers a variety of biocompatible coatings that provide insulation for strands and cables. Common coatings include ethylene tetrafluoroethylene (ETFE), polytetrafluoroethylene (PTFE) and perfluoro-alkoxy (PFA).

Cleaning

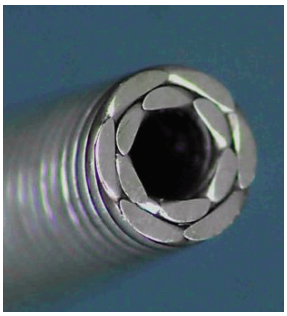
Most strand and cable systems manufactured at Fort Wayne Metals take advantage of our stringent cleaning techniques. Strands and cables have the ability to trap contaminants once the wire filaments have been grouped together. We pride ourselves on removing these contaminants (oil, dirt, dust, etc.) through a variety of cleaning steps, which include isopropyl alcohol wipe, hot alkaline cleaning and ultrasonic cleaning. Our technical staff will be glad to help you determine which cleaning method will work best with your application.

HHS® Tube

Fort Wayne Metals HHS Tube (Helical Hollow Strand) furthers our excellence in stranding and cabling of medical grade wire.

Features and Benefits

HHS Tube is a stranded wire with an open center working channel which can be constructed of numerous material types all drawn on site. HHS Tube designs are tailored to customer specifications of dimension, tension, compression, torque, and pitch direction while exhibiting high kink resistance and excellent whip free characteristics. Single, dual and triple layer HHS Tube can be manufactured for varying flexibility and control with differing filar counts and sizes per layer.



Dual layer HHS Tube

Applications

Over the wire device	Catheter devices
Manipulation components	Delivery devices
Working channels	Urological tools
Endovascular devices	Neurological components
Minimally invasive tools	Bioconductors

Specification

Helical Hollow Strands are designed using solid modeling according to mathematical formulas. Using parametric design, many design considerations can be evaluated in a short time. Materials are normally spring temper. Nitinol HHS is provided in the superelastic condition.

Flexibility can be influenced by design variables including ID, OD, Wire Size, Filar Count and other processing.

Inside Diameter: 0.003" (0.0762mm) to 0.090" (2.286mm)
Outside Diameter: 0.0025" (0.0635mm) to 0.160" (4.064mm)
Filars 6 to 18
Layers 1 to 3 (more may be available)
Lengths from 1" to 10' (longer possible depending on design)
Pitch Left, Right, Unidirectional, Reverse

Secondary Operations

Customer specified performance testing:
Droop, Compression, Yield (elongation at load) or Torque

Square cut ends	Chamfering	Formed HHS
Welding	OD step grinding	Soldering
Taper ground	Coatings (see spec sheet)	Assembly

Materials

See specification sheets for more information.

302	304V	316L
35N LT®	DFT®	L-605
CP Titanium	Ti 6Al-4V ELI	Nitinol
Pt Alloys	(Others may be available)	

Characteristics	HHS Tube	Coil	
		Unifilar	Multifilar
Torque	Excellent	Poor	Good
Windup (Low)	Good	Poor	Poor
Whip	Excellent	Excellent	Excellent
Pushability	Excellent	Excellent	Good
Use Tension	Excellent	Poor	Good
Compression (%)	Good	Excellent	Poor
Hoop Strength	Good	Excellent (Tight Wound)	Good
Wall Thickness (thinwall)	Good	Excellent	Excellent

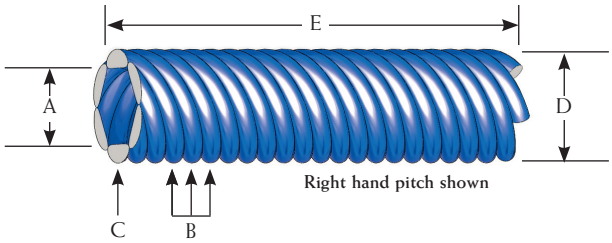
HHS® Tube

HHS Tube General Parameters

Parameter	Change	Flexibility	Pushability	Kink Resistance	Tensile Capability	Torque
Filar Diameter[1]	▲	▼	▼	▼	▲	▲
Filar Number[2]	▲	▼	▲	▼	▲	▲
Inside Diameter[3]	▲	▲	▼	▲	▼	▼
Material Modulus	▲	▼	▲	▼	▬	▲
Drawn/Swage Secondary	OD▼	▼	▲▲	▼	▲▲	▲▲

Example: As the filar size (Filar Diameter) is increased (Change) there will be a loss in Flexibility and Kink Resistance but an increase in Pushability, Tensile Capability, and Torque.

Notes: 1.Results in longer lay (greater pitch), OD will increase 2.Results in longer lay (greater pitch), OD will remain constant 3.Results in shorter lay (shorter pitch), OD will increase



Single Layer HHS Tube Description:

		A Inside Diameter	B Number of Filars	C Filar Diameter	D Outside Diameter	E Length
Range	Min.	0.003" 0.0762mm	6	0.0005" 0.0127mm	0.0025" 0.0635mm	1.0" 25.4mm
	Max.	0.090" 2.286mm	18	0.020" 0.50mm	0.160" 4.06mm	10' 3.05M

Single Layer Dual Layer Triple Layer

NDR® Wire

NDR is an acronym: Nanograin Damage Resistant. NDR is a process which comprises a thermal-mechanical treatment designed to produce nanoscale microstructural refinement. This refinement is evidenced by a significant increase in the material's ability to resist damage during high cycle mechanical loading, as encountered, for example, during the service of a long-term cardioverter defibrillator lead implant due to pulsating stresses.

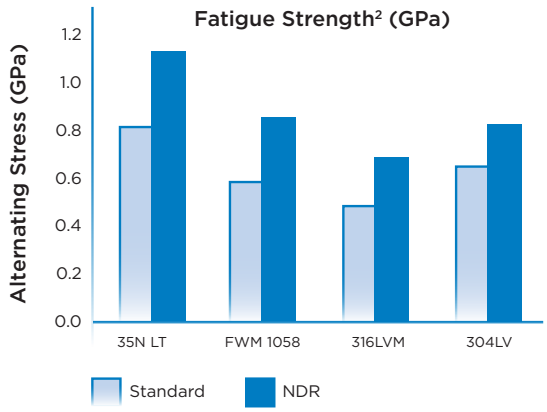
Typical Alloys

The NDR process may be applied to non-precipitation hardening, non-sensitizing, implant-grade alloys such as those called out by ASTM F562 alloy (35N LT® wire or MP35N® wire), ASTM F1058 (FWM 1058® wire) and ASTM F138 (316LVM).

Typical Fatigue Results[1]

	Fatigue Strength[2], GPa (ksi)		
	Standard	NDR Wire	Change
ASTM F562 (35N LT)	0.83 (120)	1.1 (165)	38%
ASTM F1058 (FWM 1058)	0.59 (85)	0.86 (125)	47%
ASTM F138 (316LVM)	0.48 (70)	0.67 (98)	40%
ASTM A580 (304LV)	0.65 (95)	0.86 (125)	32%

1. Typical results for 0.18 mm (0.007") drawn wire. While these results are typical, they represent data from a single laboratory exercise and will not translate directly to each application.
2. Fatigue Strength: stress amplitude in a fully reversed rotary beam fatigue test at $1x10^7$ cycles calculated using published moduli for each alloy.

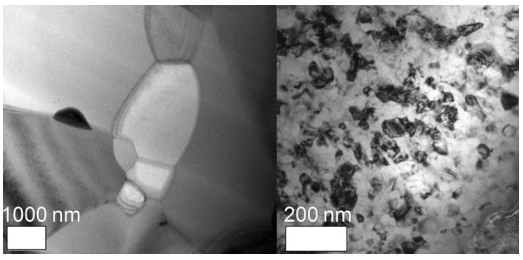


Physical Properties

NDR processing does not change the chemical or atomic makeup of the parent alloy system. Properties such as density, electrical resistivity, thermal conductivity and thermal coefficient of expansion are similar before and after the application of NDR technology.

High Performance

The performance of NDR wire is attributable to the underlying microstructure. Conventional microstructure is shown below (left), where the average breadth of each grain is 2 microns. The next image (right) shows NDR-refined microstructure where similar features are on the order of 200 nm.



Conventional NDR-microstructure

Example Mechanical Properties

The tensile mechanical properties of NDR wire are similar to conventional wire. Three examples of possible properties for 35N LT alloy are given below.

Example Mechanical Properties

	35N LT NDR Wire			35N LT Conventional Wire		
Temper:	ANLD	Hard	Spring	ANLD	Hard	Spring
Ultimate Strength GPa (ksi)	1.45 (210)	1.79 (260)	2.21 (320)	1.31 (190)	1.79 (260)	2.21 (320)
0.2% Yield Strength GPa (ksi)	1.31 (190)	1.45 (210)	2.00 (290)	0.69 (100)	1.45 (210)	2.00 (290)
Rupture Strain (%)	15	4	2	35	4	2
Fatigue Strength GPa (ksi)	1.14 (165)	1.21 (175)	1.14 (165)	0.62 (90)	0.83 (120)	0.93 (135)

Biomedical Coatings

Fort Wayne Metals has the ability to provide a variety of coated wire and cable configurations comprising a biocompatible sheath, lubricious barrier, or other medical grade material of your choice. It is common for Fort Wayne Metals to work with bioconductors that require an isolated electrical signal. In these instances, selection of the appropriate dielectric material is critical. Our engineering team can assist with the selection and design of any coating configuration. Electrical insulation is just one of many reasons why coatings are applied for wire based medical applications. Other considerations may include: chemical isolation, lubricity, or surface preparation. Fort Wayne Metals is always open to exploring new coatings for a variety of medical applications.

Fluoropolymers:

Ethylene-Tetrafluoroethylene (ETFE),Perfluroralkoxyethylene-Tetrafluoroethylene (PFA) and Fluorinated Ethylene Propylene (FEP) are all copolymers of Tetrafluoroethylene (TFE). Each material combines the chemical inertness of Polytetrafluoro-ethylene (PTFE) with another polymer to provide melt forming capability and strength. All three fluoropolymers are utilized in a variety of medical device applications due to their excellent dielectric strength, chemical resistance and mechanical toughness. Alternate coatings will be considered upon request.

ETFE possesses the greatest strength and abrasion resistance of the TFE copolymers. ETFE has a continuous service temperature range of 150°C.

PFA is most similar in terms of chemical and physical behavior to PTFE. PFA has the added benefit of a higher service temperature (260°C) over FEP.

FEP is similar in chemical and physical behavior to PFA. It possesses a lower service temperature (200°C) and is slightly less susceptible to water absorption than most other fluoropolymers.

Colorants:

Fort Wayne Metals can offer a wide variety of color concentrates. Standard colors include blue, white, red, green, yellow, orange and black. Additional colors available upon request.

Coating Capabilities:

Round Wire Sizes: 0.002" to 0.020"

Strands & Cable Sizes: 0.003" to 0.060"

Wall Thickness: Typically range from 0.005" to less than 0.0005"

Coating Substrates: Coatings can be applied to round wire and strands and cables in any alloy or material system we offer.

Configurations: Round or Shaped Wires, Strands and Cables.

Features:

Biocompatible	Thin Wall
Custom Packaging	Pin Hole Free
Medical Focus	Excellent Dielectric Strength
Tight Tolerances	

Lead Times:

Our in-house coating capabilities allow us to offer a more streamlined manufacturing approach for wire and cable needs. Fort Wayne Metals can now offer a fully integrated manufacturing option for our wire and cable customers, thus eliminating inefficiencies associated with transferring material to multiple manufacturing sites.

Typical properties of extruded thermoplastics

Name	Density [g/cc]	Typical Tensile Strength [Mpa / psi]	Coefficient of Friction	Dielectric Strength [kV/mm V/mil]	CTE @ 20°C [µm/m-°C]	Water Absorption [%]	Max. Service Temperature in Air [°C]
ETFE	1.70	41 / 6000	0.23	64 / 1600	130	0.006	150
PFA	2.15	28 / 4000	0.21	62 / 1575	140	0.050	260
FEP	2.15	25 / 3600	0.25	62 / 1575	140	0.005	200
PTFE*	2.20	24 / 3500	0.10	58 / 1470	100	0.004	270

These properties are for reference only and can vary significantly dependent on processing conditions and material grade. *PTFE is not a melt-processable thermoplastic.

PTFE Coatings

Fort Wayne Metals provides PTFE[1] based coatings and coating compositions on wires for a variety of medical applications. LubriSkin™ and DuraSkin™[2] PTFE dispersion coatings are applied to medical wires to increase lubricity and chemical resistance. The proprietary spool-to-spool process employed delivers a lower coefficient of friction than spray coating techniques. LubriSkin is the preferred coating for coiling wire applications and mandrels. DuraSkin is recommended for coating SLT® wire, Fort Wayne Metals' straight linear one-to-one torque wire, which is used for PTCA guidewires and stylets.

PTFE Coatings

	DuraSkin	LubriSkin
Coating thickness	Standard: 4 - 10 µm (0.00016 - 0.00039")	Standard: 4 - 10 µm (0.00016 - 0.00039")
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 & Cut Lengths, Spooled	Straightened & Cut Lengths, Spooled
Gamma Stable	Yes	No
ETO sterilization	Yes	Yes
Biocompatibility	For invasive techniques, but not for permanent human implants	For invasive techniques, but not for permanent human implants
Heat Stability	Up to 195° C (390° F).	Up to 205° C (400° F).
Chemical Resistance	Sensitive to some solvents like NMP, acetone, MEK etc.	Good - excellent
Relative friction (uncoated SS = 1)	0.45	0.40
Dielectric Strength	Not intended for electrical insulation	Not intended for electrical insulation

[1]PTFE; Polytetrafluoroethylene is a synthetic flouropolymer

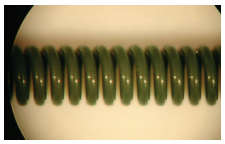
[2]LubriSkin and DuraSkin are trademarks of Merit Medical® - OEM.

LubriSkin

This proprietary coating process produces a smooth, uniform coated wire for the production of guidewires. This process is unique in that the wire is coated before it is coiled. The resulting precoated guidewire has a consistent LubriSkin coating, unlike conventional spray coated guidewires that often encounter cracking and flaking of the coating.

LubriSkin coating is available in a variety of colors and on round or flat wire.

Competition spray coated coil



LubriSkin precoated coil

DuraSkin

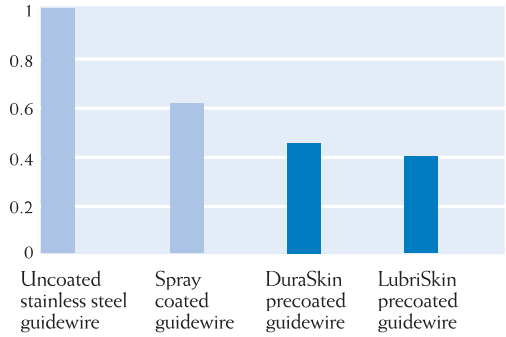
Our proprietary spool-to-spool process provides extremely uniform coating for medical device components. With excellent control over the coating thickness, we are able to guarantee tight tolerances.

Typical products include dead-straight stylets for PTCA guidewires, guidewire cores and catheter stylets using our SLT wire. This wire provides excellent one-to-one torque properties.

These PTFE based coatings can be applied to our stainless steel range of alloys, our super alloys and to our Nitinol wires without compromising their elastic properties.

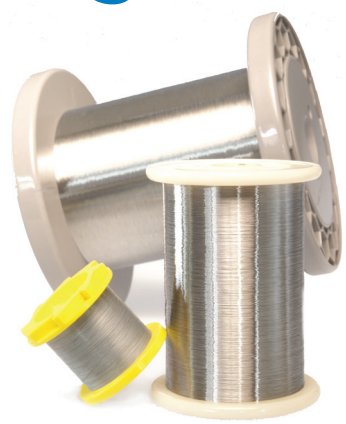
Please note our proprietary coating process increases the tensile strength of non-aged 304V by approximately 20ksi (140 MPa).

Guidewire Relative Friction



The graph above shows relative physical resistance of coated wire passing through human tissue according to coating type.

Packaging & Spooling



Packaging Options

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.

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 is listed 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.

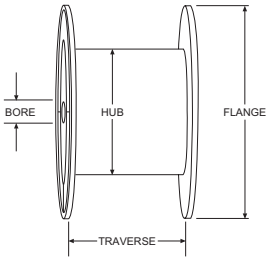
The label also indicates the average break load, ultimate tensile strength and percent elongation of the wire, based on our sampling plan. And you also have the option of having your spools 100% inspected and labeled.

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 Returns 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.



Spool	Flange (Inches)	Hub (Inches)	Traverse (Inches)	Bore (Inches)	Max Capacity* (lbs.)	Diameter (Inches)	Spool Composition
22 x 11	22.00	14.00	11.00	5.00	500.00	>=0.050	Polystyrene
18 x 10	18.00	11.00	9.60	5.00	200.00	>=0.050	Polystyrene
12 x 6	12.00	6.00	6.00	1.30	40.00	>0.012	Lexan/ABS
Weld Wire	11.70	8.30	3.62	2.00	20.00	>0.012	ABS
8 x 6	8.00	4.60	6.00	1.20	20.00	>0.012	ABS
6 x 3.5	6.00	3.50	3.50	0.62	10.00	0.004 - 0.0199	ABS
ENDURA® 11" x 3.5" SLT® spool (biconical)	13.62	11.16	3.55	2.00	15.00	>=0.002	ABS
4.5 x 3	4.50	2.50	3.00	0.62	5.00	0.003 - 0.010	ABS
2.5 x 3	2.50	1.70	3.00	0.62	1.00	<=0.003	ABS
DIN80	3.20	2.00	2.50	0.63	1.00	<=0.003	ABS
DIN100	3.90	2.50	3.10	0.63	3.00	0.003 - 0.005	ABS
DIN125	4.90	3.10	3.90	0.63	5.00	0.004 - 0.010	ABS
DIN160	6.30	3.90	5.00	0.87	10.00	0.010-0.020	ABS
DIN250	9.80	6.30	6.30	0.87	20.00	>0.012	ABS
Wardwell Bobbin	2.60	1.30	2.80	1.10 Spline	0.50	<=0.003	Nylon
Braider Bobbin**	1.56	1.015	1.10	0.41	0.20	<=0.003	ABS
New England #2 Braider Bobbin	1.70	0.62	2.50	0.30	0.50	<=0.003	Nylon
ENDURA® Bobbin** (biconical)	1.69	1.02	1.40	0.415	0.145	<=0.003	ABS

* Actual capacity varies with wire size and alloy type. Please check with your customer service associate for details.

** Designed for use on Steeger® braiders.

Stainless Steel Wire Conversion Chart

UNS 30400 (TYPES 304)

Boldface indicates AWG sizes

Dia. (in²)	Area (in²)	ft/lb
.0005	**.00000020**	**1,483,962**
.0006	**.00000028**	**1,030,529**
.0007	**.00000038**	**757,124**
.0008	**.00000050**	**579,673**
.0009	**.00000064**	**458,013**
.0010	**.00000079**	**370,991**
.0011	**.00000095**	**306,604**
.0012	**.00000113**	**257,632**
.0013	.00000133	219,521
.0014	**.00000154**	**189,281**
.0015	.00000177	164,885
.0016	**.00000201**	**144,918**
.0017	.00000227	128,370
.0018	**.00000254**	**114,503**
.0019	.00000284	102,767
.0020	**.00000314**	**92,748**
.0021	.00000346	84,125
.0022	**.00000380**	**76,651**
.0023	.00000415	70,131
.0024	.00000452	64,408
.0025	**.00000491**	**59,358**
.0026	.00000531	54,880
.0027	.00000573	50,890
.0028	**.00000616**	**47,320**
.0029	.00000661	44,113
.0030	.00000707	41,221
.0031	**.00000755**	**38,605**
.0032	.00000804	36,230
.0033	.00000855	34,067
.0034	.00000908	32,093
.0035	**.00000962**	**30,285**
.0036	.00001018	28,626
.0037	.00001075	27,099
.0038	.00001134	25,692
.0039	.00001195	24,391
.0040	**.00001257**	**23,187**
.0041	.00001320	22,070
.0042	.00001385	21,031
.0043	.00001452	20,064
.0044	.00001521	19,163
.0045	**.00001590**	**18,321**
.0046	.00001662	17,533
.0047	.00001735	16,795
.0048	.00001810	16,102
.0049	.00001886	15,452
.0050	**.00001963**	**14,840**
.0051	.00002043	14,263
.0052	.00002124	13,720
.0053	.00002206	13,207
.0054	.00002290	12,723
.0055	.00002376	12,264
.0056	**.00002463**	**11,830**
.0057	.00002552	11,419
.0058	.00002642	11,028
.0059	.00002734	10,658
.0060	.00002827	10,305
.0061	.00002922	9,970
.0062	.00003019	9,651
.0063	**.00003117**	**9,347**
.0064	.00003217	9,057
.0065	.00003318	8,781
.0066	.00003421	8,517
.0067	.00003526	8,264
.0068	.00003632	8,023
.0069	.00003739	7,792
.0070	**.00003848**	**7,571**
.0071	.00003959	7,359
.0072	.00004072	7,156
.0073	.00004185	6,962
.0074	.00004301	6,775
.0075	.00004418	6,595
.0076	.00004536	6,423
.0077	.00004657	6,257
.0078	.00004778	6,098
.0079	**.00004902**	**5,944**
.0080	.00005027	5,797
.0081	.00005153	5,654
.0082	.00005281	5,517
.0083	.00005411	5,385
.0084	.00005542	5,258
.0085	.00005675	5,135
.0086	.00005809	5,016
.0087	.00005945	4,901
.0088	.00006082	4,791
.0089	**.00006221**	**4,684**
.0090	.00006362	4,580
.0091	.00006504	4,480
.0092	.00006648	4,383
.0093	.00006793	4,289
.0094	.00006940	4,199
.0095	.00007088	4,111
.0096	.00007238	4,026
.0097	.00007390	3,943
.0098	.00007543	3,863
.0099	.00007698	3,785
.0100	**.00007854**	**3,710**
.0101	.00008012	3,637
.0102	.00008171	3,566
.0103	.00008332	3,497
.0104	.00008495	3,430
.0105	.00008659	3,365
.0106	.00008825	3,302
.0107	.00008992	3,240
.0108	.00009161	3,181
.0109	.00009331	3,123
.0110	.00009503	3,066
.0111	.00009677	3,011
.0112	.00009852	2,958
.0113	**.00010029**	**2,905**
.0114	.00010207	2,855
.0115	.00010387	2,805
.0116	.00010568	2,757
.0117	.00010751	2,710
.0118	.00010936	2,664
.0119	.00011122	2,620
.0120	.00011310	2,576
.0121	.00011499	2,534
.0122	.00011690	2,493
.0123	.00011882	2,452
.0124	.00012076	2,413
.0125	.00012272	2,374
.0126	**.00012469**	**2,337**
.0127	.00012668	2,300
.0128	.00012868	2,264
.0129	.00013070	2,229
.0130	.00013273	2,195
.0131	.00013478	2,162
.0132	.00013685	2,129
.0133	.00013893	2,097
.0134	.00014103	2,066
.0135	.00014314	2,036
.0136	.00014527	2,006
.0137	.00014741	1,977
.0138	.00014957	1,948
.0139	.00015175	1,920
.0140	.00015394	1,893
.0141	.00015615	1,866
.0142	**.00015837**	**1,840**
.0143	.00016061	1,814
.0144	.00016286	1,789
.0145	.00016513	1,765
.0146	.00016742	1,740
.0147	.00016972	1,717
.0148	.00017203	1,694
.0149	.00017437	1,671
.0150	.00017671	1,649
.0151	.00017908	1,627
.0152	.00018146	1,606
.0153	.00018385	1,585
.0154	.00018627	1,564
.0155	.00018869	1,544
.0156	.00019113	1,524
.0157	.00019359	1,505
.0158	.00019607	1,486
.0159	**.00019856**	**1,467**
.0160	.00020106	1,449
.0161	.00020358	1,431
.0162	.00020612	1,414
.0163	.00020867	1,396
.0164	.00021124	1,379
.0165	.00021382	1,363
.0166	.00021642	1,346
.0167	.00021904	1,330
.0168	.00022167	1,314
.0169	.00022432	1,299
.0170	.00022698	1,284
.0171	.00022966	1,269
.0172	.00023235	1,254
.0173	.00023506	1,240
.0174	.00023779	1,225
.0175	.00024053	1,211
.0176	.00024328	1,198
.0177	.00024606	1,184
.0178	.00024885	1,171
.0179	**.00025165**	**1,158**
.0180	.00025447	1,145
.0181	.00025730	1,132
.0182	.00026016	1,120
.0183	.00026302	1,108
.0184	.00026590	1,096
.0185	.00026880	1,084
.0186	.00027172	1,072
.0187	.00027465	1,061
.0188	.00027759	1,050
.0189	.00028055	1,039
.0190	.00028353	1,028
.0191	.00028652	1,017
.0192	.00028953	1,006
.0193	.00029255	996
.0194	.00029559	986
.0195	.00029865	976
.0196	.00030172	966
.0197	.00030481	956
.0198	.00030791	946
.0199	.00031103	937
.0200	.00031416	927
.0201	**.00031731**	**918**
.0202	.00032047	909
.0203	.00032365	900
.0204	.00032685	891
.0205	.00033006	883
.0206	.00033329	874
.0207	.00033654	866
.0208	.00033979	858
.0209	.00034307	849
.0210	.00034636	841
.0211	.00034967	833
.0212	.00035299	825
.0213	.00035633	818
.0214	.00035968	810
.0215	.00036305	803
.0216	.00036644	795
.0217	.00036984	788
.0218	.00037325	781
.0219	.00037668	774
.0220	.00038013	767
.0221	.00038360	760
.0222	.00038708	753
.0223	.00039057	746
.0224	.00039408	739
.0225	.00039761	733
.0226	**.00040115**	**726**
.0227	.00040471	720
.0228	.00040828	714
.0229	.00041187	707
.0230	.00041548	701
.0231	.00041910	695
.0232	.00042273	689
.0233	.00042638	683
.0234	.00043005	678
.0235	.00043374	672
.0240	.00045239	644
.0245	.00047144	618
.0250	.00049087	594
.0253	**.00050273**	**580**
.0255	.00051071	571
.0260	.00053093	549
.0265	.00055155	528
.0270	.00057256	509
.0275	.00059396	491
.0280	.00061575	473
.0285	**.00063794**	**457**
.0290	.00066052	441
.0295	.00068349	426
.0300	.00070686	412
.0305	.00073062	399
.0310	.00075477	386
.0315	.00077931	374
.0320	**.00080425**	**362**
.0325	.00082958	351
.0330	.00085530	341
.0335	.00088141	331
.0340	.00090792	321
.0350	.00096211	303
.0359	**.00101223**	**288**
.0360	.00101788	286
.0370	.00107521	271
.0380	.00113411	257
.0390	.00119459	244
.0400	.00125664	232
.0403	**.00127556**	**228**
.0410	.00132025	221
.0420	.00138544	210
.0430	.00145220	201
.0440	.00152053	192
.0450	.00159043	183
.0453	**.00161171**	**181**
.0460	.00166190	175
.0470	.00173494	168
.0480	.00180956	161
.0490	.00188574	155
.0500	.00196350	148
.0508	**.00202683**	**144**
.0510	.00204282	143
.0520	.00212372	137
.0530	.00220618	132
.0540	.00229022	127
.0550	.00237583	123
.0560	.00246301	118
.0570	**.00255176**	**114**
.0580	.00264208	110
.0590	.00273397	107
.0600	.00282743	103
.0610	.00292247	100
.0620	.00301907	97
.0630	.00311725	93
.0640	**.00321699**	**91**
.0650	.00331831	88
.0660	.00342119	85
.0670	.00352565	83
.0680	.00363168	80
.0690	.00373928	78
.0700	.00384845	76
.0710	.00395919	74
.0720	**.00407150**	**72**
.0730	.00418539	70
.0740	.00430084	68
.0750	.00441786	66
.0760	.00453646	64
.0770	.00465663	63
.0780	.00477836	61
.0790	.00490167	59
.0800	.00502655	58
.0810	**.00515300**	**57**
.0850	.00567450	51
.0900	.00636173	46
.0910	**.00650388**	**45**
.0950	.00708822	41
.1020	**.00817128**	**36**
.1140	**.01020703**	**29**
.1280	**.01286796**	**23**
.1440	**.01628602**	**18**
.1620	**.02061199**	**14**
.1820	**.02601553**	**11**
.2040	**.03268513**	**9**

Round wire density – 0.286 pounds per cubic inch. See reverse side for multiplication factors for other materials.

Multiplying Factors for 304/316 Footage Conversion Chart

ALLOYS		
Factor	**Type**	**Density**
1.000	302,304	0.286
0.997	316, 316 LVM	0.287
1.025	420	0.279
1.021	455	0.280
1.021	17-4 PH®	0.280
1.014	17-7 PH®	0.282
1.021	18Cr-2Ni-12Mn	0.280
1.004	22Cr-13Ni-5Mn	0.285
0.941	35N LT® Alloy	0.304
0.957	Alloy X750	0.299
0.960	Alloy 41	0.298
0.938	Alloy 625	0.305
0.941	Alloy 650	0.304
0.976	Alloy 902	0.293
0.891	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	L605	0.333
0.941	MP35N®	0.304
0.935	NiAl® II	0.306
0.905	NICLAL 47	0.316
1.227	NiTi	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

Mechanical Properties for Types 302, 304, and 316L

Finished Diameter (Inches)	Type 302 and 304				Type 316LVM	
	Spring Temper (KSI)		Hyten (KSI)		Spring Temper (KSI)	
	Min	Max	Min	Max	Min	Max
Up to .009 in.	325	355	425	455	245	275
Over .009 to .010	320	350	420	450	245	275
Over .010 to .011	318	348	418	448	240	270
Over .011 to .012	316	346	410	440	240	270
Over .012 to .013	314	344	405	435	240	270
Over .013 to .014	312	342	400	430	240	270
Over .014 to .015	310	340	395	425	240	270
Over .015 to .016	308	338	390	420	235	265
Over .016 to .017	306	336	386	416	235	265
Over .017 to .018	304	334	384	414	235	265
Over .018 to .020	300	330	382	412	235	265
Over .020 to .022	296	326	380	410	235	265
Over .022 to .024	292	322	370	400	235	265
Over .024 to .026	291	320	355	385	235	265
Over .026 to .028	289	318	345	375	235	265
Over .028 to .031	285	315	-	-	235	265
Over .031 to .034	282	310	-	-	235	265
Over .034 to .037	280	308	-	-	235	265
Over .037 to .041	275	304	-	-	235	265
Over .041 to .045	272	300	-	-	230	260
Over .045 to .050	267	295	-	-	230	260
Over .050 to .054	265	293	-	-	225	255
Over .054 to .058	261	289	-	-	220	250
Over .058 to .063	258	285	-	-	220	250
Over .063 to .070	252	281	-	-	215	245
Over .070 to .075	250	278	-	-	215	245
Over .075 to .080	246	275	-	-	210	240
Over .080 to .087	242	271	-	-	205	235
Over .087 to .095	238	268	-	-	205	235
Over .095 to .105	232	262	-	-	200	230

The minimum tensile strength for straightened and cut lengths shall be 90% of the values listed in the table. Spring Temper values are in accordance with ASTM A-313.

Round Wire Tolerance Chart

All sizes specified below in inches.
Standard size tolerances in accordance with ASTM A-555. Tighter tolerances available at additional cost.

Specified Size	Variations from Size	
	Over	**Under**
Under .100 to .044	.0010	.0010
Under .044 to .033 incl.	.0008	.0008
Under .033 to .024 incl.	.0005	.0005
Under .024 to .012 incl.	.0004	.0004
Under .012 to .008 incl.	.0003	.0003
Under .008 to .0048 incl.	.0002	.0002
Under .0048	.0001	.0001

Out of round tolerance shall be one-half the total size tolerance.

Flat Wire Conversion Factors

The first column is width divided by thickness. The factor is to be used to calculate cross-sectional area (i.e. 0.003 ÷ 0.010 Flatwire; 0.010 ÷ 0.003 = 3.3; look up 3.3 in the first column to get .984 factor in the second column; 0.003 x .010 x .984 = .0000295; this is the cross-sectional area. Look up the cross-sectional area on the previous page for the feet per pound.

Width/Thickness	Factor
1.1	.836
1.2	.867
1.3	.890
1.4	.907
1.5	.920
1.6	.930
1.7	.939
1.8	.946
1.9	.952
2.0	.957
2.1	.961
2.2	.964
2.3	.968
2.4	.970
2.5	.973
2.6	.975
2.7	.977
2.8	.978
2.9	.980
3.0	.981
3.1	.982
3.2	.983
3.3	.984
3.4	.985
3.5	.986
3.6	.987
3.7-3.8	.988
3.9-4.0	.989
4.1-4.2	.990
4.3-4.4	.991
4.5-4.7	.992
4.8-5.0	.993
5.1-5.5	.994
5.6-6.0	.995
6.1-6.9	.996
7.0-8.1	.997
8.2-10.0	.998

Round Wire / Bar Specifications

The following tables contain our standard tolerances for cold finished round bars and round wire. Fort Wayne Metals can typically produce material to diameters of up to 0.7 inches depending on alloy. However, we frequently expand our capabilities, so please check with your customer service associate for details.

Fort Wayne Metals Standard Diameter Tolerances for Cold-Finished Round Bars

Fort Wayne Metals' standard tolerance for centerless ground bar is ±0.0005" (±0.0127mm). However, we routinely produce material to smaller tolerances on customer request. Please check with your customer service associate for details.

Fort Wayne Metals Standard Diameter Tolerances for Round Wire

Fort Wayne Metals' produces round wire to the standard size tolerances listed in ASTM A-555 listed below. However, smaller tolerances are available upon request. Please check with your customer service associate for details. Also, please note that our production capabilities for most alloys are limited to diameters of 0.7 inches and below.

Standard Size tolerances in accordance with ASTM A-555

Specified Diameter, in. [mm]	Over	Under
	Diameter Tolerances, in. [mm]	
1.000 [25.00] and over	0.0025 [0.06]	0.0025 [0.06]
Under 1.000 [25.00] to 0.500 [13.00]	0.0020 [0.05]	0.0020 [0.05]
Under 0.5000 [13.00] to 0.3125 [8.00] incl	0.0015 [0.04]	0.0015 [0.04]
Under 0.3125 [8.00] to 0.0440 [1.00] incl	0.0010 [0.03]	0.0010 [0.03]
Under 0.0440 [1.00] to 0.0330 [0.80] incl	0.0008 [0.02]	0.0008 [0.02]
Under 0.0330 [0.80] to 0.0240 [0.60] incl	0.0005 [0.015]	0.0005 [0.015]
Under 0.0240 [0.60] to 0.0120 [0.30] incl	0.0004 [0.010]	0.0004 [0.010]
Under 0.0120 [0.30] to 0.0080 [0.20] incl	0.0003 [0.008]	0.0003 [0.008]
Under 0.0080 [0.20] to 0.0048 [0.12] incl	0.0002 [0.005]	0.0002 [0.005]
Under 0.0048 [0.12] to 0.0030 [0.08] incl	0.0001 [0.003]	0.0001 [0.003]

The maximum out-of-round for round wire is one half of the total size tolerance given in this table. When it is necessary to heat treat or heat treat and pickle after cold finishing, size tolerances are double those shown above for sizes 0.024 in. [0.06 mm] and over. Size tolerances have not been evolved for wire produced by cold rolling.

These tolerances apply to small diameter straightened and cut wire (sizes below approximately 1/16 in.). Refer to Table "Permitted Variations in Size of Cold-Finished Round Bars" (above).

Notes

Notes

FDA registered and ISO 13485 certified · ISO 9001 and AS 9100 certified

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Tamil Nadu, India
Tokyo, Japan
Savyon, Israel
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