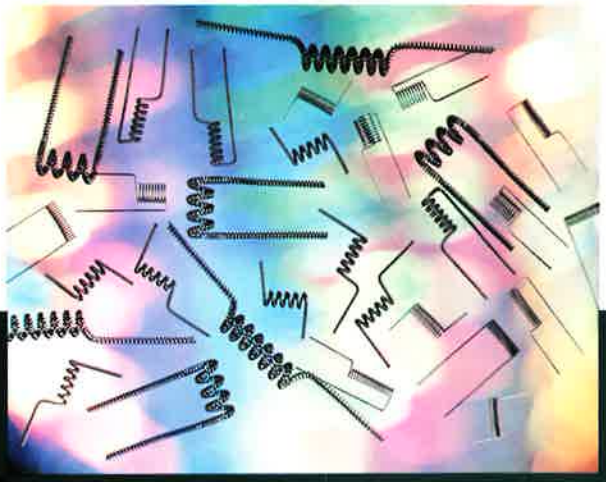
GE Components
Marketing & Sales Operation

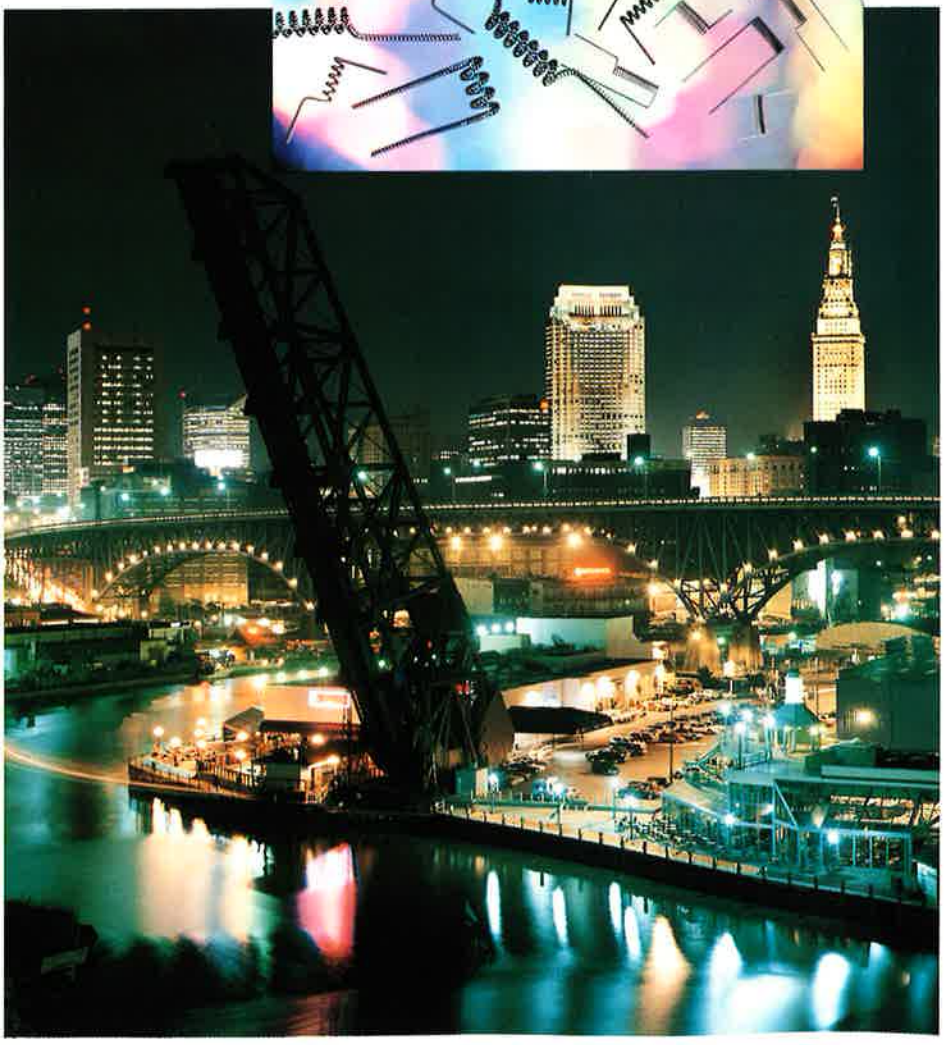
Tungsten Wire

The addition of 3% rhenium to tungsten creates a wire that resists the vibration that occurs in such applications as vacuum cleaner, refrigerator, and aircraft lamp filaments.

Lamp filaments come in a variety of sizes and shapes to meet today's lighting requirements.



A tungsten wire with enhanced coiling properties was developed by GE for automotive headlamp applications.



Tungsten Wire...

An Engineering Material For Highly Demanding Applications

Of all the materials that have emerged in America's space age, few can match the strength and high temperature characteristics of tungsten. At GE, we've devoted years to the development of this material. In the form of wire, tungsten combines the engineering properties and production versatility that makes it useful in a number of important applications.

Tungsten wire is a material born of the lamp industry. With its ability to retain strength at high temperatures, it was the natural choice for lamp filaments that were capable of burning brightly on command, cycle after cycle, without being consumed by their own heat.

Today, these high temperature attributes are being put to work in applications far afield from lighting.

Constantly Improving

Contributing to the growing use of tungsten wire is its availability in an almost infinite variety of sizes, properties and finishes. Using conventional manufacturing techniques, tungsten wire is readily coiled, formed, cut, rolled, joined and etched to meet exacting dimensional requirements.

Along with its extensive capability for producing tungsten wire, GE offers the staff and facilities to provide valuable design and manufacturing assistance to users. Our engineers are constantly improving the properties and performance of tungsten products in laboratories specially equipped to support this effort.

By providing us with information about your intended use, assistance can be given in selecting the product that is most appropriate for your application.

Lighting Applications

Nothing surpasses tungsten wire for brightness and length of service in incandescent lamps. Filaments wound from tungsten wire are used in all types of lighting, from tiny indicator lamps to gigantic flood lights.

Because of its compatibility with other lamp materials, tungsten wire is also used in lead wires for glass-to-metal seals, and as filament supports.

GE produces tungsten wire in a variety of properties and compositions for lighting and other industries. For instance, a 1% thoriated/99% tungsten wire (NF) provides maxium vibration strength in filaments used in transportation vehicles. Three percent rhenium-tungsten wire (3D) offers improved performance in miniature lamps and cathode ray tube heater coils. Type 320 is a wire with enhanced coiling properties used in difficult automotive headlamp applications, and Type 710 was engineered to meet the specific requirements of quartz-halogen lamps.

See Page 6, Types of Tungsten Wire, for a more detailed description and product selection guide.

A superior tungsten wire was developed to handle the high temperature gas exchange that occurs inside halogen lamps.

Non-Lamp Applications Continue To Grow

Stiffness is an important characteristic of plunger wires for precision syringes. Tungsten not only meets the requirements, but is available in a wide range of small diameters. (Photo courtesy of Hamilton Company)

Although lamp manufacturing still dominates in applications for tungsten wire, many other uses are emerging as designers recognize the superior properties of this remarkable material.

Tungsten wire is being specified in applications that demand high strength and close tolerances at elevated temperatures. One such use is fiber composites made in the form of tape and sheet for use on aircraft, helicopters, spacecraft, turbine engines, and specialized industrial components.

These composites are as strong as steel, twice as stiff, and as light as aluminum. They are produced by chemical vapor deposition of boron onto a thin tungsten wire heated to 1200°C. The material's strength, availability in fine sizes, and the ability to react predictablty with boron are the major contributions of tungsten wire in this application.

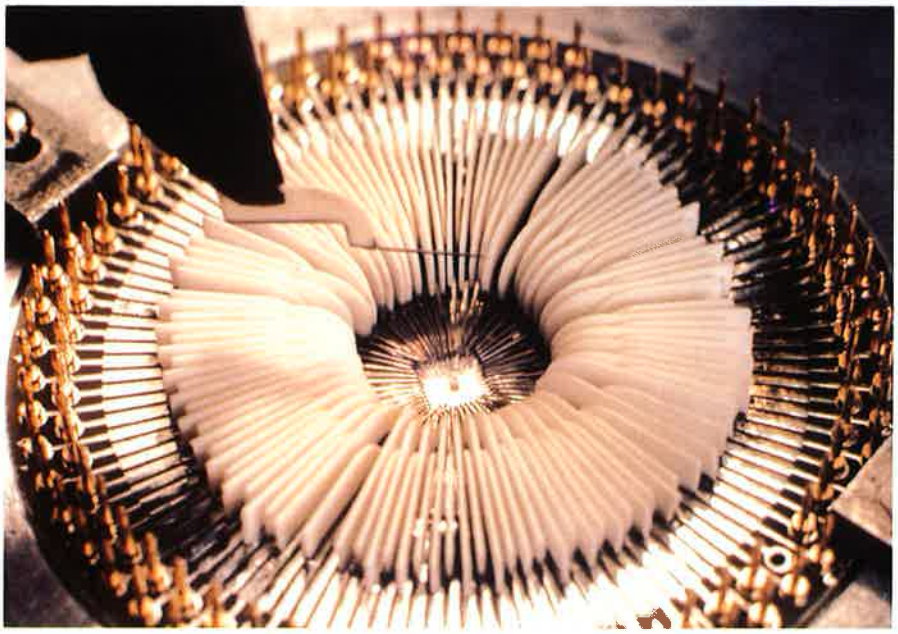
The excellent mechanical characteristics of tungsten wire are also key reasons for its use in high temperature springs, microsyringe plungers, high speed matrix printhead wires, and microneurological needles.

Electronic Applications

The electronics industry is another important user of tungsten wire for highly technical applications. Uses include heaters and grids in radio and TV picture tubes, radio transmitting tube filaments and pins, traveling wave helices, and semiconductor test probes.

For these applications, tungsten wire provides high temperature stability, strength, electron emissivity, hot-cold shock strength, and high resistivity.

Tungsten wire is the ideal substrate for producing boron fiber-reinforced composite materials used in high performance fishing rods, golf clubs, and tennis rackets.



Tungsten wire's extreme hardness and its ability to be electrolytically sharpened to a fine point are important features in its use as probe points for testing integrated circuits. (Photo courtesy of Cerprobe Corporation)

Metallizing Coils

Another important application for tungsten wire is vacuum metallizing, a production operation which creates a shiny, chrome-like finish on plastic, glass or metallic parts.

In this process, tungsten coils and aluminum clips are placed in contact in a vacuum chamber. When the coils are energized, the aluminum vaporizes and deposits on the work pieces to be coated. Metallized parts have replaced chrome-plated automotive dashboard components at a fraction of the cost, and with no sacrifice in appearance or utility. Metallizing is used for coating TV screens and mirrors, plastic toys and hobby kit pieces, and many other decorative parts. Other metals, such as chromium and silver, are also routinely metallized using tungsten filaments.

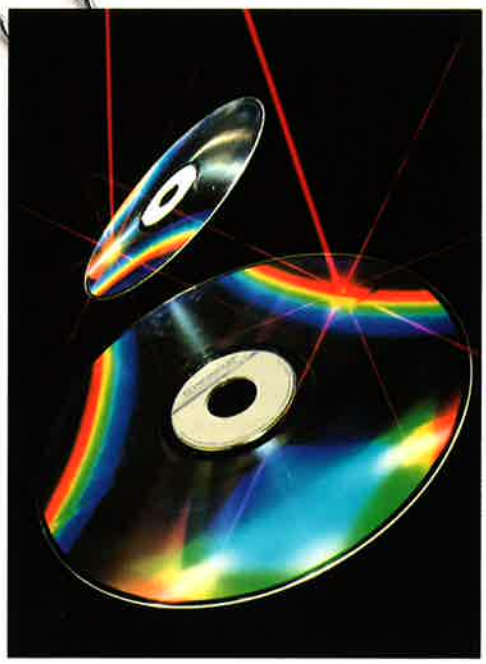
Other Uses

Tungsten wire is used as a heating element in electric furnaces, either as a winding around ceramics or as a mesh basket. The properties of tungsten wire for this application are high temperature strength, good electrical and thermal conductivity, and the ability to withstand thermal cycling stresses.

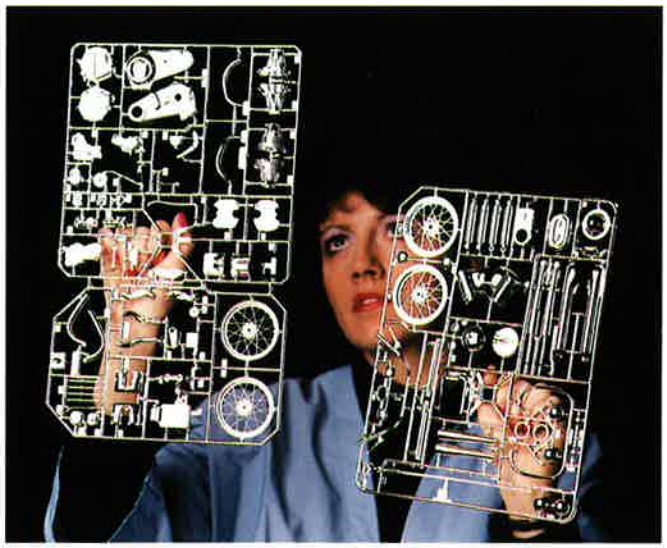
In addition to the more common applications, there exists a number of specialty applications for tungsten wire. Among these are radiation counter tubes, electro-discharge machining, fuse and igniter wires, corona wire for business copiers, thermocouple wire, and air cleaners for electrostatic precipitators.

In the vacuum chamber, metal clips to be vaporized are inserted into tungsten metallizing coils.

Hobby kit parts are just a few of the bright and shiny products of the vacuum metallizing process. High temperature tungsten filaments (right) are used to vaporize the coating medium.



The uniform reflective coating on laser video discs is efficiently applied using powerful tungsten filaments in the vacuum metallizing process. (Photo courtesy of Pioneer Video Manufacturing Inc.)



Types of Tungsten Wire

A variety of different types of tungsten wire, each with its own distinctive properties, have been developed by GE to meet the needs of industry. There is a wire size, type, finish or process variation that will provide optimum performance for each application. All types exhibit, with minor differences, properties that are vital in coiling the wire to very close tolerances.

Formability characteristics are important considerations, second only to high temperature properties, in determining the proper wire type for reliable performance under demanding service conditions.

The Product Selection guide shown below can be helpful in determining a wire type and finish for a specific application.

When a special grade is required, highly qualified application engineers, supported by experienced metallurgical and chemical personnel, are available to assist users.

218

For almost 70 years, GE Type 218 wire has been the foremost filament wire in the lighting industry. Although it is lightly doped to achieve specific metallurgical properties, Type 218 is essentially pure metal at 99.95+ percent tungsten. Its superior quality has earned it a worldwide reputation as the material of choice for general purpose lamp and specialty applications.

The most outstanding attribute of this wire is its microstructure after recrystallization. Proper "flashing" of 218 wire produces a large, elongated and interlocking grain structure which promotes high temperature strength and excellent non-sag quality. Type 218 tungsten wire also performs well in extremely difficult forming applications, especially if a low level of heat is applied at the point of coiling or forming.

310

Type 310 is a non-sag doped tungsten wire designed to supplement 218 in the larger wire sizes. Similar in composition and other properties to 218 wire, it is especially recommended for high wattage lamps. In sizes 0.5mm diameter and larger, 310 is more ductile than 218 wire due to the higher level of retained cold work resulting from processing variations. Type 310 should be worked with the aid of heat during forming. When properly recrystallized, it provides an excellent non-sag microstructure.

2TH

Type 2TH is a tungsten wire containing 2% thoria and is used primarily for electrodes in discharge lamps. The higher thoria content of 2TH provides the desired shock and vibration resistance, but lowers its work function. This wire is generally available only in sizes above 0.76mm diameter.

Product Selection Guide

ATTRIBUTE CODE

- ● Highest
- ◐ Adequate
- ○ Lowest
- × Not Recommended

FINISH CODE

- B . . . Black
- BS . . Black Straightened
- C . . . Cleaned
- CS . . Cleaned and Straightened
- CLS . . Cleaned, Annealed and Straightened
- EE . . . Electro Etched
- EES . . Electro Etched and Straightened
- EP . . . Electro Polished
- EPS . . Electro Polished and Straightened

	WIRE TYPE	NON-SAG QUALITY	HOT SHOCK STRENGTH	VIBRATION STRENGTH	FORMABILITY	THERMIONIC EMISSION	SURFACE QUALITY	ROOM TEMP. SERVICE	RECOMMENDED SIZE RANGE (mm-DIA (mils-DIA)	AVAILABLE FINISHES	APPLICATIONS
		ATTRIBUTES								AVAILABILITY	
High Temp. Service	218	●	◐	◐	●	○	◐	●	.008 - .012 (0.3 - 0.05)	EE, EES	FILAMENT, GRID, FUSE
									.012 - .500 (0.5 - 20)	B, BS, C, CS, EE, EES, EP, EPS	LAMP, ELECTRONIC, MISC.
	710	●	◐	◐	●	○	●	●	.063 - .500 (1mm min.)	B, BS, C, CS, EE, EES, EP, EPS	QUARTZ HALOGEN LAMP
	320	●	◐	◐	●	○	◐	●	.165 - .270 (6.5 - 10.6)	BS, CS, EES, EPS	RETRACTABLE MANDREL AUTO LAMP FILAMENT
	310	●	◐	◐	◐	○	◐	●	.500 - 1.500 (20 - 60)	B, C, BS, CS, EE, EES, EP, EPS	HIGH WATTAGE STD. AND DIN FILAMENT
Medium Temp. Service	MWG	●	○	◐	◐	○	◐	●	.500 - 1.500 (20 - 60)	B, C, BS, CS	VAC. METALLIZING AND FURNACE WINDINGS
	NF	○	●	●	○	●	◐	×	.015 - 1.500 (0.6 - 60)	B, C, BS, CS, EE, EES, EP, EPS	SHOCK AND VIBRATION SERVICE • FILAMENTS
	2TH	○	◐	◐	○	●	◐	×	.760 - 1.500 (30 - 60)	B, C, BS, CS	DISCHARGE LAMP ELECTRODES
	3D	◐	◐	●	◐	○	◐	◐	.010 - 1.500 (0.4 - 60)	B, C, BS, CS, CLS, EE, EES, EP, EPS	VIBRATION SERVICE FILAMENT, CATHODES

An Enabling Technology

The development of tungsten wire dates back to the beginning of the General Electric Company. At the turn of the century, lamp filaments were rather short-lived. This was a major concern to Thomas Edison and other pioneers of the lighting industry. It was the legendary Charles Steinmetz who spurred his small but growing group of researchers to overcome this major obstacle to the lamp industry's growth.

By 1907, GE had lamps with sintered tungsten filaments on the market, offering twice the lighting efficiency of then available tantalum filament lamps.

Lamp filaments made from the first ductile tungsten wire, developed in the laboratory of another GE scientist, Dr. William D. Coolidge, were introduced in 1910.

In 1916, Irving Langmuir of GE patented a lamp with a coiled tungsten filament that again doubled lamp efficiency. In the following year, GE produced a non-sag tungsten wire that further extended lamp life.

Thoriated tungsten filaments for electron tubes, introduced in 1925, were up to 50 times better as electron emitters than pure tungsten.

The doubled coiled (or coiled coil) tungsten wire lamp filament, similar to that used today, was introduced by GE in incandescent lamps in 1936. This superior design provided longer hours of illumination and improved efficiency.

GE continually improves the technology for making tungsten products. One recent achievement is tungsten rhenium wire (3D), a 3% rhenium tungsten alloy with improved high temperature structure and high resistivity.

GE is constantly looking for new ways to improve the performance of tungsten wire, and to use its properties more effectively.

Many of the newer, more efficient lighting products of recent years—the high intensity discharge lamp, halogen headlamps, and long-life lamps—have benefited from GE's vast store of knowledge about this versatile material.

320

This wire was developed specifically for sealed-beam headlamp filaments, an application which presents the most severe coiling conditions for tungsten wire. This wire has a 218 base that has been specially processed to provide a lower yield point and higher elongation for improved coilability. It is generally supplied in the cleaned and straightened condition in sizes ranging from 80mg to 225mg per 200mm.

710

A premium wire processed from 218 stock, Type 710 wire is designed for use in demanding quartz halogen lamp filaments. The highest purity wire is required for this application to avoid possible interference with the halogen cycle during lamp operation.

The superior high temperature properties of 218 wire are fully retained. The manufacturing process for 710 virtually eliminates minute surface defects that might trap impurities from either wire drawing or the coiling processes. This improved surface assures more complete removal of surface contaminants during coil cleaning and reduces breakage at coiling.

NF

Type NF is a thoriated tungsten wire that provides improved performance over pure tungsten in specialty lamps and electronic vacuum tubes. Approximately 1% thoria is dispersed uniformly in the metal and contributes in two useful ways: First, it controls recrystallized grain size and shape for enhanced vibration damping properties. Second, it lowers the thermionic work function so that when NF is used as an emission source it is a better electron emitter than pure tungsten.

NF is somewhat more difficult to work than 218 tungsten. Therefore heating during forming is usually required. The fine, equiaxed recrystallized grain structure of this type provides the desired shock and vibration resistance but tends to lower sag resistance. For that reason, NF is not recommended for filament service above the 2200°C range.

3D

An alloy of 218 tungsten with 3% rhenium, 3D was developed by GE to provide greater ductility in the partially recrystallized state. This ductility is associated with a fine grained microstructure and contributes to improved hot strength, cold strength, and vibration resistance characteristics over those of 218 wire at temperatures above 2200°C. The intrinsically higher resistivity that rhenium imparts permits the alloy to be used at larger wire diameters than 218 or NF, a factor which is frequently advantageous for strength considerations.

MWG

GE MWG tungsten wire is made expressly for use in the vacuum metallizing industry. The high degree of purity and cleanliness of this wire provides wettability and consistent results in metallizing. Overall purity is typically 99.95 percent tungsten based on trace analysis and calculated on a gas-free basis. Used in the form of single or multiple-strand configurations, MWG offers excellent forming characteristics, superior resistance to embrittlement, and longer life.

Further information about MWG tungsten wire or coils for vacuum metallizing can be found in the catalog entitled "GE Metallizing Products," available upon request.

Properties of Tungsten Wire

The variety of applications of tungsten wire demonstrates the wide range of properties of this material. Tungsten wire combines low vapor pressures at elevated temperatures, excellent room temperature strength, good electrical and thermal conductivity, high elastic modulus and hardness, and inertness to chemical reaction with many materials.

Tungsten is one of the refractory metals, a family of materials which exhibit very high strength at elevated temperatures. With a melting point of 3417°C, it is stronger than any other metal over 1900°C, and retains usable strength at 3000°C, making it unique and irreplaceable in many applications.

Tungsten can be doped or alloyed to further improve some of its properties, including its high temperature strength, creep resistance, mechanical stability, recrystallized ductility, vibration damping, and thermionic emissivity.

Although it is sometimes considered difficult to fabricate, technology developed over the last 70 years by GE makes it possible to produce tungsten in a vast array of wire sizes and properties.

Like most materials, tungsten develops additional strength as it is worked into smaller diameters. Successive draws create the fibrous grain structure needed for ductility in coiling and other fabrication processes. As the wire is drawn, the ductile-to-brittle transition temperature is progressively suppressed to values well below room temperature. Because tungsten wire is processed below its recrystallization temperature, it work hardens and must be softened by stress-relieving anneals to allow further processing to smaller diameters.

Applications of tungsten at temperatures greater than 400° are normally limited to vacuum, inert, or reducing atmospheres to prevent oxidation.

To take full advantage of the outstanding properties of tungsten wire, especially for new applications, a consultation with GE's engineering staff may be advisable. With their experience, they can provide guidelines for the most effective and cost-efficient use of the material.

An excellent aid for referencing the properties of tungsten wire is the GE conversion slide chart pictured here. It provides data on wire types and finishes, diameter to weight ratios, and other information. It is available in English, Japanese, German and Spanish languages with data in both English and metric values. (Comparable data on molybdenum wire appears on the reverse side.) For your free copy, write to GE Sales Operation headquarters, Page 16.

TABLE I—
Physical Properties of Tungsten (W)

Melting Point	3417°C
Boiling Point	5930°C
Vapor Pressure (mm Hg):	
1527°C (2780°F)	1.93×10^{-15}
2127°C (3860°F)	7.90×10^{-9}
2727°C (4940°F)	6.50×10^{-5}
3227°C (5840°F)	4.68×10^{-3}
Specific Heat at 20°C (68°F) (Cal/gram-atom)	6.25
Thermal conductivity (cal/sq cm/cm/sec/°C):	
20°C (68°F)	0.310
927°C (1701°F)	0.275
1127°C (2061°F)	0.268
1327°C (2421°F)	0.260
1527°C (2781°F)	0.253
1727°C (3141°F)	0.245
Density (g/cc):	
ASTM Wire	19.17
Coefficient of Linear Expansion, mean value 0°-500°C (32° - 932°F)	
Worked	4.98×10^{-6}
Annealed	4.45×10^{-6}
Heat of Fusion (cal/g)	44
Thermionic Data:	
Apparent electron work function (eV)	4.55
Apparent positive ion emission (eV)	11.93
Radiation emission coefficient	0.43
First ionization potential	7.60
Elastic Properties: (at 25°C)	
Young's Modulus	(58.3×10^6 psi) 41×10^3 kg/mm²
Shear Modulus	(22.8×10^6 psi) 16×10^3 kg/mm²
Poisson's Ratio	0.27
Electrical Resistivity (micro-ohm-cm):	
24°C (75°F)	5.89
100° (212°F)	7.28
700°C (1292°F)	22.43
1100°C (2012°F)	34.65
1500°C (2732°F)	49.66
1800°C (3272°F)	57.52
2100°C (3812°F)	69.61

Manufacturing

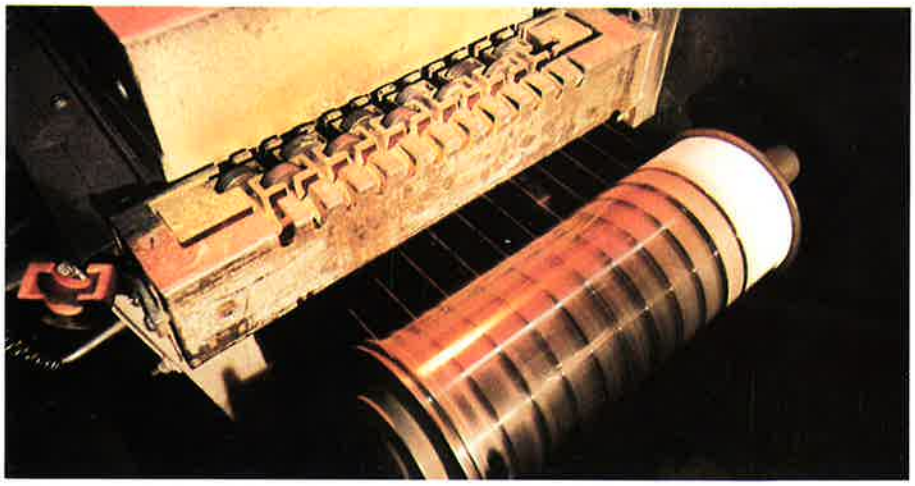
To provide 99.95% purity in the finished product, only contaminant-free starting materials are used in the production of tungsten wire. Purity levels are maintained throughout manufacturing, from the powder metallurgy process to actual drawing of the wire.

Frequent SPC audits of process temperatures, lubrication conditions, reduction drafts, and lineal speeds are performed on the equipment to maintain uniformity of dimensions and properties. Product traceability throughout GE's process establishes a reliable wire pedigree.

A highly skilled staff working with state-of-the-art equipment supports this total commitment to quality assurance and customer satisfaction.

Tungsten rod preheated to 1500°C is passed through multistand rolling mills for reduction to the desired rod diameters.

Tungsten rod is processed through a high temperature induction furnace to create a crystal structure with the properties needed for downstream wire drawing operations.



Temperature, drawing speed, and die geometry are carefully controlled through the drawing process to produce very accurate diameters with the desired properties.

Quality Control

Tungsten wire is a highly engineered material with properties specifically tailored for its various applications. GE has developed a comprehensive quality assurance system to characterize and control these properties.

Coordination of the quality control program is the responsibility of several special laboratories at GE's Tungsten Products Plant.

In our Analytical Chemistry Laboratory, purity standards are established and maintained as an integral part of the quality assurance system. Dopants used to create the unique structures and properties of tungsten wire are controlled within a few parts-per-million. Once a product chemistry has been established in powder and ingots, further processing is monitored to prevent contamination.

Microstructures Studied

Special attention is given to the presence of embrittling elements, specifically iron and nickel. Since the metallurgical structure controls the mechanical properties of tungsten wire, microstructures are carefully monitored with advanced metallographic techniques in the Structure and Properties Laboratory. The results from these analyses are closely coordinated with physical testing.

In addition to the conventional types of mechanical measurements, special techniques have been developed in the Physical Testing Laboratory to assure product performance in the most demanding applications.

In our quality control lab on the manufacturing floor, samples taken from actual production runs are tested for hot and cold tensile strength, camber, roundness, diameter and other characteristics.

Split levels in tungsten wire are continually monitored as the wire is drawn through a multiple series of dies.

Many elements can be identified on the Direct Current Plasma Spectrometer. This test provides quantitative and qualitative data on trace element impurities in the ppm to ppb range.

Mechanical properties of tungsten wire are obtained by testing representative samples in tension and/or compression at temperatures from ambient to 2200°C on the Instron Universal Tester.

Research & Development

Requests for samples with novel properties are encouraged and generally serviced from our Piloting Laboratory. Advanced research equipment is used in this laboratory to develop new and improved products, processes, and measurement techniques.

In its many uses, tungsten wire is subjected to heat treatments, mechanical deformation, and surface conditioning. Since these operations can significantly affect wire performance, GE is constantly striving for ways to assist customers in their applications of tungsten wire. In many cases, sophisticated analyses developed for internal quality assurance programs are used to help solve customer problems.

Coupling an image analyzer to a Scanning Electron Microscope is a superior technique for studying material microstructure. The SEM provides the magnification and the image analyzer allows mathematical manipulation.

Even when the chemical composition of two materials appears identical, studies of the crystalline structure using x-ray diffraction spectrometry may reveal variances which could affect performance.

Trace elements in tungsten wire are identified by atomic absorption spectroscopy. When samples are dissolved and aspirated into a flame, the radiant energy absorbed is exactly proportional to the concentration of trace elements. This method is also used to measure the level of potassium additive in tungsten.

The effect of atmopsphere and thermal treatments on the microstructure and properties of tungsten wire can be evaluated with the ultra high vacuum and temperature (UVHT) chamber.

Size Range Determination

For most tungsten wire applications, the success of the end product depends upon very close control of wire diameter.

Wire diameters above 0.51mm (20 mils) are measured with standard micrometers and reported in mils. For wire diameters below 0.51mm, none of the common methods of direct measurement can approach the degree of precision required. Therefore, an indirect method called rating is used. A precise 200mm length of wire is cut and weighed on an accurate electronic balance. The weight of the sample is recorded in milligrams to three decimal places for sizes below 1.02 mg/200mm. Above 1.02 mg/200mm, the weight is rounded and recorded to two decimal places.

Rating and Weighing

Rating and weighing of tungsten wire is performed with precision by experienced operators specifically trained for this important function. Constant checks are made to maintain accuracy of the system. Balances used for this operation are of the most accurate and dependable type available. They are always calibrated at the nearest point to the wire size being weighed, and the working calibration weights are frequently checked against standards traceable to the National Bureau of Standards. Each balance is used only for a small portion of the total size range.

Cutting blocks are designed to cut precisely to a 200 millimeter length.

Tungsten wire is cut into 200mm lengths and weighed to confirm that it meets customer size specifications. The data is displayed on the readout shown here and simultaneously cross checked through the specifications in the computer memory.

A computer generated label with wire processing information enables GE to match finished wire properties to the customer specification. Bar coding is used to speed order processing and maintain good inventory control.

TABLE II—Size-Weight Relationship of Tungsten Wire

Diameter (d) = $K\sqrt{mg/200mm}$ mg/200mm = C × d^2						
Wire Type	GE 218, MWG, 3D etc. based on 19.17 gm/cm³		For GE NF (1% Th), based on 18.80 gm/cm³		For GE 2TH (2% Th), based on 18.50 gm/cm³	
Units	K	C	K	C	K	C
μm	18.223	3011.18 × 10^{-6}	18.402	2953 × 10^{-6}	18.550	2906 × 10^{-6}
mm	.018223	3011.18	.018402	2953	.01855	2906
mils	.71745	1.9427	.72452	1.905	.73029	1.875

Product Specifications

Cleaned Wire

Clean tungsten wire should show no visible evidence of drawing lubricant residues, oxides or other foreign matter such as dirt, oil, etc. when viewed without magnification.

Depending on the final cleaning or cleaning/anneal process, tungsten wire will have different surface textures. This can result in variable degrees of luster ranging from dull-matte-grey through bright-shiny. This difference in luster is not related to cleanliness.

Straightness

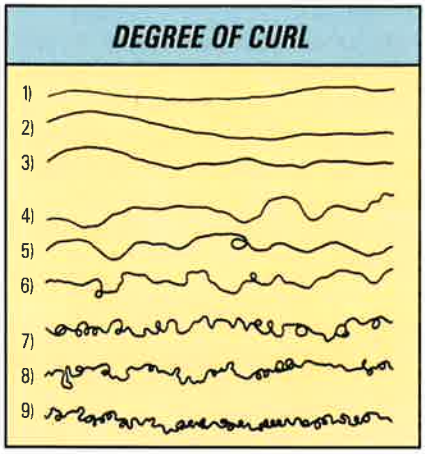
Straightness is determined by the amount of camber exhibited by the wire. For tungsten wire, camber is expressed as the maximum deviation of the wire from a straight line over a fixed span. For center sizes below 1.25 mg/200mm, degree of curl specifications are used.

Eddy Current Testing

Splits in tungsten wire are longitudinal defects of variable length and depth which can be internal or exposed to the wire surface. For most applications, the infrequent, short random occurrence of these phenomena are of no importance.

However, in applications where splits could be detrimental to the wire forming process or to end product use, eddy current testing should be specified. This procedure detects where splits are located within a single length of wire, and logs the cumulative total split length as a percent of the total wire length.

The designation "M" following the letter identifying the various finishes of tungsten wire indicates eddy current testing has been specified and performed.



Roundness

This is expressed as % out-of-round (OOR) for wire ranging in size from 0.17 mg/200mm (.0003″) to 4856 mg/200mm (.050″) diameter. Percent OOR is calculated using the formula:

$$\% \text{ OOR} = \frac{\text{Max. Dia.} - \text{Min. Dia.}}{\text{Max. Diameter}} \times 100$$

TABLE III—Wire Tolerances

Wire Size	Standard Tolerance	Special Tolerances Available
≤ 1.02 mg/200mm	± 0.03 mg/200 mm	±0.025, ±0.02, ±0.015, ±0.01, ±0.005mg/200mm
1.03 thru 777.19 mg/200mm	± 3% by weight	±2½%, ±2%, ±1½%, ±1%
≥ 0.51mm (0.020″)	± 1.5% by diameter	±1¼%, ±1%, ±¾%

TABLE IV—Wire Straightness

Size Range	Process	Maximum Curl or Camber/ Wire Length
* < 1.25mg/200mm	BS, CS, CLS, EES, EPS	#4 curl
1.25 to 2.5mg/200mm	BS, CS, CLS, EES, EPS	16mm/76mm
2.6 to 4.0mg/200mm	BS, CS, CLS, EES, EPS	12mm/76mm
4.01 to 8.0mg/200mm	BS, CS, CLS, EES, EPS	8mm/76mm
8.01 to 777mg/200mm	BS, CS, EES, EPS	32mm/200mm
8.01 to 50mg/200mm	CLS ONLY	20mm/200mm

* For sizes below 1.25mg/200mm, "curl" values are used to determine the relative straightness.

TABLE V—Out-of-Round Limits for Material Types 218, 310, 320, 710, 3D, NF

Size Range	Maximum OOR
0.17 - 2.39mg/200mm	5%
2.40 - 79.99mg/200mm	4%
80.00 - 777mg/200mm	3%
0.51mm - 1.27mm	3%

Product Options

Tungsten wire that is specified "black" or "as drawn" has a graphite coating over a layer of surface oxide. The oxide results from drawing the wire at high temperature. The graphite is the lubricant that is applied to improve wire drawing performance and inhibit oxidation.

For many users, the graphite and oxide coating is desirable, especially since it protects the wire from further oxidation during storage and acts as a lubricant during coiling. But there are many applications which require a product with characteristics other than "as drawn." For these, GE has tungsten wire available with a cleaned surface, an etched finish, straightened, or with special tensile strength or other non-standard characteristics.

Each standard type of tungsten wire has distinctive physical characteristics. The Product Selection Guide on page 6 indicates the characteristics and sizes available in each type; the available finishes shown in column 10 of the guide refer to the process designations defined in the box at right. Standard minimum lengths of tungsten wire available from GE, with their process designations, are shown in Table VI.

GE invites inquiries for wire types to suit special needs. It is helpful if inquiries are accompanied by an explanation of the desired properties and intended use of the wire.

Available Finishes (Product Designations)

B Black wire, as drawn
BS Black wire, as drawn, which has been given a straightening treatment
C Process "B" wire which has been electrochemically cleaned
CS Process "BS" wire which has been electrochemically cleaned
CLS Process "CS" wire which has been annealed for lower tensile strength and maximum straightness
EE Process "B" wire which has been electrolytically etched to reduce size and improve surface texture
EES Process "EE" wire which has been given a straightening treatment
EP Process "B" wire which has been electrolytically processed to polish and improve the surface
EPS Process "EP" wire which has been given a straightening treatment

TABLE VI—Standard Minimum Lengths (Meters)

SIZE (mg/200mm)	PROCESS						
	B	C	BS	CS	EE/EP	EES/EPS	CLS
.15 - .29	–	–	–	–	100	50	–
.30 - .49	400	200	300	200	200	100	200
.50 - 1.00	400	400	400	400	200	200	400
1.01 - 2.00	400	400	400	400	300	300	400
2.01 - 4.00	400	400	300	300	300	300	400
4.01 - 10.00	400	300	300	300	300	300	300
10.01 - 20.00	400	300	250	250	250	250	250
20.01 - 40.00	300	200	200	200	200	200	200
40.01 - 100.00	150	150	150	150	150	150	150
Above 100.00mg/200mm	50 grams of wire - all processes						

Shipping Containers & Coils

General Electric tungsten wire is packaged for shipping either in self-contained coils or wound on standard spools or bands. The material is shipped in one continuous length per container or coil, as indicated in the chart below. Any deposit charge made for shipping containers is refunded when containers are returned prepaid, in good condition.

Package Indentification

The following identification and descriptive information, where applicable, is put on each label: type of wire, standard process designation, quantity in meters or kilograms, size in milligrams per 200 millimeters or in mils, metal lot number, designation of ingot from which wire was drawn, date of packaging, and code number of operator who packaged wire. This information, backed by records from a rigid quality control system, makes possible positive identification of every piece of wire made by GE.

It is recommended that labels and tags be kept with the wire so that identification can be made at any time. Small corks are used to secure wire to spools or bands. A red cork signifies the outer end.

Designation of Container Dimensions

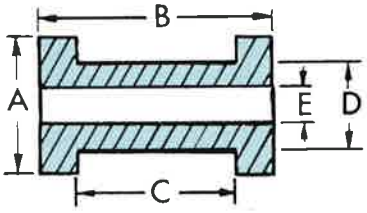


TABLE VII

	Name	Material	GE Drawing No.	Approx. Weight In Grams	CONTAINER DIMENSIONS						Wire Size Range, Standard Processes	Approx. Container Capacity (grams)
					Units	Flange Diameter (A)	Width (B)	Traverse (C)	Barrel (D)	Hole (E)		
	Bobbin	Alum.	B-10504	4.4	mm	18.26	14.94	10.97	14.91	11.11	0.08 - .40 mg/200 mm Black or Clean	8
					in.	.719	.588	.432	.587	.438		
	Small Plastic Spool	ABS	C-10749	22	mm	53.98	26.16	19.81	37.16	10.29	0.20 - 60.0 mg/200 mm Black Wire and 0.20 - 50.0 mg/200 mm Clean Wire	250
					in.	2.125	1.030	.780	1.463	.405		
	Large Plastic Spool	ABS	C-10905	63	mm	63.50	35.00	28.55	41.22	10.29		500
					in.	2.500	1.378	1.124	1.623	.405		
	Blue Special Band	Lexan®	A-8165	73	mm	119.86	27.00	20.63	105.18	96.04	20.0 - 150.0 mg/200 mm Clean Wire	650
					in.	4.719	1.063	.813	4.141	3.781		
	Orange Regular Band	Lexan®	A-8166	100	mm	126.21	33.34	25.40	108.36	98.43	41.0 mg/200 mm – 23 mils (.584 mm) Black or Clean	1050
					in.	4.969	1.313	1.000	4.266	3.875		
	10″ Band	Nylon	C-10857	95	mm	254.00	34.29	30.73	219.58	216.03	0.254 mm - (.762 mm 10 mils - 30 mils	3000
					in.	10.000	1.350	1.210	8.645	8.505		
	6×3″ Reel	Poly-styrene	C-20510	300	mm	152.40	101.6	76.25	101.6	15.56	3.0 mg / 200 mm – 30.0 mils (.762 mm) Black or Clean	3500
					in.	6.000	4.000	3.001	4.000	.625		
	304.8 mm 12″ Diameter	Self-Contained Coil, Black or Clean									0.508 mm - .838 mm 20 mils - 33 mils	N/A
	406.4 mm 16″ Diameter	Self-Contained Coil, Black or Clean									0.838 mm - 1.525 mm 33.0 mils - 62.0 mils	N/A

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A Unique Materials Resource

Tungsten wire is one of several specialized products available through GE Components Marketing & Sales Operation. In wire alone, we produce Dumet & Cumet, molybdenum—including molybdenum EDM wire and platinum clad molybdenum wire; lead wire assemblies and wire formed and fabricated parts. Other metals include tungsten carbide powders, pressed and sintered molybdenum and tungsten parts, and small precision stampings.

We also manufacture glass in the form of bulb blanks, tubing and pressed ware; Lucalox® ceramics, luminescent phosphors and inorganic chemicals.
Because of the special nature of many of these parts and materials, GE is always willing to assist in adapting them to your manufacturing operations, or to work with you in product development or application engineering.
For more information, contact your regional sales representative or the nearest sales office indicated below.

Technical Assistance

This includes helping you select and specify the optimum material and finish for your requirements, tailoring properties to application, consultation on quality control procedures, and troubleshooting parts in process or in service.

If you have a potential use for tungsten wire, or feel your present application may be improved upon, please let us know.

To Order

To order tungsten wire, contact your local sales representative, sales headquarters, or the Tungsten Products Plant customer service representative.

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