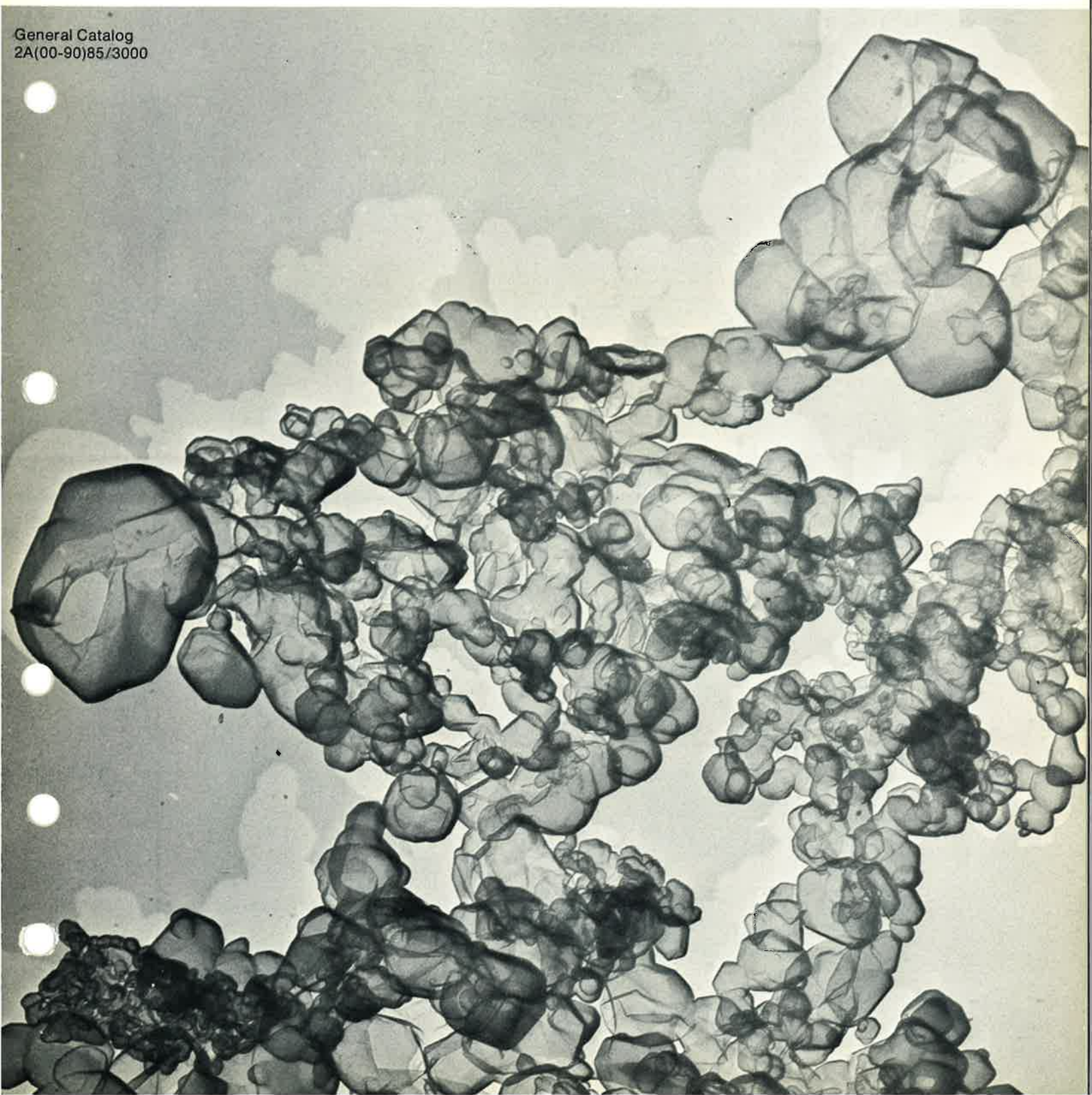
GENERAL ELECTRIC COMPANY
LAMP PARTS AND EQUIPMENT SALES OPERATION

GENERAL ELECTRIC

TUNGSTEN METAL POWDER

General Catalog
2A(00-90)85/3000



GE Leadership in Tungsten Metal Power

The Refractory Metals Products Department of the General Electric Company has produced high purity tungsten for more than fifty years. During this period, processes and controls have been developed which are designed to assure production of the most uniform and highest quality material available. Tungsten powder for carbide, pressed electrical contacts, and other applications has been produced in quantity for more than forty years. Supplementing this vast manufacturing experience, Refractory Metals Products Department is technically equipped and staffed with research and development personnel to continue this process of quality improvement and product application.

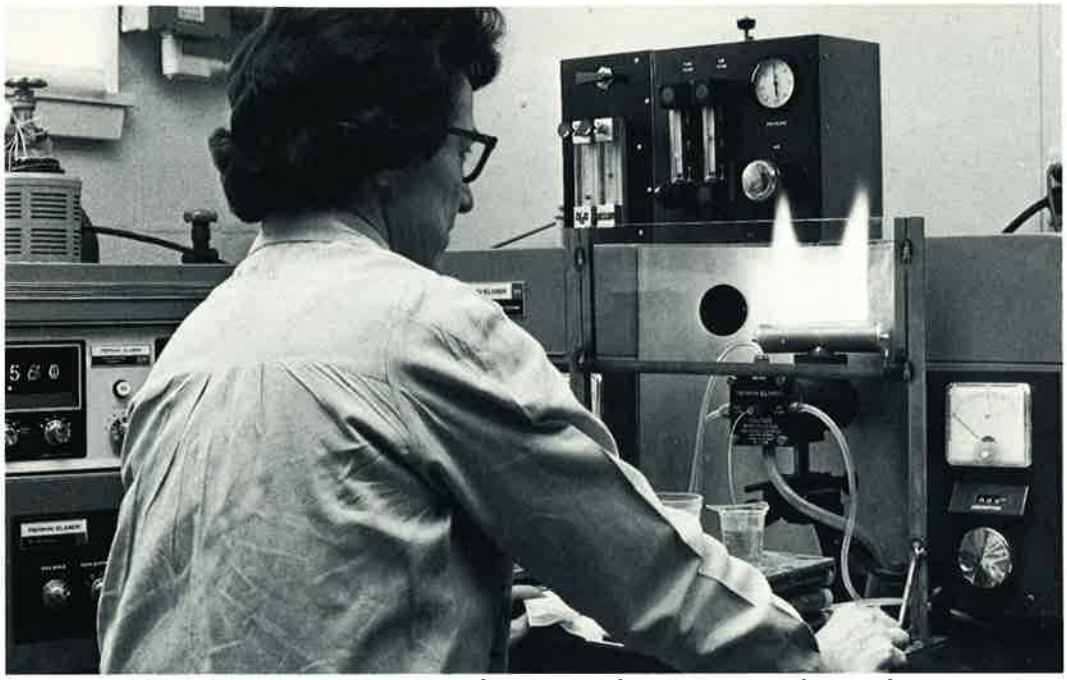
GE Technical and Engineering Service

General Electric offers a number of standard types of powder available from large on-the-shelf inventories. In addition, it provides product engineering service to "tailor make" powder to specifications required by a customer. The service also includes assistance in the development of special types of powder required in the application of tungsten to new uses.

Manufacturing Facilities

Our completely integrated process, which produces from ore the high purity tungsten necessary for lamp filaments, is also used to make tungsten powder for other applications. The production equipment which allows high volume is arranged, by type and scheduling, to have considerable flexibility. Large and small orders can be accommodated and "tailor made" to the customer's needs. All powder lots are produced with minimum variations to the specific particle size desired. A blender, capable of making lots weighing up to 25,000 lbs. in size, assures the customer that the most completely homogeneous product possible is received. The blender also provides the possibility of supplying repetitive powder shipments from the exact same powder lot, thus reducing the amount of testing normally performed by the customer.

Numerous chemical analyses are performed throughout the purification process to assure high quality and uniformity.



Modern analytical instruments, such as the atomic absorption unit shown above, speed results and improve precision.

General Physical Characteristics

Tungsten powder, which is produced by the hydrogen reduction of an oxide, is composed of semi-sintered botryoidal* agglomerates or aggregates of smaller basic particles. These agglomerates vary in size and shape and are dependent upon the type of oxide used, the reduction and processing conditions, and the basic size of the powder. The powder therefore can be characterized by its "as-supplied" agglomerate and/or basic particle physical characteristics.

Normally, tungsten powder is only sieved before it is blended and might, depending upon its size, have agglomerates ranging up to 40 mesh in size. The characteristics of flowability, green strength, green density, apparent density and tapped (or packed) density, therefore, are not only dependent upon the basic particle size of the powder but also on the size and shape of the powder agglomerates.

Determining Powder Characteristics

A number of tests are used to measure properties of tungsten powder. The more significant and commonly used ones have been standardized by American Society for Testing Materials or Metal Powder Industries Federation. Many tests, however, are not standard throughout the industry. Care must be taken that powder characteristics are evaluated by tests which are adequately defined and of proven significance and precision. Samples of tungsten powder can be tested in its "as-supplied", agglomerated condition or after it has been de-agglomerated. General Electric's engineering personnel are continually working on improvements in evaluating powder characteristics. This effort includes development of new measures as well as upgrading present tests. The major tests used to evaluate powders, listed according to powder characteristic, are described here and on the following pages.

*like a bunch of grapes

It is General Electric's practice to use as many of these physical tests as are applicable for a given type of powder and necessary to provide quality and uniformity of product.

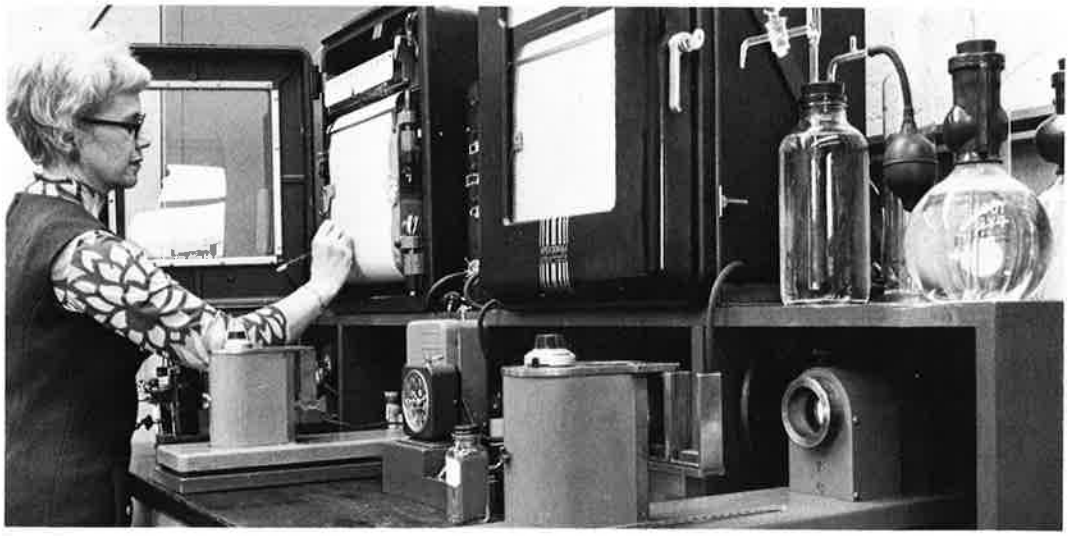
AVERAGE PARTICLE DIAMETER

This measurement is the most commonly used one in the industry and is determined with the Fisher Sub-Sieve Sizer machine per ASTM B-330 Procedure. The Fisher Sub-Sieve Sizer measures the porosity and air permeability of a packed bed of powder and converts these to an average particle diameter (Fisher number) value expressed in microns. Powder is usually sold on the basis of "as-supplied, Fisher number". The Fisher number is also determined on powder after it has been laboratory milled (or de-agglomerated) per ASTM B-430.

A technician is shown calibrating the Fisher Sub-Sieve Sizer which is used to measure the average particle diameter of powder.

PARTICLE SIZE DISTRIBUTION

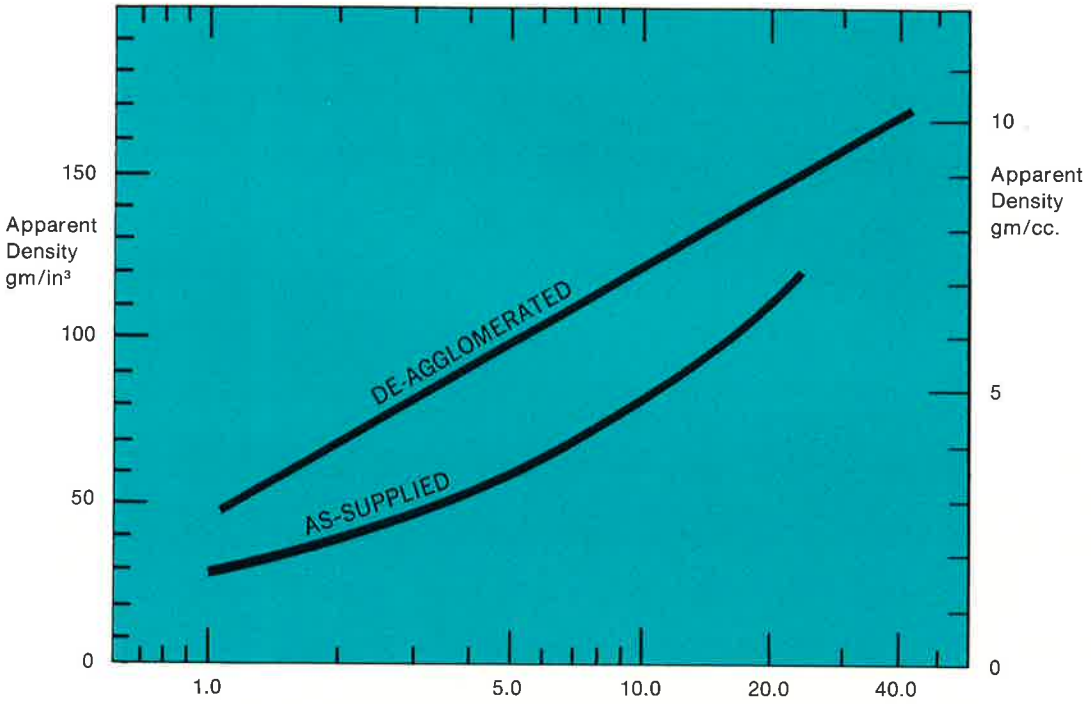
For the normal sub-sieve sizes of powder, this measurement is performed with a Turbidimeter per ASTM B-430 and is based on Stokes Law of Sedimentation. The rate of sedimentation of a uniform dispersion of powder in a liquid medium is measured photoelectrically and the weight percent particle size distribution is calculated using a modified form of Lambert-Beer Law. While the particle size distribution is normally determined on powder after it has been de-agglomerated by laboratory milling, an equivalent sphere particle size distribution of the as-supplied agglomerated powder can also be determined if necessary. For coarse tungsten powders, standard sieve analysis per ASTM B-214 can be performed on as-supplied or laboratory milled powder. For the extremely coarse sizes, sieve analysis is currently the most precise and significant measurement of particle size distribution.



Powder particle size distributions are determined using Turbidimeters as shown above.

APPARENT DENSITY

This is commonly measured according to ASTM B-329 and expressed in gm/cu.in or gm/cc. It is also measured by ASTM B-212 or B-417 and expressed in gm/cc. In these tests, the powder is allowed to free-fall into a container of known volume and, after leveling, the powder is weighed. The test is made under ideal conditions and may not measure the density of the powder as it is used. The apparent density is also highly sensitive to type and degree of agglomeration.



Typical apparent density per ASTM B-329 by Fisher Sub-Sieve Sizer number of as-supplied and de-agglomerated tungsten powder.

TAP OR PACK DENSITY

This measurement is determined per ASTM B-527 by tapping a weighed quantity of powder in a graduated container until the minimum volume is achieved. It is similar to apparent density insofar as the powder is tested under ideal conditions and, generally does not give the packed density of the powder as it is used.

SIEVE ANALYSIS

ASTM Sieve Analysis B-214 can be used to appraise powder. Testing of powders supplied may show trace quantities above stated sieve size. Also, trace undersize quantities can be present when a specific sieve size fraction of powder is supplied. This is normal and is attributed to the difference in sieving method or sieve variation.

FLOWABILITY

When using MPIF Standard 3-45, flowability measurements can only be performed on the coarsest of the standard type or sieve size powders. The test, basically, measures the time for a given quantity of powder to flow through a standardized funnel or orifice.

GREEN STRENGTH

Tungsten powder has low pressed green strength and normally cannot be tested for transverse rupture strength per ASTM B-312. It can, however, be tested for its compressive rupture strength. While a standard compressive test has not yet been established in the industry for tungsten powder, several tests, differing primarily in the specimen tested, are commonly used. With one test, three one inch diameter pellets, each weighing sixty grams and made by hydraulic pressing at six T/in^2, are stacked for rupturing. Another test uses a 1 inch diameter cylinder machined from a billet hydrostatically pressed at 30,000 psi. ASTM E-9 is used for the actual compressive rupture strength value determination.

SURFACE AREA

Actual surface area can be determined by using conventional volumetric or gravimetric apparatus or by using continuous flow type analyzers. Generally, the surface area values determined correlate directly to the lab milled Fisher Sub-Sieve Sizer values.

Powder Types Available

1. *Standard U-(Fisher number) Type (see photomicrographs page 10)* — Almost all of the hydrogen reduced powder produced is of this type powder. Available powder sizes range from 0.5 microns to 25.0 microns average particle size, as determined by the Fisher Sub-Sieve Sizer on as-supplied powder. Specific sizes based on nominal as-supplied Fisher number can be selected for custom-making or chosen from specific popular sizes listed in Price Schedule. The Price Schedule also lists standard sieving for each range of powder sizes. Special sieving as fine as 325 mesh can be performed for most powders.

Typical Turbidimeter Weight Percent Particle Size Distribution Values For Significant Micron Sizes and Typical Fisher Sub-Sieve Sizer Numbers of Standard Size Powders.

Standard Size		.8 ±.08	1.0 ±.1	1.35 ±.1	1.6 ±.15	2.0 ±.2	2.4 ±.2	3.0 ±.3	4.0 ±.3	5.2 ±.3	6.1 ±.4
Fisher Sub-Sieve Sizer Number, Microns											
On As-Supplied powder — Typical		.8	1.0	1.35	1.6	2.0	2.4	3.0	4.0	5.2	6.1
On Lab. Milled powder — Typical		.75	.95	1.25	1.5	1.9	2.2	2.8	3.6	4.8	5.5
Turbidimeter Wt. % — Lab. Milled Powder											
Micron Size											
0—1	Max.	90	70	47	34	20	12				
	Min.	65	45	26	14	4	1				
1—2	Max.	30	46	58	60	58	54	37	16	7	
	Min.	8	20	36	40	33	25	13	4	1	
2—3	Max.		13	22	28	37	39	40	28	14	9
	Min.		1	4	9	17	20	20	9	3	1
3—4	Max.			10	13	18	22	28	27	21	18
	Min.			0	1	5	8	12	12	7	5
4—5	Max.				9	11	13	18	23	25	23
	Min.				0	0	1	8	12	12	8
5—6	Max.						6	10	17	26	25
	Min.						0	2	6	11	10
6—7	Max.							9	14	17	17
	Min.							0	4	8	9
7—8	Max.							6	8	13	15
	Min.							0	0	4	5
8—9	Max.								8	11	12
	Min.								0	0	1
9—10	Max.									8	10
	Min.									0	0

2. *High Green Strength UB-5.0 Type (see Photomicrograph page 11)* — This type powder provides unusually high pressed green strength properties. In addition to the normal equiax particles of standard powders, this powder contains a significant amount of accicular (needle-like) particles. The standard as supplied average particle diameter is between 4.5 and 5.5 microns with the laboratory milled average particle diameter typically being 3.2 to 4.2 microns.

3. *Coarse UM-(Fisher number) Type (see Photomicrograph page 11)* — Very coarse hydrogen reduced powder that is actually sieve size but is rated and sold on the basis of a Fisher Sub-Sieve Sizer number determined on a laboratory milled powder sample. Powder as supplied is only sieved minus 20 mesh and is highly agglomerated. Available in the sizes shown below.

Approximate Sieve Analysis of Coarse UM-(Fisher Number) Type Powders

Designation	Fisher No. rating range, microns	Approximate Weight Percent Sieve Analysis[1]					
		−20, +60	−60, +100	−100, +150	−150, +200	−200, +325	−325
UM—25.0	20—30	<1	<5	5	10	25	55
UM—35.0	30—40	<5	10	15	20	30	30

Approximate values listed in this table do not total 100% and are intended to be only descriptive of the general size distribution of the powders. Actual sieve analysis, determined per ASTM B-214 on 200 gms of powder laboratory milled per ASTM B-430, can be expected to be within these stated tolerances:

10 weight percent for the fractions listed as having less than 50 weight percent.

20 weight percent for the fractions listed as having greater than 50 weight percent.

4. *Granular Type G (see photomicrographs page 11)* — Irregular shaped sieve size powder. Particles may vary in density from 60 to 100% of theoretical. Sold by sieve size only. Minus 325 mesh is finest available fraction.

5. *Special ID Types* — Included in this type are all powders of special characteristics:

(a) High apparent density powders (to approx. 185 gm/in^3)

(b) High packed density powders (to approx. 195 gm/in^3)

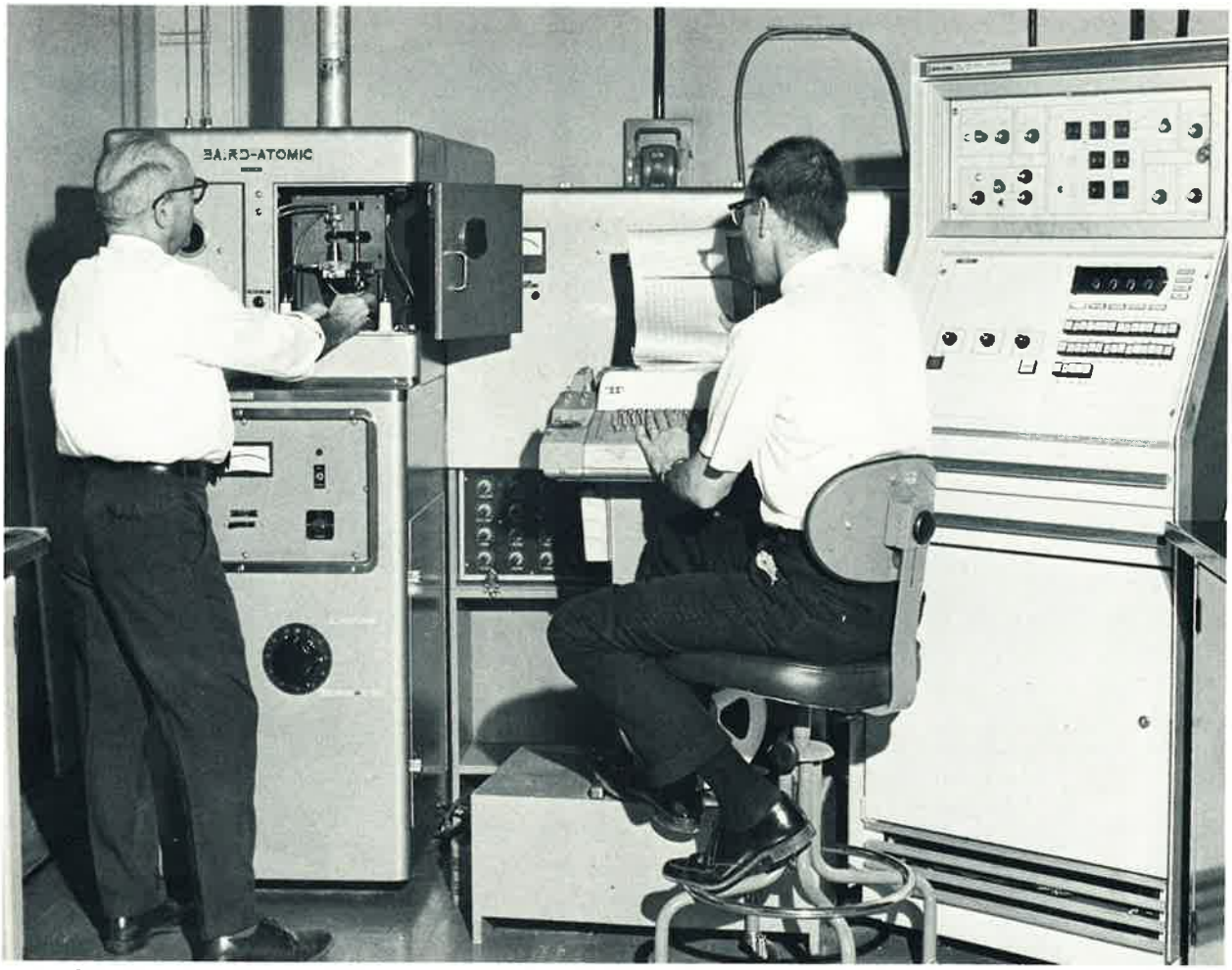
(c) Doped powders

Powder Purity

Overall purity will depend upon the type of powder. Minimum tungsten content for standard, high green strength, and coarse type powders is 99.9% on a gas free basis and is determined by difference from chemical analysis. The granular type powder is 99.5% minimum and is typically better than 99.7% on the same basis as other powders.

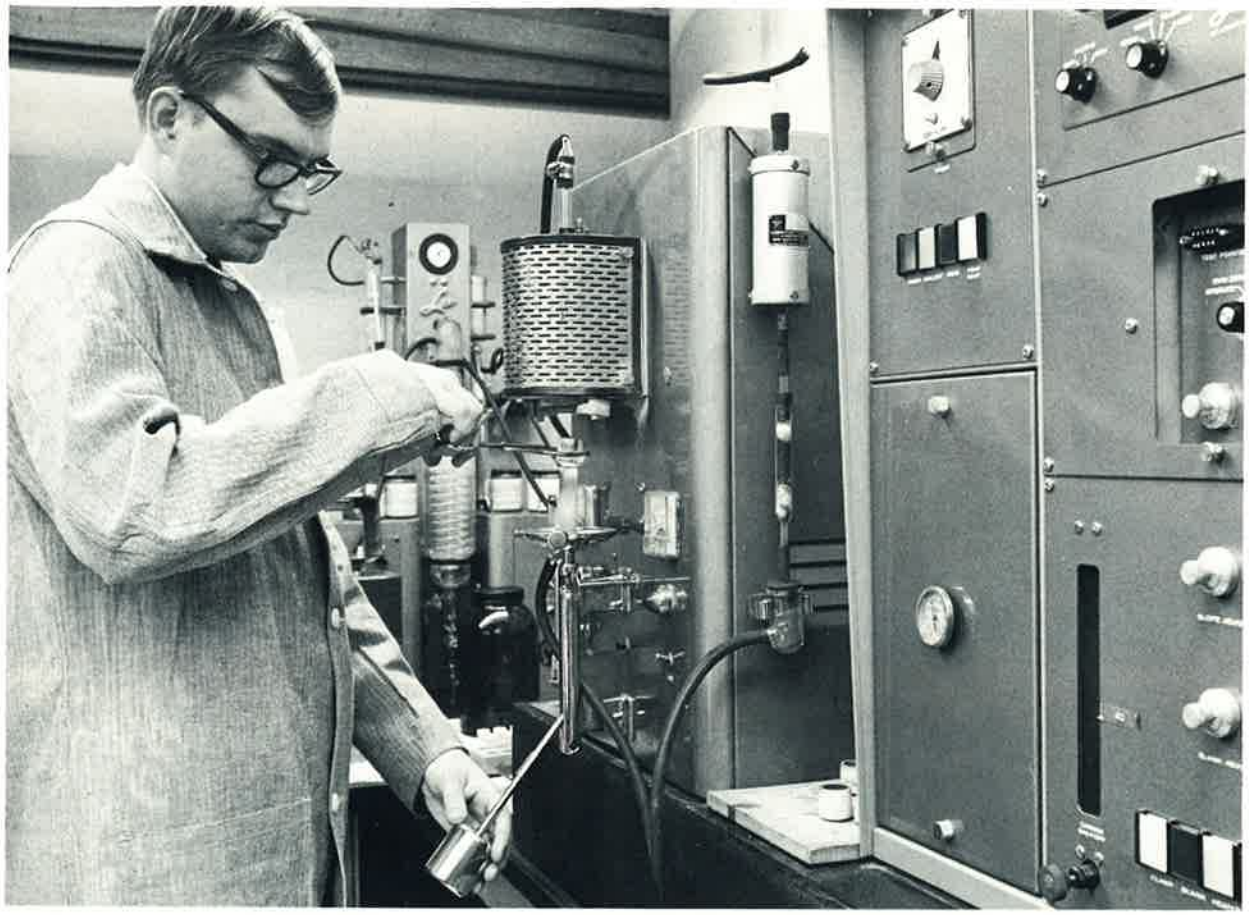
The amount of each trace impurity element normally found in tungsten powder also depends on the type. For some elements it will depend upon the specific size of the powder. Maximum contents of trace elements contained in standard type powder for any size are shown below:

Element	Max. PPM	Element	Max. PPM
Aluminum	20	Nickel	100
Calcium	50	Copper	50
Silicon	50	Manganese	20
Molybdenum	450	Magnesium	20
Iron	200	Tin	20
Chromium	100		

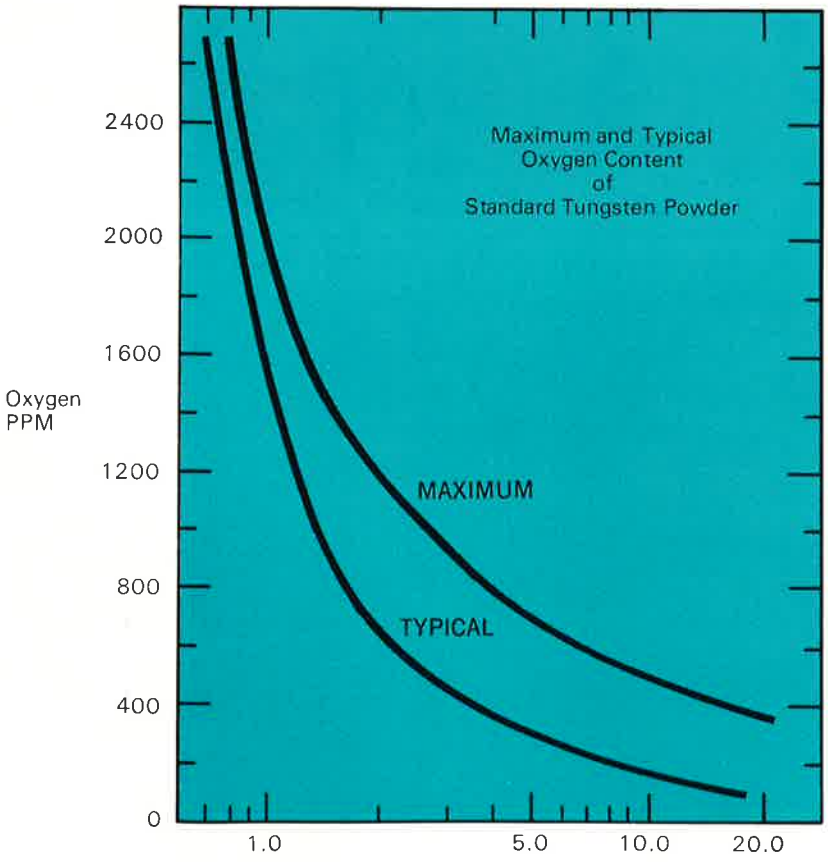


A combination of a direct reading spectrograph and a time sharing computer terminal is used in rapidly providing trace elements analyses of greater precision.

Carbon content is determined by using a combustion method with a thermal conductivity measurement and analyzes less than 50 PPM for standard type powders. Oxygen is determined by using a Leco inert gas fusion apparatus and, depending upon the particle size, ranges from 200 PPM maximum for coarse to 2500 PPM maximum for fine standard type powders. Powders of higher purity can be produced.



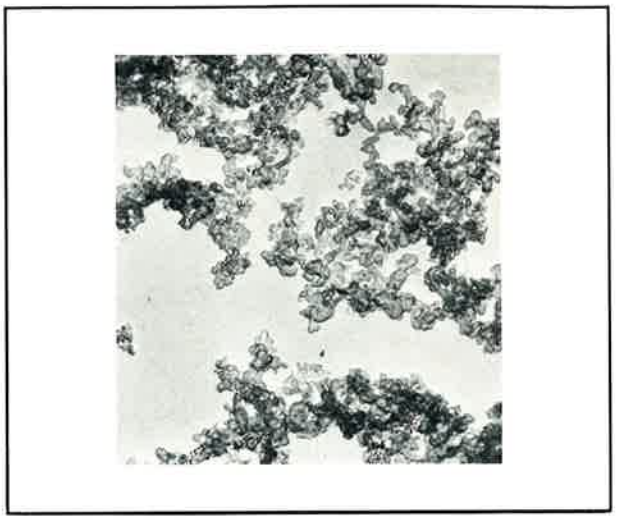
Shown above are Leco analyzers used to measure oxygen and carbon contents of tungsten metal powders.



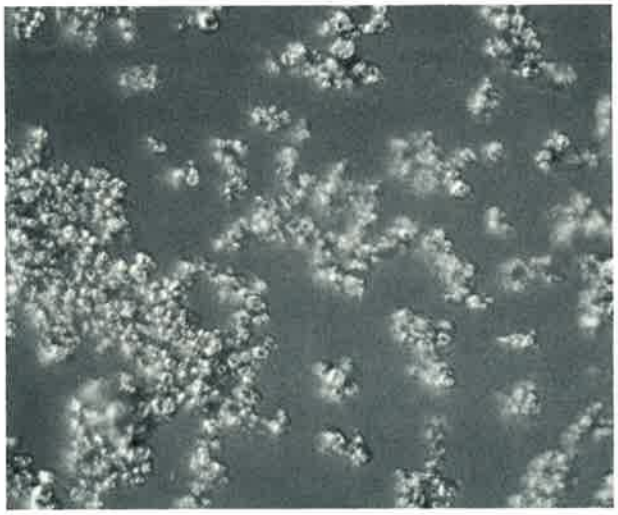
As-supplied Fisher Sub-Sieve Sizer number in microns

Photomicrographs of Standard Tungsten Powders

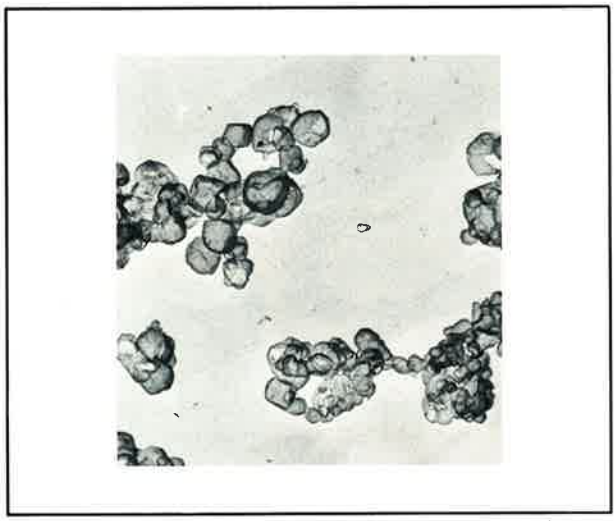
Type U-1.35 at 20,000 x - electron microscope replica



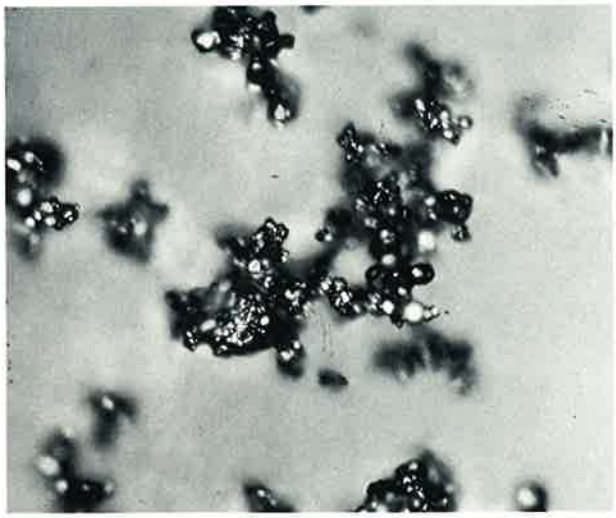
Type U-1.35 at 1500 x - electron microscope replica



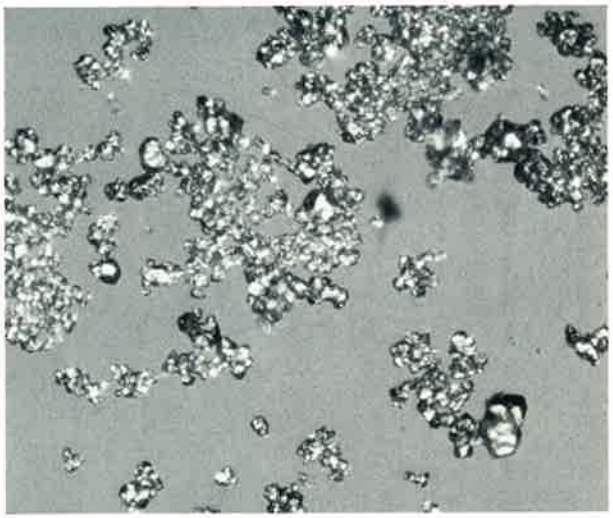
Type U-4.0 at 500 x - optical microscope



Type U-4.0 at 1500 x - electron microscope replica



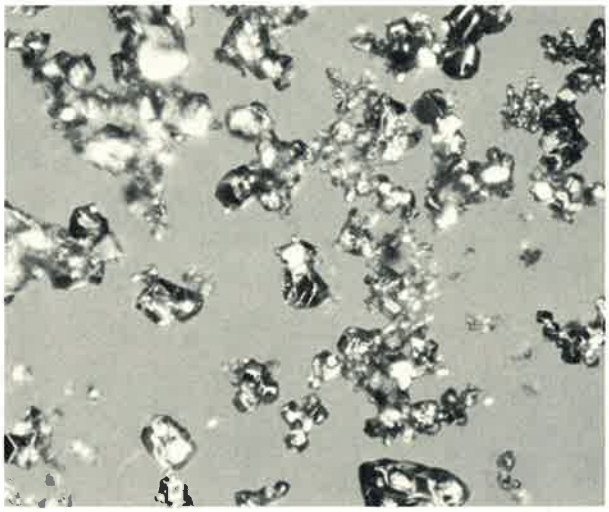
Type U-9.0 at 250 x - optical microscope



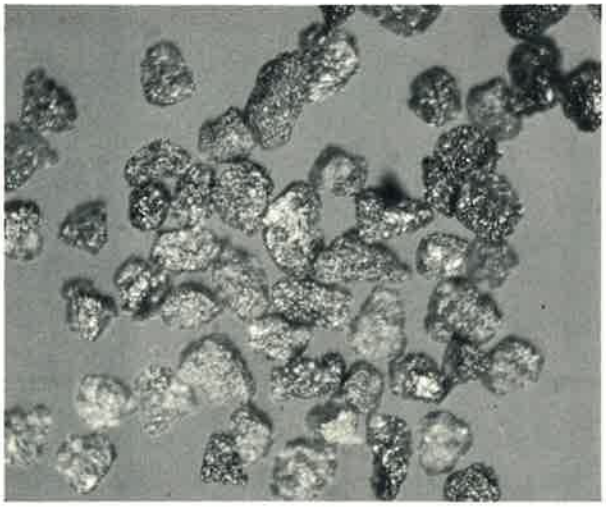
Type U-15.0 at 100 x - optical microscope

Special Tungsten Powders

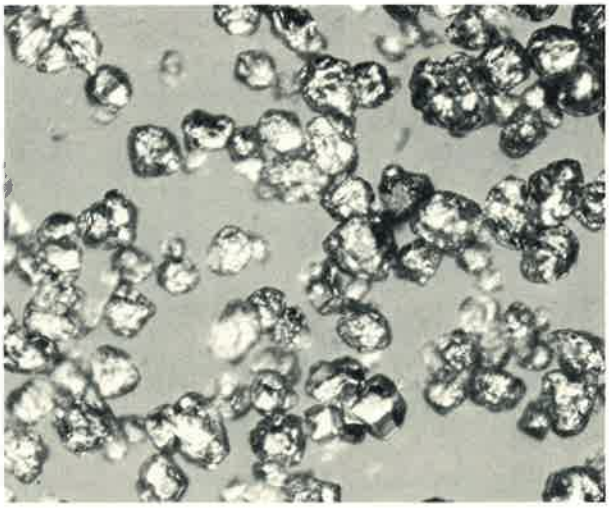
Type UB-5.0 at 1500 x - optical microscope



Type UM-35.0, as supplied, at 100 x - optical microscope



Type G, minus 200, plus 325 mesh, at 100 x - optical microscope



Type UM-35.0, de-agglomerated, at 100 x - optical microscope

Fisher Sub-Sieve Sizer Tolerances

Normal manufacturing tolerances of standard sizes of standard type powder are shown in the Price Schedule. For other than standard powders, a ±15% tolerance of nominal ordered Fisher number will normally apply.

Reports

A standard report is furnished for each powder lot shipped. This report includes results of quantitative spectrographic, oxygen, and appropriate physical analyses. The physical analyses for standard type powders include Fisher Sub-Sieve Sizer numbers per ASTM B-330 on the as-supplied and laboratory milled powder, and for nominal 9.0 micron and below average particle diameter type powders, the weight % particle size distribution determined per ASTM B-430 on laboratory milled powder. The results of physical analyses furnished for our other powders depend upon the type.

Packaging

Powder is packaged in 50 kg. or 100 lb. quantities in a 5 gal. can. Special packaging in smaller or larger units (in up to 30 gal. returnable drums) is available. All powder is packaged in a plastic bag within the can unless otherwise requested.

How to Order

Standard tungsten powder is usually ordered by nominal Fisher Sub-Sieve Sizer number. For other types of powder, the specific type, Fisher number, sieve size, and other pertinent applicable requirements should be stated. If assistance is needed in ordering, General Electric's Powder Order Service Unit should be consulted.

Your inquiry for any of the standard or special types of tungsten powder will be quickly processed. General Electric also invites you to take advantage of our product engineering service for assistance in determining the specific type or size of powder for new applications.

Send Order To

Europe
GENERAL ELECTRIC
Components Marketing & Sales Oper.
21a High Street East, Uppingham
Leicestershire LE15 9PY, England
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