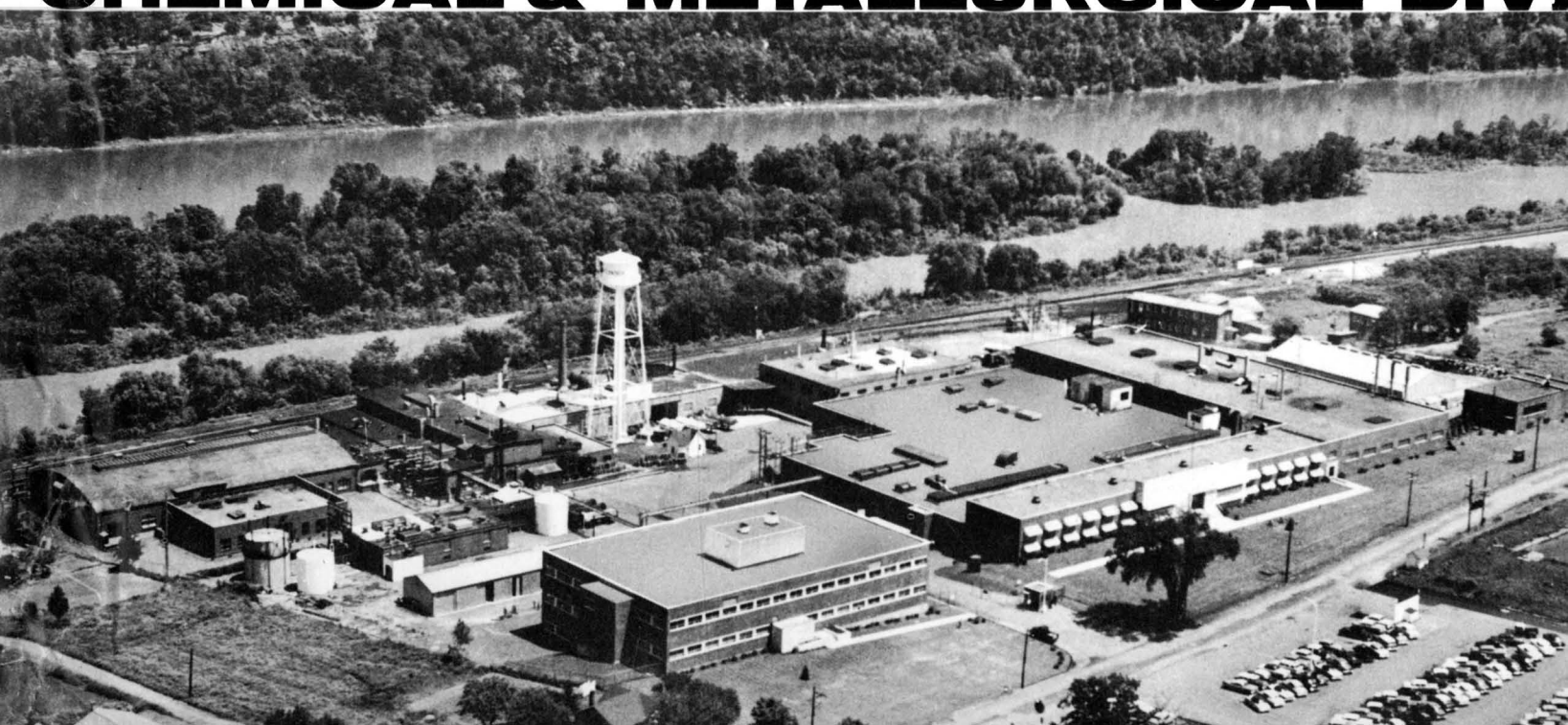
sylvania

CHEMICAL & METALLURGICAL DIV.



PRINCIPAL PRODUCTS

TUNGSTEN

- Chemicals
- Powder
- Rod
- Wire
- Strand
- Coils
- Electrodes
- Billets, Slabs, Rings and Pellets

MOLYBDENUM

- Chemicals
- Metal Powder
- Rod
- Wire
- Electrodes
- Billets, Slabs, Rings, Pellets and Discs
- Boats

CHEMICALS

- Potassium Silicate
- Emission Carbonates
- Mica Spray Coating
- Basing Cement
- Laser Crystal Chemicals

PHOSPHORS

- Fluorescent Lamp
- Sign Tubing
- TV-Black & White-Color
- Special Cathode-Ray-Tube

SEMICONDUCTOR MATERIALS

- Germanium —
  - Polycrystalline
  - Monocrystalline
- Silicon Monocrystalline
- Epitaxial Chemicals—
  - Germanium
  - Silicon
- Gallium Arsenide

PLATED WIRE

- Gold, Silver, Nickel & Other

Sylvania Electric Products Inc.
CHEMICAL & METALLURGICAL DIV.
Towanda, Pa.

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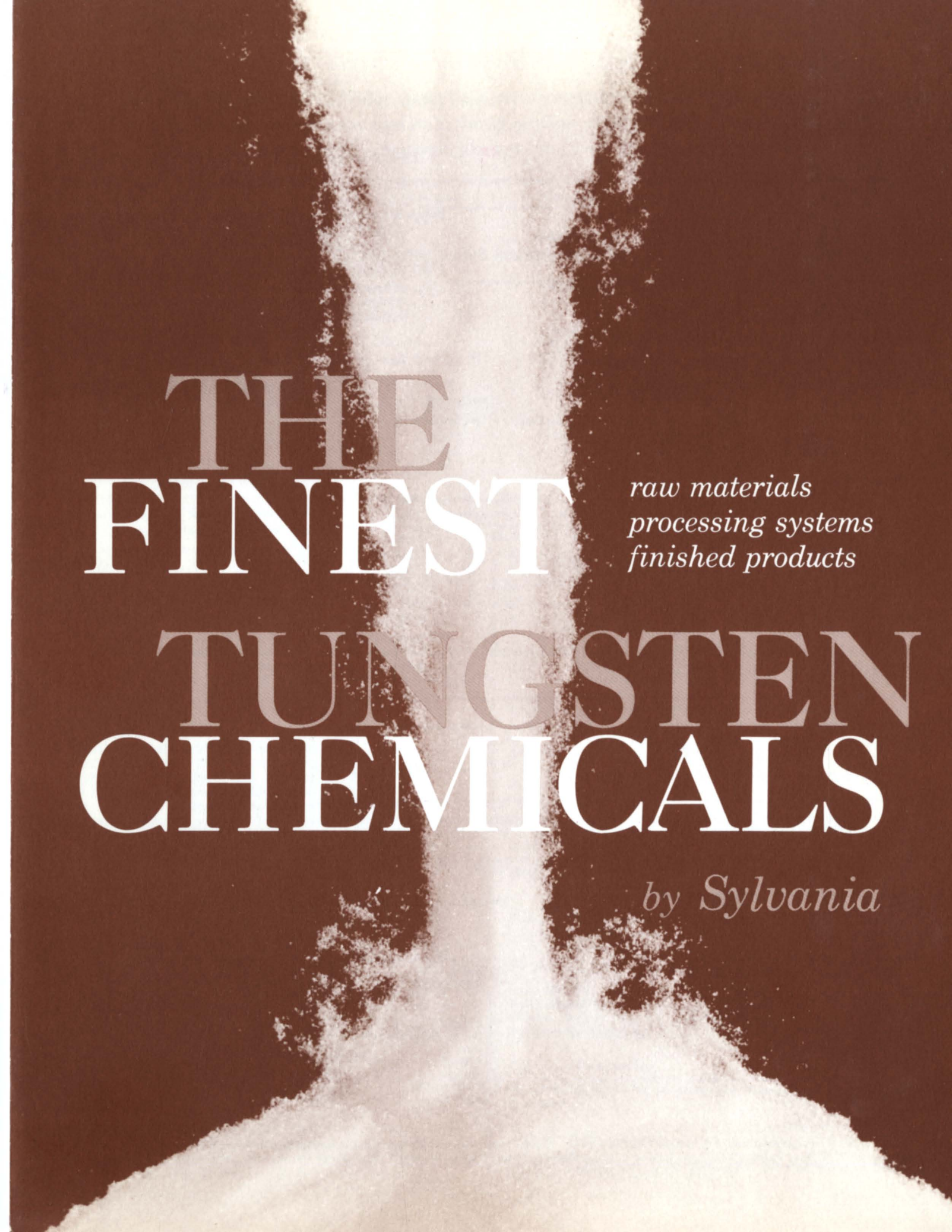
THE
FINEST
TUNGSTEN
CHEMICALS
raw materials
processing systems
finished products
by Sylvania

The Chemical and Metallurgical Division of Sylvania

is one of the world's largest producers of all forms of high-purity tungsten. Starting with the ore concentrate, uniform blends of all tungsten chemicals are available in quantities of 10,000 to 25,000 pounds, depending upon the product.

SODIUM TUNGSTATE $Na_2WO_4 \cdot 2H_2O$

MOLECULAR WEIGHT 329.96

Sodium Tungstate is a white, odorless, finely-divided crystalline material. It is produced by the digestion of the finely ground ore in hot sodium hydroxide, followed by filtration and evaporation to form high-purity sodium tungstate crystals. Four commercial grades are available, differing mainly in purity. Other types are available on request. Consideration will also be given to individual requirements on composition, impurity, or packaging.

Available Grades and Application

Available Grades	Application
ST-1 Folin	Biological Reagents
ST-2 Reagent	Laboratory Reagents
ST-3 Commercial	Light-fast Colors and Inks Tungstic Acid
ST-4 X-Ray	X-Ray Intensifying and Fluoroscopic Screen Phosphors Lamp Phosphors

Chemical Composition

	Theoretical	Specification
WO_3, %	70.29	70 Min.
Ignition Loss, %	10.92	11 Max.

Maximum Impurity Content

	ST-1 Folin	ST-2 Reagent	ST-3 Commercial	ST-4 X-Ray
Iron, %	0.0005	0.001	0.01	0.001
Other Heavy Metals, %	0.0005	0.001	0.01	0.0005
Arsenic, %	0.0003	0.001	—	0.0001
Molybdenum, %	0.001	0.01	0.05	0.002
Chloride, %	0.005	0.01	0.04	0.01
Sulfate, %	0.01	0.02	0.04	0.02
Nitrogen Compounds, %	0.001	—	—	—
Alkalinity as Na_2CO_3, %	0.10	0.20	0.30	0.20
Insoluble Matter, %	0.01	0.015	0.02	0.015

Standard Package

250 pounds packed in polyethylene bag and shipped in polyethylene-lined 24-gallon Leverpak drum.

Up to 150 pounds packed in polyethylene bag and shipped in polyethylene-lined 15-gallon Fiberpak drum.

Other packaging upon request.

PHOSPHOTUNGSTIC ACIDS $H_3(PW_{12}O_{40}) \cdot xH_2O$

Phosphotungstic Acid is available as a pale-greenish, finely-divided, high-density, crystalline material, or as a straw-colored solution. It is produced by the addition of phosphates to sodium tungstate in the presence of hydrochloric acid.

Phosphotungstic acids are complex, inorganic, heteropoly compounds formed by a unique combination of tungsten and phosphorous in the same molecule. For convenience, such compounds may be classified by the ratio of the number of tungsten to phosphorous atoms. The heteropoly tungstic acids are reported to exist with W/P ratios of 18, 12, 9, and 3. Of these, 12-tungstophosphoric acid has been the most widely investigated. Salts of tungstophosphoric acid are derived from the free acid by replacing hydrogen atoms with the appropriate cations. The sodium tungstophosphates are among the most readily available salt derivatives of the acids.

Chemical and Physical Properties

Composition	Type Number 254	253	252	251 (solution)
% WO_3, Minimum	86.0	88.0	88.0	21.5 (by wt.)
% P_2O_5	2.4	2.0	2.4	11.0 max.
W:P Ratio	12 ±1	12 ±1	12 ±1	12 ±1
% Loss in Weight on Heating for 4 Hours at 110°C in Air, Maximum	6.0	6.0	8.0	—
% Total Solids, Min.	—	—	—	38.0

Maximum Impurity Content

	Type Number 254	253	252	251 (solution)
% Sodium	0.05	2.0	2.0	—
% Ammonia	0.004	0.004	0.007	Not Detectable
% Chloride	0.03	0.03	0.05	—
% Heavy Metals as Pb	0.005	0.005	0.01	—
% Iron	0.002	0.002	0.005	0.6
% Nitrate	0.003	0.003	0.008	0.003
% Sulfate	0.02	0.02	0.07	0.07
% Insoluble in Cold Water	0.02	0.02	0.05	—

Standard Package

For solids — a polyethylene-lined, 24-gallon, Lever-Pak drum, containing 300 pounds; a polyethylene-lined, 15-gallon, Fiber-Pak carton, containing 150 pounds; or a 5-gallon, polyethylene-lined, Fiber-Pak drum containing 75 pounds. The type 251 solution is shipped in glass carboys containing 6½ or 13 gallons.

TUNGSTIC ACID

H_2WO_4

MOLECULAR WEIGHT 249.86

Tungstic Acid is a yellow, finely-divided crystalline material. It is precipitated by the addition of a purified solution of sodium tungstate to hot hydrochloric acid in a pressure reactor. After filtration, the precipitated acid is dried in special equipment which provides for large-sized uniformly-blended batches. Sylvania produces three standard grades differing in purity and particle size.

Available Grades

Applications

TA-1 Standard	Tungstic Oxide Tungsten Metal Powder Laboratory Reagents Enameling Frits
TA-2 Fine	Fluorescent Powders Laboratory Reagents
TA-3 Extra Fine	Fluorescent Powders

Maximum Impurity Content

	TA-1 Standard	TA-2 Fine	TA-3 Extra Fine
Sodium, %	—	0.005	0.005
Iron, %	0.003	0.002	0.002
Molybdenum, %	0.02	0.003	0.003
Non-Volatile Matter, %	0.01	0.01	0.01

Chemical Composition

	Theoretical	Specification
WO_3, %	92.79	92.5 Min.
Ignition Loss, %	7.21	7.5 Max.

Physical Characteristics

	TA-1	TA-2	TA-3
Average Particle Size, Microns (Fisher Sub-Sieve Sizer)	1.5 Min.	0.90 to 1.5	0.90 Max.

Standard Package

Polyethylene-lined 24-gallon Leverpak drum
Grade TA-1 — 250 pounds packed in polyethylene bag
Grades TA-2 and TA-3 — 200 pounds packed in polyethylene bag

TUNGSTIC OXIDE

WO_3

MOLECULAR WEIGHT 231.85

Tungstic Oxide is a finely-divided, yellow, crystalline powder. It is produced by roasting tungstic acid or ammonium paratungstate at closely controlled temperatures to drive off combined water and ammonia. Exact time and temperature control determines, to a large extent, the characteristics of the tungstic oxide. Sylvania produces three standard grades differing in purity and particle size. Blue oxide can be furnished on request.

Available Grades

Applications

TO-1	Tungsten Metal Powder
TO-2	Fluorescent Powders Laboratory Reagents
TO-3	Tungsten Metal Powder

Chemical Composition

	Specifications
WO_3, %	99.5 Min.
Ignition Loss, %	0.5 Max.

Maximum Impurity Content

	TO-1	TO-2	TO-3
Sodium, %	—	0.005	—
Iron, %	0.003	0.002	0.003
Molybdenum, %	0.02	0.003	0.03
Non-Volatile Matter, %	0.01	0.01	0.01

Physical Characteristics

Approx. Average Particle Size, Microns (Fisher Sub-Sieve Sizer)	3.0 Max.	3.0 Max.	15-20
Bulk Density, g/in^3 (Scott Volumeter)	11-21	11-21	32-48

Standard Package

Polyethylene-lined 24-gallon Leverpak drum
Grades TO-1 and TO-2 — 250 pounds packed in polyethylene bag
Grade TO-3 — 350 pounds packed in polyethylene bag

AMMONIUM PARATUNGSTATE

$(NH_4)_{10}W_{12}O_{41} \cdot 5H_2O$

MOLECULAR WEIGHT 3133

Ammonium Paratungstate is a white, finely-divided, crystalline material. It is produced by dissolving sodium tungstate in water, followed by precipitation in hot hydrochloric acid, after which the resulting precipitate is treated with ammonium hydroxide. This solution is then evaporated to obtain pure paratungstate crystals. Controls of time, temperature, concentration, and purity determine, to a large extent, the quality of the ammonium paratungstate crystals. Ammonium metatungstate can be supplied upon request.

Available Grade

Applications

AP-2	Tungstic Oxide Tungsten Metal Powder Laboratory Reagents

Chemical Composition

	Theoretical	Specifications
WO_3, %	86.0	88.7 Approx.
Loss on Ignition, %	14.0	11.2 Max.

Maximum Impurity Content

Iron, %	0.003
Molybdenum, %	0.025
Arsenic, %	0.0003
Non-Volatile Matter, %	0.01

Physical Properties

The physical properties of ammonium paratungstate are available on request.

Standard Package

350 pounds packed in polyethylene bag and shipped in polyethylene-lined 24-gallon Leverpak drum.

TUNGSTEN DISULFIDE

WS_2

MOLECULAR WEIGHT 247.98

Tungsten disulfide is a soft, greyish-black powder which is synthetically produced. It resists oxidation at high temperatures while exhibiting outstanding lubrication properties. These properties make it a new and useful addition to the growing list of commercially available chemicals for high temperature applications.

Chemical Composition

	Specification	Typical Analysis	Theoretical
Tungsten, %	73.0 min.	73.8	74.18
Sulfur, %	27.0 max.	26.2	25.82
Total Impurity Content, %	0.5 max.	<0.2	—

Availability — At the present time, one grade is available. Consideration will be given to other requirements with respect to purity, chemical composition or physical characteristics. Production quanities are now available.

Standard Package — Polyethylene-lined metal pails of one and 3½ gallons containing up to 5 pounds and 25 pounds of tungsten disulfide respectively.

CALCIUM TUNGSTATE, Crystal Grade

$CaWO_4$

MOLECULAR WEIGHT 287.93

Synthetic calcium tungstate is manufactured expressly for applications requiring high purity and low-alkali-metal content. Electronic-grade calcium tungstate is a white, crystalline, high-bulk-density powder having a maximum impurity content of 300 ppm. It is recommended as a starting material for making solid-state optical masers or lasers (light amplification by stimulated emission of radiation).

Chemical Composition

X-Ray Identification: Tetragonal $CaWO_4$ Pattern of ASTM X-Ray Powder Data File No. 7-210

Typical Impurity Content* — ppm

Al	50	Fe	5	Mo	5	Sr	100
Ba	50	Mg	50	Si	50	Na	5

*Quantitative spectrographic analysis.

Physical Properties

Appearance — white, crystalline powder
Fisher Sub-Sieve Size — 10 to 15 microns
Bulk Density — 38 to 42 grams per cubic inch
Melting Point — approximately 1620°C
Solubility — insoluble in water; decomposed by hot acid solutions such as HCl, HN03.

Availability

Production quantities are now available.

Standard Package

Polyethylene-lined, Fiber-Pak or Lever-Pak containers.

AMMONIUM METATUNGSTATE

$(NH_4)_6H_2W_{12}O_{40} \cdot xH_2O$

MOLECULAR WEIGHT 2958
(Anhydrous)

Ammonium metatungstate is a white, crystalline high purity powder. Its marked degree of solubility in water makes available a source of soluble tungsten which is free of alkali and other metallic impurities. It is of particular interest in the preparation of tungsten catalysts which are potentially useful for a variety of reactions including oxidation, hydroxylation, hydrogenation, and polymerization. Ammonium metatungstate is also potentially useful in the preparation of high-purity tungsten metal, chemicals, alloys, and as a source of soluble tungsten for corrosion inhibition.

Chemical Composition

	Specification	Typical Analysis
WO_3	85.0% Min.	85.8%
Ignition Loss at 750°C in Air	15.0% Max.	14.2%
Insoluble in Hot Water	0.02% Max.	0.002%

Availability

At the present time, one grade is available, but consideration will be given to inquiries for other requirements. Production quantities are now available.

Maximum Impurity Content

Calcium	0.02%
Copper	0.001%
Iron	0.02%
Magnesium	0.02%
Molybdenum	0.02%
Sodium	0.01%
Silicon	0.02%

Standard Package

Polyethylene-lined, 24-gallon Leverpak drums, 350 lb/drum.

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AMMONIUM METATUNGSTATE

Sylvania's ammonium metatungstate is a white, crystalline powder of high purity. Its marked degree of solubility in water makes available a source of soluble tungsten which is free of alkali and other metallic impurities.

FORMULA AND MOLECULAR WEIGHT

Ammonium metatungstate, as presently made, corresponds to the formula

$$(NH_4)_6H_2W_{12}O_{40}\cdot xH_2O$$

where the anhydrous material has a molecular weight of 2958. The amount of combined or zeolitic water is variable. In Sylvania's commercial product, x is controlled in the range 12 to 17, corresponding to an ignition loss of 12.2 to 14.7 percent. Further dehydration may result in the formation of water-insoluble compounds.

Chemical Composition

	Specification	Typical Analysis
WO_3	85.0% Min.	85.8 %
Ignition Loss at 750°C in Air	15.0% Max.	14.2 %
Insoluble in Hot Water	0.02% Max.	0.002%

Maximum Impurity Content

Calcium	0.02 %
Copper	0.001 %
Iron	0.02 %
Magnesium	0.02 %
Molybdenum	0.02 %
Sodium	0.01 %
Silicon	0.02 %

PHYSICAL PROPERTIES

Appearance ..... Granular; 100% Passes 20 Mesh

Absolute Density..4 g/cc

Melting Point.....None — Decomposes at 200-300°C to a relatively stable, anhydrous form — $(NH_4)_6H_2W_{12}O_{40}$ — which in turn decomposes above 300°C to form WO_3.

Solubility in water

WO_3 basis, 25°C.....1.05 g/cc; 8.8 lb/gal

WO_3 basis, 80°C.....2.9 g/cc; 24 lb/gal

pH of aqueous solutions

at 25°C.....4.0-5.0

SUGGESTED APPLICATIONS

Sylvania's ammonium metatungstate is a source of high-purity, water-soluble tungsten which is free of metallic impurities. It is of particular interest in the preparation of tungsten catalysts which are potentially useful for a variety of reactions including oxidation, hydroxylation, hydrogenation, and polymerization. Suitable carriers can be impregnated with alkali-free solutions of tungsten and processed in the normal manner to remove water and ammonia. Ammonium metatungstate dissolves in water to provide alkali-free solutions containing up to 50% by weight of WO_3. This characteristic is in marked contrast to other available alkali-free forms of tungsten which must be dissolved in caustic since they have only limited solubility in water. For instance, ammonium paratungstate is soluble in water to the extent of about 4% by weight at 25°C on a WO_3 basis.

Ammonium metatungstate is also potentially useful in the preparation of high-purity tungsten metal, chemicals, alloys, and as a source of soluble tungsten for corrosion inhibition.

AVAILABILITY

At the present time, one grade is available, but consideration will be given to inquiries for other requirements. Experimental quantities, 1 to 25 pounds, are available immediately; larger quantities can be supplied on short notice.

Standard packaging is in polyethylene-lined, 24-gallon Leverpak drums, 350 lb/drum.

TOXICITY

Tungsten or tungsten compounds in general are not considered industrial health hazards. However, inhalation or ingestion of large amounts of tungsten compounds should be avoided.

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chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN CHEMICALS

PRICE SCHEDULE

terms: Net 30 Days ***f.o.b.:*** Towanda, Pa.

replaces: Page 102 12-18-59 ***effective:*** Apr. 2, 1963

subject to change without notice.

	Quantity	Price per Pound			
SODIUM TUNGSTATE		Folin ST-1	Reagent ST-2	Commercial ST-3	X-Ray ST-4
	1750 to 6000 lbs.	$1.85	$1.45	$1.15	$1.60
	250 to 1750 lbs.	1.90	1.50	1.20	1.75
	Less than 250 lbs.	2.25	1.65	1.35	2.00

		Standard TA-1	Fine TA-2	Extra Fine TA-3
TUNGSTIC ACID				
	250 to 1750 lbs.	$1.90		
	Less than 250 lbs.	2.45		
	200 to 1800 lbs.		$2.50	$3.25
	Less than 200 lbs.		3.10	3.85

		TO-1	TO-2	TO-3
TUNGSTIC OXIDE				
	250 to 1750 lbs.	$2.05	$2.60	
	Less than 250 lbs.	2.65	3.25	
	350 to 1750 lbs.			$3.40
	Less than 350 lbs.			4.10

		AP-2
AMMONIUM PARATUNGSTATE		
	350 to 1750 lbs.	$1.80
	Less than 350 lbs.	2.45

MINIMUM CHARGE - $25.00 per item

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN CHEMICALS

PRICE SCHEDULE

terms: Net 30 Days ***f.o.b.:*** Towanda, Pa.

replaces: Page 103 11-15-60 ***effective:*** Apr. 2, 1963

subject to change without notice.

PHOSPHOTUNGSTIC ACID

Type 251

Quantity	Price/Gallon
150 gal. & over	$10.75
100 to 150 gal.	10.85
50 to 100 gal.	11.25
25 to 50 gal.	12.00
13 to 25 gal.	13.50
6 to 13 gal.	16.50
Less than 6 gal.	19.50

	Price/Pound		
Quantity	Type 252	Type 253	Type 254
600 lbs. & over	$4.65	$6.60	$6.95
300 to 600 lbs.	4.80	6.65	7.00
100 to 300 lbs.	4.95	6.80	7.15
50 to 100 lbs.	5.25	7.10	7.45
25 to 50 lbs.	6.25	7.70	8.10
13 to 25 lbs.	7.50	8.90	9.35
Less than 13 lbs.	10.00	13.00	13.65

MINIMUM CHARGE - $30.00 per item

TUNGSTEN DISULFIDE

Quantity	Price/Pound
1000 to 2500 lbs.	$4.12
500 to 1000 lbs.	4.29
100 to 500 lbs.	4.41
50 to 100 lbs.	5.29
25 to 50 lbs.	6.47
10 to 25 lbs.	7.94
Less than 10 lbs.	9.41

MINIMUM CHARGE - $25.00 per item

AMMONIUM TETRATHIOTUNGSTATE

Thiotungstates are compounds containing tungsten and sulfur. The replacement of oxygen with sulfur in normal tungstates, R_2WO_4, can result in mono-, di-, tri-, or tetrathiotungstates. The completely sulfurated tetrathiotungstates conform to the general formula R_2WS_4, where R designates an alkali metal, ammonium ion, or an organic nitrogen radical.

Sylvania's ammonium tetrathiotungstate, $(NH_4)_2WS_4$, is a stable, orange-colored, crystalline compound. It is a convenient, single source of soluble tungsten and sulfur, possessing such useful characteristics and properties as

- — high purity
- — solubility in water and ammoniacal solutions
- — ease of handling
- — good stability
- — extremely low alkali-metal content
- — convertibility to tungsten disulfide

Potential applications are in the manufacture of catalysts, lubricants, and semiconductors.

Chemical and Physical Properties

Formula: $(NH_4)_2WS_4$

Formula Weight: 348.18

Composition: Ammonium tetrathiotungstate is a heat-sensitive chemical and is difficult to dry without decomposition. It is recovered as a crystalline powder containing up to 15% by weight water.

	Tentative Specifications*			Typical Analyses*	
	Theoretical	ATT-1	ATT-2	ATT-1	ATT-2
WO_3, %	66.66	66, min.	62, min.	66.4	62.9
W, %	52.80	52, min.	49, min.	52.9	49.8
S, %	36.84	36, min.	33, min.	37.4	33.6
NH_3, %	9.78	9, min.	9, min.	9.6	9.7

*ATT-1 contains less than 1% water.
ATT-2 contains 10-15% water.

Impurity Content (WO_3 basis):

	Specification* Maximum %	Typical Analysis* %
Al	0.01	Not detectable
Ca	0.01	Not detectable
Fe	0.01	0.001
Mg	0.01	0.001
Mo	0.01	0.01
Si	0.01	0.01

*Based on spectographic qualitative analysis of WO_3 obtained by firing $(NH_4)_2WS_4$ in air.

X-Ray Analysis: Crystalline, orthorhombic system.

Appearance: Orange-colored, crystalline powder.

Odor: Hydrogen sulfide.

Absolute Density: 2.71.

Bulk Density: Approximately 9.3 g/in^3; 35 lb/ft^3.

Stability: At room temperature, i.e., $<30°C$, $(NH_4)_2WS_4$ is relatively stable, with a slight odor of H_2S. At higher temperatures, $(NH_4)_2WS_4$ decomposes, releasing H_2S, NH_3, and/or ammonium sulfide.

Melting Point: None — decomposes upon heating.

Decomposition Characteristics:

In Air — Decomposes continuously with application of heat, releasing NH_3 and H_2S until completely converted to WO_3.

In Non-Oxidizing Atmosphere, N_2, Ar, etc. — Decomposes with application of heat, releasing NH_3 and H_2S to form WS_2. Amorphous WS_2 begins to form at approximately 160°C. The product becomes more crystalline with increasing temperature and time of exposure. After one hour at 304°C, WS_2 of a very low order of crystallinity is identifiable by X-ray analysis. The degree of crystallinity increases only slightly after one hour at 358-478°C. A high order of crystallinity can be obtained by heating amorphous WS_2 at temperature of 500°C to 1000°C or higher for one hour or more. The highest degree of crystallinity results from extended heat treatment of WS_2 at temperatures of 1300-1400°C or above. Exclusion of air or oxygen is necessary to prevent contamination of WS_2 with oxides.

Solubility: Ammonium tetrathiotungstate dissolves in water, ammoniacal solutions, and mixtures of water and organic nitrogen bases to give yellowish-orange colored solutions. Suitable water-soluble organic bases are alkyl

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amines, alkylene amines, alkanolamines, morpholine, pyridine, and piperazine. The solubility is appreciably lower in essentially anhydrous organic nitrogen bases.

In water at approximately 25°C, the tendency to form cloudy solutions is attributed to colloidal sulfur and possible traces of insoluble tungsten compounds. Clear solutions can be obtained by adding ammonium hydroxide or an organic nitrogen base to the aqueous solution. Clear solutions form when ammonium tetrathiotungstate is dissolved in ammonium hydroxide. In water above 40°C, there is a tendency to release NH_3 and H_2S, and this is accompanied by a slight precipitation of an insoluble tungsten compound. In ammonium hydroxide, above 40°C, clear solutions form.

In general, ammonium tetrathiotungstate is insoluble in anhydrous organic solvents. It is slightly soluble in glycol-ethers but is insoluble in alcohol, esters, ketones, hydrocarbons, and chlorinated hydrocarbons. Alcohol is miscible with aqueous solutions or water-amine solutions of ammounium tetrathiotungstate.

Solubility varies with the water content of ammonium tetrathiotungstate, i.e., it decreases wih lower water content. Also, solublility increases slightly with increasing temperature. Data for the solubility of ammonium tetrathiotungstate in water and ammonium hydroxide are shown below.

	ATT-1	ATT-2
In water,		
at saturation, 25°C:	16 g/100 ml	29 g/100 ml
WO_3 Basis:	10 g/100 ml	18 g/100 ml
In NH_4OH (28%),		
at saturation, 25°C:	24 g/100 ml	29 g/100 ml
WO_3 Basis:	16 g/100 ml	18 g/100 ml

pH, saturated aqueous solution, 25°C: 6.0-6.5

SUGGESTED APPLICATIONS

Sylvania's ammonium tetrathiotungstate has been developed to provide a source of soluble, high-purity tungsten and sulfur in solid form. The availability of ammonium tetrathiotungstate is of interest, because it is readily convertible to high-purity tungsten disulfide.

Ammonium tetrathiotungstate is suggested as an intermediate in the manufacture of tungsten disulfide catalysts for the petroleum, petrochemical, and chemical industries. Tungsten disulfide catalysts are potentially useful in hydrogenation, desulfurization, isomerization, and aromatization reactions. The technology of impregnating suitable supports with ammonium thiotungstate solutions and converting the thio salt to tungsten disulfide or promoter-modified tungsten disulfide catalysts is well established. Starting with Sylvania's solid ammonium tetrathiotungstate to make thiotungstate solutions offers potential advantages through

a. Elimination of equipment and unit operations necessary to make normal tungstate and thiotungstate solutions.

b. Assuring high-purity, low-metal content, low-oxythiotungstate content tetrathiotungstate solutions by simply dissolving in aqueous or ammoniacal solutions.

Ammonium tetrathiotungstate is of interest also as an intermediate for the manufacture of self-lubricating, internally lubricated articles and lubricant - coated surfaces. After impregnation or treatment with ammonium tetrathiotungstate solution, tungsten disulfide can be formed in situ by conversion of the thiotungstate.

Tungsten disulfide is an effective solid lubricant under extreme pressure in high vacuum environments and at elevated temperatures. The use of ammonium tetrathiotungstate is potentially advantageous because

a. Thin films of WS_2 lubricant can be formed as part of intricately shaped objects, packing materials, etc.

b. Adherence of lubricant in thin film form can be obtained without use of a binder.

c. Relatively low temperatures, 160-300° C, convert ammonium tetrathiotungstate to WS_2.

d. The technique of impregnating and conversion provides a method of obtaining uniform coatings of WS_2.

The electrical properties of tungsten disulfide are of interest in semiconductor devices such as rectifiers. Ammonium tetrathiotungstate is suggested as a starting material for preparing high-purity, thin films of WS_2 suitable for investigation of these properties. Crystalline tungsten disulfide can be prepared by deposition of ammonium tetrathiotungstate from solution, conversion to sulfide, and heat treatment at elevated temperatures.

Ammonium tetrathiotungstate has potential usefulness for blending as a dry powder with other materials such as inert carriers, supporting material, and metal powders. Dry mixtures are amenable to compaction or pressing in a mold before conversion of the tetrathiotungstate to WS_2.

HANDLING, STABILITY, STORAGE

Ammonium tetrathiotungstate is relatively stable at room temperature but normally has an odor of hydrogen sulfide. Application of heat causes decomposition with release of hydrogen sulfide and amomnia. The material or its solutions should be handled with care to reduce formation of hydrogen sulfide. Storage should be in sealed containers at room temperature or below to minimize decomposition.

AVAILABILTY AND PACKAGING

Production quantities are available on short notice. Experimental quantities, 1 to 25 pounds, are available immediately. Ammonium tetrathiotungstate is packaged in sealed polyethylene bags contained in Fiber-Pak containers or 24-gallon Leverpak drums, 100 pounds/drum.

TOXICITY

Tungsten or tungsten compounds in general are not considered industrial health hazards. However, the usual precautions for working with hydrogen sulfide should be observed when handling ammonium tetrathiotungstate.

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AMMONIUM METATUNGSTATE

$(NH_4)_6H_2W_{12}O_{40} \cdot xH_2O$

Quantity (Pounds)	Price per Pound of Contained WO_3
1 - 24	$7.50
25 - 99	5.50
100 - 299	4.00
300 - 999	3.50
1000 - 4999	3.10
5000 - 9999	2.85
10,000 & over	On request

NOTE: Approximate Content WO_3 - 85%

STANDARD PACKAGING - 350 lbs. (approximately 300 lbs. of contained WO_3) in a 24-gallon Leverpak drum

MINIMUM CHARGE PER ITEM - $25.00

TUNGSTEN HEXACHLORIDE (WCl_6)

Tungsten hexachloride is a crystalline, reactive, relatively volatile, refractory-metal halide. The following characteristics contribute to its potential usefulness:

— Exists as a solid, therefore, it is convenient to handle, store, and use.
— Chemically reactive in vapor state or in solution.
— Volatile at moderate temperatures.
— Decomposes readily in vapor state to deposit metallic tungsten.
— Decomposition by-products are relatively non-corrosive.
— Soluble in organic solvents.

Sylvania's tungsten hexachloride is an exceptionally high-purity chemical, essentially free of oxychlorides. The high degree of purity is manifested by the essentially complete, residue-free volatilization of Sylvania's hexachloride in inert atmosphere.

Chemical Composition

	Specification		Typical Analysis	Theoretical
Tungsten, %	48.0	maximum	46.9	46.36
Chloride, %	52.0	minimum	53.1	53.64
*Carbon, %	0.002	maximum	<0.001	—
*Impurity Content, %	0.1	maximum	<0.1	—

*Based on quantitative analysis of tungsten obtained from tungsten hexachloride by vapor-deposition.

Typical Analysis of Vapor-Deposited Tungsten, ppm**

Al	<0.5	Mo	<6
Ca	<0.5	Ni	<1
Cr	<1	Si	<1
Cu	<0.2	As	<3
Fe	<1	Na	<2
Mg	<2	K	<20

**Detemined by spectrographic quantitative analysis.

Typical Gas-Content Analysis of Vapor-Deposited Tungsten, ppm**

H_2	<1.0
O_2	<10
N_2	<8

***Determined by vacuum-fusion analysis.

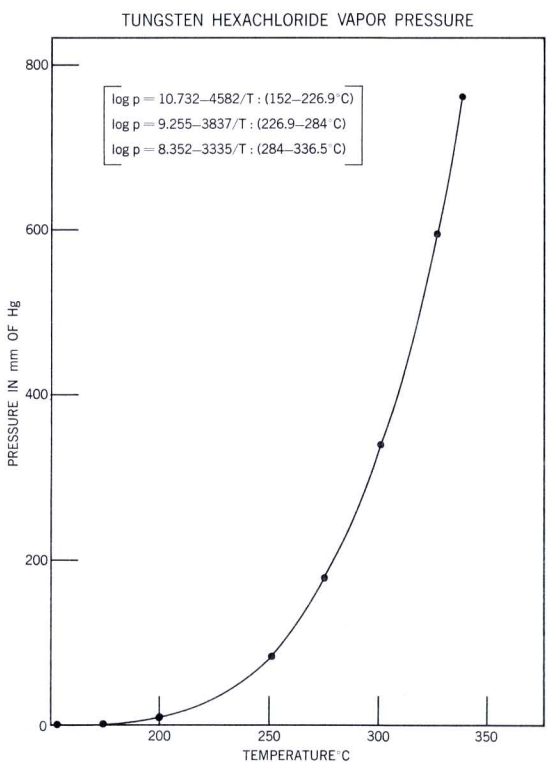
Physical Properties

Formula: WCl_6
Formula Weight: 396.57
Appearance: Reddish-violet to black, crystals
Melting Point: 275°C
Boiling Point: 347°C
Specific Gravity: 3.52
Crystal Structure: Hexagonal, close-packed; octahedral arrangement of tungsten and chloride atoms.
Electrical Conductivity: The following specific conductivity data indicate that molten tungsten hexachloride is a poor conductor:

1.98×10^{-6} mho cm^{-1} at 280°C
2.60×10^{-6} mho cm^{-1} at 300°C
2.85×10^{-6} mho cm^{-1} at 305°C
6.94×10^{-6} mho cm^{-1} at 330°C

Transition Points: $\alpha_1 \rightarrow \beta$ transition occurs at 227°C; the α_1 form undergoes modification to a second form (α_2) on cooling to 168°C and below.

Vapor Pressure: Vapor pressure varies with temperature. A plot showing increasing vapor pressure with increasing temperature is shown below.



Solubility: Soluble in alcohols, ketones, hydrocarbons, chlorinated hydrocarbons, and ethers. Typical solvents are absolute ethyl alcohol, acetone, benzene, chloroform; glycerol, ethyl ether, and pyridine. In addition, carbon disulfide and phosphorus oxytrichloride are solvents. High-purity tungsten hexachloride, essen-

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tially free of oxychlorides, is initially insoluble in cold water but hydrolizes appreciably in a few hours. Hydrolysis is rapid above 60°C. Tungsten hexachloride containing oxychlorides hydrolizes rapidly in cold water to give tungstic acid.

Heat of Vaporization: Approximately −14 kcal/mole
Heat of Transition: ($\alpha \rightarrow$ vapor) = −20.94 kcal/mole
($\beta \rightarrow$ vapor) = −17.54 kcal/mole
(liquid-vapor) = −15.24 kcal/mole
Heat of Dissociation: Approximately 9 kcal/mole

Chemical Properties and Reactivity

Tungsten hexachloride reacts in selected atmospheres to give various products. In hydrogen, at temperatures above 800°C, tungsten hexachloride is readily reducible to tungsten. The lower chlorides WCl_2, WCl_4, and WCl_5 form at lower temperatures. Reduction to tungsten pentachloride (WCl_5) occurs in carbon dioxide. Reaction with carbon monoxide results in the formation of tungsten hexacarbonyl, $W(CO)_6$. Tungsten bromides form in hot hydrogen bromide atmosphere. Ammonia, phosphine, arsine, and hydrogen sulfide react with tungsten hexachloride to form tungsten trinitride, diphosphide, diarsenide, and disulfide respectively.

Reduction of tungsten hexachloride vapors to tungsten can be accomplished with agents other than hydrogen. Sodium or magnesium reduces tungsten hexachloride to metal at high temperatures. Copper, silver, and molybdenum reduce it to lower chlorides, but tungsten has no effect. Reduction in alcoholic solution occurs with acetic anhydride.

Tungsten hexachloride is sensitive to moisture and air. In the presence of moisture or dry air, it decomposes gradually to oxychlorides. A mixture of oxychlorides ($WOCl_4$, WO_2Cl_2) and tungstic oxide (WO_3) is produced when tungsten hexachloride is heated in air.

Tungsten hexachloride, in solutions of alcohol, chloroform, or carbon tetrachloride, reacts with organic acids and amines to form complex molecules.

SUGGESTED APPLICATIONS

Sylvania's tungsten hexachloride has been developed as a source of high-purity tungsten for many applications.

In the fields of space science and metallurgy, primary interest is in chemical vapor-deposition of tungsten. High-purity tungsten can be deposited on a wide variety of metallic and non-metallic substrates to give adherent, uniform, hard coatings. The tungsten coatings exhibit many desirable characteristics of tungsten including resistance to corrosion, erosion, chemicals, and high temperatures.

Tungsten hexachloride is useful also in vapor-deposition techniques for joining refractory metals. Low-temperature vapor joining of tungsten and other refractory metals is a potentially important application. Tungsten hexachloride is suggested as a gaseous flux for brazing, soldering, or welding many metals, especially ferrous alloys. Superficial metal alloy layers may be produced on metal articles by the use of tungsten hexachloride. Tungsten powder of extremely small particle size can be produced by controlled vapor-state hydrogen reduction of tungsten hexachloride. Improved refractory-metal properties are potentially attainable.

Tungsten hexachloride is suggested as an effective metal-halide catalyst for polymerizing olefins. The potential for synthesizing polyethylene is particularly attractive. Other potentially useful catalytic reactions are the synthesis of fluorocarbons, and the dehydrochlorination of chloroethanes to produce vinyl halides.

Exposure of glass during manufacture to tungsten hexachloride vapors is suggested as a means of increasing the chemical and mechanical stability of the glass. In the manufacture of conductive glass, the addition of a small percentage of tungsten hexachloride to solutions of a tin compound before application to the glass increases the electrical conductivity of the transparent coating.

The solubility of tungsten hexachloride in organic solvents suggests the synthesis of organometallic compounds which are potentially useful as extreme-pressure lubricants and corrosion-inhibiting additives in protective coatings.

HANDLING, STABILITY, AND STORAGE

Tungsten hexachloride is relatively stable at room temperature despite its volatility at moderately high temperatures. However, it is sensitive to moisture and air, gradually decomposing to form oxychlorides. Insofar as possible, it should be handled in a dry, inert atmosphere to reduce oxychloride formation. Transfers for weighing or loading reaction vessels can be made in air if accomplished rapidly. For high-purity applications, an inert-atmosphere dry-box is suggested.

The usual operations performed with tungsten hexachloride, i.e., heating, melting, vaporization, and dissolution, are not believed to be hazardous. Heating in an inert atmosphere normally results in reddish fumes. Precautions are necessary when cooling liquid tungsten hexachloride. Solidification in inert atmosphere usually occurs without incident at about 270°C. Further cooling may result in a violent, explosion-like expansion of the solid tungsten hexachloride mass at about 168-170°C. The phenomenon may be associated with the $\alpha_2 \rightarrow \alpha_1$ transition. Experience has shown that the solid hexachloride can be safely cooled to less than 170°C if the tungsten hexachloride occupies not more than one-half the volume of the containing vessel.

Tungsten hexachloride in solid, liquid, or vapor form can be most satisfactorily handled in glass, glass-lined, or quartz equipment. In general, materials which are suitable for handling anhydrous hydrogen chloride will be satisfactory for hexachloride. The temperature limitation and chemical resistance of materials other than glass should be carefully considered when handling liquid or gaseous hexachloride.

Storage in an inert atmosphere is recommended. An inert-atmosphere dry-box is ideal. A capped or stoppered glass container can be satisfactory if air is first purged from it with an inert gas (N_2, Ar, etc.).

AVAILABILITY AND PACKAGING

Production quantities are available on short notice.
Tungsten hexachloride is packaged in capped, sealed, inert-gas-filled glass containers.

TOXICITY

Tungsten or tungsten compounds, in general, are not considered industrial health hazards. However, inhalation or ingestion of large amounts of tungsten should be avoided. On decomposition in air or moisture, tungsten hexachloride evolves hydrogen chloride. The usual precautions should be taken.

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TUNGSTEN CHEMICALS

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: Jan. 16, 1963

subject to change without notice.

TUNGSTEN HEXACHLORIDE

Any quantity, packaged in one-pound containers	$9.50/lb.

Prices on request for material packaged in other container sizes.

MINIMUM ORDER - ONE POUND

SYLVANIA

CHEMICAL AND METALLURGICAL DIVISION

NEW PRODUCT DATA

TUNGSTATE CHEMICALS, Crystal Grade

Sylvania's tungstates are manufactured especially for applications requiring high purity and low-alkali-metal content. The following tungstates are available:

Aluminum Tungstate
Barium Tungstate
Cadmium Tungstate
Calcium Tungstate
Copper Tungstate
Lead Tungstate
Magnesium Tungstate
Strontium Tungstate
Zinc Tungstate

PROPERTIES

All are high-bulk density, crystalline powders of a purity generally greater than 99.9%. Sodium content is characteristically lower than 10 ppm. Magnesium tungstate is the only one of the series which is appreciably soluble in water at room temperature. Some typical properties are tabulated below:

Material	Aluminum Tungstate	Barium Tungstate	Cadmium Tungstate	Calcium Tungstate	Copper Tungstate	Lead Tungstate	Magnesium Tungstate	Strontium Tungstate	Zinc Tungstate
Formula	$Al_2(WO_4)_3 \cdot xH_2O$	$BaWO_4$	$CdWO_4$	$CaWO_4$	$CuWO_4 \cdot 2H_2O$	$PbWO_4$	$MgWO_4$	$SrWO_4$	$ZnWO_4 \cdot 2H_2O$
Formula Weight	797.5 • x18	385.3	360.3	788.0	347.4	455.13	272.2	335.5	349.2
X-Ray Identification — ASTM X-Ray Powder Data File	—	8-457	1-0488	7-210	—	8-476	7-190	8-490	—
Absolute Density, g/cc	3.9	5.7	7.1	6.1	4.8	8.0	5.6	5.3	3.6
Bulk Density, g/in^3, approx.	27	23	10	40	13	16	11	22	8
Approx. Melting Point, °C(1)	1370	1550	1340	1620	950	1123	1420	1700	1360
Typical Purity, % (2)	99.96	99.90	99.97	99.97	99.96	99.97	99.80	99.40	99.97

(1) Published Data.
(2) Based on spectrographic qualitative analysis.

SUGGESTED USES

High-purity tungstates are of particular interest for electronic and optical applications. They are suggested as starting materials for growing single-crystal solid-state lasers (light amplification by stimulated emission of radiation). In this application, the tungstates complement a variety of molybdates and fluorides manufactured by Sylvania.

Tungstates are effective corrosion inhibitors, and they have potential as pigments in paints and other protective coatings. The advantages over more commonly used corrosion-inhibiting pigments are a low order of toxicity and white color. In aqueous and organic solutions, the tungstates are a source of efficient, corrosion-inhibiting ions. They are suggested for applications requiring colorless, non-oxidizing, corrosion-inhibiting solutions.

Tungstates are of interest also as components of high-temperature dry-film lubricants. They are potentially effective constituents of ceramic-bonded coatings for metal-to-metal lubrication at temperatures greater than 1000°F. In ceramics, porcelain, enamels, and glasses, tungstates are potentially useful as additives for modifying opacity, slip consistency and adherence.

AVAILABILITY AND PACKAGING

Production quantities are available on short notice. Standard packaging is polyethylene-lined, Fiber-Pak or Lever-Pak containers.

TOXICITY

Tungsten compounds in general, have a low order of toxicity and are not considered industrial health hazards. However, inhalation or ingestion of large amounts of these compounds or products of decomposition should be avoided.

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CALCIUM TUNGSTATE, Crystal Grade

Sylvania's synthetic calcium tungstate is manufactured expressly for applications requiring high purity and low-alkali-metal content.

Electronic-grade calcium tungstate is a white, crystalline, high-bulk-density powder having a maximum impurity content of 300 ppm. It is recommended as a starting material for making solid-state optical masers or lasers (light amplification by stimulated emission of radiation).

PHYSICAL PROPERTIES

Appearance — white, crystalline powder
Fisher Sub-Sieve Size — 10 to 15 microns
Bulk Density — 38 to 42 grams per cubic inch
Melting Point — approximately 1620°C
Solubility — insoluble in water; decomposed by hot acid solutions such as HCl, HNO_3.

Chemical Composition

Formula	$CaWO_4$
Theoretical Molecular Weight	287.93
X-Ray Identification	Tetragonal $CaWO_4$ Pattern of ASTM X-Ray Powder Data File, No. 7-210

Typical Impurity Content* — ppm

Al	50
Ba	50
Fe	5
Mg	50
Mo	5
Si	50
Sr	100
Na	5

* Qualitive spectrographic analysis.

AVAILABILITY

Production quantities are now available. Standard packaging is Polyethylene-lined, Fiber-Pak or Lever-Pak containers.

TOXICITY

Tungsten or tungsten compounds in general are not considered industrial health hazards. However, inhalation or ingestion of large amounts of tungsten compounds should be avoided.

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ZINC SULFIDE and CADMIUM SULFIDE, Crystal Grade

High-purity unactivated zinc sulfide and cadmium sulfide are now being offered in the Sylvania line of chemical products. The crystal grade sulfides are in the form of fine powders which may be used in diverse applications, for instance, the growing of single crystals or the deposition of thin films.

Sylvania has many years experience in the production of sulfide phosphors for the electronics industry. This experience in supplying phosphors with carefully controlled properties will be carried over to meet the new demands for optical grade materials.

PHYSICAL PROPERTIES

	ZnS	CdS
Fisher Sub-Sieve Size, Microns	10-15	0.7-1.5
B.E.T. surface area, m^2/g	12-18	10-16

Impurity Content

The maximum metallic impurity contents, in parts per million, are as follows:

	ZnS	CdS
Fe	0.4	0.7
Ni	0.5	0.5
Pb	3.0	3.0
Cu	0.4	0.4
Mn	0.1	0.1

Volatile impurities which would be driven off in further processing steps are limited to the following values:

	ZnS	CdS
H_2O	0.50%	0.70%
$SO_4^=$	0.40%	0.40%
Cl^-	0.60%	0.20%

AVAILABILITY

Production quantities are available on short notice. Standard packaging is in five-pound bottles and fifty-pound pails.

TOXICITY

ZnS and CdS are not considered industrial health hazards. However, inhalation or ingestion of these compounds should be avoided.

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MOLYBDATE CHEMICALS, Crystal Grade

Sylvania's molybdates are manufactured especially for applications requiring high purity and low-alkali-metal content. The following molybdates are available:

Barium Molybdate
Cadmium Molybdate
Calcium Molybdate
Copper Molybdate
Lead Molybdate
Magnesium Molybdate
Strontium Molybdate
Zinc Molybdate

PROPERTIES

Molybdates available from Sylvania are high-bulk density, crystalline powders of a purity generally greater than 99.9%. Sodium content is usually lower than 10 ppm. Magnesium molybdate is the only one of the series which is appreciably soluble in water at 25°C. Some typical properties are tabulated below:

Material	Barium Molybdate	Cadmium Molybdate	Calcium Molybdate	Copper Molybdate	Lead Molybdate	Magnesium Molybdate	Strontium Molybdate	Zinc Molybdate
Formula	$BaMoO_4$	$CdMoO_4$	$CaMoO_4$	$CuMoO_4$	$PbMoO_4$	$MgMoO_4$	$SrMoO_4$	$ZnMoO_4 \cdot 2H_2O$
Formula Weight	297.3	272.4	200.0	207.5	367.2	184.3	247.6	245.3
X-Ray Identification—ASTM X-Ray Powder Data File	8-455	7-209	7-212	—	8-475	—	8-482	—
Absolute Density, g/cc	4.7	5.7	3.5	3.4	5.9	2.8	4.0	3.3
Bulk Density, g/in^3, Approximate	14	24	23	5	25	17	9	15
Approximate Melting Point, °C (1)	1600	1250	1450	500	1060	1060	1600	1650
Typical Purity, % (2)	99.84	99.98	99.97	99.98	99.97	99.98	99.39	99.97

(1) Published Data.

(2) Based on spectrographic qualitative analysis.

SUGGESTED USES

High-purity molybdates are of particular interest for electronic and optical applications. They are suggested as starting materials for growing single-crystal, solid-state lasers (light amplification by stimulated emission of radiation). In this application, they complement a variety of tungstates and fluorides manufactured by Sylvania.

Molybdates are effective corrosion inhibitors and are potentially useful as pigments in paints and other protective coatings. The advantages over more commonly used corrosion-inhibiting pigments are a low order of toxicity and white color. The molybdates are also a source of efficient corrosion-inhibiting ions in aqueous and organic solutions. They are suggested for applications requiring colorless, non-oxidizing, corrosion-inhibiting solutions. Calcium, zinc, and strontium molybdates have found applications as anti-corrosion pigments.

AVAILABILITY AND PACKAGING

Production quantities are available on short notice. Standard packaging is polyethylene-lined Fiber-Pak or Lever-Pak containers.

TOXICITY

Molybdates, in general, have a low order of toxicity and are not considered industrial health hazards. However, inhalation or ingestion of large amounts of these compounds or their products of decomposition should be avoided.

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CHEMICAL AND METALLURGICAL DIVISION

NEW PRODUCT DATA

FLUORIDE CHEMICALS, Crystal Grade

Sylvania's fluorides are manufactured especially for applications requiring high purity. The following fluorides are available:

Barium Fluoride
Cadmium Fluoride
Calcium Fluoride
Lead Fluoride
Lithium Fluoride
Magnesium Fluoride
Strontium Fluoride

PROPERTIES: Sylvania's fluorides are low-particle size, crystalline powders having a purity greater than 99.9%. Some typical properties are tabulated below:

Material	Barium Fluoride	Cadmium Fluoride	Calcium Fluoride	Lead Fluoride	Lithium Fluoride	Magnesium Fluoride	Strontium Fluoride
Formula	BaF_2	CdF_2	CaF_2	PbF_2	LiF	MgF_2	SrF_2
Formula Weight	175.3	150.4	78.1	245.2	25.9	62.3	125.6
X-Ray Identification—ASTM X-Ray Powder Data File	4-452	5-567	4-864	6-288	4-857	6-290	6-262
Absolute Density, g/cc	4.8	6.6	3.2	8.2	2.6	3.0	4.2
Bulk Density, g/in^3	10	13	7	10	5	10	12
Approximate Melting Point, °C (1)	1354	1110	1402	824	846	1263	1463
Solubility in H_2O (g/liter, room temperature) (1)	1.21	43.5	0.016	0.66	2.7	0.076	0.12
Typical Purity, % (2)	99.98	99.89	99.93	99.93	99.92	99.80	99.20

(1) Published Data.

(2) Based on spectrographic qualitative analysis.

SUGGESTED USES

High-purity fluorides are of particular interest for electronic and optical applications. They are suggested as starting materials for growing single-crystal solid-state lasers (light amplification by stimulated emission of radiation). In this application, they complement a variety of tungstates and molybdates manufactured by Sylvania.

Fluorides are of interest also as components of high-temperature dry-film lubricants in the form of ceramic-bonded coatings. Effective lubrication at temperatures ranging from 1000°F to 1900°F is potentially obtainable. CaF_2 has received attention because of its chemical stability, low vapor pressure, and crystal structure.

AVAILABILITY AND PACKAGING

Production quantities are available on short notice. Standard packaging is in polyethylene-lined Fiber-Pak or Lever-Pak drums.

TOXICITY

The toxicological properties of the fluorides have not been fully investigated. In general, fluorides are considered toxic due to the possibility of releasing fluorine and metals such as barium, lead, etc.

Safe handling practices are recommended to avoid inhalation or ingestion of dust or fumes resulting from decomposition.

(over)

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CM-38-6/62 2.5

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SYLVANIA

chemical & metallurgical division

HIGH-PURITY CHEMICALS FOR LASER APPLICATIONS

PRICE SCHEDULE

terms: Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* June 5, 1962

subject to change without notice.

	PRICE PER POUND		
TUNGSTATES	1 to 5 lbs.	6 to 25 lbs.	26 to 100 lbs.
Barium Tungstate	$20.00	$12.00	$ 7.00
Calcium Tungstate	20.00	12.00	7.00
Strontium Tungstate	20.00	12.00	7.00
Magnesium Tungstate	45.00	30.00	22.00
Cadmium Tungstate	20.00	12.00	7.00
Cupric Tungstate	22.00	12.50	7.50
Lead Tungstate	20.00	12.00	7.00
Zinc Tungstate	22.00	12.50	7.50
Aluminum Tungstate	22.00	15.00	9.00
Zirconium Tungstate	22.00	13.00	8.00
MOLYBDATES			
Barium Molybdate	$15.00	$ 9.00	$ 5.00
Calcium Molybdate	15.00	9.00	5.00
Strontium Molybdate	15.00	9.00	5.00
Magnesium Molybdate	30.00	22.00	18.00
Cadmium Molybdate	15.00	10.00	6.00
Cupric Molybdate	15.00	10.00	6.00
Lead Molybdate	15.00	9.00	5.00
Zinc Molybdate	15.00	10.00	6.00
Lithium Molybdate	38.00	30.00	27.00
Zirconium Molybdate	17.00	8.00	5.00
FLUORIDES			
Barium Fluoride	$10.00	$ 5.00	$ 3.00
Calcium Fluoride	10.00	5.00	3.00
Strontium Fluoride	10.00	5.00	3.00
Magnesium Fluoride	20.00	15.00	10.00
Cadmium Fluoride	18.00	13.00	10.00
Lithium Fluoride	43.00	35.00	32.00
Lead Fluoride	18.00	13.00	10.00

Note: Prices on request for quantities over 100 pounds.

MINIMUM ORDER - One Pound

SYLVANIA
CHEMICAL AND METALLURGICAL DIVISION
NEW PRODUCT DATA

MOLYBDATE AND TUNGSTATE CHEMICALS, Recrystallized

Sylvania's recrystallized molybdates and tungstates are highly crystalline, extremely pure undoped chemicals which are manufactured especially for growing solid-state laser crystals. They are made by recrystallizing the corresponding crystal-grade molybdate or tungstate chemical from a suitable flux. Flux-processed crystals offer a number of advantages for growing single crystals of value for laser and other optical applications.

The following molybdates and tungstates are available in recrystallized grades:

- Barium Molybdate
- Cadmium Molybdate
- Calcium Molybdate
- Copper Molybdate
- Lead Molybdate
- Magnesium Molybdate
- Strontium Molybdate
- Zinc Molybdate
- Aluminum Tungstate
- Barium Tungstate
- Cadmium Tungstate
- Calcium Tungstate
- Copper Tungstate
- Lead Tungstate
- Magnesium Tungstate
- Strontium Tungstate
- Zinc Tungstate

PROPERTIES AND ADVANTAGES

The outstanding characteristics of Sylvania's recrystallized molybdates and tungstates are:

1. Stoichiometric Composition

Chemically stoichiometric materials are highly desirable for growing single crystals. Significant time and material savings are obtainable by using recrystallized grades of molybdates and tungstates. Experimentation and materials processing can be reduced to a minimum. Melting points are reproducible and in many cases they are lower than experienced with the corresponding precipitated chemicals.

2. Low Volatile Content

Volatilization at high temperatures is virtually eliminated. Recrystallized zinc tungstate, for example, loses only 0.1% of its starting weight during one cycle of melting and solidification. Quartz equipment, commonly used for single-crystal growing, remains uncoated and essentially uncontaminated during operation. Visibility of the melt during single-crystal growth remains unimpaired.

3. High Bulk Density

Recrystallized molybdates and tungstates have higher densities than the corresponding crystal-grade chemicals. The following typical bulk-density data illustrate the difference between flux-processed and precipitated chemicals:

	Bulk Density, g/cc, Approximately	
	Recrystallized Grade	Crystal Grade
Calcium Tungstate	3.2	1.3
Strontium Molybdate	2.1	1.3
Zinc Tungstate	3.7	0.5

The use of the denser recrystallized starting chemicals has practical advantages in increased loading per unit volume of container, reduced shrinkage on melting, and convenience of handling. In many cases, crystal pulling can be started after one loading instead of after the multiple loadings which are sometimes necessary to get a sufficient volume of molten chemical. The free-flowing characteristics of the recrystallized materials contribute to ease of handling.

4. Purity

The lower volatile content resulting from recrystallization is indicative of higher purity. Non-volatile impurity content, i.e., typical purity, is comparable to that found in crystal-grade molybdates and tungstates. Recrystallized grades are carefully processed to maintain low-sodium content.

AVAILABILITY

Production quantities can be supplied on short notice. Inquiries for materials other than those listed will be considered.

(over)

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CM-43-9/62-2.5

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SYLVANIA
• metallurgical products
Technical Information Bulletin

MOLYBDENUM DISILICIDE ($MoSi_2$)

SYLVANIA manufactures two grades of molybdenum disilicide by fusion of hydrogen-reduced molybdenum with silicon. The disilicide is a dark grey, crystalline powder that can be fabricated to sintered shapes or applied to other materials as a protective coating at high temperatures.

Composition	% Mo	% Si	Typical Impurities, %			
			Al	Fe	Ni	Ca
Theoretical:	63.1	36.9				
98% Grade	62-63	36-37.5	0.5	0.5	0.005	0.005
99.5% Grade	62-63	36.5-37.5	0.01	0.01	0.005	0.001

PHYSICAL AND CHEMICAL PROPERTIES

Molecular Weight:	152.12
Crystal Structure:	Tetragonal
Density (theoretical):	6.24 g/cc
Melting Point *:	1870—2030 C (3400—3690 F)
Electrical Resistivity at 20 C:	21.5—29 μohm cm
Maximum Service Temperature — air:	1650 C (3000 F)
— vacuum*:	1500 C (2730 F)

Corrosion:

Inert	Slow Reaction	Rapid Attack
aqua regia	fluorine	hydrofluoric + nitric acid
mineral acids	chlorine above 100 C	molten alkalis
aqueous alkalis	tin at 1000 C	
bromine	hydrofluoric acid	
iodine		
sodium to 900 C		
bismuth to 1400 C		

**Above 1500C $MoSi_2$ generates an appreciable silicon vapor pressure. Therefore, it cannot be sintered or used in vacuum above that temperature. $MoSi_2$ can be melted and cast, but some decomposition and loss of silicon occurs.*

SUGGESTED APPLICATIONS

Current applications for molybdenum disilicide depend upon its resistance to oxidation and chemical attack. With additives, it is fabricated into electrical heating elements that are operable in air at 1650 C, about 250 C above the service temperature of silicon carbide elements. Molybdenum disilicide powders have also been fabricated by hot or cold pressing into various shapes for high-temperature applications: crucibles, furnace hardware, thermocouple tubes, hot-pressing dies, and hot parts for jet and rocket engines.

A fused coating of molybdenum disilicide can also be applied in various ways to protect substrates from oxidation. It can be used in this manner for the protection of forging billets, rocket nozzles, refractory-metal sheet, rolls for hot-rolling mills, graphite shapes, and electrical filaments.

AVAILABILITY

Sylvania's two grades of molybdenum disilicide powder are supplied in either of the following standard mesh sizes:

	Typical Properties		
Mesh Size	**Fisher SSS**	**Bulk Density**	
–200	21 microns	35 g/in^3	2.1 g/cc
–325	10 microns	36 g/in^3	2.2 g/cc

Quantities up to 50 pounds are available immediately, and larger amounts can be supplied on short notice. The standard packages are Fiber-Pak or Lever-Pak containers.

TOXICITY

Molybdenum compounds in general are not considered industrial health hazards. The disilicide has no known toxic effect. Normal precautions to avoid inhalation of fine particles should be observed.

CM 44 10/62 3—Printed in U.S.A.

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SYLVANIA

chemical & metallurgical division

MOLYBDENUM DISILICIDE

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: Sept. 21, 1962

subject to change without notice.

MOLYBDENUM DISILICIDE

99.5% MINIMUM PURITY	Price per Pound Mesh Size*	
Quantity	-200	-325
500 - 1000 lbs.	$13.75	$14.50
100 - 499 lbs.	16.50	17.50
25 - 99 lbs.	18.50	19.50
Less than 25 lbs.	20.50	21.50
98% MINIMUM PURITY		
5000 lbs. & over	$ 6.85	$ 7.15
2000 - 4999 lbs.	7.15	7.40
500 - 1999 lbs.	7.70	8.00
100 - 499 lbs.	8.25	8.55
25 - 99 lbs.	8.80	9.15
Less than 25 lbs.	11.50	12.00

* 95% of material will pass through these mesh sizes.

STANDARD PACKAGING: 100 pounds in a Leverpak drum.

MINIMUM ORDER - $20.00

SYLVANIA
• metallurgical products
Technical Information Bulletin

TUNGSTEN METAL POWDERS, M SERIES

SYLVANIA Tungsten Powders, M series, are designed specifically to provide the high purity and particle size uniformity required by manufacturers of cemented Tungsten Carbide. The powders are produced by the hydrogen reduction of tungstic oxide or ammonium paratungstate.

Particle size and size distribution are vital factors in the physical and mechanical properties of both metallic tungsten products and cemented tungsten carbides. We maintain particle size within tenths of a micron by precise control of the manufacturing process.

Sylvania processes Tungsten from ore concentrates to finished powder. Ore concentrates are purchased to meet rigid chemical specifications and are chemically processed to recover pure tungsten and to remove all objectionable impurities. During the chemical processing, five critical control points have been established to assure the continued uniformity and quality of the tungsten powders. Precise chemical specifications have been set up for each of these control points.

At the completion of the chemical cycle, tungstic oxide or ammonium paratungstate is processed by hydrogen reduction to form the metal powders. During reduction, ten additional processing variables are carefully controlled to meet rigid manufacturing specifications.

Sylvania controls particle size during the production process by making frequent particle size checks at each reduction furnace. The basis for particle size measurement is the Fisher Sub-Sieve Sizer which, when properly calibrated[1], is capable of excellent reproducibility. Control is maintained on a statistical basis. By these means, powders are produced to each specified particle size.

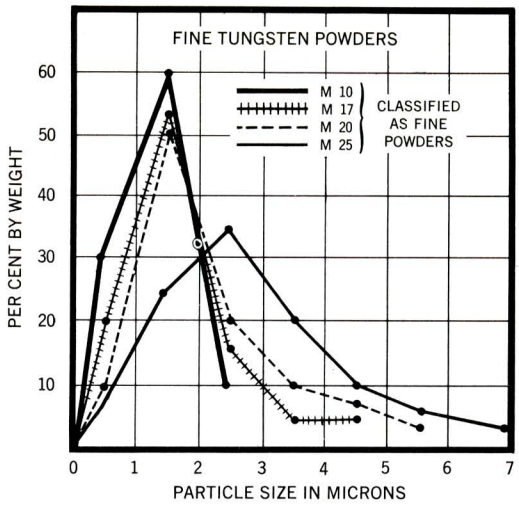
After reduction, the tungsten powder is screened and blended. Single blend lots in excess of 15,000 pounds are available.

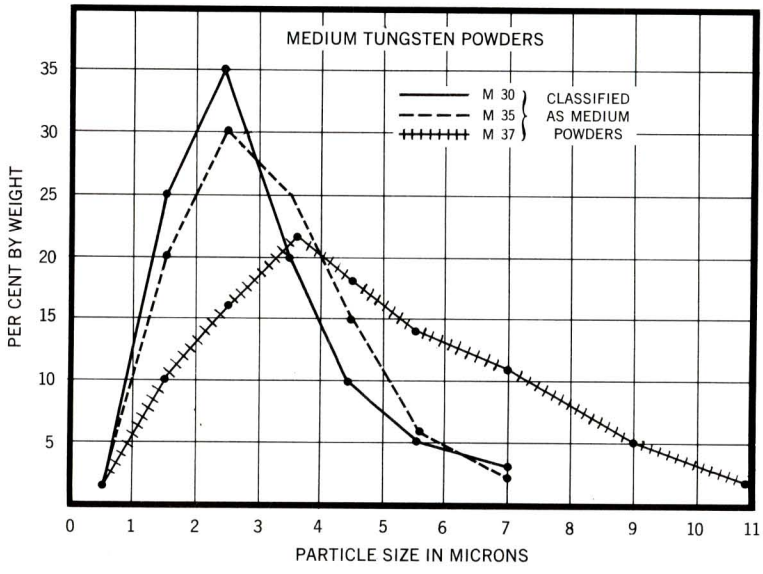
PHYSICAL SPECIFICATIONS

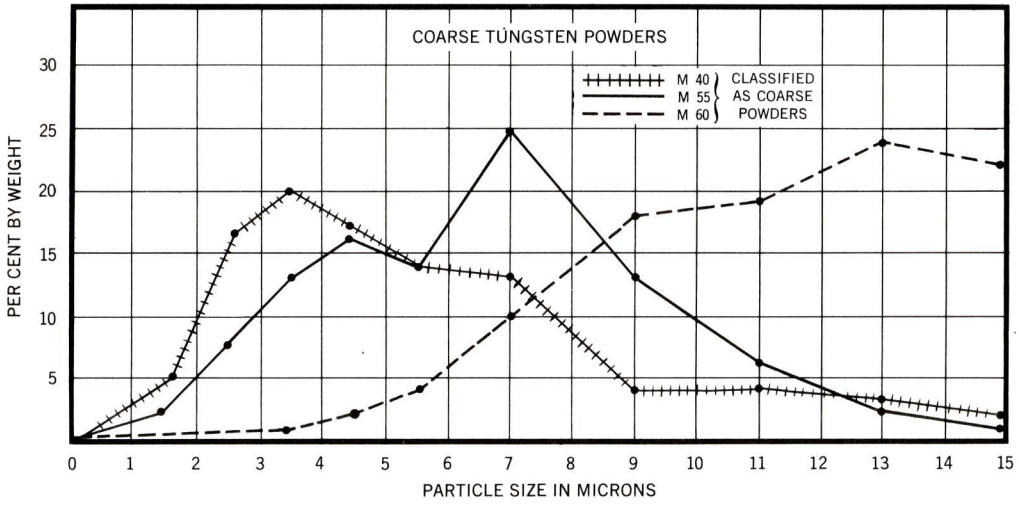
Type	Fisher Sub-Sieve Size Microns	Approx. Bulk Density Grams/Cubic Inch
M-10	0.75 ± .15	28
M-17	1.1 ± .15	34
M-20	1.25 ± .15	36
M-25	1.6 ± .2	38
M-30	2.0 ± .2	40
M-35	2.4 ± .2	42
M-37	3.0 ± .3	45
M-40	3.6 ± .3	58
M-55	5.2 ± .5	70
M-60	6.6 ± .6	75
M-70	12 plus	100

[1]*Calibration of Fisher Sub-Sieve Sizer. ASTM standard B330-58T "Method of Test for Particle Size of Refractory Metals and Compounds."*

TYPICAL PARTICLE SIZE DISTRIBUTIONS BASED ON CENCO PHOTELOMETER WITH CARBIDE-BLOCK SPATULATION.







Percent by weight is shown at interval mid-points. Intervals are one micron in width at sizes 0 to 6 microns and two microns in width for larger sizes.

CHEMICAL SPECIFICATIONS

Chemical composition of all types conform to the following as determined by quantitative analyses:

Tungsten %, Min. by Difference	Molybdenum %, Max.	Molybdenum Typical	Iron %, Max.	Iron Typical
99.95	0.05	0.005%	0.007	0.002%

In addition, trace elements conform to the following, as determined by spectrographic qualitative analysis:

Element	Analysis Maximum	Approximate Values
Aluminum	Very Faint	(0.0001-0.001%)
Calcium	Faint Trace	(0.001-0.01%)
Chromium	Very Faint	(0.0001-0.001%)
Copper	Very Faint	(0.0001-0.001%)
Magnesium	Faint Trace	(0.001-0.01%)
Nickel	Faint Trace	(0.001-0.01%)
Silicon	Faint Trace	(0.001-0.01%)
Other Metallic elements	None detected	

All powder is free of foreign matter such as boat scale, oxides, oil, dirt and other contaminants.

REPORTS

Each shipment of powder is accompanied by a standard report which includes particle size, oxygen content, bulk density, and quantitative analysis for iron and molybdenum. Also included is an analysis of trace elements by qualitative spectrographic analysis. Other test reports such as particle size distribution are furnished if requested by the purchaser.

RESEARCH AND TEST FACILITIES

Our pilot plant and laboratory are completely equipped and staffed to maintain Sylvania's position as a leading producer of tungsten powder. We maintain a continuing study of methods of improving our product. X-ray diffraction equipment is available for investigation of crystal structure and can be used for measurement of average particle size.

Measurements of particle size distribution are made using the Cenco Photelometer and the Sharples Micromerograph. We have recently acquired a Coulter Counter which will complement our established techniques for making distribution measurements.

B.E.T. gas adsorption measurements have been used to measure surface area of ultrafine tungsten powders.

Our analytical laboratories have the ability to detect approximately sixty elements in the parts per million range, and we are continually working to improve the sensitivity of these procedures.

PACKAGING

Type Powder	Container	Standard Package
M-10	3.5 gal. metal pail	85 lb.
M-17 to M-70	3.5 gal. metal pail	100 lb.

CM 26 3/62 2.5 Printed in U.S.A.

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Sylvania

MOLYBDENUM-TUNGSTEN ALLOY POWDER

CHEMICAL & METALLURGICAL DIVISION • TOWANDA, PA.

MOLYBDENUM-TUNGSTEN ALLOY POWDER

Sylvania Molybdenum-Tungsten Alloy Powders are made by the hydrogen reduction of the oxides or ammonium compounds of these two metals.

They are processed so each particle is a true solid-solution alloy, eliminating the segregation problems previously associated with fabricating mixtures of molybdenum and tungsten.

Since molybdenum and tungsten form a continuous series of solid solutions, any desired composition can be produced. Sylvania offers two grades of these alloy powders which are normally supplied in three different percentage compositions.

MA-28 SERIES

These grades contain a minimum of 99.8% molybdenum-tungsten alloy, with all impurities closely controlled. They are designed primarily for powder-metallurgical processing into rod and wire, but can be used for pressing and sintering into large ingot forms for forging, rolling and machining.

MA-39 SERIES

These grades contain a minimum of 99.9% molybdenum-tungsten alloy, with all impurities controlled to minimum levels. These powders are used where ultra-high purity, low oxygen content, or larger particle size are required. This higher level of purity is also required for the best grades of rolled rod and sheet products.

Grades Available	Grade Number	Composition	Screen Size Passed Through	Approx. Absolute Density	Typical Particle Size by Fisher Sub-Sieve Sizer
MA-28 Series	2870	70% Mo/30% W	100 Mesh	11.8 g/cc	3 to 7 micron
	2850	50% Mo/50% W	100 Mesh	13.3 g/cc	3 to 7 micron
	2830	30% Mo/70% W	100 Mesh	15.1 g/cc	3 to 7 micron
MA-39 Series	3970	70% Mo/30% W	100 Mesh	11.8 g/cc	4 to 10 micron
	3950	50% Mo/50% W	100 Mesh	13.3 g/cc	4 to 10 micron
	3930	30% Mo/70% W	100 Mesh	15.1 g/cc	4 to 10 micron

PACKAGING:

Standard Containers -

3-1/2 gallon steel pail - approximately 75 lbs.
10 gallon steel drum - approximately 180 lbs.
A suitable container will be used for quantities under 75 lbs.

CM 10-9/60-2.5

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN POWDER

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.*

replaces: Page 136 9-25-61 *effective:* Jan. 2, 1963

subject to change without notice.

Type	A.S.T.M. Fisher Number	Price/Lb.
M-10	.75 ± .15	$3.20
M-17	1.10 ± .15	2.60
M-20	1.25 ± .15	2.60
M-25	1.6 ± .2	2.60
M-30	2.0 ± .2	2.55
M-35	2.4 ± .2	2.55
M-37	3.0 ± .3	2.55
M-40	3.6 ± .3	2.55
M-55	5.2 ± .5	2.45
M-60	6.6 ± .6	2.45

Special types available upon request.

Notes:

* 1. Cheapest way transportation paid within continental U.S. for 100 pounds or more.
2. These prices apply to orders accepted for delivery within six months from date of order acceptance.
3. Standard packaging - 100 lbs. in 3-1/2 gallon pail.
4. Minimum charge - $10.00 per item.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN ROD
CONTACT OR SUPPORT

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 142 9-1-61 *effective:* April 23, 1962

subject to change without notice.

SPECIFICATION

99.95% pure tungsten, straight random lengths. Free of cracks and fissures detrimental to contact or support use.

PRICE PER KILOGRAM

Diameter (Inches)	FINE GRAIN Black or Cleaned	FINE GRAIN Finish Ground	COARSE GRAIN Black or Cleaned	COARSE GRAIN Finish Ground
.020	$39.25			
.025	36.50	$68.25		
.030	34.00	59.00		
.035	32.25	51.50		
.040	30.90	46.15		
.045	29.50	41.50		
.050	28.00	37.75		
.055	26.90	36.40		
.060	25.90	32.40		
.065	24.85	30.85		
.070	23.80	29.55	$26.05	$32.05
.080	22.30	27.80	24.05	29.80
.090	20.65	25.65	22.40	27.65
.100 - .124	19.10	24.10	20.35	25.55
.125 - .149	17.45	21.95	18.70	23.40
.150 - .174	16.30	20.55	17.05	21.45
.175 - .199	15.95	19.95	16.70	20.85
.200 - .249	15.60	19.35	16.10	20.00
.250 - .299	15.40	19.15	15.90	19.80
.300 - .399	15.20	19.70	15.65	20.35
.400 - .499	15.10	19.60		
.500 - .599	15.05	19.55		
.600 - .699	15.00	19.50		
.700 - .799	20.20	26.20	Not Available	
.800 - .899	19.80	25.80		
.900 - .999	19.40	25.40		
1.000	20.40	26.40		

DEFINITIONS

Black - Black as swaged or drawn.
Cleaned - Chemically cleaned black rod.
Finish Ground - Black rod ground to a close tolerance with a "Ground Polished" surface, or, upon request, a "Ground Etched" surface.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN ROD
CONTACT OR SUPPORT

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Page 143 9-1-61

effective: April 23, 19

subject to change without notice.

STANDARD TOLERANCES

Diameter (Inches)	FINE GRAIN Black or Cleaned	FINE GRAIN Finish Ground	COARSE GRAIN Black or Cleaned	COARSE GRAIN Finish Ground
.020 - .030	± .0015"	± 3%		
.031 - .059	± .0015"	± .001"		
.060 - .259	± .002"	± .001"		
.260 - .374	± .003"	± .0015"	Same as Fine Grain	
.375 - .499	± .005"	± .002"		
.500 - .749	± .010"	± .003"		
.750 -1.000	± .015"	± .005"		

NOTES

1. Prices for closer tolerances available on request.
2. Intermediate sizes to be priced at the next higher price, or the price of the next smaller rod.

MINIMUM CHARGE PER ITEM - $15.00

4/62/1000

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN ROD
GROUND SEAL

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 144 6-13-61 *effective:* April 23, 1962

subject to change without notice.

SPECIFICATION

99.95% pure tungsten, straight random lengths with a Ground Polished surface. Free from cracks, fissures and other imperfections detrimental for use as hard glass seals. 100% electronically inspected.

PRICE PER KILOGRAM

Diameter (Inches)	$	Diameter (Inches)	$
.025	78.50	.070	31.85
.030	66.50	.080	29.90
.035	57.15	.090	27.65
.040	50.65	.100	26.00
.045	45.15	.125	23.75
.050	41.05	.150	22.30
.055	39.00	.175	21.65
.060	35.15	.200	21.00
.065	33.35	.250	20.75
		.300 - .400	21.30

STANDARD TOLERANCES

.025 - .030 - ± 3%
.031 - .259 - ± .001"
.260 & over - ± .0015"

NOTES

1. Upon request, will be furnished with a Ground Polished and Etched Surface.
2. Prices for closer tolerances available on request.
3. Intermediate sizes to be priced at the next higher price, or the price of the next smaller rod.
4. Minimum charge per item - $15.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

NWSA INDEX 590

TUNGSTEN ELECTRODES

CONSUMER PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Point of Shipment

replaces: Pages 150-151 1/15/58

effective: June 1, 1961

subject to change without notice.

CONSUMERS NET PRICE PER PACKAGE OF 10 ELECTRODES

DIAMETER & FINISH	TYPE	Length No. of Pkgs.	3"		6"		7"		12"		18"	
			1-9	10-24	1-9	10-24	1-9	10-24	1-9	10-24	1-9	10-24
0.040"	Puretung®		$ 1.21	$ 1.15	$ 2.12	$ 2.01	$ 2.44	$ 2.32	$ 4.02	$ 3.82	$ 5.81	$ 5.51
Ground	1% Thoriated		1.46	1.38	2.54	2.41	2.93	2.78	4.82	4.58	6.98	6.62
	2% Thoriated		1.63	1.55	2.87	2.72	3.30	3.13	5.43	5.16	7.84	7.44
	Zirtung®		1.82	1.73	3.19	3.03	3.67	3.48	6.03	5.72	8.72	8.28
0.010"	Puretung		.92	.87	1.56	1.48	1.78	1.69	2.81	2.67	4.10	3.89
0.020"	1% Thoriated		1.11	1.05	1.87	1.77	2.13	2.02	3.38	3.20	4.92	4.67
0.040"	2% Thoriated		1.24	1.18	2.10	1.99	2.40	2.28	3.80	3.61	5.53	5.25
Cleaned	Zirtung		1.39	1.32	2.33	2.21	2.67	2.53	4.22	4.01	6.16	5.84
0.062"	Puretung		$ 2.00	$ 1.90	$ 3.59	$ 3.41	$ 4.13	$ 3.92	$ 6.83	$ 6.48	$ 10.10	$ 9.58
(1/16")	1% Thoriated		2.40	2.28	4.31	4.09	4.96	4.70	8.20	7.78	12.12	11.50
Ground	2% Thoriated		2.70	2.56	4.84	4.60	5.58	5.29	9.22	8.75	13.63	12.94
	Zirtung		3.00	2.85	5.39	5.11	6.20	5.88	10.26	9.73	15.16	14.38
0.062"	Puretung		1.41	1.34	2.54	2.41	2.81	2.67	4.89	4.64	7.26	6.88
(1/16")	1% Thoriated		1.69	1.60	3.06	2.90	3.38	3.20	5.87	5.57	8.71	8.26
Cleaned	2% Thoriated		1.90	1.80	3.43	3.26	3.80	3.61	6.60	6.26	9.80	9.30
	Zirtung		2.12	2.01	3.82	3.63	4.22	4.01	7.33	6.96	10.89	10.33
0.093"	Puretung		$ 3.30	$ 3.13	$ 6.13	$ 5.82	$ 7.07	$ 6.70	$ 11.86	$ 11.25	$ 17.67	$ 16.76
(3/32")	1% Thoriated		3.96	3.75	7.36	6.98	8.48	8.04	14.22	13.49	21.20	20.11
Ground	2% Thoriated		4.46	4.23	8.28	7.85	9.54	9.06	16.00	15.18	23.86	22.63
	Zirtung		4.96	4.70	9.20	8.73	10.60	10.06	17.79	16.88	26.50	25.14
0.093"	Puretung		2.68	2.54	4.93	4.68	5.63	5.34	9.48	8.99	14.10	13.38
(3/32")	1% Thoriated		3.21	3.05	5.92	5.62	6.76	6.41	11.38	10.80	16.92	16.06
Cleaned	2% Thoriated		3.61	3.43	6.66	6.31	7.60	7.21	12.80	12.14	19.03	18.06
	Zirtung		4.02	3.82	7.40	7.02	8.46	8.02	14.22	13.49	21.16	20.07
0.125"	Puretung		$ 5.54	$ 5.26	$10.17	$ 9.65	$11.69	$11.09	$ 19.54	$ 18.54	$ 28.93	$ 27.45
(1/8")	1% Thoriated		6.66	6.31	12.20	11.58	14.02	13.30	23.46	22.25	34.72	32.94
Ground	2% Thoriated		7.49	7.11	13.72	13.02	15.78	14.97	26.39	25.04	39.06	37.06
	Zirtung		8.32	7.90	15.26	14.47	17.53	16.64	29.32	27.82	43.40	41.18
0.125"	Puretung		4.44	4.22	7.97	7.56	9.16	8.69	15.19	14.41	22.40	21.25
(1/8")	1% Thoriated		5.33	5.06	9.56	9.07	10.99	10.43	18.22	17.29	26.88	25.50
Cleaned	2% Thoriated		6.00	5.69	10.76	10.20	12.36	11.72	20.50	19.45	30.24	28.70
	Zirtung		6.67	6.33	11.96	11.34	13.73	13.03	22.79	21.62	33.60	31.88

All sizes, types and finishes may be combined to obtain quantity prices.
For quantities over 24 packages deduct 10% from 1-9 package price.
For individual electrodes add 20% to 1-9 package price and divide by 10.
Electrodes of diameters and lengths other than those listed will be quoted on request.

SOLD THROUGH WELDING DISTRIBUTORS

TUNGSTEN ELECTRODES

CONSUMER PRICE SCHEDULE

terms: Net 30 Days

replaces: Pages 150-151 1/15/58

f.o.b.: Point of Shipment

effective: June 1, 1961

subject to change without notice.

CONSUMERS NET PRICE PER PACKAGE OF 10 ELECTRODES

DIAMETER & FINISH	TYPE	Length No. of Pkgs.	3" 1-9	3" 10-24	6" 1-9	6" 10-24	7" 1-9	7" 10-24	12" 1-9	12" 10-24	18" 1-9	18" 10-24
0.156"	Puretung		$ 7.96	$ 7.55	$14.74	$13.99	$16.99	$16.12	$ 28.46	$ 27.00	$ 42.17	$ 40.01
(5/32")	1% Thoriated		9.54	9.06	17.69	16.78	20.39	19.34	34.14	32.40	50.60	48.01
Ground	2% Thoriated		10.74	10.19	19.90	18.88	22.93	21.76	38.41	36.44	56.92	54.01
	Zirtung		11.93	11.32	22.12	20.99	25.49	24.18	42.69	40.50	63.26	60.02
0.156"	Puretung		6.08	5.77	11.63	11.04	13.51	12.82	22.49	21.34	33.33	31.63
(5/32")	1% Thoriated		7.29	6.92	13.96	13.24	16.21	15.38	26.99	25.61	40.00	37.95
Cleaned	2% Thoriated		8.20	7.78	15.70	14.90	18.24	17.31	30.36	28.80	45.00	42.70
	Zirtung		9.12	8.65	17.46	16.56	20.27	19.23	33.73	32.01	50.00	47.44
0.187"	Puretung		$11.34	$10.76	$21.14	$20.06	$24.40	$23.15	$ 40.97	$ 38.87	$ 60.74	$ 57.63
(3/16")	1% Thoriated		13.61	12.91	25.38	24.08	29.28	27.78	49.16	46.64	72.89	69.16
Ground	2% Thoriated		15.31	14.53	28.54	27.08	32.94	31.26	55.30	52.47	82.00	77.80
	Zirtung		17.02	16.15	31.72	30.10	36.60	34.73	61.46	58.31	91.12	86.45
0.187"	Puretung		8.52	8.09	16.48	15.63	18.89	17.92	31.70	30.08	47.41	44.98
(3/16")	1% Thoriated		10.22	9.70	19.78	18.76	22.67	21.51	38.04	36.10	56.89	53.98
Cleaned	2% Thoriated		11.50	10.91	22.24	21.11	25.50	24.19	42.80	40.61	64.00	60.72
	Zirtung		12.79	12.13	24.72	23.46	28.33	26.88	47.56	45.12	71.12	67.48
0.250"	Puretung		$18.59	$17.64	$35.06	$33.26	$40.53	$38.46	$ 69.63	$ 66.07	$101.48	$ 96.28
(1/4")	1% Thoriated		22.31	21.17	42.07	39.91	48.64	46.15	83.56	79.28	121.78	115.54
Ground	2% Thoriated		25.10	23.81	47.32	44.90	54.72	51.92	94.00	89.19	137.00	129.98
	Zirtung		27.89	26.46	52.59	49.90	60.80	57.69	104.46	99.11	152.22	144.43
0.250"	Puretung		14.49	13.75	26.84	25.47	30.94	29.36	51.86	49.20	76.77	72.83
(1/4")	1% Thoriated		17.39	16.50	32.21	30.56	37.13	35.23	62.22	59.04	92.12	87.40
Cleaned	2% Thoriated		19.56	18.55	36.24	34.39	41.78	39.64	70.00	66.41	103.63	98.33
	Zirtung		21.73	20.62	40.27	38.20	46.42	44.04	77.79	73.80	115.16	109.26

All sizes, types and finishes may be combined to obtain quantity prices.
For quantities over 24 packages deduct 10% from 1-9 package price.
For individual electrodes add 20% to 1-9 package price and divide by 10.
Electrodes of diameters and lengths other than those listed will be quoted on request.

SOLD THROUGH WELDING DISTRIBUTORS

CM16-5-61-10
Printed in U.S.A.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

BLACK TUNGSTEN WIRE

PROCESS NS-10

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days
replaces: Pg. 162 7-15-57
Pg. 164 7-15-57
subject to change without notice.

f.o.b.: Towanda, Pa.
effective: Jan. 14, 1963

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01	± .005
.3	.17	.19	-	-	-	$10.30	$11.59	$13.31
	.20	.23	-	-	-	8.60	9.68	11.11
	.24	.29	-	-	$ 7.15	7.46	8.39	9.64
.4	.30	.36	-	-	5.80	6.05	6.81	7.82
	.37	.44	-	4.85	5.07	5.29	5.95	6.83
.5	.45	.54	-	4.25	4.44	4.64	5.21	5.99
	.55	.67	$ 3.70	4.07	4.26	4.44	5.00	5.74

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
.6	.68	.83	$ 3.40	$ 3.74	$ 3.91	$ 4.08	$ 4.59	$ 5.27
.7	.84	1.02	3.38	3.72	3.89	4.06	4.56	5.24
	1.03	1.13	3.28	3.61	3.77	3.94	4.43	5.08
.8	1.14	1.26	3.20	3.52	3.68	3.84	4.32	4.96
	1.27	1.40	3.17	3.49	3.65	3.80	4.28	4.91
	1.41	1.56	3.13	3.44	3.60	3.76	4.23	4.85
.9	1.57	1.79	3.10	3.41	3.57	3.72	4.19	4.81
1.0	1.80	2.02	3.00	3.30	3.45	3.60	4.05	4.65
	2.03	2.28	3.15	3.47	3.62	3.78	4.25	4.88
	2.29	2.57	3.28	3.61	3.77	3.94	4.43	5.08
	2.58	2.90	3.42	3.76	3.93	4.10	4.62	5.30
	2.91	3.30	3.59	3.95	4.13	4.31	4.85	5.56
	3.31	3.70	3.75	4.13	4.31	4.50	5.06	5.81
	3.71	4.18	3.92	4.31	4.51	4.70	5.29	6.08
1.5	4.19	4.70	4.11	4.52	4.73	4.93	5.55	6.37
	4.71	5.35	4.31	4.74	4.96	5.17	5.82	6.68
	5.36	6.05	4.52	4.97	5.20	5.42	61.0	7.01
	6.06	6.85	4.71	5.18	5.42	5.65	6.36	7.30
	6.86	7.70	4.93	5.42	5.67	5.92	6.66	7.64
2.0	7.71	8.75	5.18	5.70	5.96	6.22	6.99	8.03
	8.76	9.90	5.43	5.97	6.24	6.52	7.33	8.42
	9.91	11.10	5.64	6.20	6.49	6.77	7.61	8.74
2.5	11.11	12.60	5.95	6.55	6.84	7.14	8.03	9.22
	12.61	14.20	6.40	7.04	7.36	7.68	8.64	9.92
	14.21	16.10	7.05	7.76	8.11	8.46	9.52	10.93

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

BLACK TUNGSTEN WIRE

PROCESS NS-10*

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days
Pg. 164 7-15-57
replaces: Pg. 165 7-15-57
subject to change without notice.

f.o.b.: Towanda, Pa.
effective: Jan. 14, 1963

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
3.0	16.11	18.20	$ 7.70	$ 8.47	$ 8.86	$ 9.24	$10.40	$11.94
	18.21	20.60	8.40	9.24	9.66	10.08	11.34	13.02
	20.61	23.20	9.10	10.01	10.47	10.92	12.29	14.11
3.5	23.21	26.30	10.00	11.00	11.50	12.00	13.50	15.50
	26.31	29.70	10.90	11.99	12.54	13.08	14.72	16.90
4.0	29.71	33.50	12.00	13.20	13.80	14.40	16.20	18.60
	33.51	38.00	13.10	14.41	15.07	15.72	17.69	20.31
4.5	38.01	43.00	14.40	15.84	16.56	17.28	19.44	22.32
	43.01	48.50	15.70	17.27	18.06	18.84	21.20	24.34
5.0	48.51	55.00	17.10	18.81	19.67	20.52	23.09	26.51
5.5	55.01	62.00	18.75	20.63	21.56	22.50	25.31	29.06
	62.01	70.00	20.40	22.44	23.46	24.48	27.54	31.62
6.0	70.01	79.00	22.40	24.64	25.76	26.88	30.24	34.72
6.5	79.01	89.50	24.40	26.84	28.06	29.28	32.94	37.82
7.0	89.51	102.00	26.90	29.59	30.94	32.28	36.32	41.70
7.5	102.01	114.00	29.00	31.90	33.35	34.80	39.15	44.95
8.0	114.01	129.00	31.60	34.76	36.34	37.92	42.66	48.98
8.5	129.01	145.00	34.50	37.95	39.68	41.40	46.58	53.48
9.0	145.01	164.00	38.00	41.80	43.70	45.60	51.30	58.90
9.5	164.01	186.00	42.70	46.97	49.11	51.24	57.65	66.19
10.0	186.01	206.00	47.00	51.70	54.05	56.40	63.45	72.85
10.5	206.01	227.00	51.00	56.10	58.65	61.20	68.85	79.05
11.0	227.01	250.00	56.00	61.60	64.40	67.20	75.60	86.80
	250.01	270.00	59.80	65.78	68.77	71.76	80.73	92.69
12.0	270.01	305.00	66.20	72.82	76.13	79.44	89.37	102.61
13.0	305.01	340.00	73.00	80.30	83.95	87.60	98.55	113.15
	340.01	375.00	80.00	88.00	92.00	96.00	108.00	124.00
14.0	375.01	415.00	87.50	96.25	100.63	105.00	118.13	135.63
15.0	415.01	465.00	97.00	106.70	111.55	116.40	130.95	150.35
16.0	465.01	515.00	106.00	116.60	121.90	127.20	143.10	164.30
17.0	515.01	580.00	118.00	129.80	135.70	141.60	159.30	182.90
18.0	580.01	650.00	131.00	144.10	150.65	157.20	176.85	203.05
19.0	650.01	720.00	143.00	157.30	164.45	171.60	193.05	221.65
	720.01	776.90	152.60	167.85	175.50	183.10	206.00	236.50

See Page 156 for diameters of 20 mils and larger.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

BLACK TUNGSTEN WIRE

PROCESS NS-10

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pg. 165 7-15-57

effective: Jan. 14, 1963

subject to change without notice.

Diameter in Mils		Price per Kilogram Based on Center Size Ordered			
		Diameter Tolerance - %			
From	To and Incl.	± 1-1/2	± 1-1/4	± 1	± 3/4
20		$39.26	$43.19	$45.15	$47.11
21		39.00	42.90	44.85	46.80
22		38.80	42.68	44.62	46.56
23		38.40	42.24	44.16	46.08
24		38.05	41.86	43.76	45.66
25		37.80	41.58	43.47	45.36
26		37.55	41.31	43.18	45.06
27		37.30	41.03	42.90	44.76
28		37.05	40.76	42.61	44.46
29		36.80	40.48	42.32	44.16
30		36.55	40.21	42.03	43.86
31		36.30	39.93	41.75	43.56
32		36.05	39.66	41.46	43.26
33		35.80	39.38	41.17	42.96
34		35.55	39.11	40.88	42.66
35	39	34.80	38.28	40.02	41.76
40	44	34.05	37.46	39.16	40.86
45	49	33.30	36.63	38.30	39.96
50	54	32.55	35.81	37.43	39.06
55	59	31.95	35.15	36.74	38.34
60	64	31.45	34.60	36.17	37.74
65	69	31.05	34.16	35.71	37.26
70	79	30.45	33.50	35.02	36.54
80	89	29.65	32.62	34.10	35.58
90	100	28.85	31.74	33.18	34.62

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-20 AND NS-30

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 166 7-15-57 *effective:* Jan. 14, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01	± .005
.4	.30	.36	-	-	$ 6.55	$ 6.80	$ 7.60	$ 8.65
	.37	.44	-	$ 5.58	5.81	6.04	6.72	7.63
.5	.45	.54	-	4.89	5.09	5.29	5.98	6.79
	.55	.67	$ 4.44	4.82	5.02	5.21	5.79	6.55

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
.6	.68	.83	$ 4.17	$ 4.52	$ 4.70	$ 4.87	$ 5.40	$ 6.11
.7	.84	1.02	4.15	4.50	4.68	4.85	5.38	6.08
	1.03	1.13	4.07	4.41	4.58	4.75	5.26	5.93
.8	1.14	1.26	4.00	4.33	4.50	4.66	5.16	5.82
	1.27	1.40	3.98	4.31	4.47	4.64	5.13	5.78
	1.41	1.56	3.96	4.28	4.45	4.61	5.09	5.74
.9	1.57	1.79	3.94	4.26	4.42	4.58	5.06	5.71
1.0	1.80	2.02	3.85	4.16	4.32	4.47	4.94	5.56
	2.03	2.28	4.01	4.34	4.50	4.66	5.15	5.80
	2.29	2.57	4.16	4.50	4.67	4.84	5.35	6.02
	2.58	2.90	4.33	4.68	4.86	5.04	5.57	6.28
	2.91	3.30	4.53	4.90	5.09	5.27	5.83	6.58
	3.31	3.70	4.71	5.10	5.29	5.49	6.07	6.84
	3.71	4.18	4.92	5.33	5.53	5.73	6.34	7.15
1.5	4.19	4.70	5.15	5.58	5.79	6.00	6.64	7.49
	4.71	5.35	5.39	5.84	6.06	6.28	6.95	7.84
	5.36	6.05	5.64	6.11	6.34	6.58	7.28	8.21
	6.06	6.85	5.87	6.36	6.60	6.84	7.57	8.55
	6.86	7.70	6.14	6.65	6.91	7.16	7.93	8.95
2.0	7.71	8.75	6.42	6.96	7.22	7.49	8.30	9.37
	8.76	9.90	6.74	7.30	7.58	7.86	8.71	9.83
	9.91	11.10	6.99	7.57	7.87	8.16	9.03	10.20
2.5	11.11	12.60	7.44	8.07	8.38	8.69	9.63	10.88
	12.61	14.20	7.95	8.62	8.96	9.29	10.30	11.65
	14.21	16.10	8.65	9.39	9.76	10.13	11.24	12.72

NOTE: Process NS-20 is Straightened, Black Tungsten Wire.
Process NS-30 is Cleaned, Unstraightened Tungsten Wire.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-20 AND NS-30

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

replaces: Pg. 166 7-15-57
Pg. 167 7-15-57

subject to change without notice.

f.o.b.: Towanda, Pa.

effective: Jan. 14, 1963

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
3.0	16.11	18.20	$ 9.37	$10.18	$10.58	$10.99	$12.20	$13.82
	18.21	20.60	10.14	11.02	11.46	11.90	13.23	14.99
	20.61	23.20	10.91	11.87	12.34	12.82	14.26	16.17
3.5	23.21	26.30	11.89	12.94	13.47	13.99	15.57	17.67
	26.31	29.70	12.89	14.04	14.61	15.18	16.90	19.19
4.0	29.71	33.50	14.08	15.34	15.97	16.60	18.49	21.01
	33.51	38.00	15.26	16.64	17.32	18.01	20.08	22.83
4.5	38.01	43.00	16.67	18.18	18.94	19.69	21.96	24.99
	43.01	48.50	18.08	19.73	20.55	21.38	23.85	27.15
5.0	48.51	55.00	19.58	21.38	22.27	23.17	25.87	29.46
5.5	55.01	62.00	21.34	23.31	24.29	25.28	28.23	32.17
	62.01	70.00	23.09	25.23	26.30	27.37	30.59	34.87
6.0	70.01	79.00	25.25	27.60	28.78	29.95	33.48	38.19
6.5	79.01	89.50	27.37	29.93	31.21	32.49	36.34	41.46
7.0	89.51	102.00	30.04	32.87	34.28	35.69	39.93	45.58
7.5	102.01	114.00	32.29	35.34	36.86	38.38	42.95	49.04
8.0	114.01	129.00	35.05	38.37	40.03	41.69	46.66	53.30
8.5	129.01	145.00	38.14	41.76	43.57	45.39	50.82	58.07
9.0	145.01	164.00	41.82	45.81	47.81	49.80	55.79	63.77
9.5	164.01	186.00	46.82	51.30	53.55	55.79	62.51	71.48
10.0	186.01	206.00	51.36	56.30	58.76	61.23	68.63	78.50
10.5	206.01	227.00	55.60	60.96	63.63	66.31	74.34	85.05
11.0	227.01	250.00	60.87	66.75	69.69	72.63	81.45	93.21
	250.01	270.00	64.87	71.15	74.29	77.43	86.85	99.40
12.0	270.01	305.00	71.62	78.57	82.05	85.52	95.95	109.85
13.0	305.01	340.00	78.78	86.45	90.28	94.11	105.61	120.94
	340.01	375.00	86.18	94.58	98.78	102.98	115.58	132.38
14.0	375.01	415.00	94.10	103.29	107.88	112.48	126.26	144.63
15.0	415.01	465.00	104.08	114.27	119.36	124.45	139.73	160.10
16.0	465.01	515.00	113.56	124.69	130.26	135.82	152.52	174.78
17.0	515.01	580.00	126.20	138.59	144.79	150.98	169.57	194.35
18.0	580.01	650.00	139.88	153.64	160.51	167.39	188.02	215.53
19.0	650.01	720.00	152.52	167.54	175.04	182.55	205.07	235.10
	720.01	776.90	162.55	178.56	186.56	194.57	218.62	250.65

See page 160 for diameters of 20 mils and larger.

NOTE: Process NS-20 is Straightened, Black Tungsten Wire.
Process NS-30 is Cleaned, Unstraightened Tungsten Wire.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-20 AND NS-30

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 167 7-15-57 *effective:* Jan. 14, 1963

subject to change without notice.

Diameter in Mils		Price per Kilogram Based on Center Size Ordered			
		Diameter Tolerance - %			
From	To and Incl.	± 1-1/2	± 1-1/4	± 1	± 3/4
20		41.83	45.95	48.01	50.07
21		41.54	45.44	47.39	49.34
22		41.32	45.20	47.14	49.08
23		40.90	44.74	46.66	48.58
24		40.52	44.33	46.23	48.13
25		40.26	44.04	45.93	47.82
26		39.99	43.75	45.62	47.50
27		39.72	43.45	45.32	47.18
28		39.46	43.17	45.02	46.87
29		39.19	42.87	44.71	46.55
30		37.42	41.11	42.95	44.80
31		37.16	40.83	42.67	44.50
32		36.91	40.56	42.37	44.19
33		36.66	40.27	42.08	43.89
34		36.41	40.00	41.79	43.59
35	39	35.65	39.16	40.92	42.68
40	44	34.89	38.33	40.05	41.77
45	49	34.13	37.50	39.18	40.86
50	54	33.38	36.67	38.30	39.95
55	59	32.77	36.00	37.61	39.22
60	64	32.26	35.45	37.03	38.62
65	69	31.86	35.00	36.57	38.13
70	79	31.25	34.34	35.87	37.41
80	89	30.45	33.45	34.94	36.44
90	100	29.64	32.56	34.01	35.47

NOTE: Process NS-20 is Straightened, Black Tungsten Wire.
Process NS-30 is Cleaned, Unstraightened Tungsten Wire.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-50, NS-55, NS-60

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 168 7-15-57 *effective:* Jan. 14, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01	± .005
.4	.30	.36	-	-	$ 7.30	$ 7.55	$ 8.40	$ 9.45
	.37	.44	-	$ 6.31	6.54	6.78	7.49	8.43
.5	.45	.54	-	5.73	5.93	6.14	6.75	7.59
	.55	.67	$ 5.17	5.57	5.76	5.96	6.56	7.35

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
.6	.68	.83	$ 4.94	$ 5.30	$ 5.49	$ 5.67	$ 6.21	$ 6.94
.7	.84	1.02	4.92	5.28	5.46	5.64	6.19	6.91
	1.03	1.13	4.86	5.21	5.39	5.56	6.09	6.79
.8	1.14	1.26	4.79	5.13	5.30	5.47	5.99	6.67
	1.27	1.40	4.79	5.13	5.30	5.47	5.98	6.65
	1.41	1.56	4.78	5.12	5.28	5.45	5.95	6.62
.9	1.57	1.79	4.77	5.10	5.27	5.43	5.93	6.60
1.0	1.80	2.02	4.69	5.01	5.17	5.33	5.81	6.46
	2.03	2.28	4.87	5.21	5.38	5.54	6.05	6.72
	2.29	2.57	5.05	5.40	5.58	5.75	6.28	6.98
	2.58	2.90	5.24	5.61	5.79	5.97	6.52	7.25
	2.91	3.30	5.46	5.84	6.04	6.23	6.80	7.57
	3.31	3.70	5.66	6.06	6.26	6.46	7.06	7.87
	3.71	4.18	5.91	6.33	6.54	6.75	7.38	8.21
1.5	4.19	4.70	6.19	6.63	6.85	7.07	7.73	8.61
	4.71	5.35	6.46	6.92	7.15	7.38	8.07	9.00
	5.36	6.05	6.76	7.24	7.49	7.73	8.45	9.42
	6.06	6.85	7.04	7.54	7.80	8.05	8.80	9.81
	6.86	7.70	7.35	7.88	8.14	8.41	9.20	10.25
2.0	7.71	8.75	7.66	8.21	8.49	8.77	9.60	10.71
	8.76	9.90	8.04	8.62	8.91	9.20	10.07	11.24
	9.91	11.10	8.32	8.92	9.22	9.53	10.43	11.64
2.5	11.11	12.60	8.91	9.57	9.89	10.22	11.20	12.51
	12.61	14.20	9.47	10.17	10.53	10.88	11.93	13.34
	14.21	16.10	10.27	11.05	11.43	11.82	12.89	14.54

PROCESS NO.	AVAILABLE SIZE RANGE
NS-50	.30 mg. to 50.00 mg.
NS-55	.30 mg. to 85 mil
NS-60	.30 mg. to 12.00 mg.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-50, NS-55, NS-60

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

replaces: Pg. 168 7-15-57
Pg. 169 7-15-57

f.o.b.: Towanda, Pa.

effective: Jan. 14, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
3.0	16.11	18.20	$11.03	$11.88	$12.30	$12.72	$13.99	$15.69
	18.21	20.60	11.88	12.80	13.27	13.73	15.11	16.96
	20.61	23.20	12.73	13.73	14.23	14.73	16.23	18.24
3.5	23.21	26.30	13.78	14.88	15.43	15.98	17.63	19.83
	26.31	29.70	14.86	16.06	16.66	17.26	19.06	21.45
4.0	29.71	33.50	16.12	17.44	18.10	18.76	20.74	23.38
	33.51	38.00	17.42	18.86	19.58	20.30	22.46	25.35
4.5	38.01	43.00	18.93	20.51	21.31	22.10	24.47	27.64
	43.01	48.50	20.43	22.16	23.02	23.88	26.47	29.93
5.0	48.51	55.00	22.03	23.91	24.85	25.79	28.61	32.38
5.5	55.01	62.00	23.92	25.98	27.01	28.05	31.14	35.27
	62.01	70.00	25.80	28.04	29.17	30.29	33.65	38.14
6.0	70.01	79.00	28.06	30.52	31.76	32.99	36.68	41.61
6.5	79.01	89.50	30.33	33.01	34.36	35.70	39.72	45.09
7.0	89.51	102.00	33.17	36.13	37.60	39.09	43.53	49.44
7.5	102.01	114.00	35.55	38.74	40.34	41.93	46.72	53.10
8.0	114.01	129.00	38.49	41.97	43.71	45.44	50.66	57.61
8.5	129.01	145.00	41.75	45.55	47.44	49.34	55.03	62.62
9.0	145.01	164.00	45.67	49.85	51.94	54.03	60.30	68.66
9.5	164.01	186.00	50.90	55.60	57.95	60.29	67.34	76.73
10.0	186.01	206.00	55.70	60.87	63.46	66.04	73.80	84.14
10.5	206.01	227.00	60.17	65.78	68.59	71.39	79.81	91.03
11.0	227.01	250.00	65.74	71.90	74.98	78.06	87.30	99.62
	250.01	270.00	69.96	76.54	79.83	83.12	92.98	106.14
12.0	270.01	305.00	77.06	84.34	87.98	91.62	102.55	117.11
13.0	305.01	340.00	84.61	92.64	96.66	100.67	112.72	128.78
	340.01	375.00	92.36	101.16	105.56	109.96	123.16	140.76
14.0	375.01	415.00	100.67	110.30	115.11	119.92	134.36	153.61
15.0	415.01	465.00	111.18	121.85	127.19	132.52	148.53	169.87
16.0	465.01	515.00	121.15	132.81	138.64	144.47	161.96	185.28
17.0	515.01	580.00	134.42	147.40	153.89	160.38	179.85	205.81
18.0	580.01	650.00	148.77	163.18	170.39	177.59	199.21	228.03
19.0	650.01	720.00	162.04	177.77	185.64	193.50	217.10	248.56
	720.01	776.90	172.54	189.60	197.72	206.11	231.29	264.83

See page 164 for diameters of 20 mils and larger.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN WIRE

PROCESSES NS-50, NS-55, NS-60

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 169 7-15-57 *effective:* Jan. 14, 1963

subject to change without notice.

Diameter in Mils		Price per Kilogram Based on Center Size Ordered			
		Diameter Tolerance - %			
From	To and Incl.	± 1-1/2	± 1-1/4	± 1	± 3/4
20		$44.40	$48.79	$50.88	$53.04
21		44.07	47.97	49.92	51.87
22		43.84	47.72	49.66	51.60
23		43.39	47.23	49.15	51.07
24		43.00	46.81	48.71	50.61
25		42.71	46.49	48.38	50.27
26		48.20	52.28	54.32	56.36
27		47.38	51.43	53.46	55.49
28		46.63	50.66	52.67	54.68
29		45.93	49.93	51.93	53.93
30		43.73	47.55	49.46	51.37
31		43.12	46.91	48.81	50.70
32		42.54	46.31	48.19	50.07
33		42.00	45.74	47.61	49.48
34		41.47	45.19	47.04	48.90
35	39	40.46	44.10	45.92	47.74
40	44	38.72	42.28	44.06	45.84
45	49	37.30	40.78	42.52	44.27
50	54	36.06	39.47	41.17	42.87
55	59	35.09	38.43	40.11	41.78
60	64	34.31	37.60	39.25	40.89
65	69	33.69	36.94	38.57	40.19
70	79	32.91	36.10	37.69	39.29
80	85	31.85	34.96	36.51	38.06

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

POLISHED TUNGSTEN WIRE

UNSTRAIGHTENED **PROCESS NS-80**

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 166 1-14-63 *effective:* Mar. 18, 1963

subject to change without notice.

Mil Size Included In Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01
.2	.08	.10	-	-	-	-	$29.00
.25	.11	.13	-	-	-	$22.00	24.20
	.14	.16	-	-	-	18.00	19.80
.3	.17	.19	-	-	-	14.50	15.95
	.20	.23	-	-	-	12.65	14.25
	.24	.29	-	-	$10.00	10.50	11.55
.4	.30	.36	-	-	6.55	6.80	7.60
	.37	.44	-	-	5.81	6.04	6.72
.5	.45	.54	-	$ 4.89	5.09	5.29	5.98
	.55	.67	$ 4.44	4.82	5.02	5.21	5.79

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1
.6	.68	.83	$ 4.60	$ 5.00	$ 5.23	$ 5.45	$ 6.08
.7	.84	1.02	4.75	5.15	5.39	5.63	6.27
	1.03	1.13	4.90	5.32	5.56	5.81	6.47
.8	1.14	1.26	5.10	5.53	5.79	6.04	6.73
	1.27	1.40	5.35	5.80	6.07	6.34	7.06
	1.41	1.56	5.65	6.13	6.41	6.70	7.46
.9	1.57	1.79	6.05	6.56	6.87	7.17	8.00
1.0	1.80	2.02	6.55	7.11	7.43	7.75	8.65
	2.03	2.28	7.05	7.65	8.00	8.35	9.10
	2.29	2.57	7.58	8.20	8.40	8.80	9.55
	2.58	2.90	7.86	8.42	8.69	8.96	9.78
	2.91	3.30	8.19	8.76	9.06	9.35	10.20
	3.31	3.70	8.49	9.09	9.39	9.69	10.59
	3.71	4.18	8.87	9.50	9.81	10.13	11.07
1.5	4.19	4.70	9.29	9.95	10.28	10.61	11.60
	4.71	5.35	9.69	10.38	10.73	11.07	12.11
	5.36	6.05	10.14	10.86	11.24	11.60	12.68
	6.06	6.85	10.56	11.31	11.70	12.08	13.20
	6.86	7.70	11.03	11.82	12.21	12.62	13.80
2.0	7.71	8.75	11.49	12.32	12.74	13.16	14.40

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

POLISHED TUNGSTEN WIRE

UNSTRAIGHTENED **PROCESS NS-80**

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 167 1-14-63 *effective:* Mar. 18, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1
	8.76	9.90	$12.06	$12.93	$13.37	$13.80	$15.11
	9.91	11.10	12.48	13.38	13.83	14.30	15.65
2.5	11.11	12.60	13.37	14.36	14.84	15.33	16.80
	12.61	14.20	14.21	15.26	15.80	16.32	17.90
	14.21	16.10	15.41	16.58	17.15	17.73	19.34
3.0	16.11	18.20	16.55	17.82	18.45	19.08	20.99
	18.21	20.60	17.82	19.20	19.91	20.60	22.67
	20.61	23.20	19.10	20.60	21.35	22.10	24.35
3.5	23.21	26.30	20.67	22.32	23.15	23.97	26.45
	26.31	29.70	22.29	24.09	24.99	25.89	28.59
4.0	29.71	33.50	24.18	26.16	27.15	28.14	31.11
	33.51	38.00	26.13	28.29	29.37	30.45	33.69
4.5	38.01	43.00	28.40	30.77	31.97	33.15	36.71
	43.01	48.50	30.65	33.24	34.53	35.82	39.71
5.0	48.51	55.00	33.05	35.87	37.28	38.69	42.92
5.5	55.01	62.00	35.88	38.97	40.52	42.08	46.71
	62.01	70.00	38.70	42.06	43.76	45.44	50.48
6.0	70.01	79.00	42.09	47.64	47.64	49.49	55.02
6.5	79.01	89.50	45.50	49.52	51.54	53.55	59.58
7.0	89.51	102.00	49.76	54.20	56.40	58.64	65.30
7.5	102.01	114.00	53.33	58.11	60.51	62.90	70.08
8.0	114.01	129.00	57.74	62.96	65.57	68.16	75.99
8.5	129.01	145.00	62.63	68.33	71.16	74.01	82.55
9.0	145.01	164.00	68.51	74.78	77.91	81.05	90.45
9.5	164.01	186.00	76.35	83.40	86.93	90.44	101.01
10.0	186.01	194.27	83.55	91.31	95.19	99.06	110.70

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

POLISHED TUNGSTEN WIRE

STRAIGHTENED—PROCESSES NS-85, NS-86, NS-87

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 168 1-14-63 *effective:* Mar. 18, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01
.3	.17	.19	-	-	-	$16.00	$17.80
	.20	.23	-	-	-	13.50	15.10
	.24	.29	-	-	$ 9.85	10.35	11.60
.4	.30	.36	-	-	7.30	7.55	8.40
	.37	.44	-	$ 6.31	6.54	6.78	7.49
.5	.45	.54	-	5.73	5.93	6.14	6.75
	.55	.67	$ 5.17	5.57	5.76	5.96	6.56

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1
.6	.68	.83	$ 5.30	$ 5.75	$ 5.95	$ 6.20	$ 6.90
.7	.84	1.02	5.45	5.89	6.10	6.38	7.09
	1.03	1.13	5.60	6.05	6.27	6.55	7.28
.8	1.14	1.26	5.80	6.26	6.50	6.79	7.54
	1.27	1.40	6.05	6.53	6.78	7.08	7.87
	1.41	1.56	6.35	6.86	7.11	7.43	8.26
.9	1.57	1.79	6.75	7.29	7.56	7.90	8.78
1.0	1.80	2.02	7.20	7.78	8.06	8.42	9.36
	2.03	2.28	7.70	8.35	8.65	9.00	10.00
	2.29	2.57	8.30	9.00	9.25	9.70	10.50
	2.58	2.90	8.65	9.25	9.55	9.80	10.85
	2.91	3.30	9.00	9.65	10.00	10.30	11.20
	3.31	3.70	9.34	10.00	10.33	10.66	11.65
	3.71	4.18	9.76	10.45	10.79	11.14	12.18
1.5	4.19	4.70	10.22	10.95	11.31	11.67	12.76
	4.71	5.35	10.66	11.42	11.80	12.18	13.32
	5.36	6.05	11.15	11.95	12.36	12.76	13.95
	6.06	6.85	11.62	12.44	12.87	13.29	14.52
	6.86	7.70	12.13	13.00	13.43	13.88	15.18
2.0	7.71	8.75	12.64	13.55	14.01	14.48	15.84

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

POLISHED TUNGSTEN WIRE

STRAIGHTENED—PROCESSES NS-85, NS-86, NS-87

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pg. 169 1-14-63

effective: Mar. 18, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1
	8.76	9.90	$13.27	$14.22	$14.71	$15.18	$16.62
	9.91	11.10	13.73	14.72	15.21	15.73	17.22
2.5	11.11	12.60	14.71	15.80	16.32	16.86	18.48
	12.61	14.20	15.63	16.79	17.38	17.95	19.69
	14.21	16.10	16.95	18.24	18.87	19.50	21.27
3.0	16.11	18.20	18.21	19.60	20.30	20.99	23.09
	18.21	20.60	19.60	21.12	21.90	22.66	24.94
	20.61	23.20	21.01	22.66	23.49	24.31	26.79
3.5	23.21	26.30	22.74	24.55	25.47	26.37	29.10
	26.31	29.70	24.52	26.50	27.49	28.48	31.45
4.0	29.71	33.50	26.60	28.78	29.87	30.95	34.22
	33.51	38.00	28.74	31.12	32.31	33.50	37.06
4.5	38.01	43.00	31.24	33.85	35.17	36.47	40.38
	43.01	48.50	33.72	36.56	37.98	39.40	43.68
5.0	48.51	55.00	36.36	39.46	41.01	42.56	47.21
5.5	55.01	62.00	39.47	42.67	44.57	46.29	51.38
	62.01	70.00	42.57	46.27	48.14	49.98	55.53
6.0	70.01	79.00	46.30	52.40	52.40	54.44	60.52
6.5	79.01	89.50	50.05	54.47	56.69	58.91	65.54
7.0	89.51	102.00	54.74	59.62	62.04	64.50	71.83
7.5	102.01	114.00	58.66	63.92	66.56	69.19	77.09
8.0	114.01	129.00	63.51	69.26	72.13	74.98	83.59
8.5	129.01	145.00	68.89	75.16	78.28	81.41	90.81
9.0	145.01	164.00	75.36	82.26	85.70	89.16	99.50
9.5	164.01	186.00	83.99	91.74	95.62	99.48	111.11
10.0	186.01	194.27	91.91	100.44	104.71	108.97	121.77

Sylvania tungsten-3% rhenium wire is an alloy of tungsten containing a nominal 3% by weight rhenium, which has characteristics which make it a useful design material for the manufacture of certain types of lamps and radio tubes. Tungsten-3% rhenium wire is available in production quantities over the full range of sizes and finishes that are available in Sylvania unalloyed tungsten wire.

When compared to unalloyed tungsten wire, this new material is distinguished by the following differences:

Resistivity

Temperature ^{o}C	Ratio of resistivity of tungsten-3% rhenium wire to that of unalloyed tungsten wire
25	1.62
1000	1.09
1200	1.08
1500	1.07

Oxidation Resistance of tungsten-3% rhenium wire in air is greater than that of unalloyed tungsten wire over the temperature range $700^{o}C$ to $1200^{o}C$.

Elongation — In as-drawn (unannealed) wire, the elongation of tungsten-3% rhenium is similar to that of unalloyed tungsten. In annealed wire, the elongation is greater than that of unalloyed tungsten.

Tensile Strength — Room-temperature tensile strength of tungsten-3% rhenium wire is similar to that of unalloyed tungsten wire.

Weight Conversion — For all practical purposes, the densities of Sylvania's tungsten-3% rhenium and Sylvania's tungsten wires are the same. For converting from milligram weight to diameter, Sylvania's tungsten wire conversion chart should be used. The formula for this conversion is:

$$\text{mg/200 mm} = (\text{diameter in mils})^2 \times 1.9427$$

Standard Process Tungsten-3% Rhenium Wire

3% RW-10 - Designates wire with the black, as-drawn, graphite-coated finish generally used for lamp filaments. Such wire may be used for radio-tube heaters where straightness is not critical, and where the graphite coating will be removed prior to the application of the heater coating.

3% RW-55 - Designates 3% RW-10 wire which has been chemically cleaned, straightened, and stress-relieved in a reducing atmosphere. Good straightness and intermediate tensile range suggest its use as receiving-tube heater and grid-lateral wire, or as miniature-lamp filaments.

3% RW-80 - Designates wire which has been electropolished. Its use is suggested for wire sizes below 0.70 mg/200 mm in applications involving receiving-tube miniature-grid-lateral wires. The wire retains the as-drawn high tensile strength.

	Process		
	3% RW-10	3% RW-55	3% RW-80
Surface	Black	Cleaned	Cleaned
Tensile Strength	High, as drawn	Intermediate	High, as drawn
Straightness	As drawn	Good	As drawn
Available Size Range	0.30 mg/200 mm and larger	0.70 mg/200 mm and larger	0.19-0.69 mg/ 200 mm

How to Order

1. Specify Sylvania process, e.g., 3% RW-10
2. Specify milligram weight and tolerance, e.g., 3.96 mg/200 mm ± 3%
3. For pricing and diameter tolerances, refer to our catalog pages 178-179.

Sylvania tungsten-3% rhenium wire is an alloy of tungsten containing a nominal 3% by weight rhenium, which has characteristics which make it a useful design material for the manufacture of certain types of lamps and radio tubes. Tungsten-3% rhenium wire is available in production quantities over the full range of sizes and finishes that are available in Sylvania unalloyed tungsten wire.

When compared to unalloyed tungsten wire, this new material is distinguished by the following differences:

Resistivity

Temperature ^{o}C	Ratio of resistivity of tungsten-3% rhenium wire to that of unalloyed tungsten wire
25	1.62
1000	1.09
1200	1.08
1500	1.07

Oxidation Resistance of tungsten-3% rhenium wire in air is greater than that of unalloyed tungsten wire over the temperature range $700^{o}C$ to $1200^{o}C$.

Elongation — In as-drawn (unannealed) wire, the elongation of tungsten-3% rhenium is similar to that of unalloyed tungsten. In annealed wire, the elongation is greater than that of unalloyed tungsten.

Tensile Strength — Room-temperature tensile strength of tungsten-3% rhenium wire is similar to that of unalloyed tungsten wire.

Weight Conversion — For all practical purposes, the densities of Sylvania's tungsten-3% rhenium and Sylvania's tungsten wires are the same. For converting from milligram weight to diameter, Sylvania's tungsten wire conversion chart should be used. The formula for this conversion is:

$$\text{mg/200 mm} = (\text{diameter in mils})^2 \times 1.9427$$

Standard Process Tungsten-3% Rhenium Wire

3% RW-10 - Designates wire with the black, as-drawn, graphite-coated finish generally used for lamp filaments. Such wire may be used for radio-tube heaters where straightness is not critical, and where the graphite coating will be removed prior to the application of the heater coating.

3% RW-55 - Designates 3% RW-10 wire which has been chemically cleaned, straightened, and stress-relieved in a reducing atmosphere. Good straightness and intermediate tensile range suggest its use as receiving-tube heater and grid-lateral wire, or as miniature-lamp filaments.

3% RW-80 - Designates wire which has been electropolished. Its use is suggested for wire sizes below 0.70 mg/200 mm in applications involving receiving-tube miniature-grid-lateral wires. The wire retains the as-drawn high tensile strength.

	Process		
	3% RW-10	3% RW-55	3% RW-80
Surface	Black	Cleaned	Cleaned
Tensile Strength	High, as drawn	Intermediate	High, as drawn
Straightness	As drawn	Good	As drawn
Available Size Range	0.30 mg/200 mm and larger	0.70 mg/200 mm and larger	0.19-0.69 mg/ 200 mm

How to Order

1. Specify Sylvania process, e.g., 3% RW-10
2. Specify milligram weight and tolerance, e.g., 3.96 mg/200 mm ± 3%
3. For pricing and diameter tolerances, refer to our catalog pages 178-179.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

BLACK TUNGSTEN-3% RHENIUM WIRE
Process 3% RW-10

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 178 8-1-62 *effective:* Jan. 14, 1963

subject to change without notice.

Mil Size Included In Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01	± .005
	.37	.44	-	$ 6.80	$ 7.11	$ 7.42	$ 8.34	$ 9.60
.5	.45	.54	-	6.10	6.38	6.66	7.49	8.60
	.55	.67	$ 5.47	6.02	6.29	6.56	7.38	8.48

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
.6	.68	.83	$ 4.83	$ 5.31	$ 5.55	$ 5.80	$ 6.52	$ 7.49
.7	.84	1.02	4.68	5.15	5.38	5.62	6.32	7.25
	1.03	1.13	4.55	5.01	5.23	5.46	6.14	7.05
.8	1.14	1.26	4.50	4.95	5.18	5.40	6.08	6.98
	1.27	1.40	4.46	4.91	5.13	5.35	6.02	6.91
	1.41	1.56	4.41	4.85	5.07	5.29	5.95	6.84
.9	1.57	1.79	4.37	4.81	5.03	5.24	5.90	6.77
1.0	1.80	2.02	4.23	4.65	4.86	5.08	5.71	6.56
	2.03	2.28	4.50	4.95	5.18	5.40	6.08	6.98
	2.29	2.57	4.85	5.34	5.58	5.82	6.55	7.52
	2.58	2.90	5.20	5.72	5.98	6.24	7.02	8.06
	2.91	3.30	5.57	6.13	6.41	6.68	7.52	8.63
	3.31	3.70	5.93	6.52	6.82	7.12	8.01	9.19
	3.71	4.18	6.38	7.02	7.34	7.66	8.61	9.89
1.5	4.19	4.70	6.80	7.48	7.82	8.16	9.18	10.54
	4.71	5.35	7.32	8.05	8.42	8.78	9.88	11.35
	5.36	6.05	7.82	8.60	8.99	9.38	10.56	12.12
	6.06	6.85	8.40	9.24	9.66	10.08	11.34	13.02
	6.86	7.70	8.95	9.85	10.29	10.74	12.08	13.87
2.0	7.71	8.75	9.62	10.58	11.06	11.54	12.99	14.91
	8.76	9.90	10.30	11.33	11.85	12.36	13.91	15.97
	9.91	11.10	11.05	12.16	12.71	13.26	14.92	17.13
2.5	11.11	12.60	11.90	13.09	13.69	14.28	16.07	18.45
	12.61	14.20	13.10	14.41	15.07	15.72	17.69	20.31
	14.21	16.10	14.50	15.95	16.68	17.40	19.58	22.48
3.0	16.11	18.20	16.00	17.60	18.40	19.20	21.60	24.80
	18.21	20.60	17.70	19.47	20.36	21.24	23.90	27.44
	20.61	23.20	19.50	21.45	22.43	23.40	26.33	30.23
3.5	23.21	26.30	21.60	23.76	24.84	25.92	29.16	33.48
	26.31	29.70	24.00	26.40	27.60	28.80	32.40	37.20
4.0	29.71	33.50	26.50	29.15	30.48	31.80	35.78	41.08
	33.51	38.00	29.00	31.90	33.35	34.80	39.15	44.95
4.5	38.01	43.00	32.00	35.20	36.80	38.40	43.20	49.60
	43.01	48.50	35.80	39.38	41.17	42.96	48.33	55.49
5.0	48.51	55.00	40.50	44.55	46.58	48.60	54.68	62.78

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

CLEANED TUNGSTEN-3% RHENIUM WIRE
Processes 3% RW-55

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 179 8-1-62 (Rev.) *effective:* Jan. 14, 1963

subject to change without notice.

Mil Size Included in Range	WEIGHT IN MILLIGRAMS PER 200 mm From	To and Incl.	Price per Thousand Meters Based on Center Size Ordered — Weight Tolerance - Mgs/200 mm ± .03	± .025	± .02	± .015	± .01	± .005
	.37	.44	-	$ 8.40	$ 8.73	$ 9.06	$10.04	$11.39
.5	.45	.54	-	7.71	8.01	8.31	9.19	10.38
	.55	.67	$ 7.06	7.65	7.94	8.23	9.11	10.28

			Weight Tolerance - % ± 3	± 2-1/2	± 2	± 1-1/2	± 1	± 1/2
.6	.68	.83	$ 6.47	$ 6.99	$ 7.25	$ 7.50	$ 8.28	$ 9.31
.7	.84	1.02	6.31	6.81	7.06	7.31	8.06	9.07
	1.03	1.13	6.22	6.71	6.95	7.19	7.92	8.90
.8	1.14	1.26	6.19	6.67	6.91	7.15	7.88	8.84
	1.27	1.40	6.17	6.65	6.89	7.12	7.84	8.79
	1.41	1.56	6.15	6.62	6.86	7.09	7.80	8.75
.9	1.57	1.79	6.13	6.60	6.83	7.07	7.77	8.70
1.0	1.80	2.02	6.01	6.46	6.69	6.92	7.60	8.50
	2.03	2.28	6.32	6.80	7.04	7.28	8.01	8.97
	2.29	2.57	6.73	7.25	7.51	7.77	8.55	9.58
	2.58	2.90	7.14	7.70	7.97	8.25	9.09	10.20
	2.91	3.30	7.58	8.18	8.47	8.77	9.67	10.86
	3.31	3.70	8.00	8.64	8.95	9.27	10.22	11.49
	3.71	4.18	8.55	9.23	9.57	9.92	10.94	12.31
1.5	4.19	4.70	9.07	9.80	10.16	10.53	11.62	13.07
	4.71	5.35	9.68	10.46	10.85	11.25	12.42	13.99
	5.36	6.05	10.29	11.13	11.55	11.96	13.22	14.89
	6.06	6.85	10.99	11.89	12.34	12.79	14.14	15.93
	6.86	7.70	11.65	12.61	13.09	13.57	15.00	16.92
2.0	7.71	8.75	12.41	13.44	13.95	14.47	16.01	18.07
	8.76	9.90	13.25	14.35	14.90	15.45	17.11	19.31
	9.91	11.10	14.11	15.29	15.88	16.47	18.25	20.61
2.5	11.11	12.60	15.45	16.76	17.41	18.07	20.03	22.65
	12.61	14.20	16.84	18.28	19.00	19.72	21.88	24.77
	14.21	16.10	18.46	20.06	20.85	21.65	24.04	27.23
3.0	16.11	18.20	20.16	21.92	22.80	23.68	26.32	29.84
	18.21	20.60	22.11	24.06	25.03	26.00	28.92	32.82
	20.61	23.20	24.17	26.32	27.39	28.40	31.68	35.97
3.5	23.21	26.30	26.54	28.92	30.10	31.29	34.86	39.61
	26.31	29.70	29.27	31.91	33.23	34.55	38.51	43.79
4.0	29.71	33.50	32.07	34.99	36.44	37.90	42.27	48.10
	33.51	38.00	34.91	38.10	39.70	41.29	46.08	52.46
4.5	38.01	43.00	38.29	41.81	43.57	45.33	50.61	57.65
	43.01	48.50	42.54	46.48	48.45	50.42	56.32	64.20
5.0	48.51	55.00	47.77	52.23	54.45	56.68	63.36	72.27

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

• metallurgical products

Technical Information Bulletin

TUNGSTEN STRAND FOR VACUUM METALLIZING

SYLVANIA's high-performance tungsten stranded wire enables vacuum metallizers who wind their own coils to obtain greater shot life from their metallizing coils. Controlled processing of tungsten, from ore to finished wire, enables Sylvania to produce uniform wire with a controlled recrystallization rate.

Controlled recrystallization is extremely important in the vacuum-metallizing process because it produces a uniform flashover eliminating sagging and brittleness, which are the major causes of premature breakage during reloading and processing. The extremes of too fast or too slow recrystallization rates, which tend to cause brittleness in the wire, are virtually eliminated.

As an added safeguard to assure uniformity and freedom from splits, Sylvania employs the Magnatester, an electronic quality-control testing device in all of its wire production lines.

Strand is commercially smooth and free of slivers. It is supplied with a clean, bright finish free of visual contamination such as oxide and lubricants. (Bright surface cannot be guaranteed after receipt by purchaser because of the effect of varied storage conditions.)

The following standard sizes are now in production:

SIZE	RIGHT HAND LAY*	KILOGRAMS per 1000 meters	KILOGRAMS per 1000 feet	METERS PER KILOGRAM	FEET PER KILOGRAM
2 x 0.030″	½″	17.9	5.46	55.8	183.1
3 x 0.020″	5/16″	12.0	3.67	83.0	272.5
3 x 0.025″	⅜″	18.9	5.75	53.0	173.9
3 x 0.030″	½″	27.1	8.27	36.9	121.1
3 x 0.040″	15/16″	47.7	14.53	21.0	68.8
4 x 0.015″	¼″	9.1	2.78	109.6	359.7
4 x 0.020″	⅜″	16.0	4.87	62.6	205.3
4 x 0.030″	9/16″	36.0	11.00	27.7	91.1
3 x 0.025″ with 0.025″ aluminum core	⅜″	20.2	6.15	49.6	162.6
3 x 0.030″ with 0.025″ aluminum core	½″	28.1	8.58	35.5	116.6

1 foot = 0.3048 meters *1 meter = 3.2808 feet* *1 kilogram = 2.2046 lbs.*

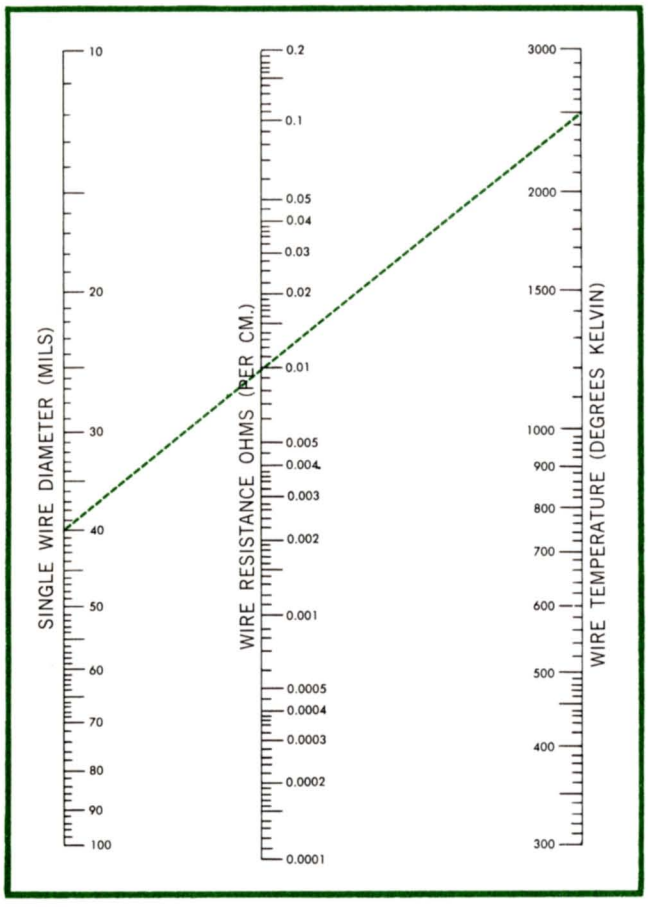
Size is indicated by the number of strands and the diameter of each strand. Current production facilities allow for further stranding of up to seven single strands. Greater number of strands may be supplied as multiple strand, for example, 3x7. Lay is the distance between the advance of any point in the strand for one complete turn.

Shipped in coils, or on wood spools when specified.

STANDARD COIL SIZE	
4 x 0.015″	7″ ID
3 x 0.020″	14″ ID
3 x 0.025″	14″ ID
3 x 0.030″	14″ ID

*Right Hand Lay — *Crevices between wires form a series of parallel lines downward from right to left when wire is held vertically.*

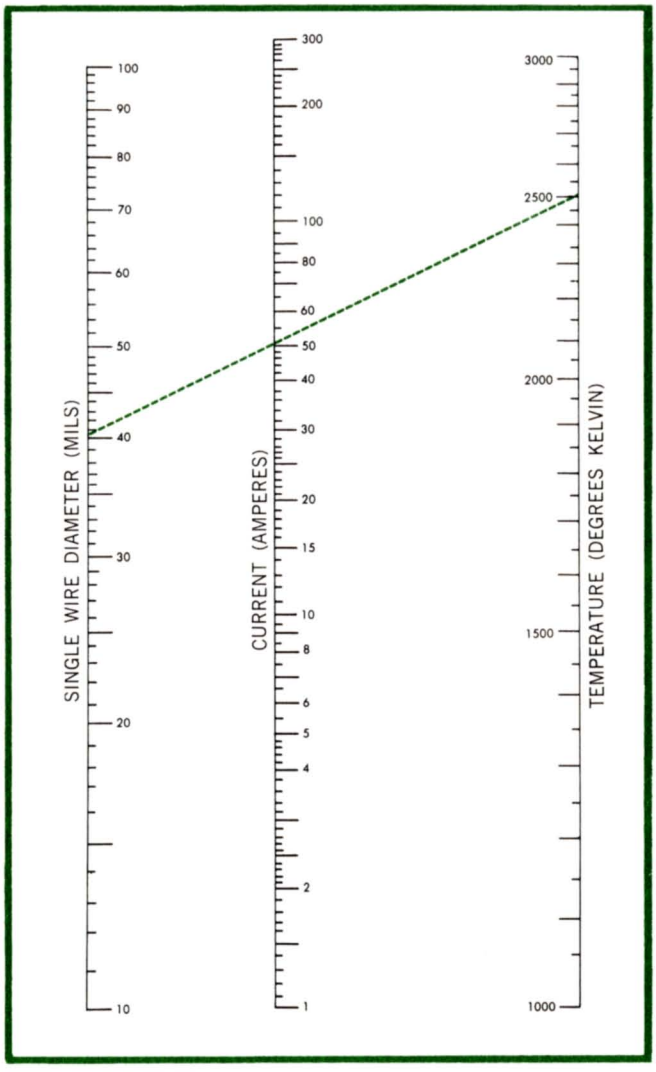
WIRE DIAMETER - RESISTANCE - TEMPERATURE NOMOGRAPH



Find the resistance per cm length of a 40 mil tungsten wire operating at 2500°K.

Answer: 0.0098

WIRE DIAMETER - CURRENT - TEMPERATURE NOMOGRAPH



Find the current required to obtain 2500°K in a 40 mil tungsten wire.

Answer: 50 amps.

To use the nomographs for stranded materials, you must find the equivalent single wire diameter of the stranded material by employing the following formula:

$$D = \sqrt{d^2 \times n}$$

D = the equivalent diameter of stranded material
d = the actual diameter of the single wire in mils
n = number of wires in the strand

CM 46 10/62 2.5 Printed in U.S.A.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN WIRE
FOR VACUUM METALLIZING

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 174 8-15-57 *effective:* January 1, 1963

subject to change without notice.

MULTIPLE STRAND - RANDOM LENGTH
CLEANED AND STRAIGHTENED

Size	Price per Kilogram	Equivalent Prices Per 1000 Meters	Per 1000 Ft.
2 x .030"	$42.50	$ 760.75	$233.75
3 x .020"	49.50	589.05	178.20
3 x .025"	45.95	859.27	261.92
3 x .030"	41.90	1,135.49	347.77
3 x .040"	41.00	1,955.70	594.50
4 x .015"	58.00	516.20	156.60
4 x .020"	50.50	808.00	247.45
4 x .030"	41.90	1,516.78	460.90
3 x .025" with .025" aluminum core	44.00	888.80	272.80
3 x .030" with .025" aluminum core	40.75	1,165.45	354.53

General Information

Size	Right Hand Lay	Kilograms Per 1000 Meters	Kilograms Per 1000 Feet	Meters Per Kilogram	Feet Per Kilogram
2 x .030"	1/2"	17.9	5.46	55.8	183.1
3 x .020"	5/16"	12.0	3.67	83.0	272.5
3 x .025"	3/8"	18.9	5.75	53.0	173.9
3 x .030"	1/2"	27.1	8.27	36.9	121.1
3 x .040"	15/16"	47.7	14.53	21.0	68.8
4 x .015"	1/4"	9.1	2.78	109.6	359.7
4 x .020"	3/8"	16.0	4.87	62.6	205.3
4 x .030"	9/16"	36.0	11.00	27.7	91.1
3 x .025" with .025" aluminum core	3/8"	20.2	6.15	49.6	162.6
3 x .030" with .025" aluminum core	1/2"	28.1	8.58	35.5	116.6

1 foot = .3048 meters 1 meter = 3.2808 feet 1 kilogram = 2.2046 lbs.

Price per kilogram will be the basis for billing. Equivalent prices are approximate, and are based on the figures in our general information.
Size is indicated by the number of strands and the diameter of each strand.
Standard lay is the distance between the advance of any point in the strand for one complete turn.
Shipped in coils, or on wood spools when specified.
Prices for stranded cut pieces and for other sizes of random length strand will be furnished on request.

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN WIRE
FOR VACUUM METALIZING

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pg. 176 7-15-57 *effective:* Jan. 1, 1963

subject to change without notice.

SINGLE STRAND - RANDOM LENGTH

AVAILABLE PROCESSES

VM-10 - Black Finish
VM-30 - Cleaned Finish, Unstraightened
VM-55 - Cleaned Finish, Straightened

Dia. Inches	Price per Kilogram			Equivalent Price/M Meters		
	VM-10	VM-30	VM-55	VM-10	VM-30	VM-55
.010	$48.45	$52.95	$57.42	$ 47.00	$ 51.36	$ 55.70
.015	44.29	47.53	50.77	97.00	104.08	111.18
.020	39.26	41.83	44.40	152.72	162.72	172.72
.025	37.80	40.26	42.71	229.45	244.39	259.26
.030	36.55	37.42	43.73	319.44	327.04	382.19
.035	34.80	35.65	40.46	414.14	424.25	481.49
.040	34.05	34.89	38.72	529.14	542.19	601.71
.045	33.30	34.13	37.30	655.00	671.32	733.67
.050	32.55	33.38	36.06	790.24	810.39	875.46

General Information

Dia. Inches	Meters per Kilogram	Feet per Kilogram
.010	1030.93	3333
.015	456.62	1493
.020	257.07	840
.025	164.74	541
.030	114.42	376
.035	84.03	275
.040	64.35	211
.045	50.84	167
.050	41.19	135

Diameter Tolerance ± 3% of weight or ± 1-1/2% of diameter.

Wire shipped on bands or in large-diameter coils.

Price per kilogram will be the basis for billing.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

TUNGSTEN PELLETS FOR VACUUM MELTING

SYLVANIA Tungsten Pellets are a high-purity, high-density form of tungsten designed particularly for use by vacuum melters. Due to their unusual degree of uniformity, however, the pellets are being used advantageously by alloy manufacturers employing air melting processes. In the manufacture of certain alloys, the low carbon content of Sylvania Tungsten Pellets is of great importance.

During the past few years manufacturers of the super critical high temperature alloys have had to tighten raw materials specifications as alloy specifications have tightened. They have found frequently that the variation in properties from lot to lot of scrap could not be tolerated, and assured supplies of uniform materials have been sought. Sylvania Tungsten Pellets were developed with these requirements in mind. Their size and shape permit easy weighing and handling. Their high density, approximately 70% of theoretical, assures a gas content well below that acceptable to vacuum melters. Finally, their uniformity will permit alloy producers to standardize their batch formulations from heat to heat.

CHEMICAL COMPOSITION

(EXCLUDING GASES)	SPECIFICATION	TYPICAL ANALYSIS
Tungsten, %	**99.9 Min.**	**99.95**
Molybdenum, %	**.05 Max.**	**.03**
Iron, %	**.007 Max.**	**.005**
Non-volatile matter, %	**.02 Max.**	**.01**

DENSITY	**12.0 g/cc Min.**	**12.5 g/cc**

PELLET SIZE – **11/16" diameter x 1/4" high (approx.)**

STANDARD PACKAGE – **400 lbs. net in 15 gallon, polyethylene-lined Leverpac drum, with clamped lid.**

AVAILABILITY – **Sylvania Tungsten Pellets are available for prompt shipment from Towanda, Pennsylvania.**

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN PELLETS

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Page 180 11-1-60

effective: June 28, 1961

subject to change without notice.

TUNGSTEN PELLETS

(99.9% Minimum Purity)

Any Quantity	$3.35/lb.

STANDARD PACKAGING

15-gallon polyethylene-lined
Leverpak drum, with clamped lid.
400 lbs. net capacity.

Minimum charge per item - $20.00

TUNGSTEN COATING BY VAPOR DEPOSITION

Sylvania can apply a coating of tungsten on various materials by the method known as "vapor deposition". This is a process in which an object to be coated is placed in a chamber which contains tungsten hexachloride vapor. The tungsten hexachloride is decomposed to elemental tungsten on the surface of the object by the proper application of heat.

A dense, high-purity coating of tungsten can be deposited on a wide variety of both metallic and nonmetallic substrates. We have worked out the technique for coating selective areas while leaving specified areas uncoated. In addition, the Sylvania process has excellent "throwing power", that is, the tungsten coating deposits uniformly on intricate surfaces such as the inside surfaces of holes, or on sharp edges.

Possible applications for tungsten coatings include:

1. Coatings to act as shields against X-ray or gamma radiation.
2. Coatings resistant to chemical attack.
3. Coatings for resistance to high temperatures in rocket nozzles or on vector control surfaces in missiles.
4. Tungsten coatings as an intermediate barrier layer to prevent interaction between a substrate and a desired primary coating.
5. Coated parts for high-temperature furnaces, such as boats, crucibles, or susceptors.
6. Abrasion-resistant coatings (where mechanical-impact properties are not severe).

PROPERTIES OF VAPOR-DEPOSITED TUNGSTEN COATINGS

Typical Chemical Composition

99.99% Tungsten, Minimum

Trace Elements, ppm		Gases, ppm	
Al	< 0.5	H_2	< 1
Ca	< 0.5	O_2	< 10
Cr	< 1	N_2	< 8
Cu	< 0.2		
Fe	< 1		
Mg	< 2		
Mo	< 6		
Ni	< 1		
Si	< 1		
As	< 3		
Na	< 2		
K	< 20		

Tungsten content is determined by difference. Trace elements are determined by spectrographic quantitative analysis. Gases are determined by vacuum-fusion analysis.

Hardness DPH (100-gram load) 350 to 390

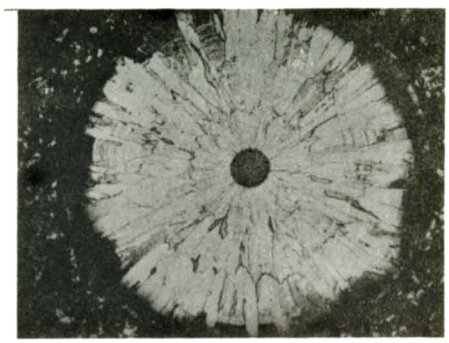
Density Sylvania vapor-deposited tungsten coatings exhibit theoretical density of 19.2g/cc.

Porosity None.

Grain Structure

Vapor-deposited tungsten has a columnar grain structure with the long axis of the grain normal to the surface of the substrate. High-temperature heat treatment of the as-deposited tungsten results in a change to an equiaxed grain structure. This change occurs in the temperature range 1500°C to 2200°C depending on the time at temperature. The following photomicrographs illustrate these typical grain structures.

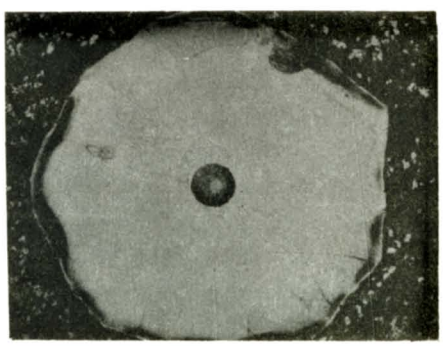
Tungsten coating, as deposited



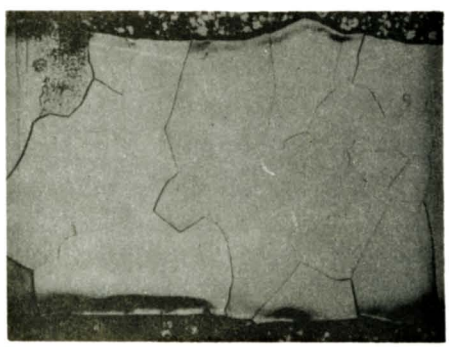
TRANSVERSE, INNER CORE TUNGSTEN WIRE, MAGNIFICATION 35X

LONGITUDINAL MAGNIFICATION 35X

Tungsten coating, after heat treatment at 2200°C for less than 5 minutes



TRANSVERSE, INNER CORE TUNGSTEN WIRE, MAGNIFICATION 35X



LONGITUDINAL MAGNIFICATION 35X

Since vapor-deposited tungsten coating is unworked, it does not have the strength of wrought tungsten, therefore, its use is not recommended in applications involving impact or high stress loading.

AVAILABILITY OF TUNGSTEN COATINGS

Substrate Materials

Sylvania has successfully applied tungsten coatings to:

tungsten	nickel
molybdenum	copper
titanium	silicon
tantalum	silica
niobium	graphite
inconel	

At present, the only substrate materials that we have been unable to coat are:

1. Iron, steel, or other ferrous alloys
2. Materials that melt or decompose below 800°C

Size of Object to be Coated

There is theoretically no limitation on the size of the object that can be coated. Our present equipment limits us to objects that can be contained within a cylinder 14 inches in diameter by 18 inches long.

Thickness of Coating

Theoretically there is no limitation. We have deposited tungsten coatings 0.070 inches thick. Thicker coatings can be supplied. There is, however, an approximately direct relationship between coating thickness and cost. In general, coatings are uniform; however, at the present time, no specific tolerances on coating thickness have been established. Tolerance will vary with the shape of the object to be coated and with coating thicknesses. Requests for quotations on coating should specify nominal or maximum or minimum thickness.

INFORMATION REQUIRED FOR PREPARATION OF QUOTATION

1. Submit sketch, print, or sample of object to be coated.
2. Describe composition of object to be coated.
3. Specify required quantity.
4. Specify nominal thickness of tungsten coating.
5. Indicate specific areas to be coated.
6. If possible, describe application or performance that is expected.

AMMONIUM MOLYBDATES

The composition of ammonium molybdates, formed by the reaction of molybdenum trioxide and ammonium hydroxide, ranges from relatively simple compounds to complex, condensed isopolymolybdates. Normal or simple molybdate ions exist in basic solution as $[MoO_4]^{2-}$. With increasing acidity, condensation results in the formation of paramolybdate $[Mo_7O_{24}]^{6-}$ and polymolybdate $[Mo_8O_{24}]^{4-}$ ions. More highly polymerized polymolybdates form in acid solutions of pH 1.0 or less. Orthomolybdates $[M_2MoO_4 \cdot xH_2O]$, tetramolybdates $[M_4(Mo_8O_{26})xH_2O]$, and paramolybdates $[M_6(Mo_7O_{24}) \cdot xH_2O]$ exist as solid crystalline compounds. Other polymolybdates are known to exist but are not so well defined.
Sylvania's ammonium molybdates are condensed products in the form of white, high-purity crystalline powders. These are a water-soluble ammonium paramolybdate and a water-insoluble ammonium polymolybdate. Their availability provides a source of high-purity, alkali-free molybdenum for applications in diverse chemical and metallurgical processes.

AMMONIUM PARAMOLYBDATE

Ammonium paramolybdate corresponds to the formula

$$(NH_4)_6Mo_7O_{24} \cdot xH_2O$$

where the anhydrous material has a molecular weight of 1164. In Sylvania's commercial product, the water content, x, is controlled to a minimum of 4 in order to insure maximum water solubility.

Chemical Composition

MoO_3	81.0-83.0%
Ignition loss at 525°C in air	19.0% maximum
Insoluble in hot water	0.005% maximum
Non-volatile matter (NVM)	0.01%

Impurity Content*

		Typical Analysis, %	Specification Maximum, %
Alkali Metals	Na	<0.0005	0.0005
	K	0.0015	0.0030
Alkaline Earth Metals	Ba	<0.0004	0.0004
	Ca	0.0002	0.0005
	Mg	0.0001	0.0003
	Sr	<0.0010	0.0010
Other Metallic Impurities	Al	0.0005	0.0010
	Cu	<0.0005	0.0005
	Cr	<0.0005	0.0005
	Fe	<0.0005	0.0010
	Pb	<0.0005	0.0005
	Mn	<0.0001	0.0001
	Ni	<0.0004	0.0004
	Si	0.0011	0.0020
	Sn	<0.0006	0.0010

*Determined by spectrographic quantitative analysis after reduction of molybdate to molybdenum metal in H_2 atmosphere.

Physical Properties

Appearance—white; granular; 100% passes 60 mesh
Bulk Density—18-19 g/in^3; 69-73 lb/ft^3
Melting Point—none—decomposes to MoO_3 upon heating
Solubility; Aqueous Saturated Solutions

MoO_3 Basis, 25°C—0.47 g/cc; 3.9 lb/gal
50°C—0.99 g/cc; 8.2 lb/gal
70°C—1.77 g/cc; 14.7 lb/gal

Note: At temperatures above 40°C, decomposition occurs and some molybdenum trioxide precipitates.

pH (5% to 25% Aqueous Solutions, 25°C)—5.2 ± 0.1

Applications

Ammonium paramolybdate is a water-soluble chemical which should be particularly useful in the preparation of catalysts for a variety of chemical and petroleum processes. The applications for molybdenum in various forms as a principal catalyst or promoter for other catalysts are extensive. Molybdenum catalysts are used commercially in processes involving oxidation, hydrogenation, dehydrogenation, isomerization, cyclization, chlorination, and condensation. Other processes where molybdenum catalysts may be used are polymerization, alkylation, desulfurization, and dehydration. Catalyst preparation with ammonium paramolybdate solutions involves impregnation of suitable carriers followed by the normal processing to remove ammonia and water and conversion to alkali-free, active oxides of molybdenum. Molybdenum chemicals may also be precipitated or co-precipitated for catalyst use with other active ingredients from paramolybdate solutions.

The effectiveness of molybdate ions as non-oxidizing, non-reducing, corrosion-inhibiting agents in aqueous and organic solutions is well established. Water-soluble ammonium paramolybdate is suggested as a starting material for the preparation of corrosion-inhibiting pigments or chemicals. In the metallurgical industry, ammonium paramolybdate is used for the preparation of high-purity molybdenum powder by hydrogen reduction. In the chemical industry, it is suggested as a starting material for manufacturing a variety of high-purity molybdenum chemicals such as polymolybdates and organomolybdenum dye complexes. Its high purity suggests its use as an analytical reagent. Electroplating applications have also been reported.

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AMMONIUM POLYMOLYBDATE

Sylvania's ammonium polymolybdate is a more condensed product than the ammonium paramolybdate. The structure has not been determined, but it is characterized by a higher molybdenum trioxide content.

Chemical Composition

MoO_3	88-93%
Ignition loss at 525°C in air	12% maximum
Non-volatile matter (NVM)	0.01%

Impurity Content*

		Typical Analysis, %	Specification Maximum, %
Alkali Metals	Na	<0.0005	0.0010
	K	0.0050	0.0100
Alkaline Earth Metals	Ba	<0.0004	0.0004
	Ca	0.0005	0.0007
	Mg	0.00008	0.0002
	Sr	<0.0010	0.0010
Other Metallic Impurities	Al	<0.0010	0.0010
	Cu	<0.0005	0.0005
	Cr	<0.0005	0.0005
	Fe	<0.0005	0.0007
	Pb	<0.0005	0.0005
	Mn	0.0002	0.0005
	Ni	<0.0004	0.0004
	Si	0.0007	0.0020
	Sn	<0.0006	0.0010

*Determined by spectrographic quantitative analysis after reduction of the molybdate to Mo metal in H_2 atmosphere.

Physical Properties

Appearance—white; granular; 100% passes 60 mesh
Bulk Density—12-13 g/in^3; 46-50 lb/ft^3

Applications

Ammonium polymolybdate is a water-insoluble material of essentially the same purity as ammonium paramolybdate. The higher oxide content and insolubility suggest that it may be advantageously used in metallurgical processes for the preparation of high-purity molybdenum powder and metal. It is suggested also as a source of high-purity molybdenum for other solid-state reactions requiring molybdenum.

AVAILABILITY

Production quantities are available on short notice. Experimental samples can be supplied immediately. Standard packaging is in polyethylene-lined, 24-gallon Lever-Pak drums, 300 pounds per drum.

TOXICITY

Molybdenum or molybdenum compounds are not considered industrial health hazards. However, inhalation or ingestion of large amounts should be avoided.

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GENERAL TELEPHONE & ELECTRONICS

CHEMICAL AND METALLURGICAL DIVISION, TOWANDA, PENNA.

BOSTON, 100 Sylvan Road, Woburn, Mass.
CHICAGO, 2001 N. Cornell Ave., Melrose Park, Ill.
DAYTON, 333 West First Street, Dayton 2, Ohio
DETROIT, 7800 Intervale Ave., Detroit, Michigan
NEW YORK, 1000 Huyler Street, Teterboro, N. J.
PHILADELPHIA, 4700 Parkside Ave., Philadelphia 31, Penna.
PITTSBURGH, 300 Mt. Lebanon Blvd., Pittsburgh, Penna.
SAN FRANCISCO, 1811 Adrian Road, Burlingame, Calif.
TOWANDA, Towanda, Penna.

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Printed in U.S.A.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

AMMONIUM PARAMOLYBDATE

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pg. 108 11-20-61

effective: Jan. 11, 1963

subject to change without notice.

AMMONIUM PARAMOLYBDATE

Quantity	Price/Lb.
Less than 300 lbs.	$2.02
300 lbs. up to 1,500 lbs.	1.42
1,500 lbs. up to 15,000 lbs.	1.41
15,000 lbs. and over	1.40

STANDARD PACKAGING: 300 lbs. in a 24-gallon Leverpak Drum.

MINIMUM CHARGE PER ORDER - $25.00

SYLVANIA

CHEMICAL AND METALLURGICAL DIVISION

NEW PRODUCT DATA

TUNGSTEN DISULFIDE, WS_2

Sylvania's tungsten disulfide is a soft, greyish-black powder which is synthetically produced. It resists oxidation at high temperatures while exhibiting outstanding lubrication properties. These properties make it a new and useful addition to the growing list of commercially available chemicals for high temperature applications.

Chemical Composition

	Specification	Typical Analysis	Theoretical
Tungsten, %	73.0 min.	73.8	74.18
Sulfur, %	27.0 max.	26.2	25.82
Total Impurity Content, %	0.5 max.	<0.2	—

Physical Properties

Molecular Weight 248.02
Particle Size, Fisher Sub-Sieve Size, microns 1-2
Absolute Density, grams/cc .. 7.4
BET, Specific Surface Area, m^2/g 1.5-3.0
BET, Calculated Average Diameter, microns 0.20-0.50
Melting Point ..... Decomposes in air starting at 460°C
Crystal Structure ..... Laminar, layer-lattice type, alternate layers of W and S

CHEMICAL PROPERTIES

Tungsten disulfide is relatively inert and unreactive. It is insoluble in water, hydrochloric acid, and organic solvents. It is soluble in hot, strong oxidizing agents such as aqua regia, concentrated sulfuric acid, and nitric acid. The material dissolves also in fused alkali and a mixture of nitric and hydrofluoric acid. Heating in air or in the presence of oxygen oxidizes WS_2 to tungsten oxide.

THERMAL STABILITY

Available data indicate that WS_2 has an advantage over other materials of its type in its resistance to oxidation. After two hours' exposure in air at 427°C, the material loses only 1.2% of its original sulfur content and decomposes steadily, as indicated by sulfur losses, until about 1160°C. After two hours at 538°C, WS_2 retains 22% of its original sulfur content. In contrast, oxidation of MoS_2 starts at 360°C and is complete at 480°C. Molybdenum disulfide loses 77% of its original sulfur content after two hours at 427°C, and 100% after two hours at 482°C.

LUBRICATING PROPERTIES

Tungsten disulfide has the ability to form adherent, soft, continuous films on surfaces and exhibits lubricating properties similar to those of molybdenum disulfide. Published values of the coefficient of friction are indicative of a low-shear strength structure which is characteristic of weak atomic bonding and of laminar or layer-lattice structure. Investigations have shown that the fundamental mechanism of lubrication is in fact similar to that of MoS_2 and graphite.

SUGGESTED APPLICATIONS

Sylvania's tungsten disulfide is a source of tungsten in a form previously available only on a limited scale. It should be a versatile addition to the expanding list of tungsten chemicals for high temperature applications.

In the field of high temperature lubrication, it is potentially useful as a solid lubricant either in solid-film form or as an additive to suitable carriers. Its relatively high resistance to oxidation, its chemical inertness and lubricity make it particularly interesting. Applied as a dry powder or suspension, it can be an effective lubricant in wire drawing, metal forming, metal cutting, metal working, valves, gears, bearings, etc.

Tungsten disulfide is also potentially useful as a catalyst in a variety of reactions including hydrogenation, isomerization, desulfurization, and aromatization in the

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petroleum and petrochemical industry. Sylvania's tungsten disulfide may have particular applicability in the catalyst field because it is synthetically produced as a high purity chemical.

Other potential uses lie in the preparation of high purity tungsten metal by reduction in a hydrogen atmosphere. Similarly, high purity tungsten chemicals may be prepared by oxidation in air or oxygen or other active gas streams such as chlorine.

AVAILABILITY

At the present time, one grade is available. Consideration will be given to other requirements with respect to purity, chemical composition or physical characteristics. Experimental quantities of one to ten pounds are available immediately; larger quantities can be supplied on short notice.

Standard packaging is in polyethylene-lined metal pails of one and 3½ gallons containing up to 5 pounds and 25 pounds of tungsten disulfide respectively.

TOXICITY

Tungsten or tungsten compounds in general are not considered industrial health hazards. However, inhalation or ingestion of large amounts of tungsten compounds should be avoided.

OTHER SYLVANIA TUNGSTEN CHEMICAL PRODUCTS

SODIUM TUNGSTATE

PHOSPHOTUNGSTIC ACID

TUNGSTIC ACID

TUNGSTIC OXIDE

AMMONIUM PARATUNGSTATE

AMMONIUM METATUNGSTATE

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CHEMICAL AND METALLURGICAL DIVISION, TOWANDA, PENNA.

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Pittsburgh, Penna.

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Burlingame, Calif.

TOWANDA
Towanda, Penna.

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SYLVANIA ELECTRIC PRODUCTS INC.
Chemical and Metallurgical Division
Towanda, Pennsylvania

Technical Information Supplement
November 1, 1961
Revised, September 27, 1962

TUNGSTEN DISULFIDE

I. LITERATURE REFERENCES

A number of references to the properties and uses of WS_2 in lubricants and catalysts are given in Appendix I. Other references pertain to thermal properties.

II. THERMAL STABILITY

A comparison of the thermal stability of WS_2 and MoS_2 is shown in Appendix II. Tungsten disulfide and molybdenum disulfide were compared by thermogravimetric analysis and oxidation in air over a range of temperatures. The data show that WS_2 has an advantage of about 200°F over MoS_2 with respect to thermal stability and resistance to oxidation at elevated temperatures.

III. LUBRICANT APPLICATIONS

The greatest potential usefulness and advantages of WS_2 as a lubricant appear to lie in its thermal stability and resistance to oxidation at elevated temperatures.

A. Lubricant Formulation and Test Data

Sylvania does not formulate or test lubricants. However, WS_2has been evaluated by private and government organizations. In general, the results show that WS_2 has potential both as a solid-film lubricant and as an additive to grease or oil. Optimum utilization may well depend on formulation, method of application and the nature of the application.

In dry- or solid-film applications, WS_2 may form thin films which can result in abbreviated lubricant film life. It is suggested that modification or formulation of the WS_2 with sulfur or sulfur-containing compounds may be advantageous for optimum film life. Metallic sulfides in general, and iron sulfide in particular, may be suitable additives. The generally accepted mechanism of lubrication ascribed to WS_2 and MoS_2 tends to support this approach. Both materials depend on the presence of an amorphous sulfur layer and the tendency of sulfur to bond to the surfaces to be lubricated. Sylvania's WS_2 is of relatively high purity, and does not contain excess sulfur. Therefore, formulation with sulfur-containing compounds may be beneficial.

As an additive in grease or oil, WS_2 exhibits lubrication properties which are at least equivalent to those shown by MoS_2. The extent to which the high-temperature properties of WS_2 can be exploited is dependent on the carrier grease or oil. Optimum formulation for a particular application may be even more important than in the case of dry film.

Very little non-proprietary test data are available to us. Dry film lubrication was evaluated by an oscillation test using polished steel washers. The washers were coated by hand-rubbing in WS_2 powder and oscillated to seizure under a load of 150 psi and 23.5 oscillations per minute. Films of WS_2 tended to be thin and resulted in short life. This may indicate a limited affinity for the type of metal/steel used. The same oscillation test, using a 3% WS_2 addition to a lithium multipurpose grease gave

results equivalent to those obtained with a fine grade of MoS_2. Similar results were obtained using this grease in a 4-ball E.P. test, U. S. Steel Procedure (abbreviated). All tests were conducted at room temperature.

Tungsten disulfide has also been evaluated at high temperature using a suspension of 1/2% WS_2 by weight in a high-temperature oil. A high-speed, high-temperature ball-bearing rig was used. Above 900°F, friction did not increase rapidly as in the case of 1/2% MoS_2 in the same high-temperature oil (4)*.

Superior sliding friction characteristics are obtained from WS_2 at elevated temperatures in both air and argon (12). MoS_2 was elevated in comparison. In air, the friction coefficient of WS_2 remained below 0.1 until about 1100°F. For MoS_2, the coefficient of friction increased sharply and rose above 0.1 in the 600-700°F temperature range. In argon, the friction coefficient of WS_2 remained below 0.1 at temperatures to about 1500°F; with MoS_2, the coefficient of friction rose above 0.1 at about 900°F.

Tungsten disulfide was evaluated on molybdenum and on 3135 steel on a Falex machine at room temperature, at 290 rpm, and under a load of 1,000 pounds (13). Endurance life on molybdenum was greater than that achieved with MoS_2 and other metallic sulfides. Tungsten disulfide shows a preferential lubricating effect on molybdenum and its alloys. A similar effect is indicated on tungsten and its alloys.

B. Coefficient of Friction

A steady-state value for the coefficient of friction in vacuum is reported as 0.065 (2). Other values are given in the literature, ranging from 0.05 to 0.28 (5,6,10).

The friction coefficient, as determined by the press-fit method, ranges from 0.025 to 0.07.

C. Effect of Environmental Conditions

Vacuum - The lubricity of WS_2 in vacuum is said to be essentially similar to that of MoS_2 (2). Tungsten disulfide is reported to be a good lubricant in vacuum primarily because of an internally generated, adsorbed sulfur film.

Low Temperatures - No data are available for the behavior of WS_2 at temperatures below freezing. M. T. Lavik, et al, report the coefficient of friction at 1°C (2). In the light of the adsorbed sulfur layer concept, lower temperatures would not be expected to affect adversely the lubrication of WS_2.

D. Specific Gravity

The specific gravity of Sylvania's tungsten disulfide is 7.4 g/cc, and is listed as Absolute Density in the New Product Data Sheet.

* Numbers in parentheses refer to Appendix I.

VC:MMW
9/27/62

APPENDIX I

Literature References - Tungsten Disulfide

1. V. R. Johnson, M. T. Lavik/G. E. Vaughn, J. App. Phys. 28, 821 (1957); Mechanism of WS_2 Lubrication in Vacuum.

2. M. T. Lavik, G. E. Gross/G. W. Vaughn, Lubrication Engineering (June 1959); Investigation of the Mechanism of Tungsten Disulfide Lubrication in Vacuum.

3. M. B. Petersen, Apex-569 (February 1958), General Electric Aircraft Nuclear Propulsion Dept., Investigation of Solid Film Lubricants and Sliding Contacts at Temperatures above 1000°F.

4. J. B. Accinelli, S. J. Beaubien, Final Report, April 1960-March 1961, Department of Navy, Bureau of Naval Weapons Contract No. No_W 60-0270-C, S-13831, Shell Development Co.; Fundamentals of High Temperature Bearing Lubrication.

5. S. L. Cosgrove, L. B. Sibley/C. M. Allen, ASLE Transactions, Vol. 2, No. 2, pp. 217-224; Evaluation of Dry Powdered Lubricants at 1000°F in a Modified Four-Ball Wear Machine.

6. M. B. Petersen, R. L. Johnson, NACA Technical Note 3334 (1958) PB116114; Friction of Possible Solid Lubricants with Various Crystal Structures.

7. N. Parravano/G. Malquori, Atti. Accad. Lincei [6], 7, pp. 189-92 (1928); C. A. Vol. 22, 2507 (1928); Equilibrium of the Reduction of Tungsten Bisulfide by H_2.

8. Picon, Compt. Rend., Vol. 189, pp. 96-98 (1928); C. A. 24, 33 (1930) Action of High Temperature on Some Metallic Sulfides.

9. K. K. Kelly, U. S. Bureau of Mines Bull. No. 406, 154 pp. (1937); C. A. 32, 1559 (1938); Data of Theoretical Metallurgy VII: The Thermodynamic Properties of Sulfur and Its Inorganic Compounds.

10. M. B. Petersen/R. L. Johnson, Lubrication Eng. 11, pp. 325-30 (1955); C. A. Vol. 50, 1296 (1956); Factors Influencing Friction and Wear with Solid Lubricants.

11. B. C. Stupp, Lubrication Eng. 14, pp. 159-63 (1958); C. A. Vol. 52, 12380 (1958); MoS_2 and Related Solid Lubricants.

12. R. L. Johnson/H. E. Sliney, Ceramic Bulletin, 41, No. 8, pp. 504-508 (1962); Ceramic Surface Films for Lubrication at Temperatures to 2000°F.

13. W. M. Stocker Jr., American Machinist/Metalworking Manufacturing June 11, 1962, pp. 101-104.

APPENDIX II

COMPARISON OF THE STABILITY OF MoS_2 AND WS_2

Thermogravimetric Analysis Data

On thermogravimetric analysis of molybdenum disulfide, the first inflection point indicating a weight loss occurs at 662°F (350°C). The loss in weight is extremely slow until a temperature of 716°F (380°C) is reached. Thereafter, weight is lost at a steady rate until a temperature of 1436°F (780°C) is reached. A gain in weight is indicated after that.

In contrast to MoS_2, tungsten disulfide begins to lose weight slowly and at a steady rate at 860°F (460°C). Decomposition as indicated by loss in weight occurs steadily up to about 2120°F (1160°C) and then there is indicated a gain in weight.

Oxidation of WS_2 and MoS_2 in Air

Data on the oxidation of WS_2 and MoS_2 in air were obtained by exposing the sulfides simultaneously for two hours in a tube furnace at temperatures ranging from 400° to 1000°F.

	MoS_2			WS_2		
Temperature, °F	%Mo	%S	%S Lost	%W	%S	%S Lost
Unfired Control	59.41	39.6	-	74.35	25.6	-
400	59.45	39.6	-	74.36	25.6	-
500	59.39	39.7	-	74.35	25.6	-
600	59.33	39.7	-	74.37	25.6	-
700	60.16	34.8	12.1	74.37	25.6	-
800	64.43	9.2	76.7	74.69	25.3	1.2
900	66.28	<0.1	100	75.65	18.4	28.1
1000	66.93	<0.1	100	78.12	5.7	77.7
Theoretical %W in WO_3				79.30		
Theoretical %Mo in MoO_3	66.05					

The data correlate reasonably well with that obtained by thermogravimetric analysis. Under the test conditions, MoS_2 lost a significant amount of sulfur at 700°F. This corresponds to the temperature range of 662°F-617°F, indicated by TGA. Similarly, WS_2 lost weight significantly between 800° and 900°F, corresponding to the 860°F temperature indicated by TGA.

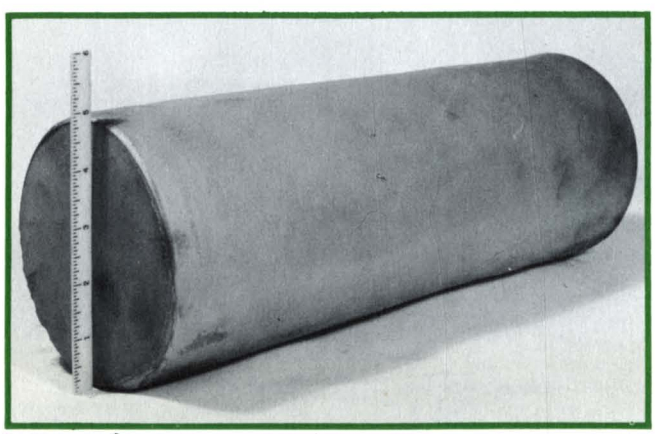
SYLVANIA
refractory metals
Technical Information Bulletin

ISOSTATIC PRESSING AND SINTERING OF REFRACTORY POWDER METALS

HIGH TEMPERATURE METALS, generally known as refractory metals, are being tested for new applications in the arc casting, forging, and electronics industries. The growing needs of the nation's missile and space programs have created an increased demand for metal parts of unusually large size and weight which have the ability to perform at extremely high temperatures.

Tungsten and molybdenum, two of the most promising refractory metals, and their alloys, are available in powder, pellet, rod, wire, and ingot, billet or electrode forms; the latter three are becoming increasingly important because of the ability of manufacturing firms, like Sylvania, to press, sinter, machine, or otherwise shape these metals in hitherto unheard-of sizes, shapes, and forms.

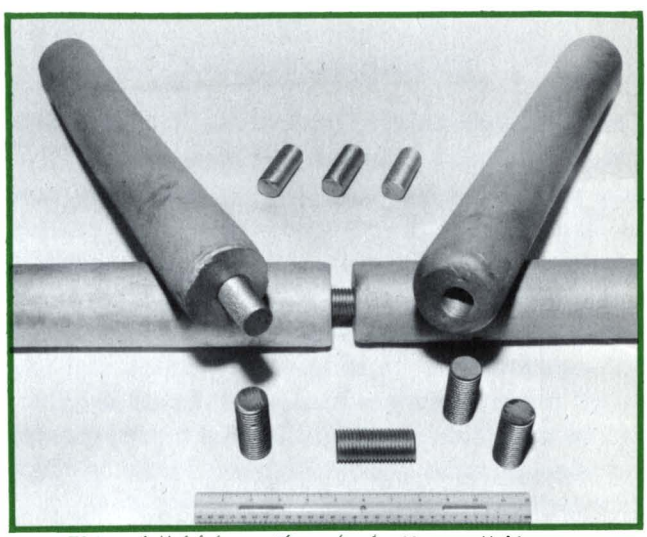
Sylvania's Chemical and Metallurgical Division developed the isostatic pressing and sintering operation to serve the requirements of the arc caster, forger, extruder, roller, and machinist. Further research and development in this field either through the use of Sylvania's products, production facilities, or engineering services are encouraged and welcomed. A complete tabulation of manufacturing capabilities is listed within.



Tungsten Forging Billet, 140 pounds, Value $1000.

TYPES OF REFRACTORY METALS

SYLVANIA can provide ingots, billets, and electrodes of pure tungsten or molybdenum, 50-50 (50% molybdenum plus 50% tungsten), or any other combination containing solid solutions of tungsten and molybdenum, and alloys of tungsten and molybdenum with rhenium and osmium. Dispersiods of tungsten or molybdenum with various metallic oxides, such as thoria (ThO_2), and other metals can be provided. Tantalum and its alloys with tungsten and molybdenum as well as certain alloys of tungsten,



70-Pound Molybdenum Electrodes for Vacuum Melting.

molybdenum, or tantalum with titania, hafnium, zirconium, and columbium may be pressed and sintered. Most refractory metal powders can be isostatically pressed and sintered to practically any shape within the dimensional capabilities of existing equipment. All metal powder combinations containing tantalum, titanium, hafnium, or columbium cannot be sintered in a hydrogen atmosphere because of the formation of hydrides. However, a vacuum furnace may be used for those combinations which form hydrides.

SIZES AND SHAPES

SYLVANIA'S new isostatic pressing and sintering operation makes possible a wide variety in sizes and shapes available for direct work by arc casters, forgers, extruders, rollers, and machinists. Rectangular, cylindrical, or hollow cylindrical shapes can be produced readily. Special sizes and shapes are handled on a special inquiry basis.

The maximum sizes of sintered refractory materials, which we can currently supply, are shown in the following table:

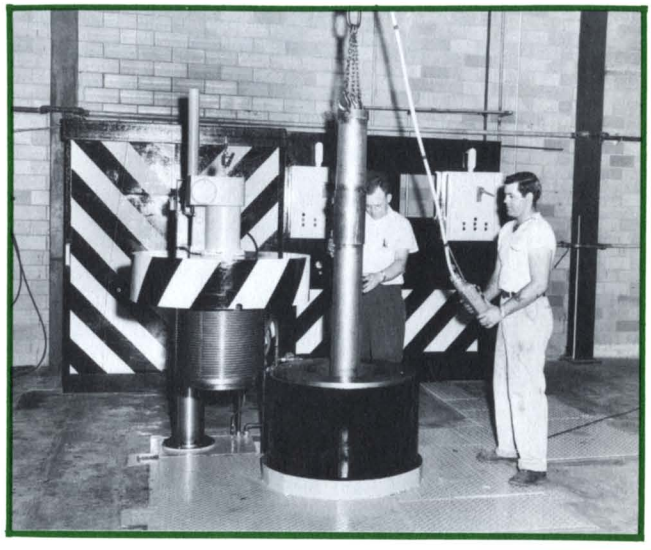
	Maximum
Vacuum Sintered	6" diam. x 8" long
Hydrogen Sintered	10" diam. x 48" long

TECHNICAL SERVICE

TO HELP EXPAND the applications for refractory metals, Sylvania's Chemical and Metallurgical Division is prepared to assist you in developing new products utilizing the isostatic pressing and sintering operation. We can furnish densities, and chemical and spectrographic analysis information and plan to supply other typical physical and chemical data as it becomes available. In addition, Sylvania's vast and varied production experience, in all forms of refractory metals, from powder to sintered ingots, provide a basic and firm background for future product development.

EQUIPMENT

ISOSTATIC PRESS Sylvania's largest isostatic press consists of a 15 inch diameter by 7 foot deep chamber into which is inserted a form or mold containing metal powder. A screw plug closes the chamber and hydraulic pressure is applied, forcing the powder to conform to the shape of the mold or form. The dimensions of the mold are determined by the customer's requirements.



Large Isostatic Press

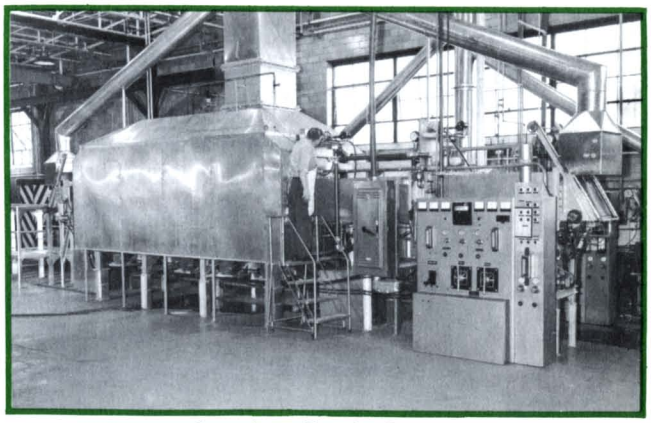
VACUUM SINTER FURNACE The vacuum sintering furnace consists of a chamber containing heating elements and a vacuum pumping system capable of reducing the chamber pressure to one micron. This furnace can maintain temperatures up to 2000° C.

SYLVANIA

refractory metals

HYDROGEN SINTER FURNACE The hydrogen sintering furnaces consist of an entrance chamber, a heating zone, and a cooling chamber, all with a hydrogen atmosphere. These furnaces were designed to sinter molybdenum in a minimum time. Tungsten requires a longer sintering period to obtain the same relative density ranges. Higher temperature sintering furnaces are now being developed so that tungsten can be sintered more rapidly. The isostatically pressed ingot, billet, or electrode is passed along a series of conveyors and fed into the hydrogen furnace. The ingot is sintered under a controlled temperature for a specified time, determined by customer requirements. It is then moved into the cooling zone of the furnace where it must remain until cooled below the oxidation temperature of the metal.

Sylvania's Chemical and Metallurgical Division has worked with selected equipment manufacturers in the development and construction of the equipment mentioned above and also other apparatus such as the molds necessary to make the varied shapes required. The years of experience in the production of the established forms of tungsten and molybdenum have enabled us to be a leader in this new field.



Large Ingot Sintering Furnace

ADVANTAGES

ISOSTATIC PRESSING and sintering of refractory metals offers the following advantages:

1. Flexibility of shapes.
2. A fine grain structure which allows direct physical working of the material by rolling, forging or extruding.
3. A smooth, clean, carbide-free, surface which, for most applications, eliminates the need for costly surface machining.
4. The ability to make more combinations of materials without the danger of losing a significant percent of a component by volatilization, or through granular segregation in the ingot as is the case in some other methods of fabrication.
5. Ability to produce variation of densities.
6. A relatively inexpensive process which results in lower price per pound over competitive processes.

POTENTIAL APPLICATIONS

Listed below are some of the present and potential fields of applications known for refractory metals:

- Jet engines
- Rockets
- Industrial furnaces
- Solid fuel motors
- Electronic tube parts
- Electrical contacts
- Furnace windings
- Forging dies
- Corrosion resistant equipment
- Furnace boats
- Gas turbine engines
- Lamp filaments
- Carbides
- Welding electrodes
- Metallizing coils
- Flame spray coatings
- Piercing points for seamless tubing

Sylvania's Chemical and Metallurgical Division welcomes and encourages your inquiries on all forms of refractory materials.

CM 3 1/60 2.5 Printed in U.S.A.

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TOWANDA Towanda, Penna.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM POWDER

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 202 3-15-61 *effective:* March 25, 1963

subject to change without notice.

MOLYBDENUM POWDER - HYDROGEN REDUCED

Grade 390 $3.55/lb.

* * * * * * *

PROCESS DESCRIPTION

This powder contains a minimum of 99.95% molybdenum, with all remaining impurities controlled to ultimate minimums. It is processed by the hydrogen-reduction of ammonium molybdate. This powder is used in specialized electronic applications; for consumable arc-casting electrodes; and in pressed and sintered billets for forging and rolling where the physical properties and chemical composition are of extreme importance.

PHYSICAL PROPERTIES

Standard Screen Size	Typical Particle Size by Fisher S.S.S.
100 mesh	3.5 to 5.5 microns

CHEMICAL COMPOSITION

	Molybdenum	99.95% min.	
Aluminum	10 ppm max.	Lead	10 ppm max.
Calcium	10 ppm max.	Magnesium	10 ppm max.
Carbon	50 ppm max.	Manganese	10 ppm max.
Chromium	50 ppm max.	Nickel	50 ppm max.
Copper	10 ppm max.	Silicon	50 ppm max.
Iron	50 ppm max.	Tin	50 ppm max.

PACKAGING

Standard Containers: 3-1/2 gallon steel pail - approximately 75 lbs.
18 gallon steel drum - approximately 300 lbs.

Other grades and mesh sizes available upon request.

Minimum charge per item - $10.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM-TUNGSTEN ALLOY POWDER

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: Aug. 15, 1960

subject to change without notice.

MOLYBDENUM-TUNGSTEN ALLOY POWDER
Hydrogen Reduced

	Grade No.	Composition	Price/lb.
MA-28 Series 99.8% Pure	2870	70% Mo/30% W	$3.50
	2850	50% Mo/50% W	3.50
	2830	30% Mo/70% W	3.50
MA-39 Series 99.9% Pure	3970	70% Mo/30% W	$3.71
	3950	50% Mo/50% W	3.65
	3930	30% Mo/70% W	3.59

Special types available upon request.

STANDARD PACKAGING: 3½ gallon steel pail - approximately 75 lbs.
10 gallon steel drum - approximately 180 lbs.
A suitable container will be used for quantities under 75 lbs.

MINIMUM CHARGE PER ITEM - $10.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM ROD SINTERED

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 208 7-7-58 *effective:* May 24, 1961

subject to change without notice.

PROCESS

Final process operation involves drawing, swaging or centerless grinding, resulting in straight random lengths.

Diameter (Inches)	Approximate Feet per Kilogram	Price per Kilogram Black	Cleaned	Ground
.020	1600	$46.00	$48.00	
.025	1026	35.50	37.00	
.030	713	30.90	31.80	$91.00
.035	523	30.90	31.80	71.50
.040	400	27.15	28.05	62.00
.045	316	27.15	28.05	53.50
.050	256	25.05	25.95	49.00
.060	178	23.70	24.60	42.00
.070	131	23.10	24.00	38.50
.080	100	22.70	23.60	35.50
.090	79	22.35	23.25	34.25
.100	64	22.10	23.00	33.75
.125	41	22.10	23.00	33.25
.150	28	21.85	22.75	30.75
.175	21	20.75	22.50	29.25
.200	16	19.60	20.50	27.50
.250	10	19.60	20.50	25.25
.300	7	18.90	19.75	24.75
.350	5	18.90	19.50	23.75
.375	4.5	18.20	19.05	23.50
.400	4.0	17.10	17.95	21.75
.500	2.5	16.60	17.45	21.00
.750	1.1	16.10	16.95	20.25
1.000	.6	16.10	16.95	20.25

Standard Tolerances			
.020 - .029	± .001"	± .001"	
.030 - .079	± .0015"	± .0015"	± .001"
.080 - .199	± .002"	± .002"	± .001"
.200 - .249	± .003"	± .003"	± .001"
.250 - .399	± .003"	± .003"	± .0015"
.400 - .499	± .005"	± .005"	± .002"
.500 - .749	± .010"	± .010"	± .003"
.750 - 1.000	± .015"	± .015"	± .005"

NOTES

1. Prices for closer tolerances and specific lengths available on request.
2. Intermediate sizes to be priced at the next higher price, or the price of the next smaller rod.
3. Minimum charge per item - $10.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM ROD
ARC CAST

PRICE SCHEDULE

terms: 3% 10, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Page 212 4-1-57

effective: July 7, 1958

subject to change without notice.

ARC CAST MOLYBDENUM ROD

SPECIFICATION

Drawn, Swaged or Ground straight random lengths.

PRICE PER KILOGRAM

Diameter (Inches)	Approximate Feet per Kilogram	Black	Cleaned	Ground
.030	713	$56.00	$57.00	$157.00
.035	523	56.00	57.00	134.00
.040	400	52.00	53.00	95.50
.045	316	52.00	53.00	85.00
.050	256	49.50	50.50	80.25
.060	178	48.00	49.00	72.00
.070	131	47.25	48.25	67.75
.080	100	46.50	47.50	63.75
.090	79	46.00	47.00	63.50
.100	64	45.00	46.00	63.00
.125	41	45.00	46.00	61.50
.150	28	45.00	46.00	58.00
.175	21	45.00	46.00	56.00
.200	16	42.00	42.75	54.50
.250	10	42.00	42.75	51.75
.300	7	40.75	41.50	50.75
.350	5	40.75	41.50	49.50
.400	4	36.25	37.00	44.50
.500 - .750	2.5 - 1.1	35.50	36.25	43.50

STANDARD TOLERANCES

.030 - .079		± .001"	± .001"	± .001"
.080 - .299		± .002"	± .002"	± .001"
.300 - .349		± .003"	± .003"	± .001"
.350 - .399		± .003"	± .003"	± .0015"
.400 - .499		± .004"	± .004"	± .002"
.500 - .750		± .005"	± .005"	± .003"

NOTES

1. Prices for closer tolerances and specific lengths available on request.
2. Intermediate sizes to be priced at the next higher price, or the price of the next smaller rod.
3. Minimum charge per item - $10.00

MOLYBDENUM BOOSTER-MELTING ELECTRODES

MATERIAL SPECIFICATIONS

MATERIAL

Fully worked molybdenum rod, 1¼" diameter, produced by pressing, sintering and rolling hydrogen-reduced metal powder.

PURITY

Molybdenum	99.95% min.
Carbon	0.005% max.
Chromium	0.005% max.
Iron	0.005% max.
Nickel	0.005% max.

PHYSICAL DIMENSIONS

Diameter:	1¼" ± 1/32" (1.250" ± 0.031")
Standard Lengths:	12", 18", 24" ± 1" 36", 48", 60" ± 3"
Straightness:	Camber not to exceed 1/16" per foot (measured by a 13" ring gauge 1 5/16" in diameter).
Ends:	Ends shall be cut square to facilitate machining.

FINISH

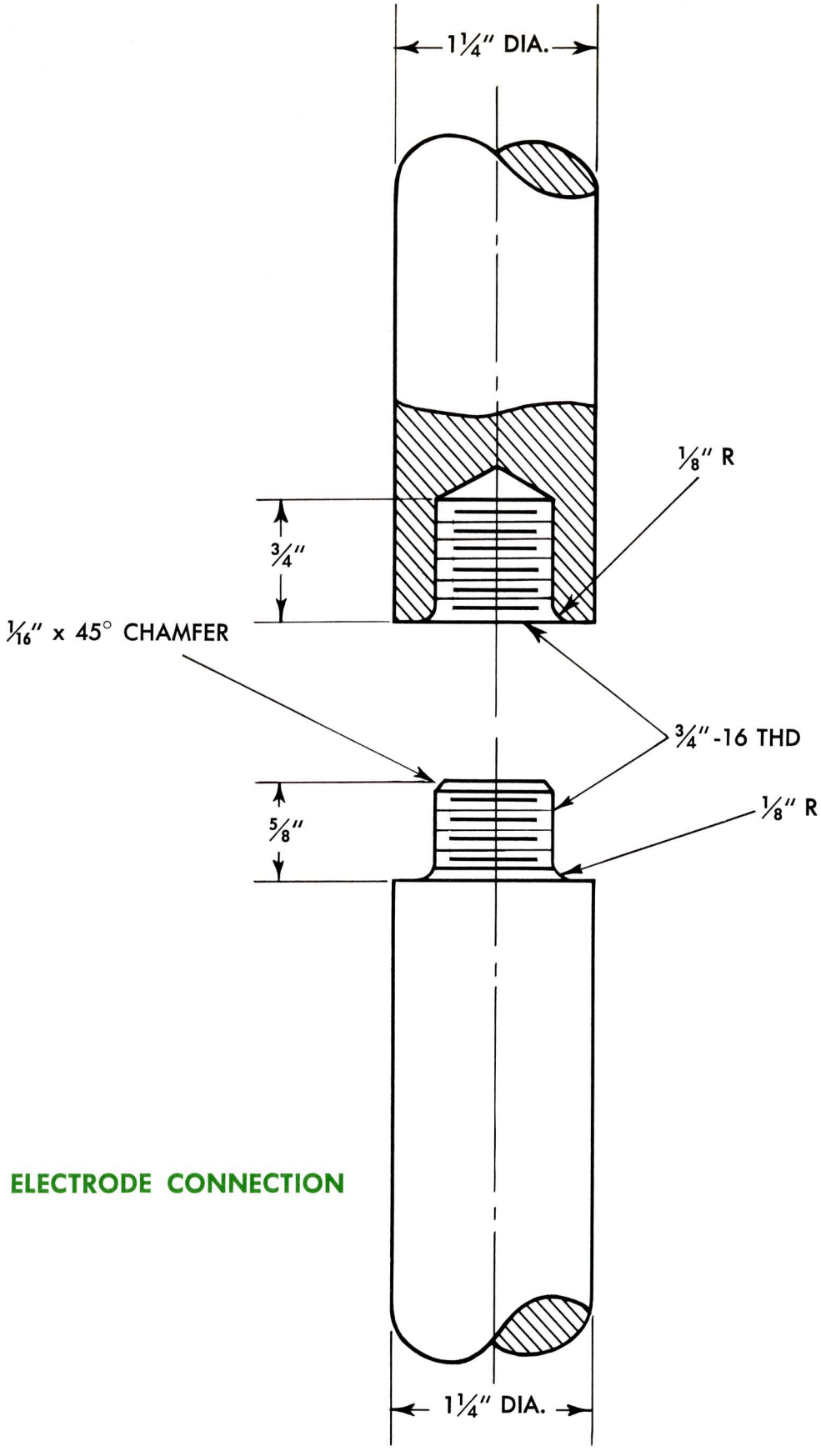
Electrodes shall be furnished with a cleaned, matte finish.

CONNECTIONS

Electrodes shall be machined to provide male or female threaded ends in accordance with the drawing on the reverse. Electrodes with unthreaded ends are available if required.

PACKAGING

Electrodes shall be packaged in sturdy wooden boxes, and shall be suitably wrapped and cushioned to prevent contamination and damage during shipment.



ELECTRODE CONNECTION

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SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM ROD

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* April 15, 1961

subject to change without notice.

MOLYBDENUM BOOSTER-MELTING ELECTRODES
Cleaned Finish

All Standard Lengths
1-1/4" Diameter — $17.50 per Kilogram

Standard Male or Female Threaded End — $5.00 per End

Approximate Cost per Electrode*

Standard Lengths	With Ends Unthreaded	With Standard Threading on Both Ends
12" ± 1"	$ 43.00	$ 53.00
18" ± 1"	64.50	74.50
24" ± 1"	86.00	96.00
36" ± 3"	129.00	139.00
48" ± 3"	172.00	182.00
60" ± 3"	215.00	225.00

*Based on a weight of 0.205 kg./inch.

For specified lengths held to a tolerance of ± 1/8", add 10% to above prices.

Prices for other lengths, diameters and special threading upon request.

Electrodes will be billed on a weight basis, at the price per kilogram shown above. One kilogram equals 2.2046 pounds.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE

BLACK

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

replaces: Page 218 5-24-61 and Page 220 8-1-58

subject to change without notice.

f.o.b.: Towanda, Pa

effective: Dec. 3, 196

PROCESS MO-10 - BLACK AS DRAWN Wire has good formability. Used for applications such as Electric Furnace Heating Elements.

PROCESS MO-11 - BLACK AS DRAWN Minimum tensile strength, low elongation, and controlled annealing properties. Used primarily for Mandrels.

Dia. in Mils	Milligrams Per 200 mm From	To	Price per M meters — Milligram Weight Tolerance ± 4%	± 3%	± 2-1/2%	± 2%	± 1-1/2%
1.0	1.00	1.46	$10.50	$10.71	$11.13	$12.08	$12.92
1.2	1.47	2.29	7.25	7.40	7.69	8.34	8.92
1.5	2.30	4.08	6.25	6.38	6.63	7.19	7.69
2.0	4.09	6.38	4.00	4.08	4.24	4.60	4.92
2.5	6.39	7.72	3.80	4.08	4.24	4.60	4.92
3.0	7.73	10.79	3.80	4.08	4.24	4.60	4.92
3.5	10.80	14.37	4.00	4.08	4.24	4.60	4.92
4.0	14.38	18.46	4.00	4.08	4.24	4.60	4.92
4.5	18.47	23.06	4.70	4.79	4.98	5.41	5.78
5.0	23.07	28.17	5.55	5.66	5.88	6.38	6.83
5.5	28.18	33.79	6.40	6.53	6.78	7.36	7.87
6.0	33.80	39.93	7.10	7.24	7.53	8.17	8.73
6.5	39.94	46.57	8.15	8.31	8.64	9.37	10.02
7.0	46.58	53.73	9.10	9.28	9.65	10.47	11.19
7.5	53.74	61.40	10.00	10.20	10.60	11.50	12.30
8.0	61.41	69.58	10.95	11.17	11.61	12.59	13.47
8.5	69.59	78.27	12.25	12.50	12.99	14.09	15.07
9.0	78.28	87.47	13.50	13.77	14.31	15.53	16.61
9.5	87.48	97.18	14.90	15.20	15.79	17.14	18.33
10.0	97.19	112.71	16.35	16.68	17.33	18.80	20.11
11.0	112.72	135.20	19.15	19.53	20.30	22.02	23.55
12.0	135.21	159.73	22.00	22.44	23.32	25.30	27.06
13.0	159.74	186.32	25.15	25.65	26.66	28.92	30.93
14.0	186.33	214.94	28.50	29.07	30.21	32.78	35.06
15.0	214.95	245.61	32.00	32.64	33.92	36.80	39.36
16.0	245.62	278.33	35.45	36.16	37.58	40.77	43.60
17.0	278.34	313.09	39.80	40.60	42.19	45.77	46.29
18.0	313.10	349.90	44.10	44.98	46.75	50.72	51.22
19.0	349.91	388.75	48.60	49.57	51.52	55.89	56.89

Closer Tolerances

± 1% - Priced at 135% of 4% prices

± 1/2% - Priced at 150% of 4% prices

MINIMUM CHARGE PER ITEM - $25.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE

BLACK

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

replaces: Page 219 5-24-61
Page 221 8-1-58

subject to change without notice.

f.o.b.: Towanda, Pa.

effective: Dec. 3, 1962

PROCESSES MO-10 AND MO-11

Dia. in Inches	Approx. Meters per Kilo	Price per Kilogram — Diameter Tolerance ± 2%	± 1-1/2%	± 1-1/4%	± 1%
.020	487	$26.38	$26.93	$28.01	$29.79
.021	441	26.05	26.60	27.67	29.41
.022	402	25.77	26.30	27.36	29.08
.023	368	25.54	26.06	27.11	28.82
.024	338	25.23	25.75	26.78	28.47
.025	311	24.94	25.45	26.48	28.33
.026	288	24.58	25.08	26.14	28.26
.027	267	24.20	24.69	25.68	28.19
.028	248	24.05	24.53	25.53	28.11
.029	231	23.98	24.46	25.45	28.01
.030-.039	216	23.25	23.74	24.71	27.25
.040-.049	122	23.00	23.48	24.44	26.96
.050-.059	78	22.25	22.72	23.65	26.09
.060-.069	54	21.75	22.21	23.12	25.50
.070-.079	40	21.25	21.70	22.59	24.92
.080-.089	30	21.00	21.44	22.32	24.63
.090-.099	24	20.75	21.19	22.06	24.34
.100-.149	19-9	20.50	20.93	21.79	24.05
.150-.250	9-3	20.25	20.68	21.53	23.76

Supplied in coils.

Process MO-10 - Available in all sizes listed.
Process MO-11 - Available through .029" diameter.

MINIMUM CHARGE PER ITEM - $25.00

SYLVANIA

chemical & metallurgical division

MOLYBDENUM WIRE

TOWANDA, PA.

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 222 5-24-61 *effective:* Nov. 1, 1962

subject to change without notice.

PROCESS MO-30 - CLEANED Drawn to finished size and cleaned in a chemical solution and/or hydrogen atmosphere. Used where high tensile strength is needed and straightness is not critical.

PROCESS MO-70 - CLEANED AND ANNEALED Drawn to finished size and cleaned and annealed in a chemical solution and hydrogen atmosphere. Used where maximum formability is critical, such as Electric Furnace Heating Elements.

Dia. in Inches	Approx. Meters per Kilo	Price per Kilogram — Diameter Tolerance ± 2%	± 1-1/2%	± 1-1/4%	± 1%
.020	487	$27.25	$27.80	$28.88	$30.66
.021	441	26.86	27.40	28.48	30.22
.022	402	26.52	27.05	28.11	29.83
.023	368	26.23	26.75	27.80	29.51
.024	338	25.89	26.41	27.44	29.13
.025	311	25.54	26.05	27.08	28.93
.026	288	25.15	25.65	26.71	28.83
.027	267	24.74	25.23	26.22	28.73
.028	248	24.56	25.04	26.04	28.62
.029	231	24.46	24.94	25.93	28.49
.030-.039	216	24.25	24.74	25.71	28.25
.040-.049	122	24.00	24.48	25.44	27.96
.050-.059	78	23.25	23.72	24.65	27.09
.060-.069	54	22.75	23.21	24.12	26.50
.070-.079	40	22.25	22.70	23.59	25.92
.080-.089	30	22.00	22.44	23.32	25.63
.090-.099	24	21.75	22.19	23.06	25.34
.100-.149	19-9	21.50	21.93	22.79	25.05
.150-.250	9-3	21.25	21.68	22.53	24.76

Supplied in coils.

Minimum charge per item - $25.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
CLEANED AND ANNEALED

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Page 224 5-24-61

effective: Nov. 1, 1962

subject to change without notice.

PROCESS MO-71 Cleaned and partially annealed, minimum tensile strength, low elongation and controlled annealing properties. Used primarily for mandrels.

PROCESS MO-72 Cleaned and partially annealed, controlled tensile strength range, and maximum straightness. Used primarily for support hooks and anchors.

PROCESS MO-73 Cleaned and annealed, with controlled physical properties. Used primarily for vacuum tube grids. Meets Class II ASTM Specification F290-57T.

Dia. in Mils	Milligrams per 200 mm From	To	Price per M meters — Milligram Weight Tolerance ± 4%	± 3%	± 2-1/2%	± 2%	± 1-1/2%	± 1%
0.8	0.60	0.70		$16.30				
0.9	0.71	0.99		15.10				
1.0	1.00	1.47	$11.11	12.02	$12.22	$13.54		
1.2	1.48	2.30	8.45	9.14	9.54	10.36	$11.07	$12.15
1.5	2.31	4.10	6.87	7.32	7.56	7.92	8.48	9.29
2.0	4.11	6.42	4.04	4.25	4.48	4.78	4.96	5.71
2.5	6.43	7.77	4.34	4.40	4.77	4.89	5.14	5.71
3.0	7.78	10.86	4.45	4.50	4.82	5.07	5.26	5.71
3.5	10.87	14.46	4.55	4.58	4.96	5.16	5.35	5.75
4.0	14.47	18.45	4.68	4.71	4.98	5.28	5.48	5.87
4.5	18.46	23.19	5.56	5.60	5.94	6.30	6.54	7.01
5.0	23.20	28.33	6.36	6.39	6.89	7.23	7.51	8.16
5.5	28.34	33.99	7.33	7.35	7.84	8.30	8.62	9.28
6.0	34.00	40.16	8.20	8.26	8.69	9.24	9.57	10.26
6.5	40.17	46.84	9.23	9.42	9.79	10.39	10.76	11.55
7.0	46.85	54.03	10.23	10.44	10.85	11.52	11.92	12.79
7.5	54.04	61.74	11.20	11.42	11.87	12.63	13.07	14.03
8.0	61.75	69.97	12.15	12.39	12.88	13.69	14.17	15.21
8.5	69.98	78.71	13.50	13.77	14.31	15.53	16.17	17.36
9.0	78.72	87.96	14.85	15.15	15.74	17.08	18.27	20.05
9.5	87.97	97.72	16.25	16.58	17.23	18.69	19.99	21.94
10.0	97.73	113.34	17.70	18.05	18.76	20.30	21.02	22.56
11.0	113.35	135.95	20.34	21.06	21.89	23.38	24.21	25.97
12.0	135.96	160.63	23.23	24.07	25.00	26.54	27.48	29.49
13.0	160.64	187.35	26.89	27.44	28.51	30.94	33.09	35.51
14.0	187.36	216.14	29.96	30.96	32.17	34.90	36.50	39.16
15.0	216.15	246.98	33.86	34.53	35.88	38.70	40.08	43.00
16.0	246.99	279.87	37.45	38.20	39.70	43.07	44.59	47.85
17.0	279.88	314.83	41.90	42.74	44.41	47.20	48.88	52.44
18.0	314.84	351.83	46.34	47.27	49.12	52.13	53.99	57.93
19.0	351.84	411.19	50.95	51.97	54.01	57.35	59.40	63.73

Closer Tolerances

± 1/2% - Priced at 150% of 4% prices.

Prices for wire meeting ASTM Class III specifications are listed on page 226.

10/62/2000 Minimum charge per item - $25.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
CLEANED AND ANNEALED

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 225 5-24-61 *effective:* Nov. 1, 196

subject to change without notice.

PROCESSES MO-71 AND MO-72

Dia. in Inches	Approx. Meters per Kilo	Price per Kilogram — Diameter Tolerance ± 2%	± 1-1/2%	± 1-1/4%	± 1%
.020	487	$27.25	$27.80	$28.88	$30.66
.021	441	26.86	27.40	28.48	30.22
.022	402	26.52	27.05	28.11	29.83
.023	368	26.23	26.75	27.80	29.51
.024	338	25.89	26.41	27.44	29.13
.025	311	25.54	26.05	27.08	28.93
.026	288	25.15	25.65	26.71	28.83
.027	267	24.74	25.23	26.22	28.73
.028	248	24.56	25.04	26.04	28.62
.029	231	24.46	24.94	25.93	28.49

Supplied in coils.

Minimum charge per item - $25.00

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
CLEANED AND ANNEALED

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Nov. 1, 1962

subject to change without notice.

MOLYBDENUM GRID WIRE

PROCESS MO-73 Cleaned and annealed, with controlled physical properties, for use in vacuum-tube grids.

ASTM Specification F290-57T - Class III

Dia. in Mils	Milligrams per 200 mm From	To	Price per M meters — Milligram Weight Tolerance ± 4%	± 3%	± 2-1/2%	± 2%	± 1-1/2%	± 1%
1.2	1.48	2.30	$ 8.80	$ 9.52	$ 9.94	$10.80	$11.53	$12.66
1.5	2.31	4.10	7.16	7.63	7.88	8.25	8.84	9.68
2.0	4.11	6.42	4.21	4.43	4.67	4.98	5.17	5.95
2.5	6.43	7.77	4.52	4.58	4.97	5.10	5.36	5.95
3.0	7.78	10.86	4.64	4.69	5.02	5.28	5.48	5.95
3.5	10.87	14.46	4.74	4.77	5.17	5.38	5.57	5.99
4.0	14.47	18.45	4.88	4.91	5.19	5.50	5.71	6.12
4.5	18.46	23.19	5.79	5.84	6.19	6.56	6.81	7.30
5.0	23.20	28.33	6.63	6.66	7.18	7.53	7.83	8.50
5.5	28.34	33.99	7.64	7.66	8.17	8.65	8.98	9.67
6.0	34.00	40.16	8.54	8.61	9.05	9.63	9.97	10.69

ASTM Specification F290-57T - Class II

Dia. in Mils	Milligrams per 200 mm From	To	Price per M meters — Milligram Weight Tolerance ± 4%	± 3%	± 2-1/2%	± 2%	± 1-1/2%	± 1%
1.0	1.00	1.47	$11.11	$12.02	$12.22	$13.54		
1.2	1.48	2.30	8.45	9.14	9.54	10.36	$11.07	$12.15
1.5	2.31	4.10	6.87	7.32	7.56	7.92	8.48	9.29
2.0	4.11	6.42	4.04	4.25	4.48	4.78	4.96	5.71
2.5	6.43	7.77	4.34	4.40	4.77	4.89	5.14	5.71
3.0	7.78	10.86	4.45	4.50	4.82	5.07	5.26	5.71
3.5	10.85	14.46	4.55	4.58	4.96	5.16	5.35	5.75
4.0	14.47	18.45	4.68	4.71	4.98	5.28	5.48	5.87
4.5	18.46	23.19	5.56	5.60	5.94	6.30	6.54	7.01
5.0	23.20	28.33	6.36	6.39	6.89	7.23	7.51	8.16
5.5	28.34	33.99	7.33	7.35	7.84	8.30	8.62	9.28
6.0	34.00	40.16	8.20	8.26	8.69	9.24	9.57	10.26

Closer Tolerances

± 1/2% - Priced at 150% of 4% prices.

Minimum charge per item - $25.00

MOLYBDENUM PELLETS FOR VACUUM MELTING

SYLVANIA Molybdenum is now available in the form of high-purity, high-density pellets. These pellets provide vacuum melters with an assured source of molybdenum suitable for the manufacture of critical high-temperature alloys having longer service life and higher stress-rupture strength requirements.

In the development of alloys containing molybdenum, the use of scrap molybdenum was satisfactory. However, as melts have become larger and more frequent, vacuum melters have found that scrap molybdenum has become less suitable for their operations. Not only is purity frequently questionable, but scrap availability, cost and density vary widely. For example, rod ends may have a density around 10 g/cc, while unsintered ingot ends may have a density as low as 5 g/cc, with a gas content as high as 2,500 ppm.

Realizing the need for inexpensive, highly uniform molybdenum, Sylvania designed its molybdenum pellets specifically for vacuum melting. The pellets are an easy-to-handle size, approximately 5/8" in diameter by 1/4" high. They have a high degree of purity, as indicated in the table below. Consumers report that Sylvania Molybdenum pellets have a gas content well below the 400 ppm considered very satisfactory for vacuum melting.

CHEMICAL COMPOSITION

(EXCLUDING GASES)	SPECIFICATION	TYPICAL ANALYSIS
Molybdenum, %	99.5 Min.	99.85
Lead, %	0.001 Max.	< 0.001
Tin, %	0.005 Max.	< 0.005
Iron, %	0.05 Max.	0.010
Cobalt, %	0.01 Max.	< 0.001
Chromium, %	0.05 Max.	0.005
Nickel, %	0.10 Max.	0.02
Manganese, %	0.01 Max.	< 0.001
Calcium, %	0.05 Max.	0.001
Magnesium, %	0.05 Max.	0.005
Aluminum, %	0.02 Max.	0.005
Copper, %	0.01 Max.	0.005
Silicon, %	0.03 Max.	0.020
DENSITY	7.5 g/cc Min.	8.5 g/cc

PELLET SIZE – 5/8" diameter x 1/4" high (approx.)

STANDARD PACKAGE – 400 lbs. net in 15 gallon Leverpac drum, with clamped lid.

AVAILABILITY – Sylvania Molybdenum Pellets are available for prompt shipment from Towanda, Pennsylvania.

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Page 232 8-4-58

effective: Sept. 12, 1960

subject to change without notice.

MOLYBDENUM PELLETS

(99.5% Minimum Purity)

Any Quantity	$3.10/lb.

STANDARD PACKAGING

3-1/2 Gal. Steel Pail - Up to 100 lbs.

7-1/2 Gal. Leverpak Drum - 400 lbs. capacity.

SYLVANIA
metallurgical products
Technical Information Bulletin

PRESSED AND SINTERED MOLYBDENUM BILLETS, SLABS AND RINGS

MATERIAL SPECIFICATIONS

SCOPE

This specification applies to billets, slabs and rings of unalloyed molybdenum. These forms are intended for further processing by forging, rolling or extruding.

MANUFACTURE

These products are produced by isostatically pressing molybdenum powder which is then sintered.

CHEMICAL COMPOSITION

MOLYBDENUM — 99.95% MINIMUM (by difference)

Trace Element	Maximum Parts Per Million	Method of Analysis
Aluminum	10	Spectrographic
Calcium	10	Spectrographic
Chromium	50	Spectrographic
Carbon	50	Chemical
Copper	10	Spectrographic
Iron	50	Spectrographic
Lead	10	Spectrographic
Manganese	10	Spectrographic
Magnesium	10	Spectrographic
Nickel	50	Spectrographic
Silicon	50	Spectrographic
Tin	50	Spectrographic
Oxygen	30	Vacuum fusion
Hydrogen	10	Vacuum fusion
Nitrogen	20	Vacuum fusion

Analyses for metallic elements are made on the metal powder. Gases are determined on a pressed and sintered coupon or on a sample taken by destructive testing. *(one ppm is equivalent to 0.0001%)*

PHYSICAL PROPERTIES

Density—9.6 g/cc minimum, or 94% of the theoretical density of 10.2 g/cc.

Dimensions and Tolerances:

BILLETS

Diameters	Up to and including 3½"	±⅛"
	From 4" to 7"	±3/16"
	From 7.5" to 10" maximum	±¼"
Weight Tolerance		+5%–0

SLABS

Widths	Up to and including 7"	±⅛"
	Above 7" to 10" maximum	±¼"
Lengths	Up to 48" maximum	±¼"
Thickness	½" minimum up to 1"	±1/16"
	1" and over	±⅛"
Taper	1/16" per foot maximum	

Limiting Conditions: Width plus length shall be no more than twenty times the thickness. The smallest cross-section must fall within a ten-inch circle.

RINGS

Outside Diameters	Up to and including 7"	±3/16"
	7" to 10" maximum	±¼"
Inside Diameters	Up to 7" maximum	±3/16"
Wall Thickness	Minimum 1½", variations not to exceed ±⅛". Thinner wall can be obtained by green or final machining, when requested.	

Local variations on billets and rings shall not exceed 3/16" of the average diameter.

FINISH AND SURFACE CONDITION

Parts shall be supplied with a smooth, clean, carbide-free matte finish.

SOUNDNESS

Parts shall be free of internal and external imperfections such as seams, cracks, piping, surface checks, scale, inclusions, or any other defect that might have an adverse effect in subsequent use.

IDENTIFICATION

Parts shall be identified as to material with lot numbers, weight and density. The characters shall be applied using a suitable marking fluid that will withstand ordinary handling.

PACKING AND SHIPPING

The parts shall be packaged in suitable containers or on pallets, and sufficiently protected to prevent damage and contamination during ordinary handling and transit. Each container shall be identified with the customer's name, gross weight, net weight, and Sylvania's order number.

REPORTS AND SPECIAL TESTS

On request, Sylvania will furnish three copies of a certified chemical analysis, a spectrographic quantitative analysis, a gas analysis by the vacuum-fusion method, surface-defect analysis by dye penetration, and internal-defect analysis by ultrasonic (immersion or contact) techniques.

REJECTIONS

The Chemical & Metallurgical Division of Sylvania must be notified in writing of all rejections. The rejection notice must include the purchase order number, lot number, size, number of pieces rejected, weight, and reason for rejection. Sylvania reserves the right to inspect the material at the customer's plant to determine the basis for rejection. If the material is found to be defective, a Return Materials Authorization (RMA) will be issued by Sylvania before the material can be returned.

POTENTIAL APPLICATIONS

Listed below are some of the present and potential fields of applications known for refractory metals:

- Jet engines
- Rockets
- Industrial furnaces
- Solid fuel motors
- Electronic tube parts
- Electrical contacts
- Furnace windings
- Forging dies
- Corrosion resistant equipment
- Furnace boats
- Gas turbine engines
- Lamp filaments
- Carbides
- Welding electrodes
- Metallizing coils
- Flame spray coatings
- Piercing points for seamless tubing

Sylvania's Chemical and Metallurgical Division welcomes and encourages your inquiries on all forms of refractory materials.

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SYLVANIA
SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC. / Chemical & Metallurgical Division / TOWANDA, PENNA.

FIELD SALES OFFICES

BOSTON 100 Sylvan Road Woburn, Mass.
CHICAGO 2001 N. Cornell Ave. Melrose Park, Ill.
DAYTON 333 West First Street Dayton 2, Ohio
DETROIT 7800 Intervale Ave. Detroit, Mich.
NEW YORK 1000 Huyler Street Teterboro, N. J.
PHILADELPHIA 4700 Parkside Ave. Philadelphia 31, Penna.
PITTSBURGH 300 Mt. Lebanon Blvd. Pittsburgh, Penna.
SAN FRANCISCO 1811 Adrian Road Burlingame, Calif.
TOWANDA Towanda, Penna.

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: Mar. 27, 1961

subject to change without notice.

PRESSED AND SINTERED MOLYBDENUM ROUND BILLETS FOR FORGING AND METAL WORKING

ROUND BILLETS - RANDOM LENGTH

Standard Diameter Inches	Price/lb.	Maximum Length Inches	Approx. Weight Full Length in Lbs.
1.0	$7.35	15	4
1.25	6.70	18	8
1.50	6.05	22	13
1.75	5.85	24	20
2.0	5.65	30	33
2.5	5.45	36	61
3.0	5.30	48	118
3.5	5.20	48	160
4.0	5.15	48	209
4.5	5.10	48	265
5.0	5.05	48	327
5.5	5.00	48	396
6.0	5.00	48	471
7.0	4.95	48	641
8.0	4.95	48	837
9.0	4.95	48	1059
10.0	4.95	48	1308

Intermediate weights and diameters are priced at the next smaller weight or diameter.

Minimum Charge per Item - $25.00

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Mar. 27, 1961

subject to change without notice.

PRESSED AND SINTERED MOLYBDENUM ROUND BILLETS FOR FORGING AND METAL WORKING

ROUND BILLETS - SPECIFIC WEIGHTS

Standard Diameter Inches	Price per Pound in Dollars — Weight per Billet										Max. Weight Available in Lbs.
	4#	8#	12#	16#	20#	30#	50#	100#	200#	300#	
1.25	7.05										7
1.50	6.50	6.35	6.30								12
1.75	6.40	6.20	6.15	6.10							18
2.0	6.30	6.05	5.95	5.90	5.85	5.85					30
2.5	6.40	6.00	5.85	5.75	5.75	5.65	5.65				55
3.0	6.60	6.00	5.80	5.70	5.65	5.55	5.50	5.45			106
3.5	6.95	6.10	5.85	5.70	5.65	5.50	5.45	5.35			144
4.0		6.30	5.95	5.80	5.65	5.55	5.40	5.35			188
4.5		6.55	6.10	5.85	5.75	5.55	5.40	5.30	5.25		239
5.0		6.80	6.25	6.00	5.80	5.60	5.40	5.30	5.25		294
5.5			6.45	6.10	5.90	5.65	5.45	5.30	5.20	5.15	356
6.0			6.65	6.25	6.00	5.70	5.45	5.25	5.15	5.15	424
7.0				6.65	6.35	5.90	5.55	5.30	5.20	5.15	577
8.0					6.70	6.15	5.70	5.40	5.20	5.15	753
9.0						6.45	5.90	5.45	5.25	5.20	953
10.0						6.80	6.10	5.55	5.30	5.20	1177

Weight Tolerance - Plus 5% Minus 0

Intermediate weights and diameters are priced at the next smaller weight or diameter. Billets weighing less than 4 pounds will be priced on special request.

Minimum Charge per Item - $25.00

MOLYBDENUM SHEET AND PLATE

SYLVANIA molybdenum sheet and plate are manufactured by powder-metallurgical techniques. Extensive and precise controls are exercised in each step of manufacture. Highly refined molybdenum chemicals are hydrogen-reduced to molybdenum powder, having a purity of 99.95% minimum, and controlled average particle size. The powder is isostatically pressed and sintered into slabs of a uniform fine-grained structure. The slabs are then worked by rolling to the customer's required dimensions. After rolling, the sheet and slab are cleaned chemically or by sandblasting.

Molybdenum sheet is processed to obtain maximum ductility for applications involving bending, spinning, drawing, or stamping. If the customer designates his specific application, Sylvania can supply material best suited for the customer's use.

SIZES AND TOLERANCES

Molybdenum sheet is available in thickness from 0.030″ to 0.187″. Molybdenum plate is available in thickness from 3/16″ to 1½″. Sheet and plate are supplied in either specific lengths or random lengths. All plate and sheet are supplied in specific widths.

Molybdenum Sheet

Thickness Inches	Thickness Tolerance	Maximum Width Inches	Maximum Length Inches
0.030-0.033	±0.0015″	11	96
0.034-0.048	±0.002″	11	72
0.049-0.063	±0.003″	11	60
0.064-0.078	±0.004″	11	60
0.079-0.125	±0.005″	11	60
0.126-0.187	±4%	11	60

Length Tolerance ±3/32 inch (on specific length). Width Tolerance ±1/16 inch.

Molybdenum Plate

Thickness Inches	Maximum Width Inches	Maximum Length	
		On Widths up to 6 Inches	On Widths 6 to 12 Inches
3/16	11	60 Inches	30 Inches
¼	11	60 Inches	24 Inches
½	11	60 Inches	12 Inches
¾	3	48 Inches	—
1	3	36 Inches	—
1½	3	24 Inches	—

Thickness Tolerance ±4%. Length Tolerance +¼″, −0 (on specific length). Width Tolerance ±1/16″.

MECHANICAL PROPERTIES

PROPERTIES	SHEET Minimum	SHEET Typical	PLATE Minimum	PLATE Typical
*Ultimate Tensile Strength, psi	90,000	100,000	75,000	90,000
*Yield Tensile Strength (0.2% offset), psi	85,000	90,000	65,000	70,000
*Elongation (2.0" gauge)	10%	13%	2.5%	4%
Hardness Range DPH (Vickers, 10 kg load)	220-300		170-210	

* *Tensile properties are determined both parallel to and normal to the primary direction of rolling. Specimens are tested at 65°F to 85°F using a strain rate of 0.005 in/in/minute to 0.6% offset, and then at a rate of 0.050 in/in/minute to fracture. All sheet and plate are furnished in a stress-equalized condition.*

Bend Ductility

Bend ductility tests are performed on sheet of up to 0.065" thickness. Specimens of sheet are bent at room temperature at a uniform loading rate of 10 inches per minute. Sheet can be bent through an angle of 105 degrees over a radius two times the sheet thickness in a direction transverse to the rolling direction without exhibiting any fracture. Specimen size is one inch wide by three inches long.

CHEMICAL COMPOSITION

Sheet and Plate

Trace elements conform to the following limits as determined by quantitative spectrographic analysis of the metal powder.

MOLYBDENUM—99.95% MINIMUM (by difference) Trace Element	Maximum Parts per million
Aluminum	10
Calcium	10
*Carbon	50
Chromium	50
Copper	10
Iron	50
Lead	10
Magnesium	10
Manganese	10
Nickel	50
Silicon	50
Tin	50

* *Determined conductometrically.*

Vacuum-Fusion Analysis

Element	Maximum Parts per million
Oxygen	80
Hydrogen	10
Nitrogen	30

Vacuum-fusion analyses can be supplied upon request. Pending approved methods of analysis, deviations from these limits shall not be cause for rejection. Vacuum-fusion determinations are made from representative samples of sheet or plate.

FLATNESS

Molybdenum sheet or plate is inspected on a flat plate. Maximum deviation from flatness is 1/16 inch.

FINISH

Sheet above 0.060" thick, and all plate is furnished with a chemically or mechanically cleaned, matte surface. Sheet 0.060" thick and below, is supplied with a clean bright surface. If requested, a cleaned matte surface can also be supplied.

SOUNDNESS

Sheet and plate are free of internal and external imperfections such as seams, cracks, surface checks, scale, inclusions, and laminations.

PACKAGING AND SHIPPING

Sheet will be packaged in suitable containers, protected to prevent damage during ordinary handling and transit.

Each shipping container will be identified with the following information:

Customer's purchase order number
Sylvania Sales Order number
Lot number
Number of pieces
Gross and net weights

CM31 5/62 2.5 Printed in U.S.A.

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SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC. / Chemical & Metallurgical Division TOWANDA, PENNA.

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TOWANDA Towanda, Penna.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM SHEET and PLATE

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pgs. 260-261 11-13-61 *effective:* Feb. 8, 1962

SINTERED MOLYBDENUM SHEET AND PLATE
SPECIFIC WIDTH - RANDOM LENGTH

Thickness in Inches	Price per Kilogram in Dollars — Width in Inches								Max. Length at 11" Width	Grams per sq.in.
	0.5"	1.0"	1.5"	2"/Over	3.0"	4.0"	5.0"	6"/Over		
.030	37.90	37.25	36.45	36.00					96"	4.980
.035	36.70	36.00	35.25	34.85					72"	5.810
.040	35.60	35.00	34.20	33.75					72"	6.640
.050	34.00	33.50	32.65	32.30					60"	8.300
.060	32.75	32.20	31.40	31.10					60"	9.960
.070	31.65	31.00	30.20	30.00					60"	11.620
.080		30.65	29.75	29.50	29.00	28.25	27.50	26.75	60"	13.280
.090			29.25	28.35	26.15	25.15	24.60	24.15	55"	14.940
.100			28.35	25.80	24.25	23.80	23.60	23.25	50"	16.600
.150			24.25	22.80	22.00	21.85	21.25	21.25	30"	24.900
.200			22.40	21.20	20.60	20.20	19.85	19.85	21"	33.200
.250			21.20	19.85	19.40	19.00	18.85	18.85	18"	41.500
.300			20.40	19.40	18.95	18.75	18.40	18.40		49.800
.350			20.00	19.00	18.65	18.00	18.00	18.00		58.100
.400			19.60	18.85	18.40	17.85	17.85	17.85		66.400
.450			19.20	18.40	18.20	17.65	17.65	17.65		74.700
.500			18.65	18.20	17.65	17.40	17.40	17.40		83.000
.600			18.00	17.50	17.00	17.00	17.00	17.00		99.600
.800 to 1.5			17.00	16.50	16.50	16.50	16.50	16.50		

SPECIAL PRICE NOTES

1. Prices listed are for quantities of 2 kilograms and over per item. For less than 2 kilograms, add 5% to the prices listed.
2. Intermediate thicknesses and widths are priced at the next smaller dimension.

HOW TO ORDER

Thickness should be specified in inches. Standard tolerances listed are the basis for pricing. Prices for closer tolerances are available upon request.

Width should be specified in inches. Maximum width available is 11.0".

Length Random length will include pieces between 10.0" and our maximum length.

Note: Billing will be based on kilograms shipped.

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pgs. 260-261 11-13-61 *effective:* Feb. 8, 1962

subject to change without notice.

SINTERED MOLYBDENUM SHEET AND PLATE
SPECIFIC WIDTH - RANDOM LENGTH

STANDARD TOLERANCES

Sheet Thickness	Thickness Tolerance	Width Tolerance	Length Tolerance
.030" - .033"	± .0015"	± 1/16"	10.0" Minimum
.034" - .048"	± .002"	"	"
.049" - .063"	± .003"	"	"
.064" - .078"	± .004"	"	"
.079" - .125"	± .005"	"	"
.126" & over	± 4%	"	"

FINISH

.030" - .060" thickness - Bright
Over .060" thickness - Matte

ANALYSES

Prices available on request for:

1. A quantitative spectrographic analysis of metallic impurities.
2. A chemical analysis of carbon.
3. A vacuum-fusion analysis (oxygen, hydrogen and nitrogen.)
4. Determination of other special residual impurities.
5. Determination of mechanical properties such as tensile strength, yield strength, percent elongation, hardness, or brittle-ductile transition temperature.

PACKAGING

All sheet will be packaged flat in suitable protective containers.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM SHEET and PLATE

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pgs. 260-261 11-13-61

effective: Feb. 8, 1962

subject to change without notice.

SINTERED MOLYBDENUM SHEET AND PLATE
SPECIFIC WIDTH - SPECIFIC LENGTH

Thickness in Inches	Price per Kilogram in Dollars — Width in Inches								Max. Length at 11" Width	Grams per sq.in.
	0.5"	1.0"	1.5"	2"/Over	3.0"	4.0"	5.0"	6"/Over		
.030	39.80	39.15	38.30	37.80					96"	4.980
.035	38.55	37.80	37.05	36.60					72"	5.810
.040	37.40	36.75	35.95	35.45					72"	6.640
.050	35.70	35.20	34.30	33.95					60"	8.300
.060	34.40	33.85	33.00	32.70					60"	9.960
.070	33.25	32.55	31.75	31.50					60"	11.620
.080		32.20	31.25	31.00	30.45	29.70	28.90	28.10	60"	13.280
.090			30.75	29.80	27.50	26.45	25.85	25.40	55"	14.940
.100			29.80	27.10	25.50	25.00	24.80	24.45	50"	16.600
.150			25.50	23.95	23.10	22.95	22.35	22.35	30"	24.900
.200			23.55	22.30	21.65	21.25	20.85	20.85	21"	33.200
.250			22.30	20.85	20.40	19.95	19.80	19.80	18"	41.500
.300			21.45	20.40	19.90	19.70	19.35	19.35		49.800
.350			21.00	19.95	19.60	18.90	18.90	18.90		58.100
.400			20.60	19.80	19.35	18.75	18.75	18.75		66.400
.450			20.20	19.35	19.15	18.55	18.55	18.55		74.700
.500			19.60	19.15	18.55	18.30	18.30	18.30		83.000
.600			18.90	18.40	17.85	17.85	17.85	17.85		99.600
.800 to 1.5			17.85	17.35	17.35	17.35	17.35	17.35		

SPECIAL PRICE NOTES

1. Prices listed are for quantities of 2 kilograms and over per item. For less than 2 kilograms, add 5% to the prices listed.
2. Intermediate thicknesses and widths are priced at the next smaller dimension.

HOW TO ORDER

Thickness should be specified in inches. Standard tolerances listed are the basis for pricing. Prices for closer tolerances are available upon request.

Width should be specified in inches. Maximum width available is 11.0".

Length Prices listed are for specific lengths 10.0" and over. For pieces less than 10.0" long, prices will be furnished on request.

Note: Billing will be based on kilograms shipped.

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Pages 260-261 11-13-61 *effective:* Feb. 8, 1962

subject to change without notice.

SINTERED MOLYBDENUM SHEET AND PLATE
SPECIFIC WIDTH - SPECIFIC LENGTH

STANDARD TOLERANCES

Sheet Thickness	Thickness Tolerance	Width Tolerance	Length Tolerance
.030" - .033"	± .0015"	± 1/16"	± 3/32"
.034" - .048"	± .002"	"	"
.049" - .063"	± .003"	"	"
.064" - .078"	± .004"	"	"
.079" - .125"	± .005"	"	"
.126" & over	± 4%	"	"

FINISH

.030" - .060" thickness - Bright
Over .060" thickness - Matte

ANALYSES

Prices available on request for:

1. A quantitative spectrographic analysis of metallic impurities.
2. A chemical analysis of carbon.
3. A vacuum-fusion analysis (oxygen, hydrogen and nitrogen.)
4. Determination of other special residual impurities.
5. Determination of mechanical properties such as tensile strength, yield strength, percent elongation, hardness, or brittle-ductile transition temperature.

PACKAGING

All sheet will be packaged flat in suitable protective containers.

SYLVANIA
metallurgical products
Technical Information Bulletin

MTC ALLOY SHEET (Mo-0.5Ti-0.03C)

MTC is a molybdenum alloy which was developed by Sylvania for applications requiring hardness and high-temperature properties superior to those of unalloyed molybdenum. MTC contains 0.5% titanium and 0.02 to 0.04% carbon, a level of additives that gives, with proper processing, an alloy dispersion-strengthened with finely divided titanium carbide. The high-temperature properties of wrought MTC rival those of commercially available arc-cast alloys, but MTC costs less because it is consolidated by less expensive powder-metallurgical techniques.

MECHANICAL AND METALLURGICAL PROPERTIES

Typical values on as-rolled 0.040″ sheet, unless indicated otherwise.

TENSILE STRENGTH AND ELONGATION

Test Temperature	MTC			UNALLOYED MOLYBDENUM		
	Elongation %	TENSILE STRENGTH[1] PSI		Elongation %	TENSILE STRENGTH[1] PSI	
		Ultimate	Yield[2]		Ultimate	Yield[2]
70 F (20 C)	7	150,000	140,000	12	100,000	90,000
2000 F (1090 C)	10	78,000	61,000	30	18,000	14,000
2200 F (1200 C)	10	55,000	38,000	20	11,000	6,000
2400 F (1320 C)	20	28,000	21,000	—	—	—
Recrystallized:						
70 F (20 C)	32	80,000	67,000	75	67,000	42,000

STRESS RUPTURE[1], PSI

		MTC	UNALLOYED MOLYBDENUM
2200 F (1200 C)	1 hour	39,000	10,000
	10 hours	28,000	6,000

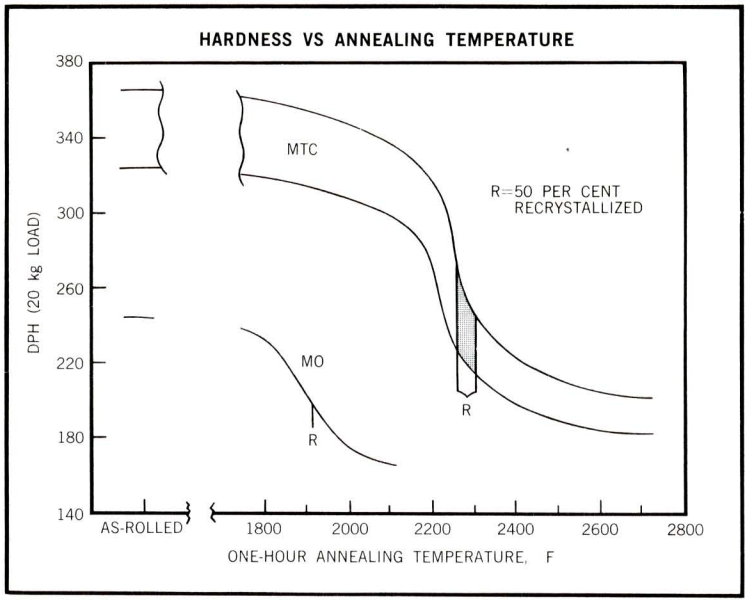
DIAMOND PYRAMID HARDNESS

	MTC	UNALLOYED MOLYBDENUM
(20-kg load)	330	250

[1] *Determined parallel to the final direction of rolling.*
[2] *0.2% offset.*

RECRYSTALLIZATION

MTC sheet is about 50% recrystallized after one hour at 2300 F, and 100% recrystallized after one hour at 2500 F. (See graph) The corresponding temperatures for unalloyed molybdenum sheet are 1900 F and 2000 F.



DUCTILITY AND TRANSITION TEMPERATURE

MTC sheet specimens 0.040″ x 1″ x 3″ can be bent 105° without failure by a punch of the noted radius moving at 10 inches/minute. The bend is perpendicular to the final rolling direction.

	TEMPERATURE, F	PUNCH RADIUS
Bend ductility	70	1T (0.040″)
Ductile-Brittle transition	−50	4T (0.16″)

CHEMICAL COMPOSITION

ALLOY CONSTITUENTS[1]

	Max %	Min %
Molybdenum		99.36
Titanium	0.55	0.45
Carbon	0.04	0.02

TRACE ELEMENTS

	Maximum[2] ppm	Typical ppm	
Al	10	Oxygen[3]	100
Ca	10	Nitrogen[4]	50
Cr	50	Hydrogen[5]	<10
Cu	10		
Fe	50		
Pb	10		
Mg	10		
Mn	10		
Ni	50		
Si	50		
Sn	50		

[1] *Analysis on sintered billets.*
[2] *Determined by spectrographic analysis of the molybdenum powder.*
[3] *By inert-gas fusion.*
[4] *By micro-Kjeldahl.*
[5] *By vacuum fusion.*

PHYSICAL PROPERTIES

The physical properties of the MTC alloy closely resemble those of unalloyed molybdenum. The density of MTC is 10.14 g/cc.

SUGGESTED APPLICATIONS

Some suggested high-temperature, load-bearing applications for MTC sheet are: components for rocket nozzle and vector control, leading edges for reentry vehicles, and high-temperature furnace parts such as heat shields, supports and hearth plates. The high hardness and resistance to thermal shock suggest its use as abrasion-resistant parts for the electrical and metalworking industries: die cores for casting aluminum, magnesium and zinc; piercing points for ferrous alloy tubing. Like unalloyed molybdenum and all other molybdenum-base alloys, MTC oxidizes rapidly in air. It must be used either in inert or reducing atmospheres, or be protected by coatings.

AVAILABLE SIZES AND TOLERANCES

MTC sheet and plate can be supplied in an as-rolled or stress-relieved condition.

MTC SHEET

Thickness Inches	Thickness Tolerance Inches	Maximum Width Inches	Maximum Length Inches
0.040	± 0.002	6	30
0.050	± 0.003	6	24
0.060	± 0.003	6	20
0.080	± 0.005	6	15
0.100	± 0.005	6	12

Tolerances: width, ± 1/16"; length ± 3/32".

MTC PLATE

Thickness Inches	Maximum Width Inches	Maximum Length Inches
3/16	6	7
1/4	5	6
1/2	2 1/2	6

Tolerances: thickness, ±4%; width, ±1/16"; length, +1/4", −0.

Inquiries for larger sizes and other thicknesses are solicited.

SURFACE FINISH

MTC sheet above 0.060″ thick and all plate are supplied with a chemically or mechanically cleaned, matte surface. Sheet, 0.060″ thick and below, is supplied with a clean, bright surface. If requested, a matte surface will be furnished.

SOUNDNESS

MTC sheet and plate are free of internal and external imperfections such as seams, cracks, surface checks, scale, inclusions, and laminations.

PACKAGING AND SHIPPING

Sheet and plate will be packaged in suitable containers, protected to prevent damage during ordinary handling and transit.

Each shipping container will be identified with the following information:

Customer's purchase order number
Lot number
Number of pieces
Gross and net weights

CM 45 10/62 3. Printed in U.S.A.

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PITTSBURGH 300 Mt. Lebanon Blvd. Pittsburgh, Penna.
SAN FRANCISCO 1811 Adrian Road Burlingame, Calif.
TOWANDA Towanda, Penna.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM, 0.5% Ti, .03% C (MTC) SHEET AND PLATE

PRICE SCHEDULE

terms: 3% 15/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Dec. 11, 1962

subject to change without notice.

MTC SHEET AND PLATE
SPECIFIC WIDTH - SPECIFIC LENGTH

Thickness in Inches	Price per Kilogram in Dollars — Width in Inches								Max. Width	Max. Length	Grams per sq.in.
	0.5"	1.0"	1.5"	2"/Over	3.0"	4.0"	5.0"	6"/Over			
.040	75.00	74.00	72.00	71.00					6"	30"	6.64
.050	72.00	71.00	69.00	68.00					6"	24"	8.30
.060	69.00	68.00	66.00	66.00					6"	20"	9.96
.080		65.00	63.00	62.00	61.00	60.00	58.00	57.00	6"	15"	13.2
.100			60.00	55.00	51.00	50.00	50.00	49.00	6"	12"	16.6
.187			51.00	48.00	47.00	46.00	45.00	45.00	6"	7"	31.0
.250			45.00	42.00	41.00	40.00	40.00		5"	6"	41.5
.500			40.00	39.00					2-1/2"	6"	83.0

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

HOW TO ORDER

Thickness, Width and Length should be specified in inches. Standard tolerances listed on reverse side are the basis for pricing.

NOTES

1. Billing will be based on kilograms shipped.
2. Intermediate thicknesses and widths are priced at the next smaller dimension.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM, 0.5% Ti, .03% C (MTC) SHEET AND PLATE

PRICE SCHEDULE

terms: 3% 15/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Dec. 11, 1962

subject to change without notice.

STANDARD TOLERANCES

MTC SHEET

Thickness Inches	Thickness Tolerance Inches
.040	± 0.002
.050	± 0.003
.060	± 0.003
.080	± 0.005
.100	± 0.005
Tolerance on Width	± 1/16"
Tolerance on Length	± 3/32"

MTC PLATE

From .187" to .500" thick

Tolerance on Thickness	± 4%
Tolerance on Width	± 1/16"
Tolerance on Length	+ 1/4" - 0

FINISH

.040" to .060" thickness - Bright Finish
Over .060" thickness - Matte Finish

ANALYSES

Prices available on request for:

1. A quantitative spectrographic analysis of metallic impurities.
2. A chemical analysis of carbon or titanium.
3. Analysis of oxygen, hydrogen and nitrogen.
4. Determination of other special residual impurities.
5. Determination of mechanical properties such as tensile strength, yield strength, percent elongation, hardness, or brittle-ductile transition temperature.

PACKAGING

All sheet will be packaged flat in suitable protective containers.

Sylvania

MOLYBDENUM BOATS

CHEMICAL & METALLURGICAL DIVISION • TOWANDA, PA.

MOLYBDENUM BOAT

Molybdenum boats are useful in applications requiring high temperature firing of parts at temperatures exceeding 1300°C. Although the melting point of molybdenum is high (2622°C.), the metal oxidizes rapidly above 500°C. The use of molybdenum boats, therefore, is limited to inert or reducing atmosphere furnaces, where molybdenum can be used at temperatures approaching 2000°C.

Applications for molybdenum boats include hydrogen-cleaning of electronic parts, high-temperature annealing of refractory metals, and high-temperature sintering of powder metals or ceramics.

Sylvania molybdenum boats are cut from sheet and folded into a rectangular shape with closed ends. Purity of the sheet (99.95%) is controlled from processing of molybdenum chemicals through reduction to metal powder, pressing, sintering, and subsequent rolling. Boats are furnished from sheet which has been annealed to minimize distortion in use.

Boat Dimensions

thickness - available in .025", .030", .035", .040", .045"

length - up to 18"

width and depth - width plus 2 times depth not to exceed 11"

material finish - boats are furnished with a smooth, clean, matte finish

shape - rectangular, with folded, closed ends.

To Order

1. Select material thickness
2. Specify inside length, width, and depth
3. Specify application, if possible.

Other shapes available on request.

SYLVANIA
metallurgical products
Technical Information Bulletin

PRESSED AND SINTERED TUNGSTEN BILLETS, SLABS AND RINGS

MATERIAL SPECIFICATIONS

SCOPE

This specification applies to billets, slabs and rings of unalloyed tungsten. These forms are intended for further processing by forging, rolling or extruding.

MANUFACTURE

These products are produced by isostatically pressing tungsten powder which is then sintered.

CHEMICAL COMPOSITION

TUNGSTEN — *99.95% MINIMUM (by difference)*

Trace Element	Maximum Parts Per Million	Method of Analysis
Aluminum	30	Spectrographic
Arsenic	10	Spectrographic
Calcium	30	Spectrographic
Carbon	50	Chemical
Chromium	10	Spectrographic
Copper	10	Spectrographic
Iron	20	Spectrographic
Magnesium	10	Spectrographic
Molybdenum	50	Chemical
Nickel	20	Spectrographic
Silicon	10	Spectrographic
Oxygen	100	Vacuum fusion
Hydrogen	25	Vacuum fusion
Nitrogen	25	Vacuum fusion

Analyses for metallic elements are made on the metal powder. Gases are determined on a pressed and sintered coupon.

PHYSICAL PROPERTIES

Density—17.8 g/cc minimum, or 92% of the theoretical density of 19.3 g/cc.

Basic Dimensions and Tolerances:

BILLETS

Diameters	Up to and including 7.0"	±⅛"
	7.0" to 10.0" maximum	±¼"
Weight Tolerance		+5%, −0%

SLABS

Widths	Up to and including 7.0"	±⅛"
	Above 7.0" to 10.0" maximum	±¼"
Lengths	Up to 24" maximum	±¼"
	Above 24" to 48" maximum	±1"
Thickness	½" minimum up to 1.0"	±1/16"
	1.0" and over	±⅛"
Taper	1/16" per foot maximum	

Limiting Conditions: Width plus length shall be no more than twenty times the thickness. The largest cross-section must fall within a ten-inch diameter circle.

RINGS

Outside Diameters	Up to and including 7.0"	±⅛"
	Above 7.0" to 10.0" maximum	±¼"
Inside Diameters	Up to 7.0" maximum	±⅛"
Wall Thickness	Mimimum 1½". Thinner wall can be obtained by green or final machining, when requested. Variations not to exceed ±⅛".	

Local variations on billets and rings shall not exceed ⅛" of the average diameter.

FINISH AND SURFACE CONDITION

Parts will be supplied with a smooth, clean, carbide-free matte finish.

SOUNDNESS

Parts will be free of internal and external imperfections such as seams, cracks, piping, surface checks, scale, inclusions or any other defect that might have an adverse effect in subsequent use. Upon request, parts can be inspected by penetrant or ultrasonic methods.

IDENTIFICATION

Parts are identified by weight, density and material lot numbers. The characters will be applied using a suitable marking fluid that will withstand ordinary handling.

PACKING AND SHIPPING

The parts will be packaged in suitable containers or on pallets, and sufficiently protected to prevent damage and contamination during ordinary handling and transit. Each container will be identified with the customer's name, gross weight, net weight, and Sylvania's order number.

REPORTS AND SPECIAL TESTS

On request, Sylvania will furnish three copies of a certified chemical analysis, a spectrographic quantitative analysis, a gas analysis by vacuum fusion, surface-defect analysis by dye penetration and internal-defect analysis by ultrasonic inspection.

REJECTIONS

The Chemical & Metallurgical Division of Sylvania must be notified in writing of all rejections. The rejection notice must include the purchase order number, lot number, size, number of pieces rejected, weight and reason for rejection. Sylvania reserves the right to inspect the material at the customer's plant to determine the basis for rejection. If material is found to be defective, a Return Materials Authorization (RMA) will be issued by Sylvania before the material can be returned.

POTENTIAL APPLICATIONS

Listed below are some of the present and potential fields of applications known for refractory metals:

- Jet engines
- Rockets
- Industrial furnaces
- Solid fuel motors
- Electronic tube parts
- Electrical contacts
- Furnace windings
- Forging dies
- Corrosion resistant equipment
- Furnace boats
- Gas turbine engines
- Lamp filaments
- Carbides
- Welding electrodes
- Metallizing coils
- Flame spray coatings
- Piercing points for seamless tubing

Sylvania's Chemical and Metallurgical Division welcomes and encourages your inquiries on all forms of refractory materials.

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SYLVANIA ELECTRIC PRODUCTS INC. / Chemical & Metallurgical Division TOWANDA, PENNA.

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CHICAGO 2001 N. Cornell Ave. Melrose Park, Ill.
DAYTON 333 West First Street Dayton 2, Ohio
DETROIT 7800 Intervale Ave. Detroit, Mich.
NEW YORK 1000 Huyler Street Teterboro, N. J.
PHILADELPHIA 4700 Parkside Ave. Philadelphia 31, Penna.
PITTSBURGH 300 Mt. Lebanon Blvd. Pittsburgh, Penna.
SAN FRANCISCO 1811 Adrian Road Burlingame, Calif.
TOWANDA Towanda, Penna.

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: May 22, 1961

subject to change without notice.

PRESSED AND SINTERED TUNGSTEN ROUND BILLETS FOR FORGING AND METAL WORKING

ROUND BILLETS - RANDOM LENGTH

Standard Diameter Inches	Price/lb.	Maximum Length Inches	Approx. Weight Full Length in Lbs.
1.0	$12.40	15	8
1.25	10.65	18	14
1.50	8.70	22	25
1.75	8.20	24	37
2.0	7.65	30	61
2.5	7.05	30	95
3.0	6.70	36	163
3.5	6.50	36	222
4.0	6.40	48	387
4.5	6.35	48	490
5.0	6.25	48	605
5.5	6.20	48	732
6.0	6.20	48	871
7.0	6.10	48	1186
8.0	6.10	48	1549
9.0	6.10	48	1960
10.0	6.10	48	2420

Intermediate weights and diameters are priced at the next smaller weight or diameter.

Minimum Charge per Item - $25.00

PRICE SCHEDULE

terms: 3% 15th/EOM, Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* May 22, 1961

subject to change without notice.

PRESSED AND SINTERED TUNGSTEN ROUND BILLETS FOR FORGING AND METAL WORKING

ROUND BILLETS - SPECIFIC WEIGHTS

Standard Diameter Inches	Price per Pound in Dollars — Weight per Billet										Max. Weight Available in Lbs.
	2#	4#	6#	8#	10#	15#	25#	50#	100#	150#	
1.0	10.05	9.90	9.75								7
1.25	9.50	9.30	9.20	9.20	9.10						12
1.50	9.20	8.95	8.85	8.80	8.80	8.75					22
1.75	8.90	8.65	8.55	8.50	8.45	8.40	8.35				33
2.0	8.70	8.40	8.25	8.20	8.20	8.15	8.10	8.00			55
2.5		8.10	7.95	7.90	7.85	7.80	7.75	7.70			85
3.0		7.90	7.65	7.55	7.50	7.45	7.35	7.30	7.25		147
3.5			7.65	7.50	7.40	7.30	7.20	7.15	7.10	7.10	200
4.0				7.50	7.40	7.25	7.15	7.05	7.00	7.00	348
4.5					7.35	7.25	7.10	7.00	6.95	6.95	441
5.0						7.25	7.10	6.95	6.85	6.85	544
5.5						7.25	7.10	6.90	6.85	6.80	659
6.0							7.10	6.90	6.80	6.80	784
7.0							7.10	6.90	6.75	6.70	1067
8.0								6.90	6.75	6.70	1394
9.0								6.90	6.75	6.70	1764
10.0								6.90	6.75	6.70	2178

Weight Tolerance - Plus 5% Minus 0

Intermediate weights and diameters are priced at the next smaller weight or diameter. Billets weighing less than 2 pounds will be priced on special request.

Minimum Charge per Item - $25.00

SYLVANIA
metallurgical products
Technical Information Bulletin

TUNGSTEN WIRE

SYLVANIA tungsten wire is manufactured to meet a broad range of uses which include applications in the lamp, electronic-tube, vacuum-metallizing, and electric-furnace industries.

Through various drawing methods and annealing steps, Sylvania can produce different physical characteristics in wire of a given size. Above, general view of tungsten wire drawing department.

Tungsten-wire drawing is accomplished by coating the wire with a graphite lubricant, heating to a red heat, and then drawing through tungsten carbide or diamond dies. This process is sometimes referred to as "hot cold-working," a term which means that, while the wire is hot, the temperature is still below the recrystallization range. Accordingly, as the cross-sectional area is reduced, the strength and ductility increase. The as-drawn wire at finished size may be cleaned, straightened, or annealed as determined by its intended application. Sylvania's control of each step of wire manufacture from tungsten ore concentrates to finished wire is the customer's assurance of reliability.

TYPES OF TUNGSTEN WIRE

Sylvania manufactures wire having the following descriptions:

NS - is the Sylvania designation for non-sag tungsten wire for filaments and supports in fluorescent and incandescent lamps, electronic-tube grids and heaters, and electric-furnace elements. It is available in the broadest range of standard processes, and has the widest variety of applications.

VM - is the Sylvania designation for tungsten wire furnished in either stranded or single-strand form that has been processed specifically for vacuum-metallizing applications. *(Refer to technical information bulletin "Tungsten Strand for Vacuum Metallizing.")*

TH - is the Sylvania designation for tungsten wire containing 0.75% to 1.1% thoria. Its principal use is for power-tube filaments and for vibration service in some types of incandescent lamps.

RW - is the Sylvania designation for tungsten-rhenium wire. *(Refer to technical bulletin on Sylvania Tungsten-3% Rhenium Wire.)*

MEASUREMENT OF WIRE SIZE AND TOLERANCE

Wire sizes 20 mils and larger are expressed in mils (or inches). Wire sizes below 20 mils are expressed in milligrams per 200 millimeters (mg/200mm).

The relationship of milligram weight to diameter in mils can be shown as:

For NS wires: $mg/200mm = 1.943 \times (\text{diameter in mils})^2$

For 1% TH wires: $mg/200mm = 1.924 \times (\text{diameter in mils})^2$

Calculated milligram weights are rounded off by Sylvania to a value consistent with the sensitivity of weighing (usually to the nearest 0.01 mg.).

Wire tolerances are based on the center size and are expressed as the center size plus or minus milligram/200mm, percent of milligram weight, or percent of diameter in mils as outlined in the following table:

Wire Size Range	Tolerance Expressed As	Standard Tolerance	Other Available Tolerances
0.08mg/200mm to 0.67mg/200mm	mg/200mm	Varies with center size. Refer to published price sheets.	± 0.03, ± 0.025, ± 0.02, ± 0.015, ± 0.01 ± 0.005mg/200mm
0.68mg/200mm to 19.9 mils	percent of milligram weight	± 3%	± 2½%, ± 2%, ± 1½%, ± 1%, ± ½%
20 mils and larger	percent of diameter	± 1½%	± 1¼%, ± 1%, ± ¾%

STANDARD PROCESSES

NON-SAG TUNGSTEN WIRE

NS-10 - Designates as-drawn wire, which retains the black finish from the graphite drawing lubricant. The wire is unstraightened and has high tensile strength. NS-10 is generally used for coils for incandescent and fluorescent lamps.

NS-20 - Designates NS-10 wire which has been straightened but not cleaned.

NS-30 - Designates NS-10 wire which has been chemically cleaned but not straightened.

NS-50 - Designates tungsten wire which has been cleaned, straightened, and annealed in a reducing atmosphere. It is generally used in electronic-tube grid and heater applications where optimum straightness and low tensile strength are required.

NS-55 - Designates tungsten wire which has been chemically cleaned, straightened, and stress-relieved in a reducing atmosphere. NS-55 wire has good straightness and intermediate tensile properties, finding broad usage wherever a cleaned and straightened tungsten wire is required. Generally it is used for electronic-tube grids and heaters and for lamp coils, but it serves other applications when a cleaned and straightened tungsten wire is needed.

NS-60 - Designates tungsten wire which has been partially straightened under heat and tension, and chemically cleaned. NS-60 retains the high tensile strength of the as-drawn wire.

NS-80 - Designates an unstraightened, electropolished wire with a high tensile strength. It is generally used in sizes below diamond-die drawing range and may be used in larger sizes where the very smooth electropolished surface is desired.

NS-85 - Designates an electropolished wire with a low tensile strength, which has been straightened with heat in a reducing atmosphere. Straightness and tensile strength are comparable to those of NS-50.

NS-86 - Designates an electropolished wire having intermediate tensile strength and straightness. Tensile strength and straightness are comparable to those of NS-55.

NS-87 - Designates a partially straightened electropolished wire with high tensile strength. Straightness and tensile strength are comparable to those of NS-60. NS-87 wire is recommended for electron-tube grids at sizes 0.5 mil and below, where a high tensile strength and a very smooth finish are required for efficient operation of automatic grid-winding machines.

STANDARD PROCESSES

THORIATED TUNGSTEN WIRE

TH-10 - Designates black, as-drawn wire containing thoria.

TH-20 - Designates TH-10 wire which has been straightened but not cleaned.

TH-30 - Designates TH-10 wire which has been cleaned but not straightened.

TH-55 - Designates TH-10 wire which has been chemically cleaned and straightened.

TH-60 - Designates TH-10 wire which has been partially straightened under heat and tension, and chemically cleaned. TH-60 retains the high strength of as-drawn wire.

NON-SAG WIRES

Process	Surface Finish	Tensile Strength	Straightness	Available Size Range
NS-10	Black	High	1	0.17 mg/200mm to 100 mils
NS-20	Black	High	2	0.45 mg/200mm to 100 mils
NS-30	Clean	High	1	0.45 mg/200mm to 100 mils
NS-50	Clean	Low	4	0.45 to 50 mg/200mm
NS-55	Clean	Intermediate	3	0.45 mg/200mm to 85 mils
NS-60	Clean	High	2	0.45 to 12 mg/200mm
NS-80	Clean	High	1	0.04 mg/200mm to 10 mils
NS-85	Polished	Low	4	0.45 to 50 mg/200mm
NS-86	Polished	Intermediate	3	0.45 mg/200mm to 10 mils
NS-87	Polished	High	2	0.17 to 12 mg/200mm

THORIATED WIRES

TH-10	Black	High	1	1.25 mg/200mm to 40 mils
TH-20	Black	High	2	1.25 mg/200mm to 40 mils
TH-30	Clean	High	1	1.25 mg/200mm to 40 mils
TH-55	Clean	Intermediate	3	1.25 mg/200mm to 40 mils
TH-60	Clean	High	2	1.25 mg/200mm to 40 mils

Straightness: 1 = unstraightened
2 = partially straightened
3 = intermediate straightness
4 = best straightness

CONTAINERS

Sylvania tungsten wire is supplied on returnable containers or in coils depending on the size ordered. The following tables list our standard containers. Other containers are available on request.

RETURNABLE CONTAINERS FOR TUNGSTEN WIRE

	Container Number	Description	Bore Diameter Inches	Barrel Diameter Inches	Traverse Inches	Spool Weight Grams
	1	Aluminum Spool	3/8	1 5/8	1	81
	2	Plastic Spool	3/8	1 5/8	1	34
	3	Aluminum Spool	3/8	1 1/2	1	17
	30	Plastic Bobbin	1 9/16	1 7/8	5/8	17
	31	Aluminum Bobbin	1 9/16	1 11/16	5/8	18
	32	Aluminum Bobbin, Tapered	1/2 to 5/8	3/4	7/16	4
	33	Plastic Bobbin	7/16	19/32	27/64	2
	45	Metal Band	3 3/4	3 7/8	13/16	82
	46	Metal Band	3 7/8	4	1	195
	47	Plastic Band	3 3/4	3 7/8	13/16	64
	48	Plastic Band	3 7/8	4	1	100

When the container is not specified by the customer, the following standard containers will be used.

For NS-10 and TH-10 Wire

Container No. 1 for all sizes up to 153.9 mg/200mm
Container No. 46 for all sizes from 154 mg/200mm to 19.9 mils

For All Other NS and TH Wire

Wire Size Range	Container Numbers
Up to 0.44 mg/200mm	2 or 32
0.45 to 25 mg/200mm	1 or 45
25.01 mg/200mm to 19.9 mils	45 or 46

Tungsten wire at sizes 20-mils and above is supplied in coils. Each coil is tied securely with a soft tie-wire at three positions on the coil.

Wire Size Range	Coil Diameter, Inches	
	NS-10 NS-30 TH-10 TH-30	NS-20 NS-55 TH-20 TH-55
20 to 38.9 mils	7½	12 to 14
39 to 50.9 mils	12 to 14	14 to 16
51 mils and over	20 to 22	20 to 22

A nominal deposit charge is made for spools and bands used in shipping wire. Credit will be allowed at the prices billed, when containers are returned in good condition to our plant in Towanda, Pennsylvania; transportation paid, within six months of receipt by the buyer.

All spools, bands, and coils are either labeled or tagged with complete data identifying the wire. Only one continuous length of wire is wound on a container. On spools, the outer end of the wire is held by a red cork to distinguish it from the inner end.

Sylvania also supplies plated tungsten wire. (*Refer to our technical bulletin on Plated Wire.*)

HOW TO ORDER

1. Specify wire type and process.
2. Specify wire size and tolerance.
3. Specify container number.

Examples:

NS-55 tungsten wire
7.00 mg/200mm ± 3%
Supply on container #1.

NS-10 tungsten wire
60 mil diameter ± 1½ %
Supply in coil.

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NEW YORK 1000 Huyler Street Teterboro, N. J.
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Technical Information Bulletin

PLATED WIRE

SYLVANIA'S Chemical and Metallurgical Division offers the capability of electroplating fine wire with a wide variety of metals. Heretofore, the major application for fine plated wire has been as electronic-tube grid-lateral wire. Since 1950, Sylvania plated tungsten and molybdenum wire has been the standard of the electronic-tube industry.

The possibility of electroplating to improve oxidation resistance or solderability of the base wire suggests the use of plated wire in other applications, such as high-temperature electrical conductors and leads for semiconductor devices.

In addition to the plating of tungsten and molybdenum wire, other metals such as copper, stainless steel, or nickel alloys, may be plated according to the customer's specifications. Also, base wire supplied by the customer may be toll-plated and finished according to the customer's specifications. Composite platings such as tungsten wire plated with nickel and then with gold, are also available.

AVAILABLE RANGE OF WIRE DIAMETERS

BASE WIRE	DIAMETER OF BASE WIRE, MILS
Tungsten	0.2 to 10
Tungsten—3% Rhenium	0.2 to 10
Molybdenum	0.5 to 10
Other Metals	up to 10

Inquiries for plating other base metals are solicited.

SPECIFICATION OF WIRE SIZE AND PLATING WEIGHT

Although wire diameter is often expressed in inches or mils, it is recommended that size measurements and tolerances be expressed in milligrams per 200 millimeters (mg/200mm). The conversion factors for tungsten and molybdenum are as follows:

Tungsten: $mg/200mm = (\text{diameter in mils})^2 \times 1.943$
Molybdenum: $mg/200mm = (\text{diameter in mils})^2 \times 1.028$

Plating weight is expressed as *percent plate* based on the weight of the bare-wire. Pieces of wire 200mm long are weighed before and after plating, and the percent plate is calculated as follows:

$$\text{Percent Plate}^* = \frac{(\text{Wt. of plated wire}) - (\text{Wt. of bare-wire})}{(\text{Wt. of bare-wire})} \times 100$$

Following are listed the plate materials and the maximum percent plate normally supplied for electronic application.

Other plates and higher percent plates are available upon customer request.

TYPE OF PLATE	MAXIMUM PERCENT PLATE NORMALLY SUPPLIED
Copper	10
Gold	10
Indium	10
Nickel	10
Palladium	4
Rhenium	3
Rhodium	3
Silver	10

**A percent plate based on the weight of the plated wire will be determined if specified by the customer. Unless specified by the customer, percent plate will be calculated on the bare-wire basis.*

How to Calculate percent plate when plating thickness is specified:

When the plating thickness is specified, the percent plate may be calculated by substituting the proper values in the following formula:

$$\text{Percent Plate} = \frac{400\,\rho_p\,T\,(d_b + T)}{\rho_b\,d_b^2}$$

$T =$ *Plating thickness in mils*

$\rho_p =$ *Density of plate material in g/cc*

$\rho_b =$ *Density of base wire in g/cc*

$d_b =$ *Diameter of base wire in mils*

Density of Typical Materials, g/cc	
Copper	8.9
Indium	7.3
Molybdenum	10.14
Nickel	8.9
Palladium	12.0
Rhenium	20.0
Rhodium	12.4
Tungsten	19.17

PLATING TOLERANCE

Plating tolerance refers to allowable variations from the nominal percent plate. For example, molybdenum wire specified with a 4% gold plate and a plating tolerance of ±1%, is supplied with a 3% to 5% gold plate. The following table lists standard plating tolerances:

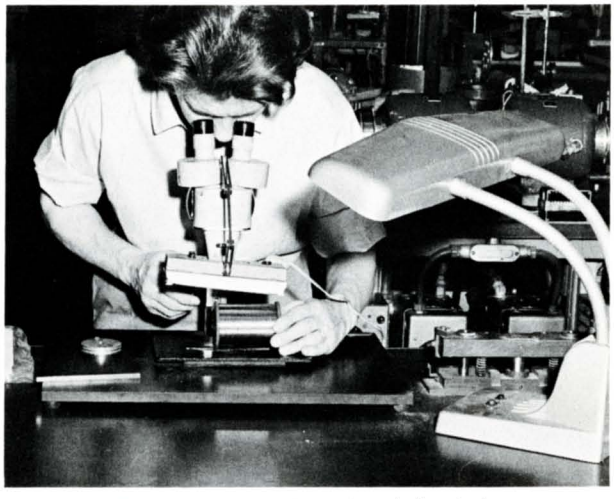
DIAMETER OF BASE WIRE, MILS	STANDARD PLATING TOLERANCE
0.6 to 10	±1%
0.41 to 0.59	±1½%
0.20 to 0.40	±2½%

Other tolerances are available on request.

Sylvania's rigid control of quality in the manufacture of plated wires provides lower operating costs for the customer by minimizing rejected parts or assemblies caused by faulty wire.

CONTROL OF PLATING QUALITY

The primary inspection method for plating quality consists of the microscopic examination of the plated wire surface at 30X magnification under bright light. Defects such as lack of plate, loose plate, damage, discoloration, poor spooling, and non-uniform plating are determined in this manner.



Routine microscopic inspection of plated wire.

Another important check made on plating quality is the knife-edge adherence test. In this test, the plated wire is drawn over a 90° knife-edge of 0.010″ radius, the wire being held against the edge by the thumb. The wire is pulled at a 45° angle to the plane of the blade. The plating must not flake or "pipe" in order to meet the Sylvania quality requirements.

CONTROL OF SPOOLING QUALITY

All Sylvania plated wire is respooled with controlled tension to give a uniform, layer-type winding. There is no "soft spooling" from winding too loosely, and no stretching or sticking from winding too tightly. This combination of layer winding and controlled winding tension permits the wire to unreel readily from top to bottom of the spool, minimizing breakage on the customer's grid-winding machines. Each spool is carefully checked for spooling quality and examined visually and microscopically for evenness of winding. The wire is unreeled by hand to check for any defects such as kinks, curl, or twist.

CONTROL OF WIRE SIZE AND PERCENT PLATE

All plated wire supplied by Sylvania is measured on a weight basis with precision torsion balances. Balances having different weighing capacities are employed so that the most accurate balance can be matched to the specific wire size to be measured, giving the customer added assurance of accuracy. All Sylvania balances and 200mm cutters are calibrated daily against standards.

Regular checks for percent plate are also made by chemical analysis and, in special situations, by X-ray diffraction techniques.

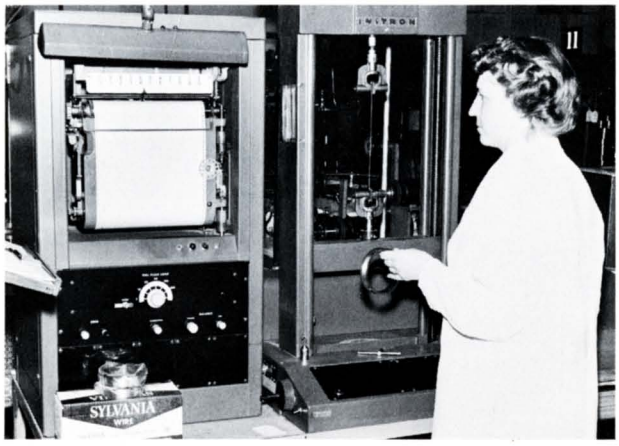
X-ray diffraction unit, set up for measuring thickness of nickel plate on molybdenum wire.

Rating of wire for milligram weight. (Note that balances with different weighing capacities are employed so that the best accuracy can be maintained with each different wire size.)

CONTROL OF PHYSICAL PROPERTIES

Sylvania plated tungsten and molybdenum wires are controlled to specific physical properties.

The equipment for tensile measurements is the Instron tester, which measures and records ultimate tensile strength, yield strength, and elongation, under a constant rate of loading. Tensile strength is specified in gram/mg/200mm. In the case of finer wires, a minimum breaking load in grams may be specified.



Instron tester located in Production Plating Department.

PLATED TUNGSTEN WIRE

Sylvania plated tungsten wire is designed specifically for electron-tube grid application. Standard wire is controlled to a 10-point spread in tensile strength in the size range 0.5 to 2.5 mils and to a minimum tensile strength of 95 g/mg/200mm in sizes below 0.5 mils.

Plated tungsten wire having controlled minimum elongation as well as controlled strength is also available.

TYPE OF PLATE	STANDARD NOMINAL PERCENT PLATE
Gold	3 to 7
Silver	3 to 6
Nickel	1 to 3

PHYSICAL PROPERTIES OF PLATED TUNGSTEN WIRES

FINE WIRE

STANDARD CONTROLLED TENSILE STRENGTH

Wire Diameter, mils	Tensile Strength, Grams/mg/200mm
2.5 to 0.8	65 to 75
	75 to 85
0.7	65 to 75
	75 to 85
0.6	75 to 85
0.5	75 to 85

ULTRA-FINE WIRE

STANDARD CONTROLLED TENSILE STRENGTH

Wire Diameter, mils	Breaking Load, Grams	Tensile Strength Grams/mg/200mm
0.5	46.2 min.	95 min.
0.4	29.5 min.	95 min.
0.3	16.6 min.	95 min.
0.2	7.4 min.	95 min.

In addition to wire as listed in the tables above, we can furnish wire having the same tensile strengths, but with controlled elongation, as follows:

STANDARD CONTROLLED TENSILE STRENGTH AND CONTROLLED ELONGATION

Wire Diameter mils	Tensile Strength Grams/mg/200mm	Minimum Percent Elongation
2.5 to 0.8	65 to 75	1.5
	75 to 85	
0.7	65 to 75	1.4
	75 to 85	
0.6	75 to 85	1.4
0.5	75 to 85	1.3
0.4	95 min.	1.25
0.3	95 min.	1.25
0.2	95 min.	1.0

Other specifications can be supplied on request.

PLATED MOLYBDENUM WIRE

The physical properties of Sylvania plated molybdenum wire are controlled to the specific values of tensile strength, yield strength, work range, and elongation outlined in ASTM F290-57T. Either Class II or Class III wire can be supplied. Other specifications can be furnished on request.

TYPE OF PLATE	STANDARD NOMINAL PERCENT PLATE
Gold	4 to 6
Nickel	1 to 4
Silver	4 to 6

NOTE: Standard plates shown for tungsten and molybdenum wires reflect current production. We are constantly increasing our range of capabilities as our customers' requirements change. Please ask us for engineering assistance on plated wires, either by contacting our plant at Towanda, Pennsylvania, or your local Sylvania Sales Engineer.

CONTAINERS

Sylvania plated wires are furnished on returnable containers, packaged to prevent damage. The following table lists the containers available for Sylvania plated wires.

CONTAINER TYPES

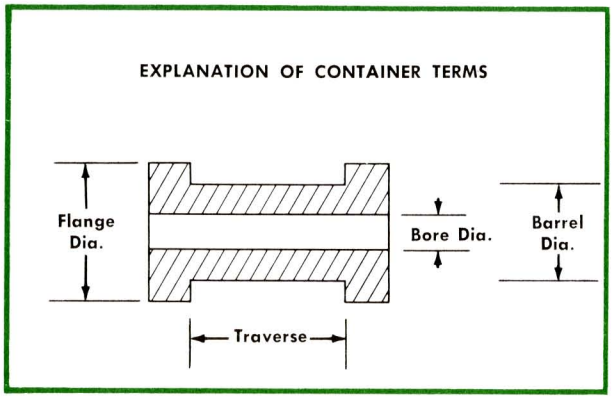
	Container No.	Description	Traverse In.	Bore Dia. In.	Barrel Dia. In.	Flange Dia. In.	Average Wt.	Wire Diameter Mils
	1	Aluminum spool	1	3/8	1 5/8	2 1/4	81	0.6 to 3
	2	Plastic spool	1	3/8	1 5/8	2 1/4	34	0.3 to 3
	8	Aluminum spool	3	5/8	4 1/8	4 3/4	166	2 to 10
	9	Plastic spool	3	5/8	1 13/16	2 1/2	46	1.2 to 6
	13	Aluminum spool	3/4	3/8	1 9/16	1 15/16	23	0.2 to 0.8
	30	Plastic bobbin*	5/8	1 9/16	1 7/8	2 3/16	17	0.5 to 5
	31	Aluminum bobbin*	5/8	1 9/16	1 11/16	2 1/8	18	0.5 to 5
	32	Aluminum bobbin	7/16	Tapered 1/2 to 5/8	3/4	27/32	4	0.2 to 0.5
	33	Plastic bobbin	27/64	7/16	9/16	25/32	3	0.2 to 0.5
	45	Metal band	13/16	3 3/4	4 1/4	4 1/4	82	0.8 to 10
	47	Plastic band	13/16	3 3/4	4 5/8	4 5/8	64	0.8 to 10

**Container number 30 is furnished with no deposit charge. Both container 30 and 31 are designed for automatic grid-winding equipment. Other containers can be made available on request.*

A small deposit is charged the customer for these containers. Credit will be allowed at the prices billed when spools and bands are returned by the buyer in good condition to our plant in Towanda, Pennsylvania, within six months.

When the container is not specified by the customer, the preferred containers listed in the following table will be used. Also shown are suggested alternate containers.

SIZE RANGE, MILS	PREFERRED CONTAINER NO.	ALTERNATE CONTAINER NO.
6.1 to 10	8	45
2.1 to 6	9	45
0.8 to 2	2	1, 9 or 45
0.51 to 0.79	2	
up to 0.5	32	2



HOW TO ORDER PLATED WIRES

1. Specify base wire to be plated, including wire size, size tolerance, and physical properties desired.
2. Specify type of plating and percent plate.

Example 1. Molybdenum wire, 2-mil diameter (4.11 mg/200mm ± 3%). ASTM F290 Class III properties
Nickel-plated 4%
No. 45 band, 500 meters minimum to 5000 meters maximum per container.

Example 2. Music wire, 3-mil diameter, ±0.12-mil (7.17 mg/200mm ±10%); 8.5-10.5% silver-plated, tensile strength 303,000-620,000 lb/sq. in. (150-250 g/mg/200mm); No. 8 container—supply in maximum possible lengths.

CM 49 3/63 3. Printed in U.S.A.

SYLVANIA
SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC. / Chemical & Metallurgical Division / TOWANDA, PENNA.

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SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN WIRE
GOLD PLATED

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pg. 402 1-2-58

effective: Feb. 11, 1963

subject to change without notice.

GOLD-PLATED TUNGSTEN WIRE
CONTROLLED TENSILE STRENGTH

TENSILE STRENGTH - 10-point range within standard tensile-strength limits.

BARE WIRE ± 3% Tolerance		Price per Thousand Meters Gold by Weight ± 1%				
Diameter Inches	Weight Mg/200 mm	7%	6%	5%	4%	3%
.0007	.95	$ 9.10	$ 9.05	$ 9.00	$ 8.95	$ 8.90
.0008	1.24	9.00	8.90	8.80	8.70	8.60
.0009	1.57	9.10	8.95	8.80	8.65	8.50
.0010	1.94	9.10	8.95	8.80	8.65	8.50
.0011	2.35	9.85	9.65	9.45	9.25	9.05
.0012	2.80	10.45	10.20	9.95	9.70	9.45
.0013	3.28	11.05	10.80	10.55	10.30	10.05
.0014	3.81	12.00	11.70	11.40	11.10	10.80
.0015	4.37	12.75	12.40	12.05	11.70	11.35
.0016	4.97	13.50	13.10	12.70	12.30	11.90
.0017	5.61	14.25	13.80	13.35	12.90	12.45
.0018	6.29	15.00	14.50	14.00	13.50	13.00
.0019	7.01	15.85	15.25	14.65	14.05	13.45
.0020	7.77	16.75	16.10	15.45	14.80	14.15
.0025	12.14	22.05	21.05	20.05	19.05	18.05

Other sizes and plating weights available on request.

For quantities of less than 10,000 meters, add $2.00 per thousand meters.

Intermediate diameters will be priced at the next higher price.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN WIRE
GOLD PLATED

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: Pg. 403 1-2-58

effective: Feb. 11, 1963

subject to change without notice.

GOLD-PLATED TUNGSTEN WIRE
CONTROLLED TENSILE STRENGTH AND ELONGATION

TENSILE STRENGTH - 10-point range within standard tensile-strength limits.

ELONGATION - 1.5% minimum guaranteed.

BARE WIRE ± 3% Tolerance		Price per Thousand Meters Gold by Weight ± 1%				
Diameter Inches	Weight Mg/200 mm	7%	6%	5%	4%	3%
.0007	.95	$ 9.35	$ 9.30	$ 9.25	$ 9.20	$ 9.15
.0008	1.24	9.25	9.15	9.05	8.95	8.85
.0009	1.57	9.35	9.20	9.05	8.90	8.75
.0010	1.94	9.35	9.20	9.05	8.90	8.75
.0011	2.35	10.10	9.90	9.70	9.50	9.30
.0012	2.80	10.75	10.50	10.25	10.00	9.75
.0013	3.28	11.35	11.10	10.85	10.60	10.35
.0014	3.81	12.30	12.00	11.70	11.40	11.10
.0015	4.37	13.10	12.75	12.40	12.05	11.70
.0016	4.97	13.85	13.45	13.05	12.65	12.25
.0017	5.61	14.60	14.15	13.70	13.25	12.80
.0018	6.29	15.35	14.85	14.35	13.85	13.35
.0019	7.01	16.25	15.65	15.05	14.45	13.85
.0020	7.77	17.15	16.50	15.85	15.20	14.55
.0025	12.14	22.50	21.50	20.50	19.50	18.50

Other sizes and plating weights available on request.

For quantities of less than 10,000 meters, add $2.00 per thousand meters.

Intermediate diameters will be priced at the next higher price.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

TUNGSTEN WIRE
SILVER OR NICKEL PLATED

PRICE SCHEDULE

terms: Net 30 Days

replaces: Pg. 404 2-24-58

subject to change without notice.

f.o.b.: Towanda, Pa.

effective: Feb. 11, 1963

SILVER- OR NICKEL-PLATED TUNGSTEN WIRE
3% to 6% Silver Plate by Weight
1% to 3% Nickel Plate by Weight

BARE WIRE ± 3% Tolerance		Price per Thousand Meters Plating Tolerance by Weight ± 1%	
Diameter Inches	Weight Mg/200 mm	C. T. Wire*	C. T. & E. Wire**
.0007	.95	$ 8.80	$ 9.05
.0008	1.24	8.60	8.85
.0009	1.57	8.55	8.80
.0010	1.94	8.45	8.70
.0011	2.35	9.05	9.30
.0012	2.80	9.50	9.80
.0013	3.28	9.95	10.25
.0014	3.81	10.75	11.05
.0015	4.37	11.30	11.65
.0016	4.97	11.85	12.20
.0017	5.61	12.35	12.70
.0018	6.29	12.90	13.25
.0019	7.01	13.45	13.85
.0020	7.77	14.10	14.50
.0025	12.14	17.95	18.40
The following prices apply to 1% to 3% Nickel-Plated Wire ONLY			
.0030	17.48	22.15	22.75
.0035	23.80	27.15	27.90
.0040	31.08	31.95	32.85
.0045	39.34	37.55	38.60
.0050	48.57	43.70	44.90

* C. T. Wire - Controlled tensile strength - 10-point range within standard tensile-strength limits.

** C. T. & E. Wire - Controlled tensile strength (10-point range within standard tensile-strength limits) with guaranteed minimum elongation of 1.5%.

For quantities of less than 10,000 meters, add $2.00 per thousand meters.
Other sizes and plating weights available on request.
Intermediate diameters will be priced at the next higher price.

MINIMUM CHARGE: $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
GOLD PLATED

PRICE SCHEDULE

terms: Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 406 2-9-59 *effective:* Nov. 1, 1962

subject to change without notice.

GOLD-PLATED CLASS II MOLYBDENUM WIRE

Price per Thousand Meters
Gold by Weight (± 1% Tolerance)

Bare Wire		6%		5%		4%	
Dia. In.	Weight Mg/200 mm	Bare Wire Tol. ± 4%	± 3%	Bare Wire Tol. ± 4%	± 3%	Bare Wire Tol. ± 4%	± 3%
.0012	1.48	$11.60	$12.29	$11.48	$12.17	$11.35	$12.04
.0015	2.31	9.84	10.29	9.70	10.15	9.55	10.00
.0016	2.63	10.30	10.70	10.08	10.48	9.85	10.25
.0017	2.97	10.70	11.05	10.45	10.80	10.20	10.55
.0018	3.33	11.01	11.31	10.73	11.03	10.45	10.75
.0019	3.71	10.82	11.07	10.51	10.76	10.20	10.45
.0020	4.11	8.25	8.46	7.90	8.11	7.55	7.76
.0021	4.53	8.73	8.91	8.35	8.53	7.97	8.15
.0022	4.97	9.49	9.64	9.07	9.22	8.65	8.80
.0023	5.44	9.79	9.91	9.34	9.46	8.88	9.00
.0024	5.92	10.01	10.10	9.51	9.60	9.01	9.10
.0025	6.42	9.80	9.86	9.27	9.33	8.73	8.79
.0026	6.95	10.15	10.21	9.57	9.63	8.99	9.05
.0027	7.49	10.60	10.66	9.97	10.03	9.34	9.40
.0028	8.06	11.11	11.16	10.43	10.48	9.75	9.80
.0029	8.64	11.61	11.66	10.88	10.93	10.15	10.20
.0030	9.25	11.87	11.92	11.09	11.14	10.31	10.36
.0031	9.87	12.40	12.45	11.58	11.63	10.75	10.80
.0032	10.52	13.04	13.08	12.15	12.19	11.26	11.30
.0033	10.89	13.54	13.58	12.60	12.64	11.66	11.70
.0034	11.88	13.86	13.89	12.87	12.90	11.87	11.90
.0035	12.59	14.09	14.12	13.04	13.07	11.98	12.01
.0036	13.32	14.71	14.74	13.59	13.62	12.47	12.50
.0037	14.07	15.44	15.47	14.26	14.29	13.07	13.10
.0038	14.84	16.01	16.04	14.77	14.80	13.52	13.55
.0039	15.63	16.45	16.48	15.14	15.17	13.82	13.85
.0040	16.44	16.92	16.95	15.54	15.57	14.15	14.18
.0041	17.27	17.47	17.50	16.02	16.05	14.57	14.60
.0042	18.13	18.12	18.15	16.60	16.63	15.07	15.10
.0043	19.00	18.76	18.79	17.17	17.20	15.57	15.60
.0044	19.89	19.41	19.44	17.74	17.77	16.07	16.10
.0045	20.81	20.02	20.05	18.28	18.31	16.53	16.56
.0046	21.74	20.97	21.00	19.15	19.18	17.32	17.35
.0047	22.70	21.98	22.01	20.08	20.11	18.17	18.20
.0048	23.68	23.37	23.40	21.17	21.20	18.97	19.00
.0049	24.67	24.99	25.02	22.38	22.41	19.77	19.80
.0050	25.69	25.94	25.97	23.27	23.30	20.60	20.63

Bare wire meets ASTM Class II Specification F290-57T.
For quantities of less than 10,000 meters, add $2.00 per thousand meters.
Prices available upon request for other sizes, tolerances and plating weights.

Minimum charge per item - $25.00

10/62/2000

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
GOLD PLATED

PRICE SCHEDULE

terms: Net 30 Days

f.o.b.: Towanda, Pa.

replaces: None

effective: Nov. 1, 1962

subject to change without notice.

GOLD-PLATED CLASS III MOLYBDENUM WIRE

Bare Wire		Price per Thousand Meters Gold by Weight (± 1% Tolerance)					
		6%		5%		4%	
Dia. In.	Weight Mg/200 mm	Bare Wire Tol. ± 4%	± 3%	Bare Wire Tol. ± 4%	± 3%	Bare Wire Tol. ± 4%	± 3%
.0012	1.48	$12.68	$12.68	$12.56	$12.56	$12.43	$12.43
.0015	2.31	10.60	10.60	10.46	10.46	10.31	10.31
.0016	2.63	11.01	11.01	10.79	10.79	10.56	10.56
.0017	2.97	11.36	11.36	11.11	11.11	10.86	10.86
.0018	3.33	11.62	11.62	11.34	11.34	11.06	11.06
.0019	3.71	11.38	11.38	11.07	11.07	10.76	10.76
.0020	4.11	8.70	8.70	8.35	8.35	8.00	8.00
.0021	4.53	9.16	9.16	8.78	8.78	8.39	8.39
.0022	4.97	9.88	9.88	9.46	9.46	9.04	9.04
.0023	5.44	10.16	10.16	9.70	9.70	9.24	9.24
.0024	5.92	10.34	10.34	9.84	9.84	9.34	9.34
.0025	6.42	10.13	10.13	9.59	9.59	9.05	9.05
.0026	6.95	10.48	10.48	9.90	9.90	9.31	9.31
.0027	7.49	10.92	10.92	10.29	10.29	9.66	9.66
.0028	8.06	11.42	11.42	10.74	10.74	10.06	10.06
.0029	8.64	11.92	11.92	11.20	11.20	10.47	10.47
.0030	9.25	12.18	12.18	11.40	11.40	10.62	10.62
.0031	9.87	12.72	12.72	11.89	11.89	11.06	11.06
.0032	10.52	13.34	13.34	12.45	12.45	11.56	11.56
.0033	10.89	13.84	13.84	12.90	12.90	11.96	11.96
.0034	11.88	14.15	14.15	13.16	13.16	12.16	12.16
.0035	12.59	14.39	14.39	13.33	13.33	12.27	12.27
.0036	13.32	15.06	15.06	13.92	13.92	12.77	12.77
.0037	14.07	15.73	15.73	14.55	14.55	13.37	13.37
.0038	14.84	16.32	16.32	15.07	15.07	13.82	13.82
.0039	15.63	16.75	16.75	15.44	15.44	14.12	14.12
.0040	16.44	17.22	17.22	15.84	15.84	14.45	14.45
.0041	17.27	17.83	17.83	16.38	16.38	14.93	14.93
.0042	18.13	18.48	18.48	16.96	16.96	15.43	15.43
.0043	19.00	19.12	19.12	17.53	17.53	15.93	15.93
.0044	19.89	19.77	19.77	18.10	18.10	16.43	16.43
.0045	20.81	20.38	20.38	18.64	18.64	16.89	16.89
.0046	21.74	21.33	21.33	19.51	19.51	17.68	17.68
.0047	22.70	21.37	21.37	19.95	19.95	18.53	18.53
.0048	23.68	23.87	23.87	21.63	21.63	19.38	19.38
.0049	24.67	25.39	25.39	22.79	22.79	20.18	20.18
.0050	25.69	26.35	26.35	23.68	23.68	21.01	21.01

Bare wire meets ASTM Class III Specification F290-57T.
For quantities of less than 10,000 meters, add $2.00 per thousand meters.
Prices available upon request for other sizes, tolerances and plating weights.

Minimum charge per item - $25.00

10/62/2000

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
SILVER PLATED

PRICE SCHEDULE

terms: Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Jan. 28, 1963

subject to change without notice.

SILVER-PLATED MOLYBDENUM WIRE
3% to 6% Silver Plate by Weight

Dia. in Inches	Weight Mg/200 mm	Price per Thousand Meters, Plating Tolerance by Weight ± 1%: ASTM Class II, Bare Wire Tol. ± 4%	ASTM Class II, Bare Wire Tol. ± 3%	ASTM Class III, Bare Wire Tol. ± 4%	ASTM Class III, Bare Wire Tol. ± 3%
.0012	1.48	$11.48	$12.17	$12.56	$12.56
.0015	2.31	9.45	9.90	10.21	10.21
.0020	4.11	7.19	7.40	7.64	7.64
.0025	6.42	8.14	8.20	8.46	8.46
.0030	9.25	9.48	9.53	9.79	9.79
.0035	12.59	10.80	10.83	11.09	11.09
.0040	16.44	12.14	12.17	12.45	12.45
.0045	20.81	14.59	14.63	14.96	14.96
.0050	25.69	19.13	19.16	19.54	19.54

For quantities less than 10,000 meters ordered for shipment at one time, add $2.00 per thousand meters.

Intermediate diameters will be priced at the next higher price.

Other sizes and plating weights available on request.

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MOLYBDENUM WIRE
NICKEL PLATED

PRICE SCHEDULE

terms: Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: None *effective:* Jan. 28, 1963

subject to change without notice.

NICKEL-PLATED MOLYBDENUM WIRE
1% to 4% Nickel Plate by Weight

Dia. in Inches	Weight Mg/200 mm	Price per Thousand Meters — Plating Tolerance by Weight ± 1% — ASTM Class II — Bare Wire Tol. ± 4%	ASTM Class II — Bare Wire Tol. ± 3%	ASTM Class III — Bare Wire Tol. ± 4%	ASTM Class III — Bare Wire Tol. ± 3%
.0012	1.48	$14.56	$15.59	$16.14	$16.14
.0015	2.31	11.98	12.63	13.09	13.09
.0020	4.11	8.78	9.09	9.36	9.36
.0025	6.42	9.89	9.97	10.24	10.24
.0030	9.25	11.34	11.42	11.69	11.69
.0035	12.59	12.77	12.82	13.09	13.09
.0040	16.44	14.22	14.17	14.46	14.46
.0045	20.81	17.08	17.14	17.49	17.49
.0050	25.69	22.12	22.17	22.57	22.57

For quantities less than 10,000 meters ordered for shipment at one time, add $2.00 per thousand meters.

Intermediate diameters will be priced at the next higher price.

Other sizes and plating weights available on request.

MINIMUM CHARGE - $25.00 per item ordered for shipment at one time.

SYLVANIA

chemical & metallurgical division

TOWANDA, PA.

MISCELLANEOUS WIRES
GOLD PLATED

PRICE SCHEDULE

terms: Net 30 Days *f.o.b.:* Towanda, Pa.

replaces: Page 422 1-1-58 *effective:* Jan. 1, 1959

subject to change without notice.

GOLD PLATED HB ALLOY GRID WIRE

Bare Wire			Price per Thousand Meters Gold by Weight		
Diameter Inches	Weight Mg./200 mm	± % Tolerance	6%	5%	4%
.001	.95	4	$8.05	$8.00	$7.95
.0012	1.37	4	7.65	7.55	7.45
.0015	2.14	4	7.80	7.65	7.50
.002	3.80	4	8.25	7.95	7.65
.0025	5.94	4	9.30	8.80	8.30
.003	8.55	4	11.00	10.30	9.60
.0035	11.64	4	13.05	12.15	11.25
.004	15.20	4	15.10	13.90	12.70
.0045	19.24	4	17.70	16.10	14.50
.005	23.75	4	20.55	18.55	16.55
.0055	28.74	4	24.80	22.40	20.00
.006	34.20	4	29.00	26.10	23.20

For quantities of less than 10,000 meters, add $2 per 1,000 meters.

Prices for intermediate diameters will be at the next higher price.

Plating tolerance is ± 1% of bare wire weight.

Minimum charge per item - $20.00

SPECIFICATIONS

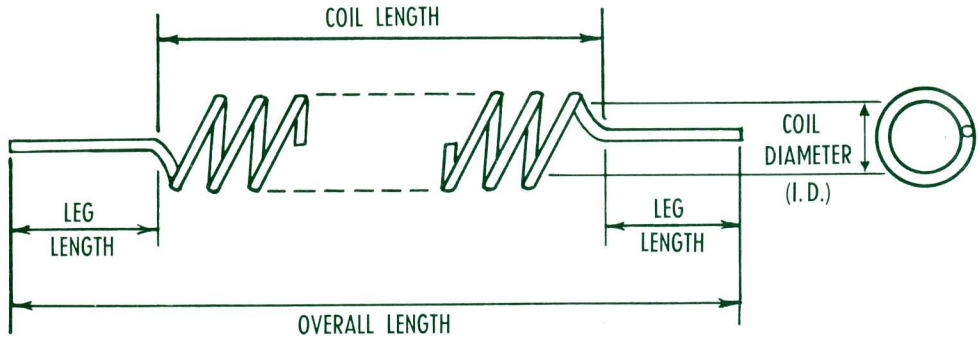
Tungsten Coils FOR VACUUM METALLIZING

Sylvania is one of the world's largest manufacturers of tungsten coils for vacuum metallizing. Modern machinery and equipment, plus vital engineering experience in coil-making, enable the Ipswich and Waldoboro plants to produce coils to customer specifications.

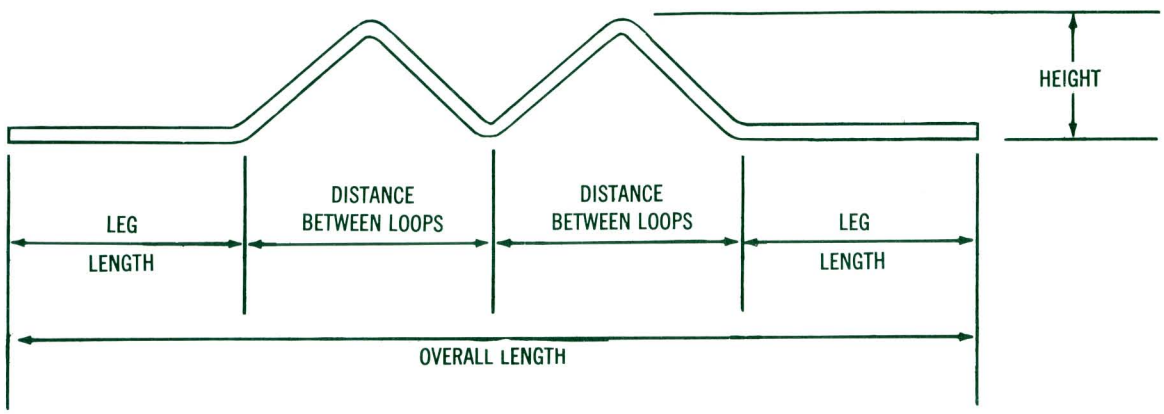
Listed on the following pages are the specifications of the standard vacuum metallizing coils produced by Sylvania. They are suitable for practically every vacuum plating operation in commercial use.

Sylvania coil-making facilities are completely flexible. Small volume orders, rigid specifications, mass production quantities, or engineering consultation are all available through the Field Sales Offices listed on the back cover of this booklet.

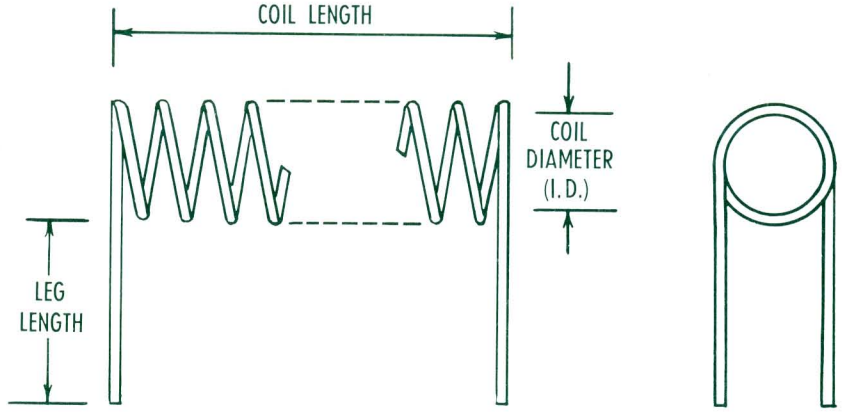
SYLVANIA ELECTRIC PRODUCTS INC.
Chemical & Metallurgical Division
TOWANDA, PENNA.



COIL MATERIAL	DIMENSIONS INCHES Overall Length	Coil Length	Leg Length	Coil Dia. (I.D.)	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	Inches	COIL NUMBER
.060	6	2 1/2	1 3/4	3/8	10	4	458	18.00	1082-A
3 x .020	3 3/8	5/8	1 3/8	3/16	5	8	165	6.50	1057
	4	1/2	1 3/4	5/32	4	8	164	6.46	1269
	4	3	1/2	1/4	12	4	337	13.27	1078
	4 1/8	2 5/8	3/4	9/32	5	2	180	7.09	1003
3 x .025	4 1/4	1 3/4	1 1/4	5/32	4	2.33	150	5.90	1161-C
	3 3/4	2	7/8	17/32	3	1.5	200	7.87	1121-C
	3 3/4	2 1/4	3/4	9/32	4	1.7	153	6.02	1154-C
	3 7/8	1 5/8	1 1/8	1/4	10	6	300	11.81	1171-C
	4 1/4	3/4	1 3/4	1/8	3	4	128	5.04	1056-C
	4 1/4	2	1 1/8	5/16	5	2.5	210	8.27	1242-C
	6	5	1/2	3/16	5	1	190.5	7.50	1141-C
3 x .030	2 1/4	1 1/8	9/16	1/2	5	4.5	254	10.00	1176-D
	3	1	1	5/32	5	5	142.5	5.61	1210-D
	3	1	1	5/16	3	3	144	5.67	1371-D
	3 1/4	1/2	1 3/8	5/32	4	8	132	5.20	1059-D
	4	2	1	1/4	8	4	277	10.9	1076-D
	4 1/8	2	1 1/16	3/16	5	2.5	172	6.77	1178-D
	4 3/4	3/4	2	5/32	6	8	209	8.23	1188-D
	4 3/4	3/4	2	11/32	3	4	191	7.52	1071-D
	4 3/4	3 1/2	5/8	1/4	5	1.5	190.5	7.50	1134-D
	6	2 1/2	1 3/4	15/32	6	2.5	338	13.31	1010-D
	6	3	1 1/2	3/8	6	2	305	12.0	1376-D
	6	4 1/2	3/4	9/32	4.5	1	200	7.87	1250-D
	6	4 1/2	3/4	3/8	6	1.3	305	12.01	1136-D
	6	5	1/2	3/16	5	1	190.5	7.50	1141-D
	6	5	1/2	7/16	5	1	271	10.67	1001-D
	7	5	1	3/16	5	1	216	8.50	1151-D
	7	5	1	13/32	5	1	290	11.41	1268-D
	7	5	1	15/32	5	1	290	11.42	1021-D
4 x .015	4 1/4	3/4	1 3/4	1/8	3	4	128	5.04	1056-B

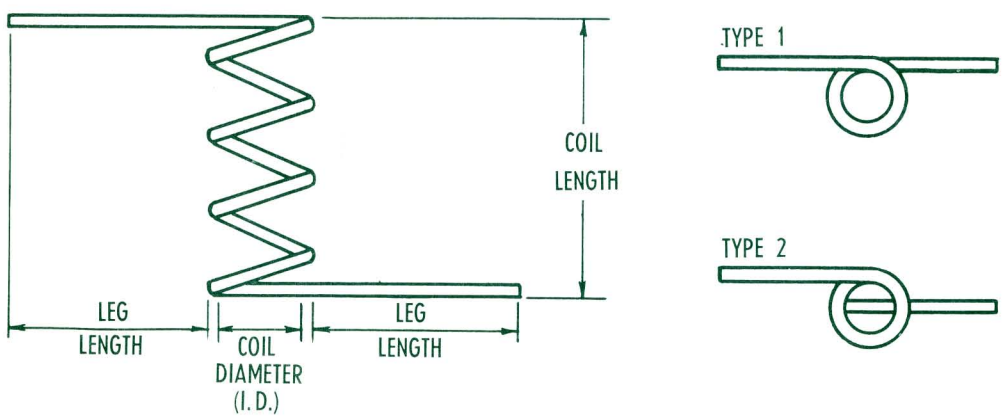


COIL MATERIAL	DIMENSIONS INCHES Overall Length	Leg Length	Distance Between Loops	HEIGHT	TOTAL FILAMENT LENGTH Number Loops	Mm's	Inches	COIL NUMBER
3 x .025	3 3/4	11/16	1 3/16	27/64	2	105	4.13	1381-C
3 x .030	3 3/4	11/16	1 3/16	27/64	2	105	4.13	1381-D

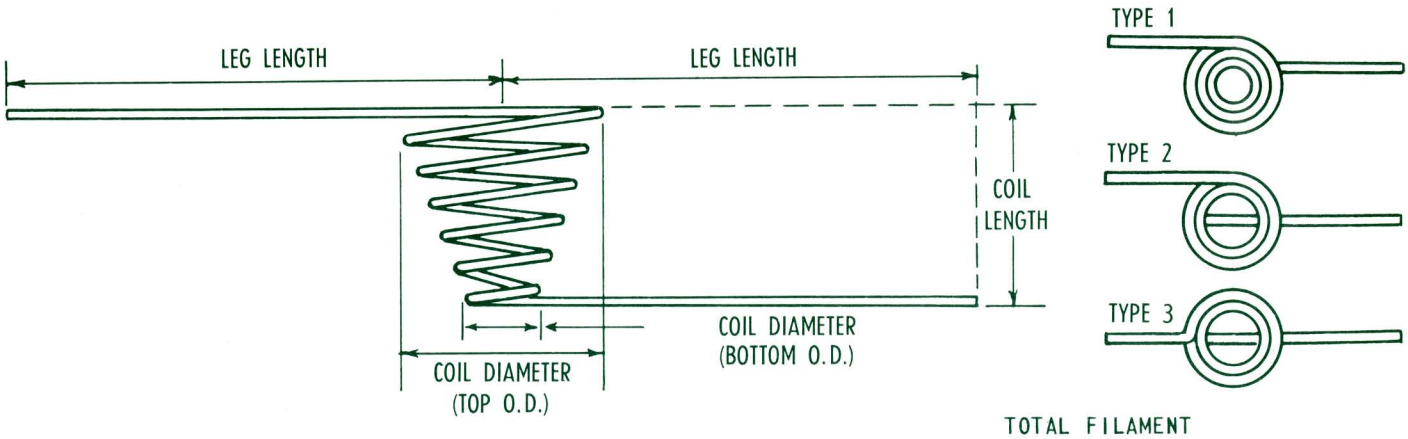


COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length	Coil Dia. (I.D.)	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	Inches	COIL NUMBER
.030	1/2	7/8	3/16	2.5	5	102	3.94	1179-A
	11/16	3/16	1/4	6.5	8.5	170	6.69	1195-A
	3/4	7/8	3/16	3.5	4.5	118	4.02	1180-A
	1 1/8	7/8	3/16	4.5	4	127	4.70	1181-A
2 x .030	5/8	3/4	5/32	5.5	9	141	5.20	1020-G
3 x .020	5/8	5/8	5/32	5.5	9	132	5.20	1020
	1	3/4	9/32	3.5	3	142	5.59	1005
	1 3/8	3/4	9/32	5.5	4	190	7.48	1008
3 x .025	5/8	5/8	5/32	5.5	9	132	5.20	1020-C
	3/4	3/4	9/32	5.5	7	195	7.56	1045-C
3 x .030	3/4	3/4	9/32	5.5	7	195	7.56	1045-D
	1	3/4	9/32	3.5	3	142	5.59	1005-D
	2 9/16	7/8	25/64	6.5	2.53	318	12.52	1365-D *
	3	1	3/8	8.5	3	400	15.75	1053-D *
3 single .030	2 1/2	5/8	13/64	4.5	1.5	421	16.57	1212-A *

* WOUND LEFT HAND



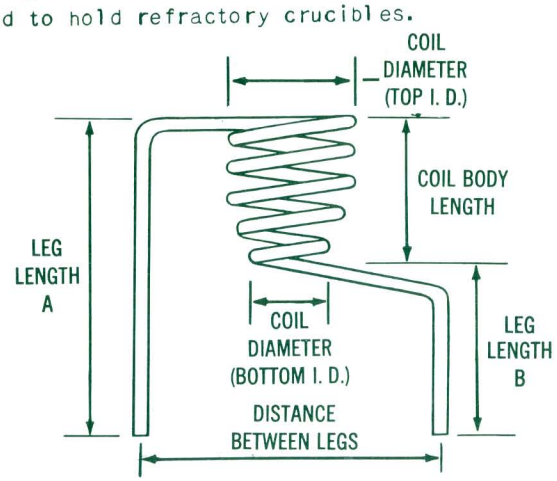
COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length	Coil Dia. (I.D.)	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	Inches	COIL NUMBER
Type 1								
3 x .020	9/16	1 5/8	11/64	4	7.1	152	5.79	1349
3 x .030	3/4	1 4/5	3/8	3	4	191	7.52	1061-D
Type 2								
4 x .015	9/16	1 15/16	11/64	5 3/4	10	206	8.10	1184-B
	5/8	2	11/64	5 3/4	10	207	8.15	1072-B



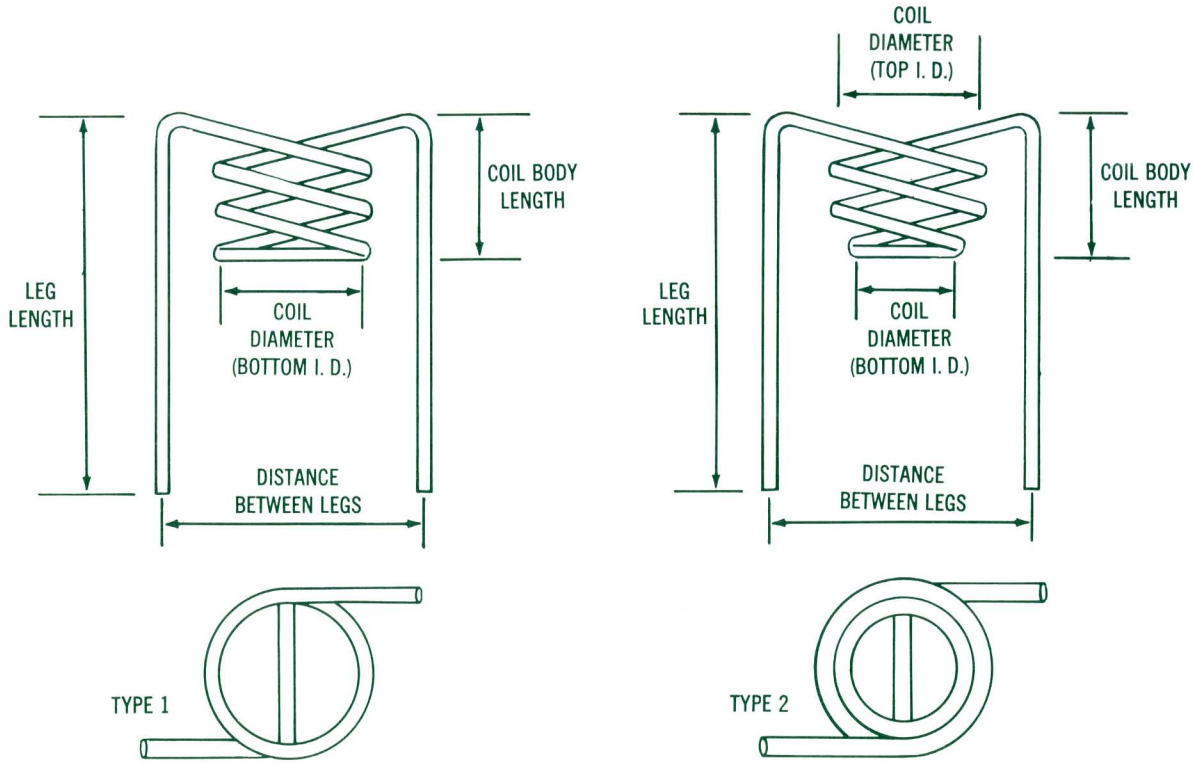
COIL MATERIAL	Coil Length	Leg Length	Coil Dia. (O.D.) Top	Coil Dia. (O.D.) Bottom	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	TOTAL FILAMENT LENGTH Inches	COIL NUMBER
Type 1									
.030	9/16	2	7/16	1/16	8	14	251	9.88	1208-A
.050	3/8	2 1/2	7/16	11/64	5	13	220	8.66	1081-A
3 x .030	29/32	2 7/16	1	5/8	4	4.4	375	14.76	1373-D**
	1 1/8	2 7/16	1 3/16	7/8	5	4.4	488	19.22	1377-D**
	2	3 1/16	1	3/16	6	3	440	17.32	1196-D
	2	4	1	5/16	6	3	485	19.09	1012-D
4 x .015	11/16	2 1/8	1/4	3/32	6	9	188	7.40	1130-B
	11/16	2 1/4	23/64	9/16	6	8.7	214	8.43	1367-B
Type 2									
4 x .015	1/4	1 3/4	1/4	11/64	3	12	130	5.12	1040-B
Type 3									
.020	13/64	1 11/32	7/32	5/32	3	15	99	3.90	1198-A
	7/32	1 9/16	7/32	1/16	9	30.5	184	7.24	1096-A
	19/64	1 13/32	3/16	1/16	7	24	123	4.84	1236-A*

*Coated with alumina oxide. Alumina oxide coating may also be provided on similar single wire designs.

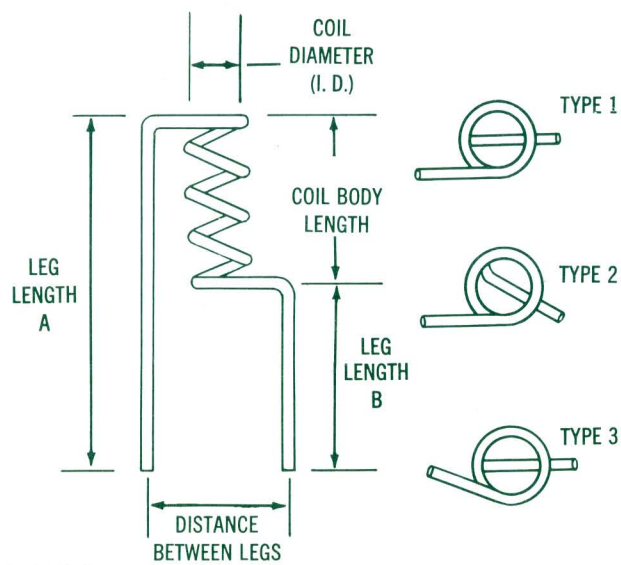
**Designed to hold refractory crucibles.



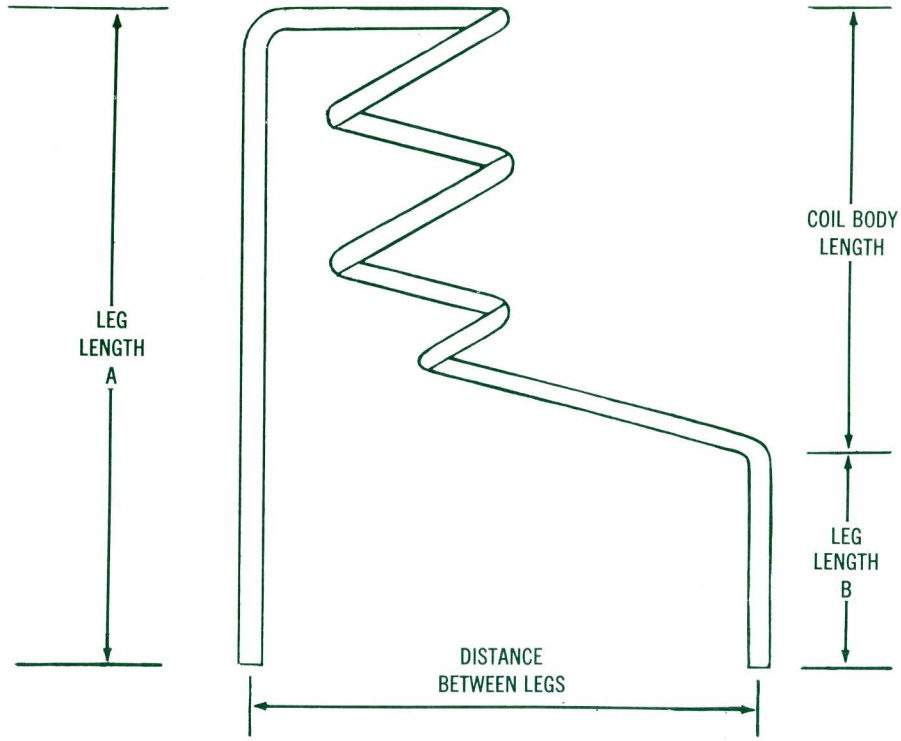
COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length A	Leg Length B	Coil Dia. (I.D.) Top	Coil Dia. (I.D.) Bottom	Distance Between Legs	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	TOTAL FILAMENT LENGTH Inches	COIL NUMBER
3 x .020	1/2	1	1/2	11/64	1/16	1/2	5	10	125	4.92	1227
3 x .025	1/2	1	1/2	11/64	1/16	1/2	5	13	127	5.00	1227-C
	1/2	1	1/2	11/64	1/16	5/8	5	13	133	5.00	1233-C
	5/8	1	3/8	1/4	1/16	3/8	6	10.5	180	7.09	1234-C
	1/2	1 3/16	11/16	11/64	1/16	3/8	5	1.3	137	5.39	1310-C
	1/2	1 3/16	11/16	11/64	1/16	1/2	5	10	138	5.43	1370-C
	5/8	1 1/4	5/8	1/4	1/16	5/8	6	10.5	184	7.25	1340-C
	3/4	1 3/8	5/8	11/64	1/16	7/16	6	8	163	6.42	1355-C
	1	1 5/8	5/8	1/2	1/16	1	10	10	451	17.75	1375-C

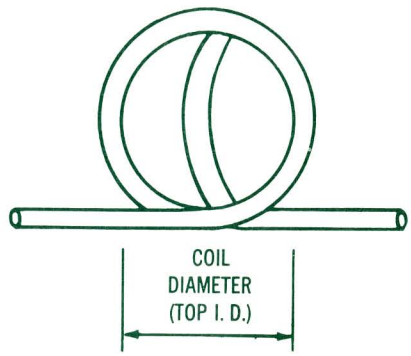


COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length A	Leg Length B	Coil Diameter Top	Coil Diameter Bottom	Distance Between Legs	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's	TOTAL FILAMENT LENGTH Inches	COIL NUMBER
Type 1											
3 x .030	1/2	1 1/4	3/4	3/16	3/16	9/16	3	6	144	5.67	1263-D
Type 2											
3 x .025	3/8	1 1/8	3/4	11/64	5/32	9/16	3	9.4	132	5.20	1266-C

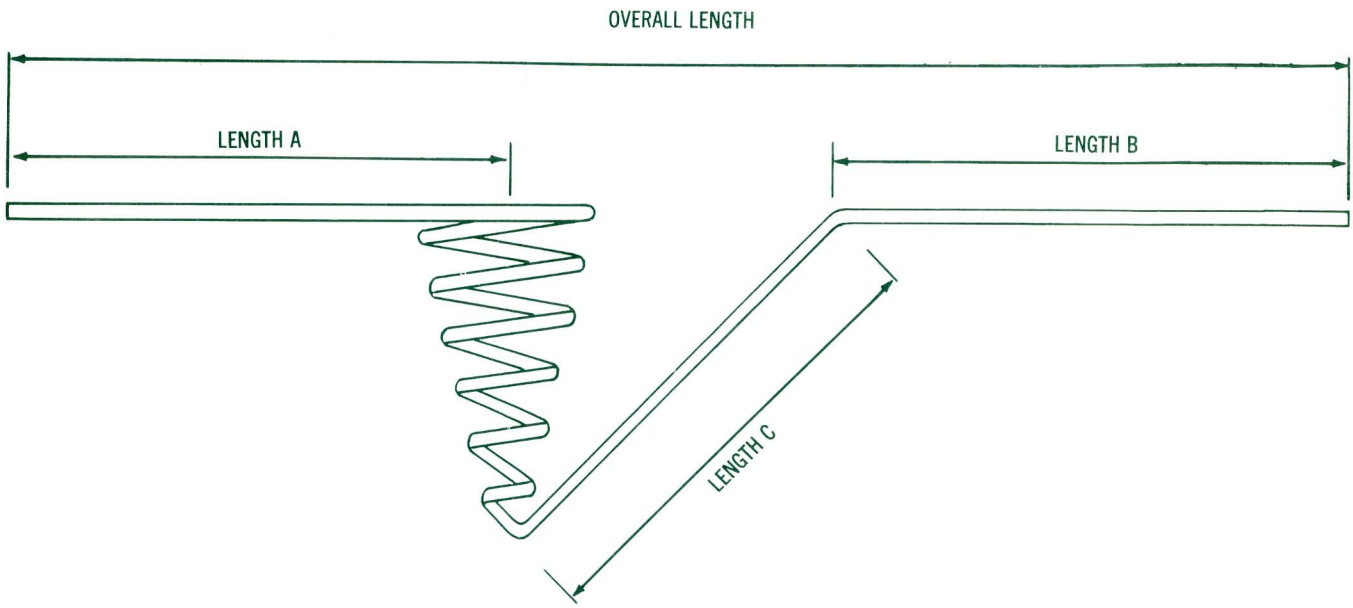


COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length A	Leg Length B	Coil Diameter (I.D.)	Distance Between Legs	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	TOTAL FILAMENT LENGTH Inches	COIL NUMBER
Type 1										
3 x .025	7/16	1	9/16	5/32	1/2	3.75	8.3	113	4.45	1257-C
Type 2										
3 x .025	5/8	1 3/16	1/2	11/64	1/2	3.5	5.4	126	4.96	1175-C
Type 3										
3 x .025	5/8	1 1/4	5/8	11/64	1/2	3.5	5.6	127	5.0	1322-C





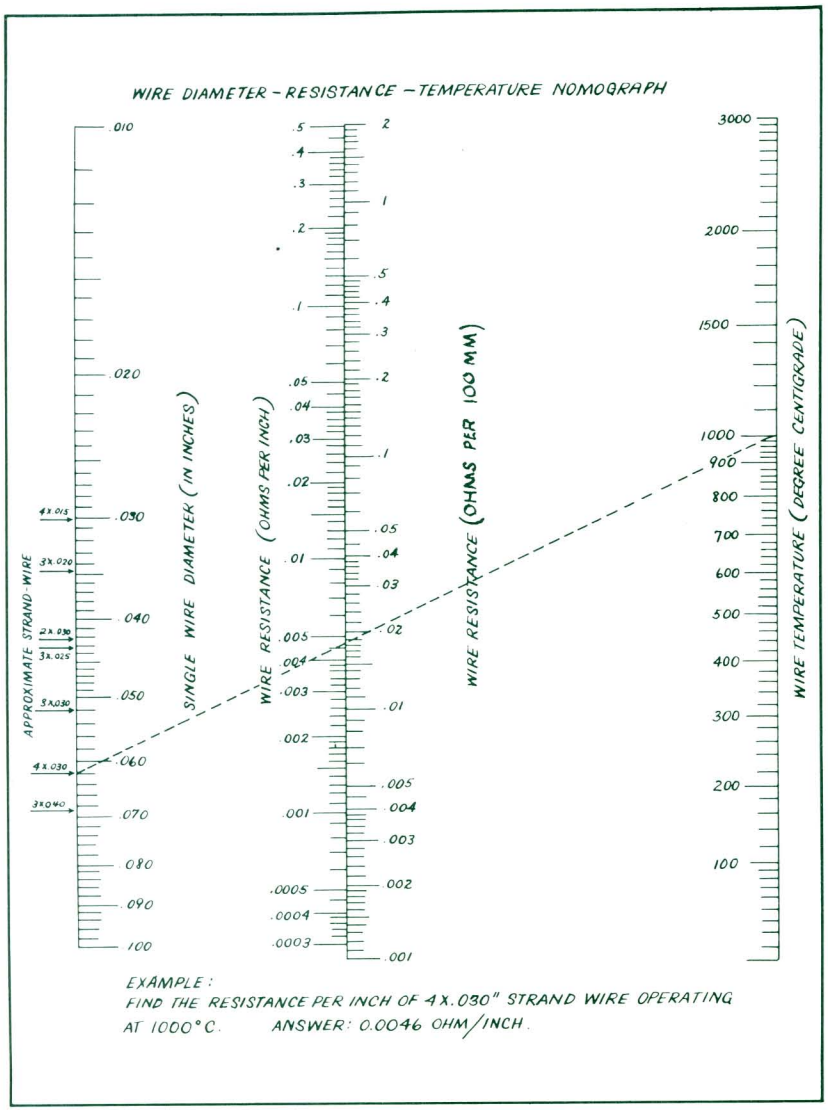
COIL MATERIAL	DIMENSIONS INCHES Coil Length	Leg Length A	Leg Length B	Coil Diameter (I.D.)	Distance Between Legs	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mm's.	Inches	COIL NUMBER
3 x .020	11/16	1 3/16	1/2	11/64	1/2	3.5	5	124	4.88	1095
3 x .025	11/16	1 3/16	1/2	11/64	1/2	3.5	5	124	4.88	1095-C



COIL MATERIAL	DIMENSIONS INCHES Overall Length	Coil Body	LEG LENGTH A	B	C	COIL DIAMETER (I.D.) Top	Bottom	TURNS	TURNS PER INCH	TOTAL FILAMENT LENGTH Mms.	Inches	COIL NUMBER
.040	3 3/16	5/8"	1 19/32	25/32	25/32	7/32	1/16	6	9	145	5.71	1334-A
3 x .025	3 3/16	5/8"	1 19/32	25/32	25/32	7/32	1/16	6	9	145	5.71	1334-C

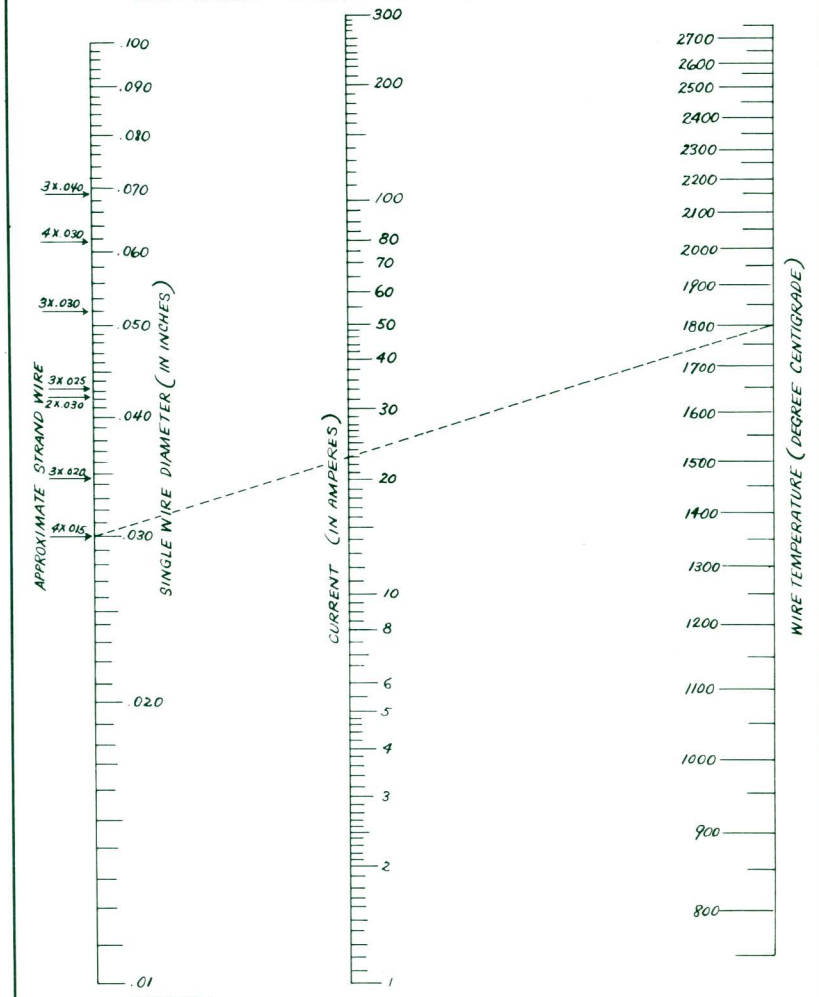
Many of the coils listed in this booklet may be obtained with open tungsten strand or with an aluminum core strand in the 3 x .025 and 3 x .030 sizes.

WIRE DIAMETER - RESISTANCE - TEMPERATURE NOMOGRAPH



EXAMPLE:
FIND THE RESISTANCE PER INCH OF 4 x .030" STRAND WIRE OPERATING AT 1000°C. ANSWER: 0.0046 OHM/INCH.

WIRE DIAMETER - CURRENT - TEMPERATURE - NOMOGRAPH



EXAMPLE:
FIND THE CURRENT OF 4 x .015" STRAND WIRE OPERATING AT 1800°C.
ANSWER: 23 AMPERES.

DISTRICT SALES OFFICES

BOSTON
100 Sylvan Road
Woburn, Mass.
Phone: Wells 3-3500

CHICAGO
2001 N. Cornell Avenue
Melrose Park, Ill.
Phone: Fillmore 5-0100

DAYTON
333 West First Street
Dayton, Ohio
Phone: Baldwin 3-6227

DETROIT
7800 Intervale Avenue
Detroit, Mich.
Phone: Webster 3-8765

NEW YORK
1000 Huyler Street
Teterboro, N. J.
Phone: Atlas 8-9484

PHILADELPHIA
4700 Parkside Avenue
Philadelphia, Pa.
Phone: Greenwood 7-5000

PITTSBURGH
300 Mt. Lebanon Blvd.
Pittsburgh, Penna.
Phone: Lehigh 1-4975

SAN FRANCISCO
1811 Adrian Road
Burlingame, Calif.
Phone: Oxford 7-3500

TOWANDA
Towanda, Penna.
Phone: Andrew 5-2121

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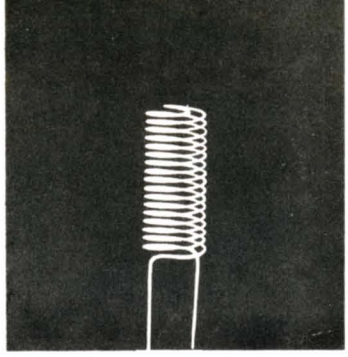
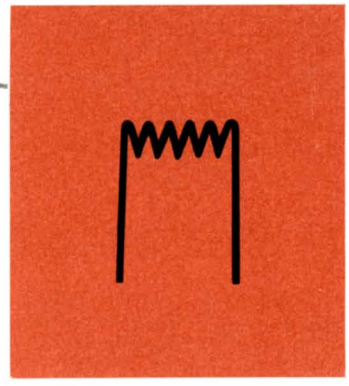
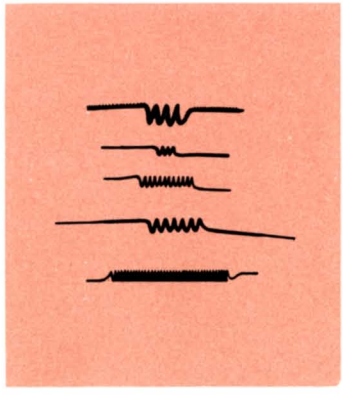
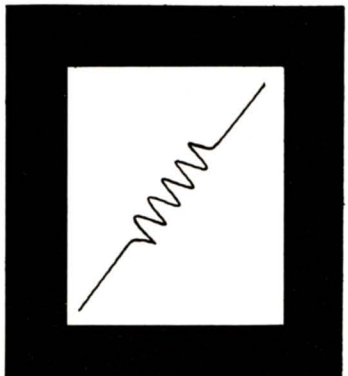




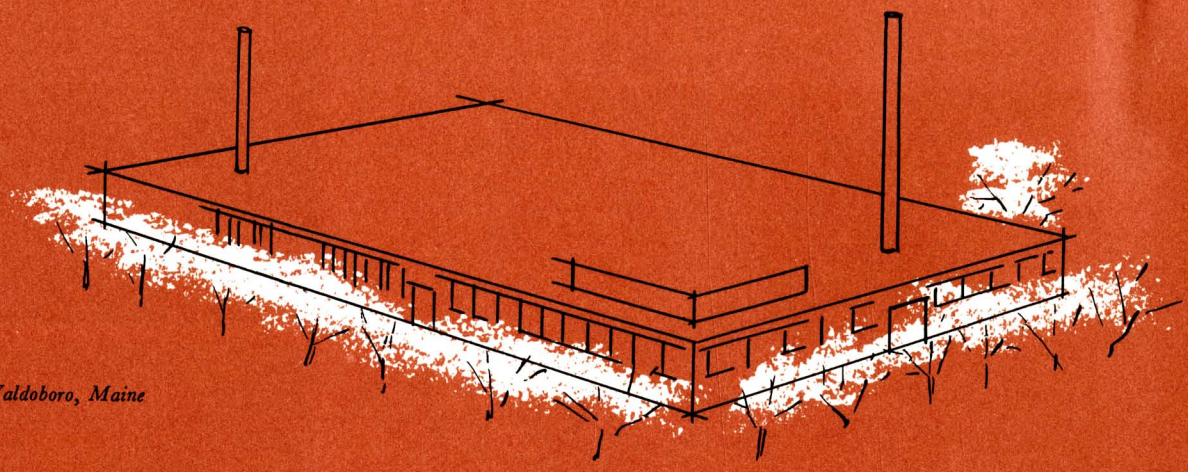
sylvania

TUNGSTEN COIL PRODUCTS





Sylvania Electric Products Inc.



Waldoboro, Maine

Good Coils Don't Just Happen ...Experience Makes the Difference!

Sylvania is one of the world's largest manufacturers of Tungsten Coil Products. The Ipswich and Waldoboro plants are devoted exclusively to the development and mass-production of thousands of varieties of coils, filaments and heaters used in incandescent lamps, fluorescent lamps, vacuum tubes, cathode ray tubes, television tubes and such special application as vacuum metallizing.

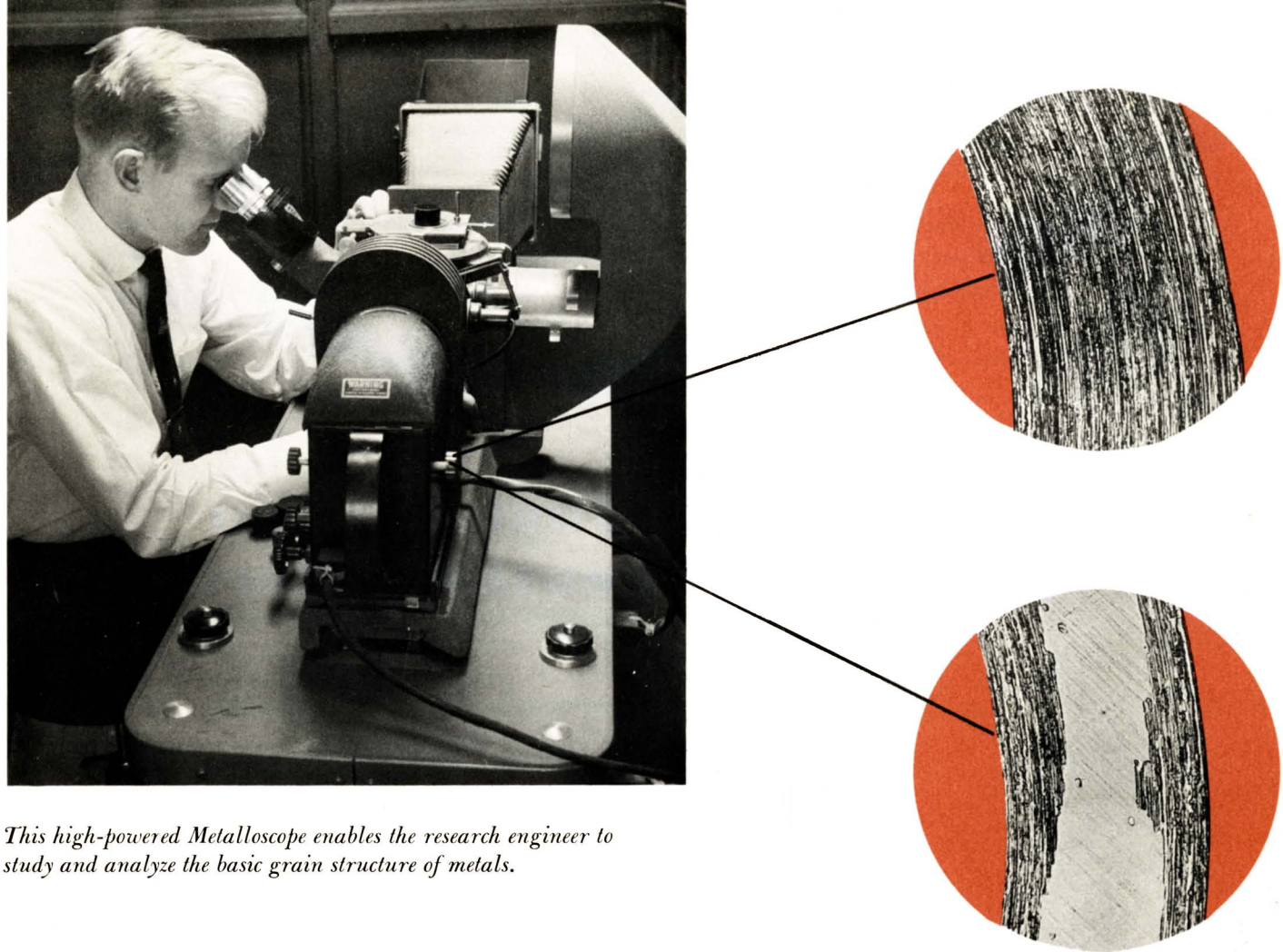
Modern machinery and equipment, plus vital coil-making experience, enable the Ipswich and Waldoboro plants to mass-produce over 40 million coils and heaters every month. Not only are these coils used in components produced by other Sylvania divisions . . . but also they are sold to manufacturers in the United States and throughout the world.

Today, Sylvania stocks many standard types of coils and heaters. Also, to fill special orders, the facilities and experience of the entire Sylvania organization are available — including well-equipped chemical and metallurgical laboratories.

●

Any coil that can be made on a machine, can be made in volume at these Sylvania plants. Yet, in spite of their high capacity, Sylvania's coil-making facilities are completely flexible — can handle small-volume orders as well.

Ipswich, Massachusetts



This high-powered Metalloscope enables the research engineer to study and analyze the basic grain structure of metals.

A Precision Product at a Volume Price

Sylvania's extensive coil-making experience . . . its high-speed automated machines . . . and the careful inspection given all coils, assure you of getting a precision product at a volume price.

Experienced Sylvania engineers and technicians work closely with interested outside manufacturers, on the engineering of coils and heaters to meet their specific requirements. To produce a precision coil within extremely close tolerances requires continual research and exacting quality control methods. At Sylvania, research, engineering and quality control work hand in hand with production.

For example, metallurgists continually conduct microscopic examinations of the basic metal's grain structure to make certain that hardness, tensile strength, and other physical characteristics required by the customer are fully met. They also help design new types of coils for specific applications.

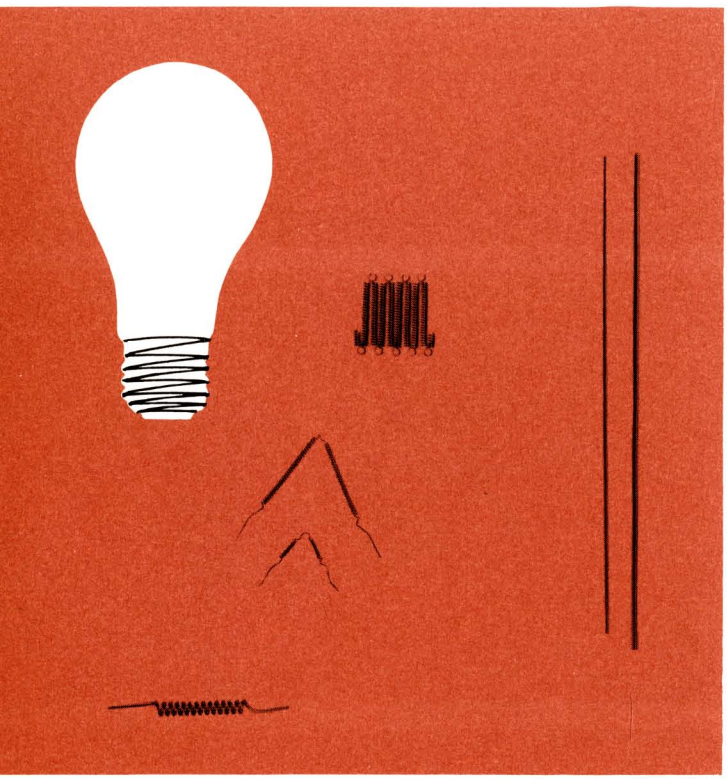
Design engineers are continually seeking new methods of mechanization and automation for the production line to make certain that mass-production runs are uniform and less costly.

Finished coils are neither shipped nor accepted for stock until they have passed many rigid tests. For example, in producing lamp filaments, a variation of only .00001 of an inch in diameter might affect the life of a lamp as much as 25 percent. Thus, as a check on diameter, accurately measured lengths of filament wire are weighed to tenths of milligrams.

These are just a few of the reasons why you can be certain that the coil you buy or contract for at Sylvania is a product of the highest quality . . . at a mass-production price.

What coils do you need?

Continuous coils, gap-space coils, double helical coils, folded filaments . . . through the years Sylvania has developed and produced an almost endless variety of coils in varying shapes and sizes. For incandescent lighting alone, Sylvania manufactures over 6000 different filaments—ranging from the tiny ½-watt telephone switchboard filament to the high 10,000-watt types designed for studio or special lighting.

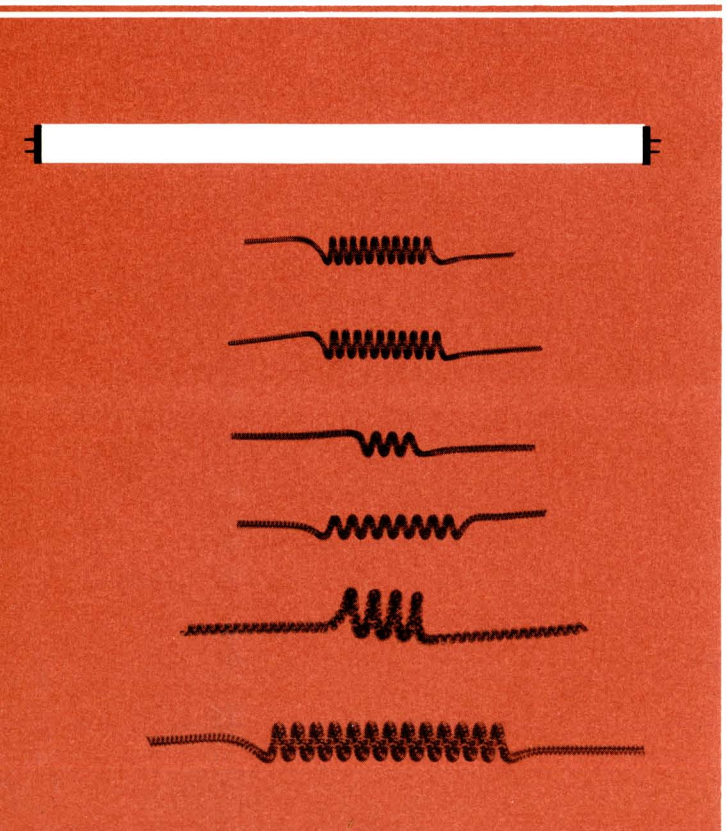


coils for incandescent lamps

High-speed volume production is absolutely essential in manufacturing coiled filaments for low-cost products such as incandescent bulbs. Sylvania is the third largest manufacturer of lamps in the U. S. A. — and the coiled filaments for these lamps are all made at Sylvania's Ipswich or Waldoboro plants.

The wire used in Sylvania incandescent filaments varies in size from .045″ diameter to .0004″ (about ⅛ the diameter of a human hair). In the finer sizes, filaments are wound up to 2200 turns per inch. These filaments all are carefully inspected for uniformity and adherence to specifications before shipment.

Telephone Switchboard Lamps . Street Lamps . Infra-red Lamps . Incandescent Bulbs . Motion Picture and Still Projectors . Spotlights . Outdoor Sports Lighting . Studio Lamps Floodlights . Railway Lights



coils for fluorescent lighting

A pioneer in fluorescent lighting, Sylvania is known the world over for its research and engineering leadership. Sylvania improvements of lamp design and performance have substantially increased average rated life and light output. The quality of these lamps is due in no small part to the quality of the coils they contain.

These quality coils, used as electrodes sealed in at both ends of the fluorescent tube, must consistently withstand high voltages.

Sylvania tungsten coils for fluorescent lighting fall into two classifications: double coils and triple coils. They cover a broad variety of lamp types — from 4 to 200 watts.

Standard Bi-pin Preheat Lamps . . . Circline Preheat and Rapid Start Lamps . . . other Rapid Start Lamps, including High Output and Very High Output types for outdoor and high-bay lighting . . . Instant Start Lamps, including long, slim types.

SYLVANIA makes them all

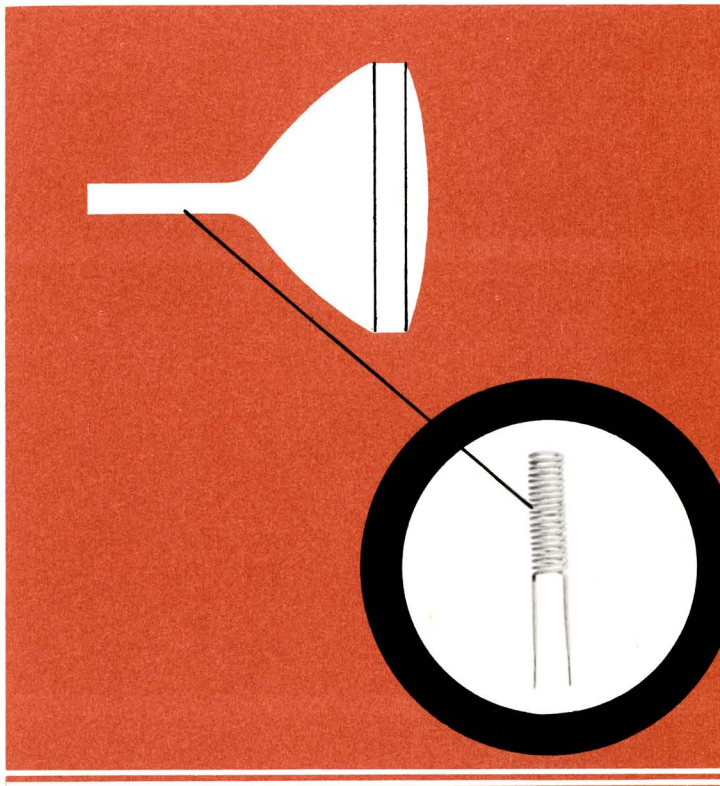
Perhaps your application is for fluorescent lighting . . . or radio . . . or television . . . or electronics . . . or vacuum metallizing . . . or possibly you need insulator coils for television rectifier tubes. You will find that Sylvania, because of its unsurpassed facilities and experience, is a dependable, economic source for whatever types of coils or heaters you need. Many of these are carried in stock for immediate delivery.

heater coils for television

Television picture tubes need high-quality, long-life heater coils to heat up the tube's cathode to the point where an electron beam is emitted.

One of the world's largest producers of television picture tubes, Sylvania manufactures reverse wound helical coils for use in its own tubes as well as for many other TV tube manufacturers. One reason Sylvania is able to meet high-volume demands for these heaters is that Sylvania engineers have developed and refined special machinery to greatly increase production speed . . . while still maintaining the highest degree of uniformity and quality.

TV heaters are sold through Sylvania Electric Products Parts Division, 12 Second Ave., Warren, Pa.



heater coils for electronics

Sylvania has had considerable experience in manufacturing heater coils for electronic use. One of the nation's largest radio tube manufacturers, Sylvania of course also uses its own coils for these tubes.

Dependable electron tubes for radio, television, radar and guided missiles are possible because of dependable heater coils. In making heaters for its own tubes — as well as for other manufacturers — Sylvania engineers have developed rugged coils with long-life characteristics. Durability and long life are most important in modern electron tubes.

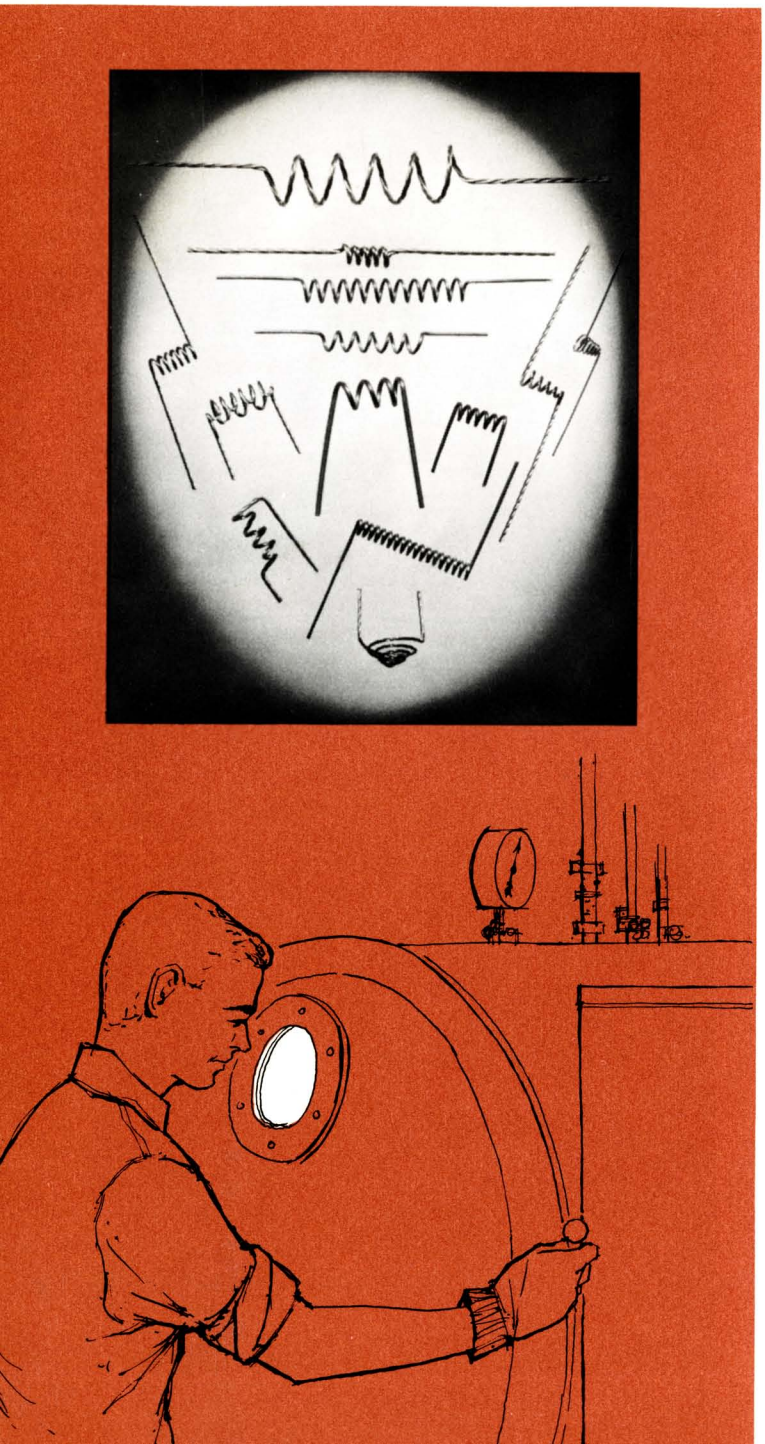
Following is a general list of various tubes for which Sylvania manufactures heater coils.

Receiving Tubes . Transmitting Tubes . Klystrons . Magnetrons . Hydrogen Thyratrons . Subminiature Tubes . Special Purpose Tubes

coils for vacuum metallizing

Modern vacuum techniques . . . and improved long-lasting coils . . . are responsible for the tremendous growth of vacuum metallizing during the past few years. Jewelry, auto parts, mirrors and countless other products can be attractively coated at low cost with aluminum, gold, silver, chromium, nickel or other metals by means of the metallizing technique.

In this process, the part to be metallized and the heating coil supporting the metal to be deposited are enclosed in a high-vacuum chamber. After a high vacuum is attained and the coil is brought to a sufficiently high temperature, the metal vaporizes onto the object. The coating deposited is extremely thin — as thin as one ten-millionth of an inch. The result — a smooth, attractive, mirror-like surface. (Note the High Vacuum Evaporation Table at the back of this booklet which shows appropriate metals and heater coils for metallizing.)



Sylvania's stranded tungsten coils are a most efficient and low-cost element for the vaporization of metal. Because of Sylvania's mass-production facilities, these coils can be supplied in any desired quantity . . . in practically any specified design. Moreover, many standard types of metallizing coils are stocked — a decided advantage for fast delivery and prompt service.

Naturally, in vacuum metallizing, the design and shape of a coil are extremely important . . . because they determine the manner in which the metal vaporizes onto the object. Sylvania makes certain that these coils are precisely engineered for controlled metallizing. As a manufacturer of aluminized incandescent lamps and television picture tubes, Sylvania has had many years of experience and understanding of the basic problems of vacuum metallizing.

television picture tube aluminizing

Practically every television picture tube manufactured today is aluminized on the inside for a sharper, more clearly defined picture. In this aluminizing process, the tube is lowered over a coil which is designed specifically for wide area aluminizing. Major picture tube producers use and specify Sylvania's tungsten stranded coils in their aluminizing operations.

In addition to television picture tubes, here is a general classification of types of products being metallized today:

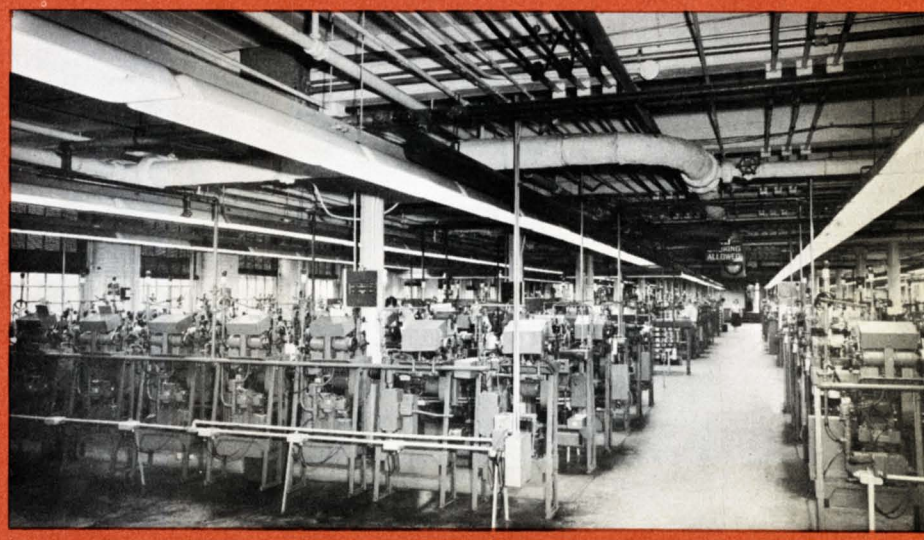
Plastics . Hardware . Jewelry . Auto parts . Toys . Tubes . Glass . Optical Instruments . Wax . Musical Instruments . Light Bulbs . Electronic Components

Here is how Sylvania makes

over 40 million coils a month

The next few pages show typical facilities and testing procedures used in the development and manufacture of Sylvania coils and heaters. The Ipswich and Waldoboro plants employ several hundred people — from experienced production workers to skilled technicians and highly specialized engineers — whose exclusive business it is to produce superior coils at competitive prices.

In the following pages you can make a quick inspection of some of the highlights of Sylvania plant facilities that produce over 40 million precision-wound coils every month.



These Continuous Coiling Machines are part of an automated production line. Tungsten wire is wound continuously into primary coils at extremely high speeds . . . one of the reasons why Sylvania is able to maintain its high-volume production

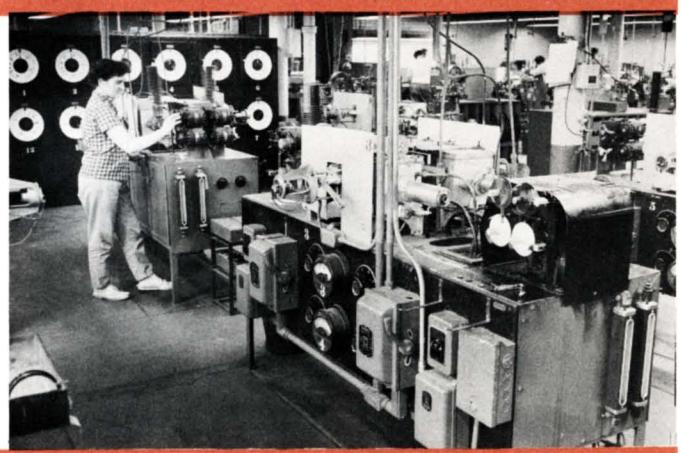
Closeup of a Continuous Coiling Machine . . . a precision machine that turns out primary coiling. Here a technician is checking accuracy of winding, using a microscope of high magnification.

It takes a lot of production **"Know-How"**

Gap-Space Coiling Machines wind coils which require an uncoiled gap between windings. Such coils are used in incandescent lamps and electronic tubes of various types. The machines are extremely accurate . . . the tolerance for the spacing between coil sections being kept to ±0.2 mm.

Many applications require coils which are themselves wound into double or triple coils. This type of winding operation is performed on machines shown here, in which retractable mandril pins are held to ±.0001 of an inch in diameter to assure the high degree of coil quality required.

Annealing Furnaces. These electronically controlled furnaces have hydrogen atmospheres heated between 1000°C and 1700°C. They remove graphite from the wires and relieve the coil of stresses. Note temperature control panels in background.



Sintering Furnaces . . . both high and low-temperature. Double and triple coils which are still wound around molybdenum mandrils are heat-treated in these furnaces. This "sets" the coils and helps to maintain their uniformity. The dials in the background are automatic temperature controls.

to turn out over **40,000,000** *coils a month*

Cutting Machine operator checks the length of a coil. This machine cuts straight and primary coils within a tolerance of ±0.1 mm.

During the Opal Plate Inspection, skillful operators line up finished coils on a flat translucent glass plate. They immediately reject any coil that is short, long, distorted . . . or otherwise damaged in any way.

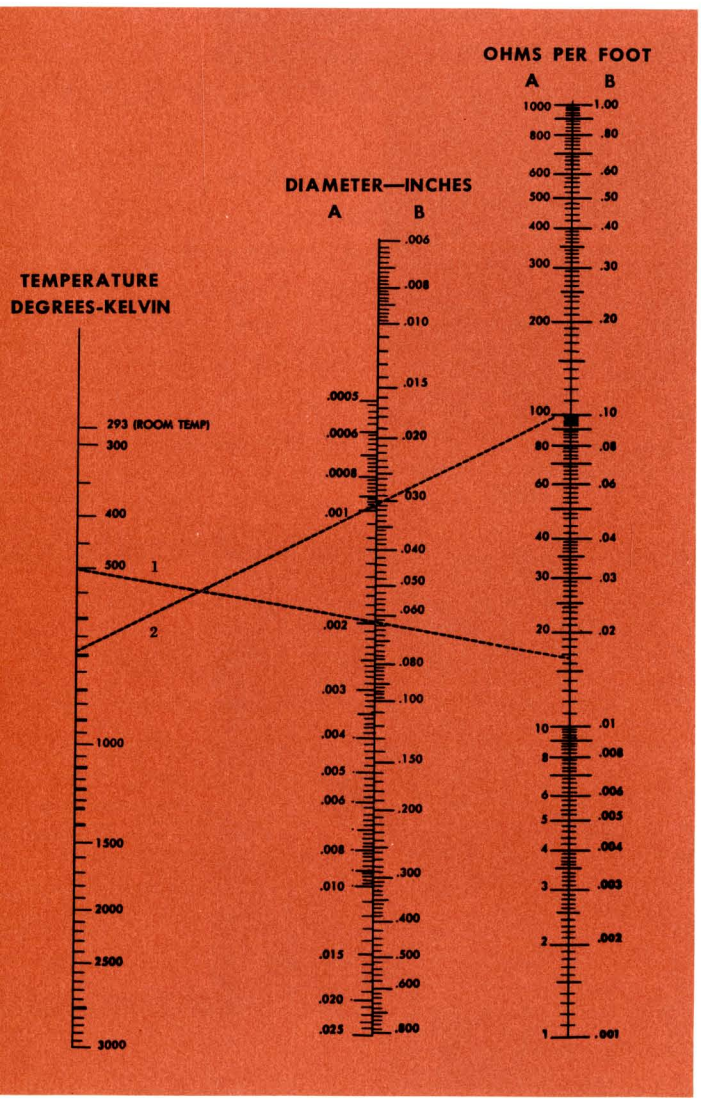
The Projector Inspection is for coils that are too small for Opal Plate Inspection. Here the coil image is projected and magnified on a screen . . . and thus the coil can easily be checked for irregularities, damage, jagged ends, or other imperfections.

The final weighing operation is an important step in the manufacture of tungsten coils. Here they are weighed to make sure they fall within design specifications and to determine the quantity being shipped. For these reasons, highly trained operators and accurate equipment are essential.

some useful charts and graphs

Tungsten is the basic metal used in Sylvania coils and heaters, because of its extremely high melting point (3380°C). The charts and graphs on these pages give basic information on tungsten . . . plus a helpful chart on the use of metals in metallizing.

Tungsten Resistance-Temperature Chart



EXAMPLES:

1. Find resistance per foot of 0.002″ tungsten at 500° K. Answer: 16.7 ohms per foot.

2. Find temperature at which 0.001″ tungsten has a resistance of 100 ohms per foot. Answer: 685° K.

Tungsten Conversion Factors

FILAMENT WIRE					WIRE AND ROD					
DIAMETER INCHES	DIAM. IN APPROX. MILLIMETERS	MILLIGRAMS PER 200 MILLIMETERS	GRAMS PER 1000 METERS	METERS PER KILOGRAM	DIAMETER INCHES	DIAM. IN APPROX. MILLIMETERS	MILLIGRAMS PER 200 MILLIMETERS	GRAMS PER METER	METERS PER KILOGRAM	GRAMS PER FOOT
.00040	.0102	.31	1.55	645,160						
.00045	.0114	.39	1.95	512,820						
.00050	.0127	.49	2.45	408,160						
.00055	.0140	.59	2.95	338,980						
.00060	.0152	.70	3.50	285,710						
.00065	.0165	.82	4.10	243,900						
.00070	.0178	.95	4.75	210,530						
.00075	.0191	1.09	5.45	183,490						
.00080	.0203	1.24	6.20	161,290						
.00085	.0216	1.40	7.00	142,860						
.00090	.0229	1.57	7.85	127,390	.01000	.2540	194.27	.97	1030.93	.30
.00095	.0241	1.75	8.75	114,290	.01100	.2794	235	1.18	847.46	.36
.00100	.0254	1.94	9.70	103,090	.01200	.3048	280	1.40	714.29	.43
.00105	.0267	2.14	10.70	93,458	.01300	.3302	328	1.64	609.76	.50
.00110	.0279	2.35	11.75	85,106	.01400	.3556	381	1.90	526.32	.58
.00115	.0292	2.57	12.85	77,821	.01500	.3810	437	2.19	456.62	.67
.00120	.0305	2.80	14.00	71,429	.01600	.4064	497	2.49	401.61	.76
.00125	.0318	3.04	15.20	65,789	.01700	.4318	561	2.81	355.87	.86
.00130	.0330	3.28	16.40	60,976	.01800	.4572	629	3.15	317.46	.96
.00135	.0343	3.54	17.70	56,497	.01900	.4826	701	3.51	284.90	1.07
.00140	.0356	3.81	19.05	52,493	.02000	.5080	777	3.89	257.07	1.19
.00145	.0368	4.08	20.40	49,020	.02100	.5334	857	4.28	233.64	1.30
.00150	.0381	4.37	21.85	45,767	.02200	.5588	940	4.70	212.77	1.43
.00155	.0394	4.67	23.35	42,827	.02300	.5842	1,028	5.14	194.55	1.57
.00160	.0406	4.97	24.85	40,241	.02400	.6096	1,119	5.59	178.89	1.70
.00165	.0419	5.29	26.45	37,807	.02500	.6350	1,214	6.07	164.74	1.85
.00170	.0432	5.61	28.05	35,651	.02600	.6604	1,313	6.57	152.21	2.00
.00175	.0445	5.95	29.75	33,613	.02700	.6858	1,416	7.08	141.24	2.16
.00180	.0457	6.29	31.45	31,797	.02800	.7112	1,523	7.62	131.23	2.32
.00185	.0470	6.65	33.25	30,075	.02900	.7366	1,634	8.17	122.40	2.49
.00190	.0483	7.01	35.05	28,531	.03000	.7620	1,748	8.74	114.42	2.66
.00195	.0495	7.39	36.95	27,064	.03200	.8128		9.95	100.50	3.03
.00200	.0508	7.77	38.85	25,740	.03400	.8636		11.23	89.05	3.42
.00205	.0521	8.16	40.80	24,510	.03500	.8890		11.90	84.03	3.63
.00210	.0533	8.57	42.85	23,337	.04000	1.016		15.54	64.35	4.74
.00215	.0546	8.98	44.90	22,272	.04500	1.143		19.67	50.84	6.00
.00220	.0559	9.40	47.00	21,277	.05000	1.270		24.28	41.19	7.40
.00225	.0572	9.83	49.15	20,346	.06000	1.524		34.97	28.60	10.66
.00230	.0584	10.28	51.40	19,455	.07000	1.778		47.60	21.01	14.51
.00235	.0597	10.73	53.65	18,639	.08000	2.032		62.17	16.08	18.95
.00240	.0610	11.19	55.95	17,873	.09000	2.286		78.68	12.71	23.99
.00245	.0622	11.66	58.30	17,153	.10000	2.540		97.14	10.29	29.62
.00250	.0635	12.14	60.70	16,474	.11000	2.794		117.53	8.51	35.83
.00255	.0648	12.63	63.15	15,835	.12000	3.048		139.87	7.15	42.64
.00260	.0660	13.13	65.65	15,232	.12500	3.175		151.77	6.59	46.27
.00265	.0673	13.64	68.20	14,663	.13000	3.302		164.16	6.09	50.05
.00270	.0686	14.16	70.80	14,124	.14000	3.556		190.38	5.25	58.04
.00275	.0699	14.69	73.45	13,615	.15000	3.810		218.55	4.58	66.63
.00280	.0711	15.23	76.15	13,132	.16000	4.064		248.67	4.02	75.81
.00285	.0724	15.78	78.90	12,674	.17000	4.318		280.72	3.56	85.59
.00290	.0737	16.34	81.70	12,240	.17500	4.445		297.48	3.36	90.70
.00295	.0749	16.91	84.55	11,827	.18000	4.572		314.72	3.18	95.95
.00300	.0762	17.48	87.40	11,442	.18750	4.763		341.49	2.93	104.11
.00350	.0889	23.80	119.00	8,403	.19000	4.826		350.66	2.85	106.91
.00400	.1016	31.08	155.40	6,435	.20000	5.080		388.54	2.57	118.46
.00450	.1143	39.34	196.70	5,084	.22500	5.715		491.75	2.03	149.92
.00500	.1270	48.57	242.85	4,118	.25000	6.350		607.09	1.65	185.09
.00550	.1397	58.77	293.85	3,403	.27500	6.985		734.58	1.36	223.96
.00600	.1524	69.94	349.70	2,860	.30000	7.620		874.22	1.14	266.53
.00650	.1651	82.08	410.40	2,437	.35000	8.890		1,189.90	.84	362.77
.00700	.1778	95.19	475.95	2,101	.40000	10.160		1,554.16	.64	473.83
.00750	.1905	109.28	546.40	1,830	.45000	11.430		1,966.98	.51	599.69
.00800	.2032	124.33	621.65	1,609	.50000	12.700		2,428.38	.41	740.36
.00850	.2159	140.36	701.80	1,425						
.00900	.2286	157.36	786.80	1,271						
.00950	.2413	175.33	876.65	1,141						
.01000	.2540	194.27	971.35	1,029						

Physical Properties of Tungsten

Atomic Number	74	
Atomic Weight	183.85	
Atomic Volume	9.53	
Density (20°C) gm/cc	19.3	
Density (20°C) lb./cu. in.	0.697	
Melting Point	3400°C. approx.	
Boiling Point (760 mm Hg)	5900°C. approx.	
Linear Coefficient of Expansion	20°C to 590°C.	4.4×10^{-6}
	600°C to 1000°C.	4.6×10^{-6}
Atomic Heat (700°K) cals./gm/atom/degree	6.20	
Thermal Conductivity (20°C) cal./sec./cm/dc		.399
Electrical Conductivity % IACS	31	
Young's Modulus of Elasticity, kg/mm^2	40,000 approx.	
Modulus of Torsion, kg/cm^2	1.45×10^6	

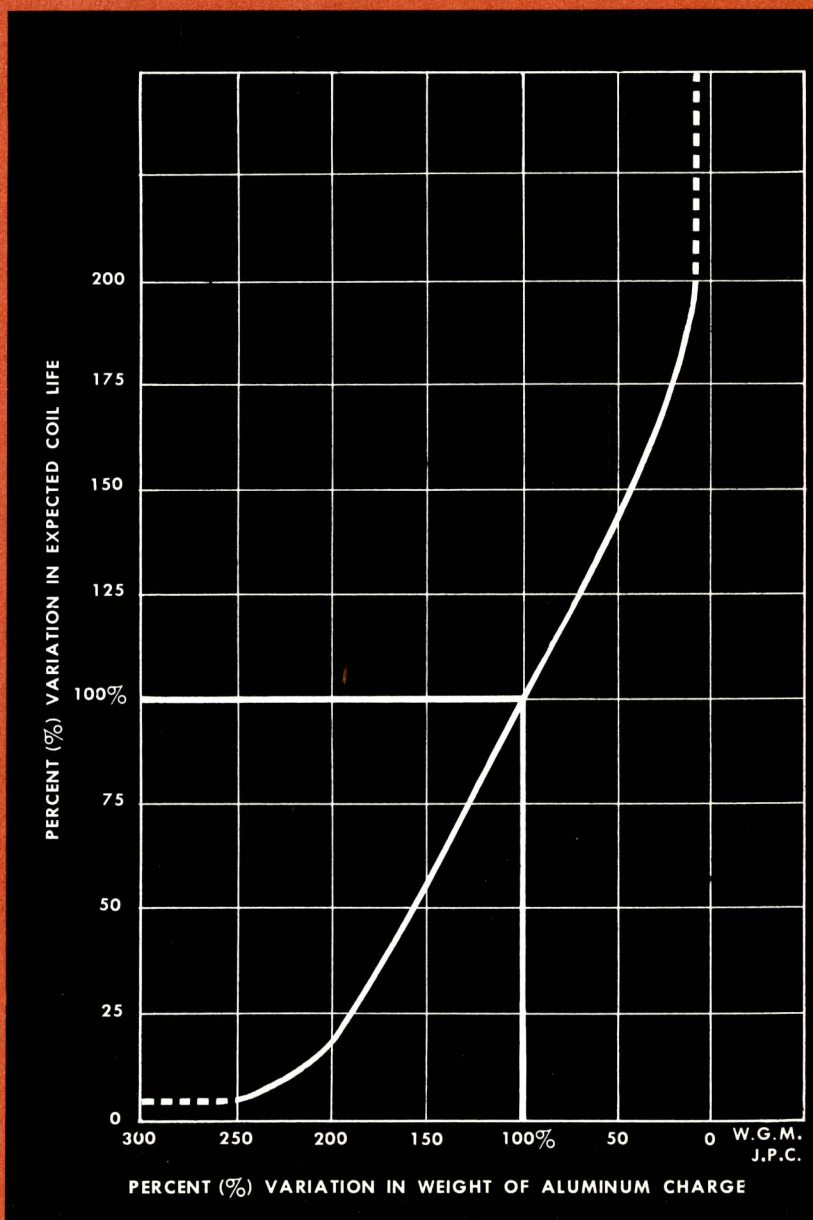
Metals Used in High Vacuum Evaporation

NAME	SYMBOL	M.P.°C	SUGGESTED HEATER
Aluminum	Al	658	Helical coil of W
Antimony	Sb	630	Conical Basket of W or W coated with Alundum
Beryllium	Be	1350	Conical Basket of W
Cadmium	Cd (s)	320	Conical Basket of W
Chromium	Cr (s)	1615	Basket or Grid of heavy tungsten wire
Copper	Cu	1084	Conical Basket or Helical Coil of W
Germanium	Ge	958	Conical Basket of W
Gold	Au	1063	Helical coil of W
Magnesium	Mg	651	Conical Basket or Helical coil of W
Molybdenum	Mo	2620	Direct from fine wire filament of Mo
Nickel	Ni	1452	Helical coil of W
Palladium	Pd	1552	Helical coil of W
Platinum	Pt	1755	Helical coil of W
Selenium	Se	217	Conical Basket of W
Silver	Ag	960	Helical coil of Ta
Tin	Sn	232	Conical Basket of W
Zinc	Zn	420	Conical Basket of W

S=SUBLIMES

The listing above does not include many metals which are sometimes evaporated nor does it include a considerable number of compounds useful in the coating of optics. In many cases of low melting metals and compounds an alundum coated conical basket of tungsten or an alundum crucible directly or indirectly heated is the most satisfactory arrangement. In some cases heaters made of other than the preferred above listed materials are also useful.

Effect of Variations From Normal Weight of Aluminum On Expected Coil Life



*W*hether you need special coils or standard stock coils . . . we welcome your inquiries. Experienced Sylvania engineers and technicians are always ready to help you with technical information and advice on coil design and application. Inquiries concerning tungsten coils for electronics, lighting, metallizing and other uses should be directed to one of the convenient addresses below.

BOSTON
100 Sylvan Road
Woburn, Mass.
Phone: WEIls 3-3500

CHICAGO
2001 N. Cornell Avenue
Melrose Park, Ill.
Phone: FIllmore 5-0100

DAYTON
333 West First Street
Dayton 2, Ohio
Phone: BAldwin 3-6227

DETROIT
7800 Intervale Avenue
Detroit 38, Mich.
Phone: WEbster 3-8765

NEW YORK
1000 Huyler Street
Teterboro, N. J.
Phone: ATlas 8-9484

PHILADELPHIA
4700 Parkside Avenue
Philadelphia 31, Penna.
Phone: GReenwood 7-5000

PITTSBURGH
300 Mt. Lebanon Blvd.
Pittsburgh 34, Penna.
Phone: LEhigh 1-4975

SAN FRANCISCO
1811 Adrian Road
Burlingame, Calif.
Phone: OXford 7-3500

TOWANDA
Towanda, Penna.
Phone: ANdrew 5-2121

CHEMICAL AND METALLURGICAL DIVISION

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SYLVANIA
phosphors
Technical Information Bulletin

TELEVISION PHOSPHORS

Black and White Television Picture Tube Phosphors

A P-4 sulfide screen is used for "black and white" (monochromatic) TV picture tubes. Sylvania's P-4 series is composed of types CR-402 to 421, tabulated below. These are blends of blue silver-activated zinc sulfide, ZnS:Ag, and yellow silver-activated zinc cadmium sulfide, (Zn,Cd)S:Ag. Sylvania P-4 phosphors are superior because of a carefully controlled production process, together with the stringent quality standards which all finished P-4 blends must meet before shipment to the customer.

Type No.	
CR-402	Uncoated. For aluminized tubes.
CR-405	Same as 402, but has higher light output.
CR-407	Same as 405, but is more resistant to contamination.
CR-408	Higher light output than 405 and 407.
CR-421	Protectively coated for crossburn resistance. For non-aluminized tubes.

PARTICLE SIZE AND DISTRIBUTION

Particle size control is extremely important in assuring good settling characteristics of phosphors. Sylvania phosphors excel in this respect, since the particle size and distribution are controlled to give optimum results in meeting a given customer's process requirements in screen uniformity, brightness, shrinkage, etc. Each customer is assured uniformity from lot to lot.

Typical Particle Size Distribution (By the Andreasen method)

Size range, microns	Per cent by Weight	
Average size in microns	10	11.5
0– 5	5	3
5–10	45	32
10–15	35	40
15–25	12	20
Above 25	3	5

SCREEN ADHERENCE

The wet and rewet adherence of the phosphor screen are important and depend principally upon the potassium silicate and electrolyte concentrations of the settling medium, but are also affected by settling time, screen drying conditions, etc. All Sylvania P-4 phosphors possess good adherence properties which assist in achieving low screen shrinkage in either the spray filming or flotation lacquer filming process. *Figure 1* shows typical wet and rewet adherence at various settling concentrations using a given set of test conditions. Wet screen strength is determined by measuring the diameter of holes eroded in the screen by a standard jet of water. Thus, smaller diameter values indicate higher strength, and vice versa.

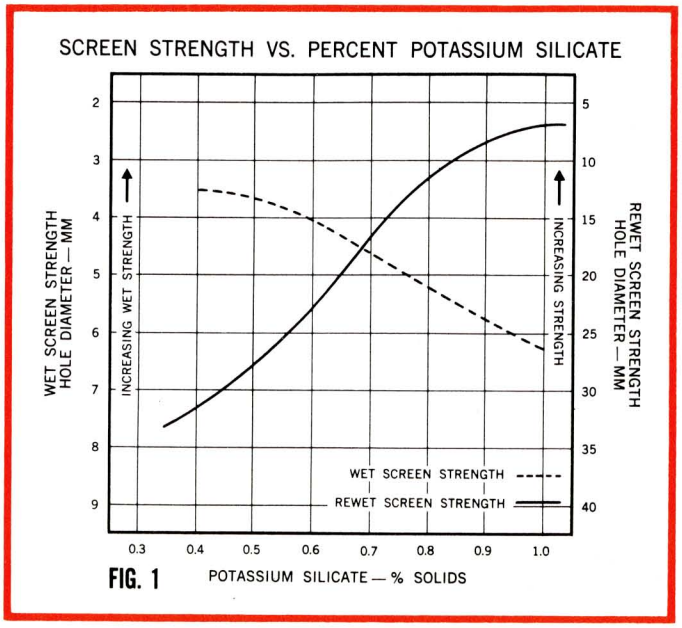

FIG. 1

RESISTANCE TO CONTAMINATION

All Sylvania P-4 phosphors are very resistant to poisoning from impurities which may be encountered during tube processing. CR-402 and CR-407 especially excel in the respect. *Figure 2* shows the resistance to copper contamination. A standard Blue Spot test also shows Sylvania P-4 phosphor to have excellent resistance to iron contamination.

Sylvania maintains a high purity level in all finished P-4 blends through the use of high purity raw materials and a carefully controlled manufacturing process.

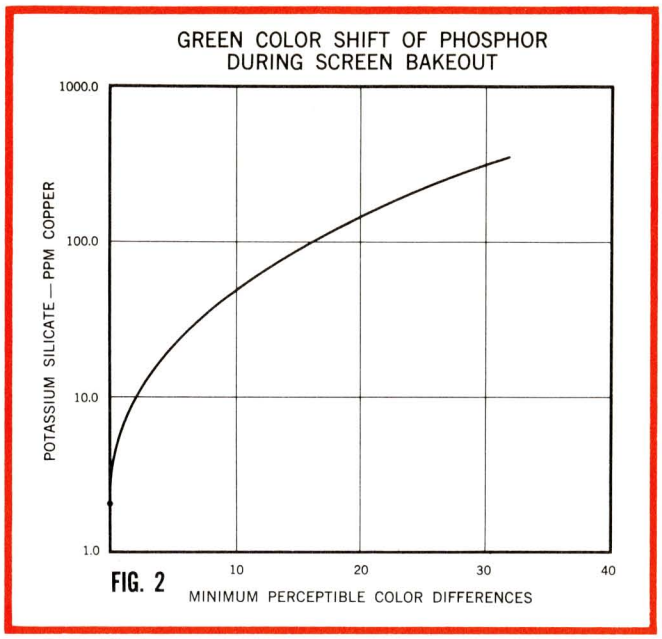

FIG. 2

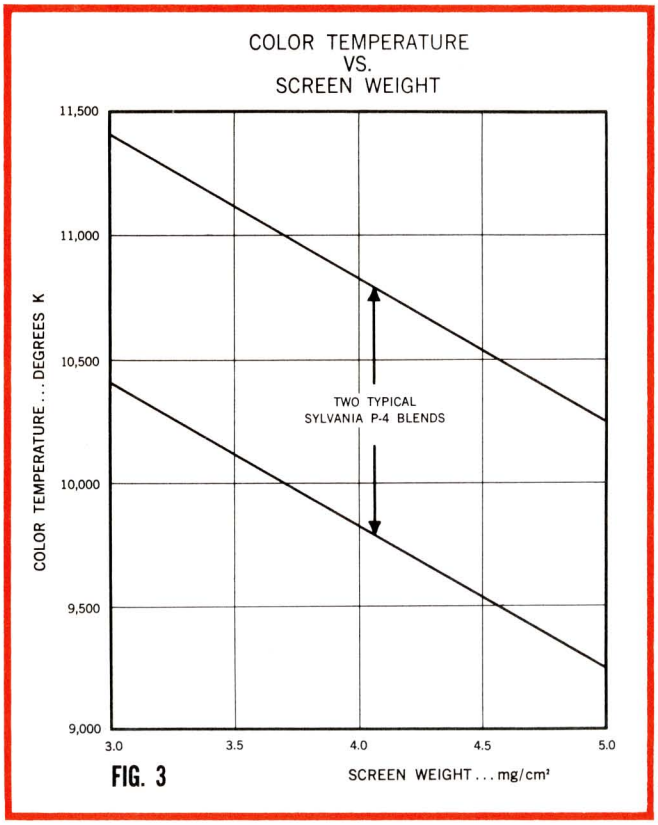

FIG. 3

COLOR

The light body color and particle size distribution of Sylvania P-4 phosphors assure minimum screen color shift with variations in screen weight, as indicated by *Figure 3.* A typical spectral energy distribution curve for a P-4 phosphor blend is shown in *Figure 4.*

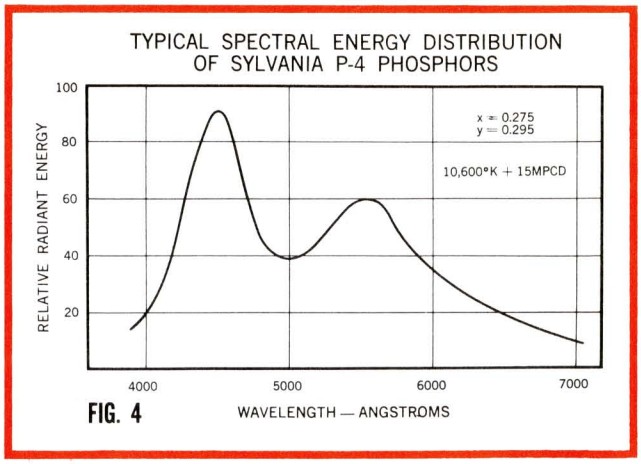

FIG. 4

BRIGHTNESS

Maintenance of good brightness as well as high initial screen brightness must be considered when evaluating phosphors. Sylvania P-4 phosphors are designed to give high initial light output at low screen weights, and to maintain a high percentage of the initial brightness for long periods of time under electron excitation. *Figure 5* exhibits the excellent brightness maintenance of Sylvania P-4 phosphors. *Figure 6* shows that optimum initial screen brightness is obtained at 3.8—4.2 mg/cm² and that only a small percentage of maximum brightness is lost at lower screen weights. *Figure 7* shows the effect of screen current on tube brightness, indicating that saturation is not a problem with Sylvania P-4 phosphors.

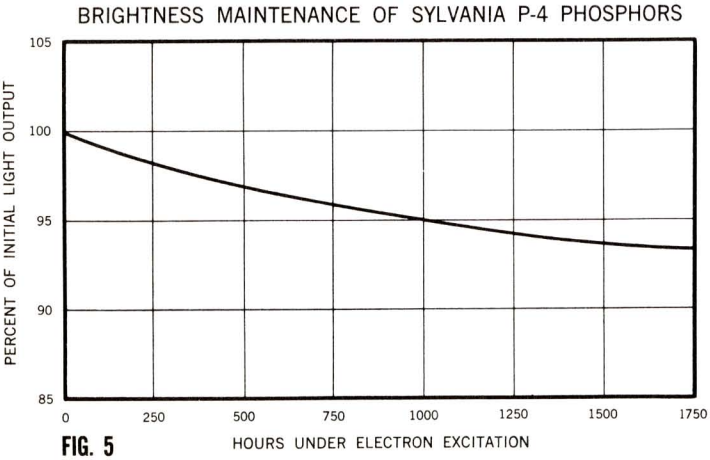

FIG. 5

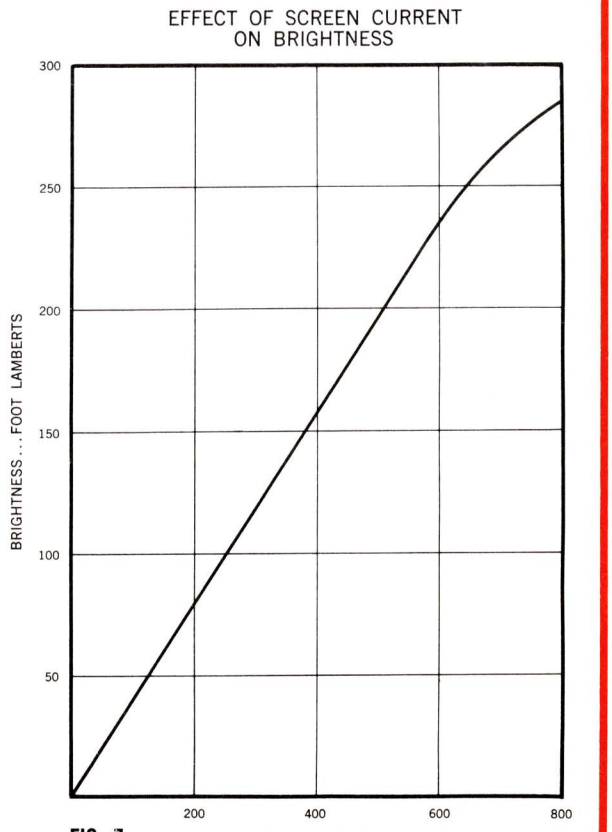

FIG. 7

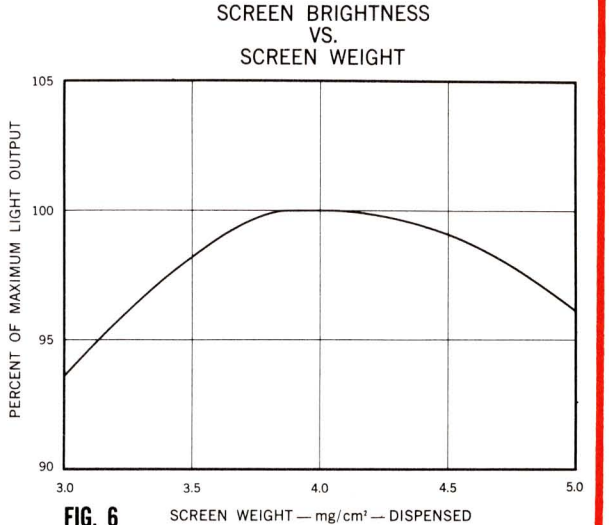

FIG. 6

AVAILABILITY

Sylvania P-4 phosphors are supplied to meet customer color specifications. Samples can be supplied to represent up to 3000-pound blends. Stocks of Sylvania phosphor components are maintained so that rapid deliveries meeting customer color specifications can be made. Standard packaging is in 5-lb bottles or 50-lb pails.

Technical service on all problems relating to the screening of cathode-ray tubes is available upon request.

Color Television Picture Tube Phosphors

Color TV phosphors have the general classification of P-22 phosphors. Sylvania supplies the following series for this application:

Sylvania Type No.	Chemical Composition	Color	Approximate Chromaticity Coordinates x	y
110	(Zn,Cd)S:Ag	Red	0.640	0.360
120	(Zn,Cd)S:Ag	Green	0.265	0.555
131	ZnS:Ag	Blue	0.160	0.062
151	$Zn_3(PO_4)_2$:Mn	Red	0.668	0.332
161	Zn_2SiO_4:Mn	Green	0.223	0.700

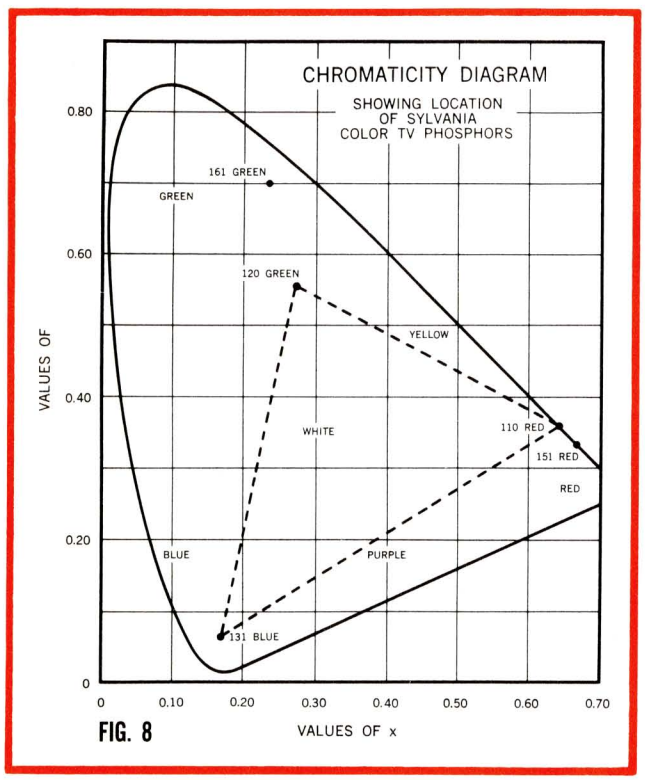

FIG. 8

The sulfide series consisting of types 110 red, 120 green, and 131 blue, are the most widely used for the manufacture of color television picture tubes at the present time, although the 151 red and 161 green are being used by some manufacturers. *Figure 8* is the I.C.I. chromaticity diagram, showing the locations of the colors of Sylvania's red, green, and blue sulfides. Thus, a color TV tube can cover the range of color within the triangle defined by these three points.

The average particle size, particle size distribution, aggregation, bulk density, etc. are properties of the phosphor that can be varied to some extent. The screen deposition procedure and other process variations largely determine what these properties should be to give optimum screening results.

RADAR AND OSCILLOSCOPE PHOSPHORS

JEDEC* No.	SYLVANIA TYPE No.	CHEMICAL COMPOSITION	FLUORESCENT COLOR	REMARKS	APPLICATION
P- 1	160	Zn_2SiO_4:Mn	Green	Small particle size	Oscilloscopes and radar
P- 1	161	Zn_2SiO_4:Mn	Green	Medium part. size	Oscilloscopes and radar
P- 1	221	Zn_2SiO_4:Mn	Green	Large part. size	Oscilloscopes and radar
P- 2	145	ZnS:Cu	Green		Oscilloscopes
P- 5	135	$CaWO_4$	Blue		Photographic applications
P- 7	130 140	ZnS:Ag (Zn,Cd)S:Ag	Blue Yellow	Two layer cascade screen	Oscillography and radar
P-11	132	ZnS:Ag	Blue		Photographic applications
P-12	144	$(Zn,Mg)F_2$:Mn	Orange		Radar
P-13	211	$MgSiO_3$:Mn	Red		
P-14	130 146	ZnS:Ag (Zn,Cd)S:Cu	Blue Orange	Two layer cascade screen	Radar
P-15	137	ZnO:Zn	Green		Flying spot scanners
P-16	147	$CaMg(SiO_3)_2$:Ce	Purple		Flying spot scanners
P-20	122	(Zn,Cd)S:Ag	Yellow		Storage tubes
P-23	148	ZnS:Ag + (Zn,Cd)S:Ag	White	Sepia color	Television receivers
P-24	149	ZnO:Zn	Green		Flying spot scanner tubes
P-25	156	$CaSiO_3$:Mn	Orange		Military display systems
P-31	139	ZnS:Cu	Green		Oscilloscopes

Joint Electron Device Engineering Council of the Electronic Industries Association

JEDEC No.	Wavelength Peak (Angstroms)	Band Width 50% (Angstroms)	I.C.I. Coordinates x	I.C.I. Coordinates y	Decay Classification	Decay 10% of Max. After Excitation	% Relative Energy of Peak Compared to P-20
P- 1	5250	5100-5450	0.218	0.712	Medium	25 m. sec.	115
P- 2	5450	5000-5800	0.279	0.534	Medium	40 μ sec.	70
P- 5	4150	3800-4750	0.169	0.132	Short	20 μ sec.	30
P- 7 (Blue)	4500	4150-4850	0.151	0.032	Medium-short	25 μ sec.	300
(Yellow)	5600	5200-6000	0.357	0.537	Long	0.15 sec.	87
P-11	4600	4300-5050	0.139	0.148	Short	30 μ sec.	125
P-12	5900	5600-6300	0.605	0.394	Medium-long	250 m. sec.	31
P-13	6500	6100-6900	0.670	0.329	Medium	50 m. sec.	10
P-14 (Blue)	4500	4150-4850	0.150	0.093	Medium-short	25 μ sec.	300
(Orange)	5950	5500-6450	0.504	0.443	Medium	5 m. sec.	41
P-15*	3900	3800-4100	0.246	0.439	Short	2.5 μ sec.	10
*	5050	4700-5450	0.246	0.439	Short	2.5 μ sec.	10
P-16	3850	3600-4200	0.175	0.003	Very Short	0.12 μ sec.	55
P-20	5600	5100-6150	0.380	0.560	Medium-short	0.2 m. sec.	100
P-23 (Blue)	4600	4200-4800	0.375	0.390	Medium-short	—	—
(Yellow)	5700	5100-6200	0.375	0.390	Medium-short	—	—
P-24	5100	4600-5700	0.245	0.441	Short	1.5 μ sec.	18
P-25	6150	5600-6600	0.557	0.430	Medium	40 m. sec.	14
P-31	5300	4950-5700	0.260	0.490	Medium	40 μ sec.	92

*Two Peaks

The above tables list the special purpose phosphors and their properties that are for sale by Sylvania at the time of this publication. Spectral-Energy Distribution and persistence curves are available on all the listed phosphors upon request.

New phosphors are continually being developed; therefore inquiries are invited from customers interested in phosphors not listed, since others will be added as needs arise and their preparation developed in our laboratories.

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