FINER POINTS

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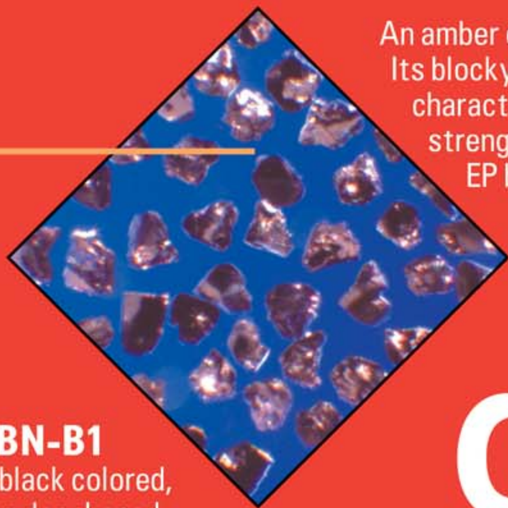
Particle Size And Size Distribution Of Superabrasive Powders

INTERTECH 2008 Call For Papers

The Technology And Application Of Sieves For Superabrasives Mesh Classification



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FINER POINTS

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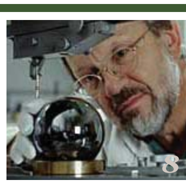

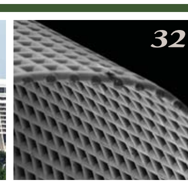

COVER PHOTO

Photo courtesy of Precision Eforming. Photo of mesh sieves used to sort, sift and classify diamond and cBN crystals.

FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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A Finer Point of View…

I would like to start my first dialogue as president of the IDA by saying what a privilege it will be to spend the next year in this position. I am fortunate to have been preceded by several outstanding individuals that have made this position easier, Robert Linares, Joe Tabling, Joe Haag and Andre Spelbrink. I have been so fortunate to serve under these gentlemen as an officer and board member. I have also been involved with the current officers and board members and I can guarantee you the IDA is in a very felicitous position. The IDA membership has done well in electing these individuals to guide and lead our organization into the future.

Member as defined by Random House Unabridged Dictionary is a person, animal, plant, group, etc **that is part** of a society, party, community, taxon, or other body. **Part**icipation, as defined by the same source is an act or instance of participating, the fact of taking part, as in some action or attempt or a sharing as in benefits or profits. With that being said I would like to issue a challenge to the IDA membership. Participate! I have belonged to the IDA for close to 10 years and been fortunate enough to have attended the last 9 annual meetings. At every one of those meetings, we discuss several issues as well as have a roundtable discussion to entertain the participating members ideas on how to continue making the IDA a stronger Association as a whole, more useful Association to the membership and an annual meeting that is an accession of value.

The IDA board has heard several ideas and acted upon those ideas, such as wanting to interface with end users at the annual meetings. So what did the board do, we sought out companies & speakers like Jim Campbell at Pratt & Whitney or David Yen at Delphi to not only educate, but also offer an opportunity for a foot in the door with these companies. Other requests for educational speakers to offer ideas on improving our own businesses, resulted in speakers such as economist Gina Martin of Wachovia Bank, Foreign Trade & Kimberley Process experts Maria Iseman and Wendy Peebles from the US Census Bureau and Chuck Mers from Colonial Insurance speaking on employer supplemental benefits to employees. No discussion goes by without action. In regard to the constant improvement of the IDA website, our Executive Director Terry Kane has made it very user friendly, very interactive, gave it a product and services information search engine for member companies and added a “members only” link to provide literature, market information and proprietary information accessible only to IDA

PRESIDENT
David Simpson

members. The list goes on, a copulation of global standards for sizing of diamond and CBN mesh products by Ion Benea of Engis (see article this issue), a long overdue certificate course is being established with the guidance of Monica Jones from Action Superabrasives, a renewed interest reestablishing the statistical reporting program headed by Tim Keene of Wendt and the list goes on!

I appreciate the great efforts of all of the individuals above, as well as all assisting in these programs. These efforts combined with many not mentioned are what has helped make this organization healthy and strong since 1946. Participation as defined above can be as simple as an **act or instance of participating** like attending the upcoming 2008 Annual Meeting and Intertech conference. Participation as defined above as **in taking some action** like volunteering for the board or volunteering for one of the committees, The last element of participation is a **sharing of benefits or profits** such as participating in the statistical program or sharing knowledge in the certificate course.

The IDA is in a strong and healthy position, but it can be of greater influence and contribute more to the industry and each of its members with more member participation and more new members from the industry. If you are currently a member, get involved more and if you are not an IDA member join today… Together we have a stronger voice in the industry and can contribute to the greater good for all members.

Sincerely,

David Simpson, President
Industrial Diamond Association of America

FINER POINTS is the official publication of the Industrial Diamond Association of America, Inc. and is published fours times a year. Contributions are welcomed but the Editor reserves the right to accept or reject any material for publication. All by-lined articles published in this magazine represent solely the individual opinions of the writers and not necessarily those of the Industrial Diamond Association. Executive and Editorial Offices: Finer Points, P.O. Box 29460, Columbus, Ohio 43229, (614) 797-2265. Editor and Advertising, Terry Kane. Advertising rates and deadlines available upon request.

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Editorial

TERRY KANE, Editor

New And Improved Versus Established And Proven

I just celebrated my sixth anniversary as Executive Director of the Industrial Diamond Association. Thankfully I am just as excited and pumped up today as I was in 2001. I have seen a number of changes as the technology and research of our industry continues to be innovative and far-reaching. It seems every month someone is calling me about a new product or material that "rivals" diamond or approaches the hardness of cubic boron nitride. While many of these are unproven by independent research or simply one-time laboratory successes, it still says that this industry is not sitting on its collective hands but pushing the envelope of what could be the next big breakthrough. This keeps our industry fresh and exciting…

New superabrasive products aren't the only innovations; new applications and new workpiece materials are being introduced as well. I recently attended a meeting and listened to one scientist describe a new abrasive cutting tool material and then later in the day heard an aerospace engineer talk about a new material being introduced for an aircraft component and a new machine design for the manufacture of an intricate part. Likely the scientist and engineer would be having discussions by the day's end.

Even as the new and improved are waiting to be unveiled, the established and proven are making inroads and setting new application standards. Since I have the opportunity to review abstracts and papers that are submitted for each INTERTECH I have seen current applications for sawing, machining or grinding being looked at from different perspectives. Too many times we hear the old line: "I've heard about this before" or "That's old news, we did that in (fill in the year)". While many of the topics seem old news, this is usually not the case. A different or revisited perspective sometimes leads to very eye opening results. For instance, metal coatings have been used for many years to improve the performance of crystals and cutting tools, but new alloys and combinations are still changing the application results for the better.

Bonding materials have been around as far back as the first use of diamond in a grinding wheel or sawblade, but companies continue to expound on the capabilities and performance of "new" resin bonds and innovative electroplated or metal bond processes. I read as many articles and press releases as I can to sort out the truth from the tale and the facts from the figment. I have to admit; sometimes it is a daunting task!

One truth has come through over and over again… if one person says it can be done or can be made or can perform… another person will surely make it happen. As we start receiving abstracts for INTERTECH 2008 I read each submission with great interest because in every paper there is that gem waiting to be uncovered. The new and improved ideas of today will soon be the established and proven products of yesterday … now that's exciting!

IDA 61ST ANNUAL MEETING HELD IN LAS VEGAS

New Officers and Board announced for 2007 term

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The IDA Annual Meeting featured a tremendous speaker list including James Campbell from Pratt & Whitney, Dr. Ajay Malshe from NanoMech, Dr. Mahendra K. Sunkara from the University of Louisville, Gina Martin from Wachovia Bank plus Wendy Peebles and Jerome Greenwell from the US Trade Bureau. The talks gave attendees an excellent insight to new technological breakthroughs for diamond and cBN as well as new materials and applications in aerospace. Ms Martin took the attendees through an excellent review of the current economy and projections for the coming years and our speakers from the Trade Bureau updated us on the Kimberley Process and directed members to ways they can improve the Harmonization Code reporting system. The IDA Business Meeting was packed with new projects and suggestions led by the development of the new Certificate Course with SME and updates in our Standards Documents (see article in this issue). The Executive Director pointed out many highlights and provided an overall glowing report on the IDA status and programs. Everyone is excited about 2008 with the upcoming INTERTECH and Annual Meeting in Orlando May of 2008. All in all, everyone enjoyed the meeting, gleaned many useful ideas and shared some quality time with their peers.

ABC SUPERABRASIVES LAUNCHES NEW WEBSITE

ABC Superabrasives, a manufacturing unit of Saint Gobain - with over 60 years of service in the surface conditioning industry has announced the launch of their new web site – www.abcsuperabrasives.com . ABC Superabrasives manufactures the finest Natural, Synthetic and CBN Superabrasives available to industry today. For more information visit our web site or contact us Toll free: 800.368.5155

AUSTRALIAN SCIENTISTS AND OPTICAL ENGINEERS WILL BE MAKING A PERFECT SPHERE THAT MAY ONE DAY REDEFINE THE KILOGRAM

The kilogram is one of seven base units in the International System (SI) used in science, commerce and everyday life. However, it is the only one still defined by a physical object – a lump of metal, known as the International Prototype, sitting in a vault in France. All the others have moved with the scientific times and are defined in terms of a fundamental constant of nature so anyone anywhere can reproduce them and they do not change over time. Under the auspices of the International Bureau of Weights and Measures (BIPM), near Paris, the decision has been made that international effort will focus on two ways of redefining the kilogram: one of which involves making a perfect sphere from a single crystal of exceptionally pure silicon. The work will be done with the close cooperation of Australia's National Measurement Institute (NMI) and CSIRO's Australian Centre for Precision Optics (ACPO), which share the same site in the Sydney suburb of Lindfield.

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PARTICLE SIZE AND SIZE DISTRIBUTION OF SUPERABRASIVE POWDERS

ION C. BENEA, Ph.D. – Engis Corporation

The purpose of this article is to present the techniques and standards that are currently employed in the superabrasive industry for the determination of particle size/particle size distribution of diamond and CBN powders.

PARTICLE SIZE CHARACTERIZATION

Knowledge of particle size and size distribution of a powder system is a prerequisite for most production and processing operations. Particle size and size distribution have a significant effect on the surface and bulk properties (mechanical, electrical, thermal), of the finished product. In most instances powder suppliers provide size and size distribution information, but that information needs to be checked for quality control purposes. An adequate control of size and size distribution of the superabrasive powders is imperative to avoid production losses due to high rejection rates of the finished product. Particle size and size distribution can be determined using numerous commercially available instruments. It is important to understand that as different instruments are based on different physical principles, there are bound to be differences in the results obtained from these instruments. Furthermore, even when using instruments based on the same physical principle, the use of proprietary components and variations in adaptations of the same basic physical principle, as well as, the use of proprietary mathematical algorithms, can result in significant variations of the size measurement results. In addition, powder size and size distribution is greatly impacted by particle shape. Thus, comparison of size and size distribution results from different instruments should be conducted with great care and should be based on adequate protocols. The development of such protocols would require instrument calibration coupled with extensive analysis of "standard", well characterized powders that are similar to the powders under investigation. The use of particle size and size distribution data as relative measurements is extremely important when using particle size distribution as a process control tool. The magnitude and/or direction of change are indicative of the changes in the manufacturing process, which can significantly impact on the quality of the product. In such cases, acceptable limits for these fluctuations have to be defined and particle size and/or size distribution has to be monitored to ensure that it lies within these limits. Absolute precision in particle size analysis can only be achieved when the two principle parameters of length and weight are directly traceable to International Standards. Techniques that fulfill these criteria are called "primary" or direct methods and include: microscopy and image analysis, sieve analysis, electrical sensing zone, gravity sedimentation and centrifugal sedimentation. On the other hand, "secondary" or indirect methods of particle size characterization depend on second order effects such as diffraction patterns, Brownian motion, turbidity, etc. In addition, these techniques involve computer modeling (mathematical algorithms coupled with a number of hypothesis) for the interpretation of experimental data. Laser light diffraction, dynamic light scattering and photon correlation spectroscopy are the most popular secondary or indirect particle size measurement techniques/methods. Absolute measurements can be conducted with some degree of reliability when using techniques such as microscopy-based analysis. With these techniques, the particles being measured are visually examined. However, the reliability of the absolute measurement is affected by the number of particles that are being measured, the representative nature of the particles included in the analysis, the particle shape, the state of dispersion and the specimen preparation technique followed. Furthermore, the particles to be analyzed must be spherical so a single dimension can describe their size. *Given the above considerations, it is obvious that powder size and size distribution measurements should be regarded as relative measurements, where results from one run can be compared with those from another run, obtained on the same or, different instrument under similar measurement conditions.*

CENTRIFUGAL SEDIMENTATION PARTICLE SIZE ANALYZER

Therefore, the measurement precision is of far greater importance than the accuracy. Effective communication between powder manufacturers/suppliers and customers/end users is a critical factor in the development of robust size measurement procedures, protocols and specifications. Incorporating appropriate audits also enable tracking performance and conformity to the agreed upon protocols and specifications. A recommended general procedure for particle size and size distribution analysis is presented in Figure 1 below.

Figure 1 – Flow chart of a general procedure recommended for particle size and size distribution analysis

Some of the definitions and calculations used for particle size and size distribution characterizations are presented in Appendix 1.

The correspondence between Mesh grit size, equivalent micron size and approximate number of particles in one carat are presented in Appendix 2.

ELECTRICAL SENSING ZONE PARTICLE SIZE ANALYZER

GRIT OR SIEVE SIZES DIAMOND AND CBN POWDERS - SIZING AND STANDARDS SIZE DETERMINATION BY SIEVING TECHNIQUE

In the most general sense, sieving consists of shaking the free flowing dry powder sample through a stacked series of sieves with decreasing mesh size. The mesh with the largest aperture is at the top, and that with the smallest aperture is at the bottom of the stack. Size distribution is reported as the mass of the material retained on a mesh of a given size, but may also be reported as the cumulative mass retained on all sieves above a mesh size or as the cumulative mass fraction above a given mesh size.

The following similar ASTM and ISO standards describe the requirements for sieve construction including details on aperture openings, means to measure the same, wire diameter, frame diameter and techniques for maintenance and cleaning of sieves: ASTM E11-95 – Defines specifications for metal wire sieves, ASTM E161-96 – Defines specifications for electroformed sieves. ISO 3310-1 – Technical requirements and testing / Part 1 – Test sieve of metal wire sieves and ISO 3310-3 – Technical requirements and testing / Part 3 – Test sieve of electroformed sheets

TYPICAL SIEVES

Figure 1 – Flow chart of a general procedure recommended for particle size and size distribution analysis.

CALIBRATION OF SIEVES

Sieve calibration is most practically conducted by sieving a material with a known size distribution and determining the similarity of the test results to that of the test material. The National Institute has developed standard Reference Materials, (SRM), for sieve calibration for Standards and Technology (NIST). These materials are certified by electron and optical microscopy methods for dimension and are intended for sieve calibration. The appropriate NIST SRMs for sieve calibration are listed in Appendix 3 – Part 1.

Other proposed techniques for sieve calibration include optical and photometric examination of sieve to determine the distribution of aperture size in a particular sieve.

APPLICABLE STANDARDS

The purpose of the standards is to establish a common basis for checking the size of diamond and CBN powders, which are used to manufacture a wide range of industrial superabrasive products (i.e. saws, grinding wheels, etc.). It is intended to serve as common basis of understanding for the producers of superabrasive powders, and for the manufacturers, distributors and users of the superabrasive products. The following equivalent standards apply to grit or sieve size diamond and CBN powders: American Standard ANSI B74.16 / July 12, 2002 – Checking the Size of Diamond and Cubic Boron Nitride Abrasive Grains International Standard ISO 6106 / May 16, 2005 – Abrasive Products – Checking the Grit Size of Superabrasives

SPECIFICATIONS FOR PARTICLE SIZE DISTRIBUTION OF DIAMOND AND cBN GRIT OR SIEVE SIZES

The specification for particle size distribution from electroformed sieves applicable to grit or sieve sizes diamond and CBN powders according to American Standard ANSI B74.16-2002, is defined in Table 1.1.

Table 1.1 – SPECIFICATION FOR PARTICLE SIZE DISTRIBUTION FROM ELECTROFORMED SIEVE ACCORDING TO ANSI B74.16-2002

USA Mesh Size	ISO Size Design	Nominal ISO Sieve	Test Weight for (Sieve (g)		0.1% Max. On	Oversize Control		Undersize Control			0.5% Max. Through
		Aperature Range (µm)	8" (200mm)	3" (75mm)	Sieve (µm)	Sieve (µm)	Max. % On	Sieve (µm)	Min. % On	Max. % Thru	Sieve (µm)
NARROW RANGE GRADES											
16/18	1181	1180/1000			1830	1280		1010			710
18/20	1001	1000/850			1530	1080		840			600
20/25	851	850/710			1280	915		710			505
25/30	711	710/600			1080	770		600			425
30/35	601	600/500			915	645		505			360
35/40	501	500/425	80-120	9.6-14.5	770	541	5	425	93	5	302
40/45	426	425/355			645	455		360			255
45/50	356	355/300			541	384		302			213
50/60	301	300/250			455	322		255			181
60/70	251	250/212			384	271		213			151
70/80	213	212/180			322	227		181			127
80/100	181	180/150			271	197		151			107
100/120	151	150/125			227	165	7	127	90	7	90
120/140	126	125/106	40-60	4.8-7.2	197	139		107			75
140/170	107	106/90			165	116		90			65
170/200	91	90/75			139	97	8	75	88	8	57
200/230	76	75/63			116	85		65			49
230/270	64	63/53			97	75		57			41
270/325	54	53/45	20-30	2.4-3.6	85	65	12	49	80	12	37
325/400	46	45/38			75	57		41			32

USA Mesh Size	ISO Size Design	Nominal ISO Sieve	0.1% Max. On	Oversize Control		Midpoint Control			Undersize Control		0.5% Max. Through	
		Aperature Range (µm)	Sieve (µm)	Sieve (µm)	Max. % On	Sieve (µm)	Min. % On	Max. % Thru	Sieve (µm)	Min. % On	Max. % Thru	Sieve (µm)
WIDE RANGE GRADES												
16/20	1182	1180/850	1830	1280		1046			840			600
20/30	852	850/600	1280	915		741			600			425
30/40	602	600/425	915	645	5	525	45	55	425	93	5	302
35/40	502	500/355	770	541		440			360			255
40/50	427	425/300	645	455		372			302			213
60/80	252	250/180	384	271		221			181			127

Calendar of EVENTS

To have your event or conference listed, please send information to:

Finer Points Event Calendar
P.O. Box 29460, Columbus OH 43229
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July 16-20, 2007
Semicon West
San Francisco, CA
www.semi.org

July 22-27, 2007
Defects in Semiconductors
Hyatt Regency Hotel
Albuquerque, New Mexico, USA
www.semiconductors.co.uk/icds24/index.htm

EASTPO 2007
9th SHANGHAI INTERNATIONAL MACHINE TOOL FAIR

July 25-28, 2007
www.eastpo.net

August 23-24, 2007
CSDA B&C Meeting
Ritz-Carlton Hotel
Phoenix, AZ

September 9-14, 2007
18th European Conference on Diamond, Diamond-Like Materials, Carbon Nanotubes, and Nitrides
Berlin, Germany
www.diamond-conference.elsevier.com

September 17-22, 2007
EMO Hannover
www.emo-hannover.de

September 19-20, 2007
DISKCON USA 2007
Santa Clara, CA
www.idema.org

September 26-28, 2007
International Symposium on Advances in Abrasive Technology
ISAAT2007 at SME International Grinding Conference
Hyatt Regency
Dearborn, MI USA
For information:
http://www.sme.org/isaat2007

October 3-6, 2007
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October 16-19, 2007
Wire South East Asia
Bangkok International Trade & Exhibition Centre (BITEC)
Bangkok, Thailand
www.wire-southeastasia.com

November 7-9, 2007
China World Trade Center
Beijing, P.R. China
http://www.wireasia.com.cn

November 8-9, 2007
CSDA B&C Meetings
Renaissance Fort Lauderdale Hotel
Fort Lauderdale, FL
CSDA at 727-577-5004 or visit
www.csda.org

November 11-14, 2007
Industrial Diamond Association FABTECH International & AWS Welding Show 2007
Society of Manufacturing Engineers (SME) McCormick Place
Chicago, IL USA

November 13-15, 2007
Sawing & Drilling 101 Training
St. Petersburg College
Clearwater, FL
CSDA at 727-577-5004 or visit
www.csda.org

November 14-15, 2007
Estimating Training
St. Petersburg College
Clearwater, FL
CSDA at 727-577-5004 or visit
www.csda.org

CALENDAR EVENTS for 2008

January 21-25, 2008
World of Concrete 2008
Las Vegas Convention Center
Las Vegas, NV
http://www.worldofconcrete.com

MAY 3-4, 2008
Industrial Diamond Association of America *Annual Meeting*
The Contemporary Resort
Orlando, Florida USA
www.superabrasives.org

INTERTECH 2008
An International Technical Conference on Diamond, Cubic Boron Nitride and their applications.
www.intertechconference.com
THE CONTEMPORARY RESORT ORLANDO, FLORIDA USA May 5-7, 2008

MAY 5-7, 2008
The Contemporary Resort
Orlando, Florida USA
www.intertechconference.com

June 8-12, 2008
MPIF/APMI 2008 World Congress on Powder Metallurgy & Particulate Materials
Gaylord National Resort & Convention Center
National Harbor on the Potomac
Washington, DC
www.mpif.org

The specification for particle size distribution from wire woven sieves applicable to grit or sieve sizes diamond and CBN powders according to American Standard ANSI B74.16-2002 standard is defined in Table 1.2.

Table 1.2 – SPECIFICATION FOR PARTICLE SIZE DISTRIBUTION FROM WOVEN WIRE SIEVES – ANSI B74.16-2002 STANDARD

USA Grit Size	Test Weight 8" (200mm) Sieves	Sieve through which 99.9% Must Pass	Max. of Oversize on Sieve		Sieve	Min. Retained	Max. Through	Max. of 2% Through Sieve
	GRAMS	MESH	%	MESH	MESH	%	%	MESH
8/10		6		8	10			14
10/12		7	8	10	12	90	8	16
12/14	80 to 120	8		12	14			18
14/16		10		14	16			20

The specification for particle size distribution from electroformed sieves applicable to grit or sieve sizes diamond and CBN powders according to International Standard ISO 6106-2005, is defined in Table 2.0.

Table 2.0

ISO Size Design	Equivalent Mesh Sizes	Test Weight for		99.9% Must Pass Through	Upper Control Sieve	Max. On Sieve	Lower Control Sieve	Min. On Sieve	Max. Through Sieve	0.5% Max. Through
		200 mm Sieves (g)	75 mm Sieves (g)	Sieve (µm)	Sieve (µm)	%	Sieve (µm)	%	%	Sieve (µm)
NARROW RANGE GRADES										
1181	16/18			1830	1280		1010			710
1001	18/20			1520	1080		850			600
851	20/25			1280	915		710			505
711	25/30			1080	770		600			425
601	30/35			915	645		505			360
501	35/40	80-120	9.6-14.5	770	541	5	425	93	5	302
426	40/45			645	455		360			255
356	45/50			541	384		302			213
301	50/60			455	322		255			181
251	60/70			384	271		213			151
213	70/80			322	227		181			127
181	80/100			271	197		151			107
151	100/120			227	165	7	127	90	7	90
126	120/140	40-60	4.8-7.2	197	139		107			75
107	140/170			165	116		90			65
91	170/200			139	97	8	75	88	8	57
76	200/230			116	85		65			49
64	230/270			97	75		57			41
54	270/325	20-30	2.4-3.6	85	65	12	49	83	12	37
46	325/400			75	57		41			32

ISO Size Design	Equivalent Mesh Sizes	Test Weight for		99.9% Must Pass Through	Upper Control Sieve	Max. On Sieve	Lower Control Sieve	Min. On Sieve	Max. Through Sieve	0.5% Max. Through
		200 mm Sieves (g)	75 mm Sieves (g)	Sieve (µm)	Sieve (µm)	%	Sieve (µm)	%	%	Sieve (µm)
WIDE RANGE GRADES										
1182	16/20			1830	1280		840			600
852	20/30			1280	915		600			425
602	30/40			915	645		425			302
502	35/40	80-120	9.6-14.5	770	541	5	360	93	5	255
427	40/50			600	455		302			213
252	60/80			384	271		181			127

The specification for particle size distribution from electroformed sieves applicable to grit or sieve sizes diamond and CBN powders according to Chinese Standard GB/T6406-1996 are defined in Table 3.0.

Table 3.0

Grit Size		99.9% thru Sieve	Upper Control Sieve		Lower Control Sieve			Max. 2% thru Sieve
Mesh	(µm)	(µm)	Sieve (µm)	Pass (%)	Sieve (µm)	Pass (%)	Not Pass (%)	(µm)
NARROW RANGE GRIT SIZES								
16/18	1180/1000	1700	1180		1000			710
18/20	1000/850	1400	1000		850			600
20/25	850/710	1180	850		710			500
25/30	710/600	1000	710		600			425
30/35	600/500	850	600		500			355
35/40	500/425	710	500		425			300
40/45	425/355	600	455	8	360	90	8	255
45/50	355/300	500	384		302			213
50/60	300/250	455	322		255			181
60/70	250/212	384	271		213			151
70/80	212/180	322	227		181			127
80/100	180/150	271	197		151			107
100/120	150/125	227	165	10	127	87	10	90
120/140	125/106	197	139		107			75
140/170	106.90	165	116		90			65
170/200	90/75	139	97	11	75	85	11	57
200/230	75/63	116	85		65			49
230/270	63/53	97	75		57			41
270/400	53/45	85	65	15	49	80	15	–
325/400	45/38	75	57		41			–
WIDE RANGE GRIT SIZES								
16/20	1180/850	1700	1180		850			600
20/30	850/600	1180	850		600			425
30/40	600/425	850	600	8	425	90	8	300
40/50	425/300	600	455		302			213
60/80	250/180	384	271		181			127

The specification for particle size distribution from electroformed sieves applicable to grit or sieve sizes diamond and CBN powders according to Russian Standard GOST 9206-1980 is defined in Table 4.0.

Table 4.0

Size Designation	99.9% thru Sieve	Oversize Control Max. % of Sieve					Main Fraction Min. Retain on Sieve			Max. 2% thru Sieve
	(µm)	8	10	12	13	15	90	80	75	(µm)
NARROW RANGE GRADES										
2500/2000	3000	2500					2000			1600
2000/1600	2500	2000					1600			1250
1600/1250	2000	1600					1250			1000
1250/1000	1600	1250					1000			800
1000/800	1250	1000					800			630
800/630	1000		800					630		500
630/500	800		630					500		400
500/400	630		500					400		315
400/315	500		400					315		250
315/250	400		315					250		200
250/200	315		250					200		160
200/160	250			200				160		125
160/125	200			160				120		100
125/100	160			125				100		80
100/80	125			100					80	63
80/63	100				80				63	50
63/50	80				63				50	40
50/40	63					50			40	

Table 4.0 ... *Continued*

Size Designation	99.9% thru Sieve	Oversize Control Max. % of Sieve					Main Fraction Min. Retain on Sieve			Max. 2% thru Sieve
	(µm)	8	10	12	13	15	90	80	75	(µm)
WIDE RANGE GRADES										
2500/2000	3000	2500					1600			1250
1600/1000	2000	1600					1000			600
1000/630	1250	1000					630			500
630/400	800		630					400		315
400/250	500		400					250		200
250/160	315		250					160		125
160/100	200			160					100	80
100/63	125			100					63	50
63/40	80				63				40	

Standard specifications for particle size distribution of grit size diamond and CBN powders as defined by American Standard ANSI B74.16-2002, International Standard ISO 6106-2005, Japanese Standard JIS 4130-1982, Chinese Standard GB/T6406-1996 and Russian Standard GOST 9206-1980 are presented in Table 5.1.

Table 5.1

Grit Designation #	International Standard ISO 6106-2005		USA Standard ANSI B74.6-2002		Japanese Standard JIS 4130-1982		Chinese Standard GB/T 6406-1996		Russian Standard GOST 9206-80	
	Mesh	(µm)	Mesh	(µm)	Mesh	(µm)	Mesh	(µm)	Mesh	(µm)
										2000/1600
										1600/1250
1182	16/20		16/20	1280/840			16/20	1180/840		
1181	16/18		16/18	1280/1010	16/18	1180/1000	16/18	1180/1000		1250/1000
1001	18/20		18/20	1080/840	18/20	1000/850	18/20	1000/850		1000/800
852	20/30		20/30	915/600	20/30	850/600	20/30	850/600		
851	20/25		20/25	915/710			20/25	850/710		
711	25/30		25/30	770/600			25/30	710/600		800/630
602	30/40		30/40	645/425	30/40	600/425	30/40	600/425		630/400
601	30/35		30/35	645/505			30/35	600/500		630/500
502	35/45		35/45	541/360						
501	35/40		35/40	541/425			35/40	500/425		500/425
427	40/50		40/50	455/302	40/50	425/300	40/50	425/300		
426	40/45		40/45	455/360			40/45	425/355		
356	45/50		45/50	384/302			45/50	355/300		400/315
301	50/60		50/60	322/255	50/60	300/250	50/60	300/250		315/250
252	60/80		60/80	271/181	60/80	250/180	60/80	250/180		250/160
251	60/70		60/70	271/213			60/70	250/212		250/200
213	70/80		70/80	227/181			70/80	212/180		
181	80/100		80/100	197/151	80/100	180/150	80/100	180/150		200/160
151	100/120		100/120	165/127	100/120	150/125	100/120	150/125		160/125
126	120/140		120/140	139/107	120/140	125/106	120/140	125/106		125/100
107	140/170		140/170	116/90	140/170	106/90	140/170	106/90		
91	170/200		170/200	97/75	170/200	90/75	170/200	90/75		100/80
76	200/230		200/230	85/65	200/230	75/63	200/230	75/63		80/63
64	230/270		230/270	75/57	230/270	65/53	230/270	63/53		63/50
54	270/325		270/325	53/45	270/325	53/45	270/325	53/45		50/40
46	325/400		325/400	45/38	325/400	45/38	325/400	45/38		
										< 40

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A cross reference chart for grit size diamond and CBN powders, between American Standard ANSI B74.16-2002, International Standard ISO 6106-2005, Chinese Standard GB/T6406-1996 and Russian Standard GOST 9206-1980, based on percentage of main fraction of the particle size distribution of the powder that falls between the upper and lower control sieves (µm) is presented in Table 5.2.

Table 5.2

USA Mesh Size Design	ISO Design	ANSI B74.16-200			ISO 6106-2005			Chinese Standard			Russian Standard		
		Upper Control Sieve µm	Lower Control Sieve µm	Main Fraction %	Upper Control Sieve µm	Lower Control Sieve µm	Main Fraction %	Upper Control Sieve µm	Lower Control Sieve µm	Main Fraction %	Upper Control Sieve µm	Lower Control Sieve µm	Main Fraction %
											2000	1600	
											1600	1250	
16/20	1182	1280	840		1280	840		1180	850				
16/18	1181	1280	1010		1280	1010		1180	1000		1250	1000	90
18/20	1001	1080	840		1080	850		1000	850		1000	800	
20/30	852	915	600		915	600		850	600				
20/25	851	915	710		915	710		850	710				
25/30	711	770	600		770	600		710	600		800	630	
30/40	602	645	425		645	425		600	425		630	400	
30/35	601	645	505		645	505		600	500		630	500	
35/45	502	541	360		541	360							
35/40	501	541	425	93	541	425	93	500	425	90	500	400	
40/50	427	455	302		455	302		455	302				
40/45	426	455	360		455	360		455	360				
45/50	356	384	302		384	302		384	302		400	315	80
50/60	301	322	255		322	255		322	255		315	250	
60/80	252	271	181		271	181		271	181		250	160	
60/70	251	271	213		271	213		271	213		250	200	
70/80	213	227	181		227	181		227	181				
80/100	181	197	151		197	151		197	151		200	160	
100/120	151	165	127	90	165	127	90	165	127	87	160	125	
120/140	126	139	107		139	107		139	107		125	100	
140/170	107	116	90		116	90		116	90				
170/200	91	97	75	88	97	75	88	97	75	85	100	80	
200/230	76	85	65		85	65		85	65		80	63	
230/270	64	75	57		75	57		75	57				
270/325	54	65	49		65	49		65	49		63	50	75
325/400	46	57	41	80	57	41	83	57	41	80	50	40	
											40	/	

MICRON OR SUB-SIEVE SIZES DIAMOND AND CBN POWDERS SIZING AND STANDARDS TECHNIQUES AND EQUIPMENT FOR THE CHARACTERIZATION OF PARTICLE SIZE

Optical microscopy has been traditionally used to develop, define and qualify sub-sieve diamond and CBN powders. Based on optical microscopy, particle size is defined as the diameter of the minimum circumscribed circle that completely encloses the projected image of the particle; another common measure of particle size being the longest single dimension (LSD). With an appropriate calibration scale, an operator can characterize a distribution of particles by visually classifying and manually accumulating counts of particles in different size ranges. Automated optical counting systems (optical or SEM microscopes coupled with a computerized image analyzer) eliminate most of the fatiguing work of this type of analysis. Optical microscopy allows the operator to "really" see the particles and evaluate their range of shape and sizes. However, its major drawback is represented by the fact that it may be difficult to collect enough data to give reliable results. The number of particles measured is usually small compared to other particle sizing methods, so representative sampling becomes critical. In addition, optical microscopy is a tedious and tiresome technique that requires a long time to perform the analysis. Over the years, more sophisticated techniques have been developed to overcome drawbacks and limitations of optical microscopy. Electrical sensing zone, forward and right angle light scattering, dynamic light scattering, centrifugal sedimentation and automated image analysis (optical or SEM microscopy) are techniques used most widely today for determination of particle size distribution. A number of instruments/devices, known as particle size analyzers, are currently available for the determination of particle size distribution of sub-sieve diamond and CBN powders. These instruments are capable of measuring large numbers of micron size particles quickly and accurately. Most are relatively easy to operate, and in one form or another have replaced older methods of characterizing the particle size of diamond and CBN powders based on optical microscopy. As expected, not a single technique/device can be used to measure the whole size spectrum of micron powders with consistent accuracy. Each technique/device is capable of providing optimal performance over a certain size range. Therefore, it is almost impossible to choose a single technique/device to develop a standard for the particle size of micron powders. The main criteria in choosing the right device to measure the size distribution of a particular powder are: 1) highest accuracy over the whole size range under investigation, and 2) lowest interference between the size range, and lower and upper detection limits of the device.

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CALIBRATION OF TEST EQUIPMENT

The use of primary and secondary standards for calibration can significantly improve the reliability of analysis. The measurement of particle size is ultimately based on primary standards of length. The use of light or electron microscopy based techniques that can be calibrated to standards certified for length serve as the primary size measurements methods to which other methods, such as electrical sensing zone, light scattering, centrifugal sedimentation, etc. are often calibrated. Following the calibration procedure recommended by the equipment manufacturer, the particle size analyzer employed for the characterization of particle size of diamond and CBN powders shall be calibrated against the following standards:

Primary Standards – National Institute of Standards and Technology (NIST) Standard Reference Materials (SRM)
These SRMs are used for evaluating and calibrating specific types of particle size measuring instruments, including light scattering, electrical sensing zone, flow-through counters, optical and scanning electron microscopes, sedimentation systems, and wire cloth sieving devices.

Secondary Standards – National Institute of Standards and Technology (NIST) Traceable Polymer Spheres Size Standards
Nano-sphere size standards are uniform polystyrene spheres in size range 20 nm to 900 nm, which are calibrated with NIST traceable methodology. The methods used to calibrate the diameters of the nano-spheres are photon correlation spectroscopy (PCS) and transmission electron microscopy (TEM). Nano-sphere size standards are ideal for the calibration of electron and atomic force microscopes. They are also used in laser light scattering studies. Nano-sphere size standards are packaged as aqueous suspensions in 15 milliliter (ml) dropper-tipped bottles; concentrations being optimized for ease of dispersion and colloidal stability. The spheres have a density of 1.05g/cm3 and an index of refraction of 1.59 @ 589 nanometers. Micro spheres size standards are uniform polystyrene spheres in size range 1.0 µm to 160 µm, which are NIST-traceable by calibration methods, such as optical or electron microscopy. Products from 1µm to 160µm in diameter are packaged as aqueous suspensions of polystyrene spheres in dropper-tipped bottles. Diameters of 200 µm and larger are packaged as dry spheres in screw-capped bottles. The spheres have a density of 1.05g/cm3 and an index of refraction of 1.59 @ 589 nanometers. Details on the recommended NIST Standard Reference Materials (SRM), as well as, NIST traceable polymer spheres size standards are presented in Appendix 3 – Part 2.

APPLICABLE STANDARDS

The purpose of the standards is to establish a common basis for checking the size of diamond and CBN powders, in sub-sieve sizes. It is intended to serve as common basis of understanding for the producers of micron superabrasive powders, and for the distributors and users of micron superabrasive powders. The following American Standard applies to micron or sub-sieve size diamond and CBN powders: ANSI Standard B74.20 / February 3, 2004 – Specification for Diamond and Cubic Boron Nitride Powders in Sub-Sieve Sizes

SPECIFICATIONS FOR PARTICLE SIZE DISTRIBUTION OF DIAMOND and cBN MICRON SIZES

The specification for particle size distributions applicable to micron size diamond and CBN powders according to American Standard ANSI B74.20-2004 is defined in Table 6.0.

Table 6.0

Size Range (µm)	D5 Minimum (µm)	D50 ± Tolerance (µm)	D95 Maximum (µm)	D99.9 Largest Particle (µm)
0-0.25	0.0	0.125 ± 0.025	0.25	0.75
0-0.5	0.0	0.25 ± 0.050	0.5	1.5
0-1	0.0	0.5 ± 0.1	1.0	3.0
0-2	0.0	1.0 ± 0.2	2.0	4.0
1-2	1.0	1.5 ± 0.22	2.0	6.0
2-4	2.0	3.0 ± 0.3	4.0	9.0
2-6	2.0	4.0 ± 0.4	6.0	12.0
4-8	4.0	6.0 ± 0.6	8.0	15.0
6-12	6.0	9.0 ± 0.9	12.0	20.0
8-16	8.0	12.0 ± 1.2	16.0	24.0
10-20	10.0	15.0 ± 1.5	20.0	26.0
15-25	15.0	20.0 ± 2.0	25.0	34.0
20-30	20.0	25.0 ± 2.5	30.0	40.0
25-35	25.0	30.0 ± 3.0	35.0	48.0
30-40	30.0	35.0 ± 3.5	40.0	52.0
40-50	40.0	45.0 ± 4.5	50.0	68.0
40-60	40.0	50.0 ± 5.0	60.0	78.0
50-70	50.0	60.0 ± 6.0	70.0	90.0

The specification for particle size distributions applicable to micron size diamond and CBN powders according to Chinese Standard JB/T7900 is defined in Table 7.0.

Table 7.0

Size	Nominal Diameter D µm)	Max. Particle Size D max (µm)	Min. Particle Size D min µm)	Particle Size Distribution
M0/0.5	0 ~ 0.5	0.7	-	1. No particles are larger than the maximum size (Dmax) 2. The content of large particles can not be more than 3% 3. The content of fine particles is <8% for M3/6 or smaller grades, <18% for M4/8 to M10/20 grades, and <28% for M12/22 to M36/54 grades 4. The content of the finest particles is <2% for all particle grades
M0/1	0 ~ 1	1.4	-	
M0.5/1	0.5 ~ 1	1.4	0	
M0.5/1.5	0.5 ~ 1.5	1.9	0	
M0/2	0 ~ 2	2.5	-	
M1/2	1 ~ 2	2.5	0.5	
M1.5/3	1.5 ~ 3	3.8	1	
M2/4	2 ~ 4	5.0	1	
M2.5/5	2.5 ~ 5	6.3	1.5	
M3/6	3 ~ 6	7.5	2	
M4/8	4 ~ 8	10.0	2.5	
M5/10	5 ~ 10	11.0	3	
M6/12	6 ~ 12	13.2	3.5	
M8/12	8 ~ 12	13.2	4	
M8/16	8 ~ 16	17.6	4	
M10/20	10 ~ 20	22.0	6	
M12/22	12 ~ 22	24.2	7	
M20/30	20 ~ 30	33.0	10	
M22/36	22 ~ 36	39.6	12	
M36/54	36 ~ 54	56.7	15	

The specification for particle size distribution applicable to micron size diamond and CBN powders according to Russian Standard GOST 9206-1980 is defined in Table 8.0

Table 8.0

Size Range		Grain Size (µm)	
	Oversize (µm) Max. 5%	Main Fraction (µm) Min. 70%	Undersize (µm) Max. 5%
NARROW RANGE GRADES			
1/0	Over 1 to 2	1 & smaller 95%	---
2/1	Over 2 to 3	From 1 to 2	Smaller than 1
3/2	Over 3 to 5	From 2 to 3	Smaller than 2
5/3	Over 5 to 7	From 3 to 5	From 1 to 2
7/5	Over 7 to 10	From 5 to 7	From 2 to 3
10/7	Over 10 to 14	From 7 to 10	From 3 to 5
14/10	Over 14 to 20	From 10 to 14	From 5 to 7
20/14	Over 20 to 28	From 14 to 20	From 7 to 10
28/20	Over 28 to 40	From 20 to 28	From 10 to 14
40/28	Over 40 to 60	From 28 to 40	From 14 to 20
60/40	Over 60 to 80	From 40 to 60	From 20 to 28
WIDE RANGE GRADES			
2/0	Over 2 to 3	2 and finer	---
3/0	Over 3 to 5	3 and finer	---
3/1	Over 3 to 5	From 1 to 3	---
5/2	Over 5 to 7	From 2 to 5	Smaller than 2
7/3	Over 7 to 10	From 3 to 7	From 1 to 2
10/5	Over 10 to 14	From 5 to 10	From 2 to 3
14/7	Over 14 to 20	From 7 to 14	From 3 to 5
20/10	Over 20 to 28	From 10 to 20	From 5 to 7
28/14	Over 28 to 40	From 14 to 28	From 7 to 10
40/20	Over 40 to 60	From 20 to 40	From 10 to 14
60/28	Over 60 to 80	From 28 to 60	From 14 to 20

Standard specifications for particle size distribution of micron size diamond and CBN powders as defined by American Standard ANSI B74.20-2004, Japanese Standard, JIS6002-63, Chinese Standard JB/T7900 and Russian Standard GOST 9206-1980 are presented in Table 9.0.

Table 9.0

USA Standard ANSI B74.20-2004	Japanese Standard JIS6002-63		Chinese Standard JB/T7900		Russian Standard GOCT 9206-80	
Size Range (µm)	Size Designation	Size Range (µm)	Size Designation	Size Range (µm)	Size Designation	Size Range (µm)
					0.1/0	< 0.1
0-0.25						
					0.3/0	< 0.3
0-0.5			M0/0.5	0-0.5	0.5/0	< 0.5
					0.5/0.1	0.5-0.1
					0.7/0.3	0.7-0.3
			M0.5/1	0.5-1	1/0.5	1-0.5
0-1	15000	1/0	M0/1.0	0-1	1/0	< 1
			M0.5/1.5	0.5-1.5		
0-2			M0/2	0-2	2/0	< 2
					3/0	< 3
1-2	8000	2/1	M1/2	1-2	2/1	2-1
					3/1	3-1
			M1.5/3	1.5-3		
	5000	3/2			3/2	3-2
2-4			M2/4	2-4		
					5/2	5-2
			M2.5/5	2.5-5		
	4000	4/3				
					5/3	5-3
2-6						
	3000	5/4				
			M3/6	3-6		
	2500	6/5				
					7/3	7-3
					7/5	7-5
4-8			M4/8	4-8		
	2000	8/6				
					10/7	10-7
	1500	10/8	M5/10	5-10	10/5	10-5
6-12			M6/12	6-12		
			M8/12	8-12		
	1200	13/10				
8-16			M8/16	8-16		
					14/7	14-7
					14/10	14-10
	1000	16/13				
10-20			M10/20	10-20	20/10	10-20
			M12/22	12-22		
					14/20	20-14
15-25					28/14	28-14
20-30			M20/30	20-30	28/20	28-20
25-35	700	24/20	M22/36	22-36		
	600	38/24				
500	34/28					
					40/20	40-20
30-40					40/28	40-28
	400	37/34	M36/54	36-54		
40-50						
					60/28	60-28
40-60					60/40	60-40
50-70						

As stated, the purpose of this document is to provide a comprehensive review of the techniques and standards employed for checking the size distribution of grit size diamond and CBN powders which are used for the manufacturing of a wide range of superabrasive tools for machining, grinding and sawing applications as well as, micron diamond and CBN powders that are incorporated into compounds and slurries for lapping, polishing and super finishing applications. It is also intended for this document to serve as a common basis of understanding between manufacturers/suppliers of superabrasive powders and manufactures/end users of superabrasive products and tools.

REFERENCES: Particle Size Characterization – NIST Special Publication 960-1
ANSI Standard B74.16 / 2002 – Checking the Size of Diamond and Cubic Boron Nitride Abrasive Grains
ANSI Standard B74.20 /2004 – Specification for Diamond and Cubic Boron Nitride Powders in Sub-Sieve Sizes
ISO Standard 6106 / 2005 – Abrasive products – Checking the grit Size of Superabrasives
Chinese Standard GB/T6406-1996
Chinese Standard JB/T7900
Russian Standard GOST 9206-1980
Japanese Standard, JIS6002-63
Japanese Standard JIS 4130-1982

APPENDIX 1

Units for Particle Size:

Micro Meter (μm) = 10^{-6} meter (m)
Nano Meter (nm) = 10^{-3} μm = 10^{-9} m
Angstrom (Å) = 10^{-1} nm = 10^{-4} μm = 10^{-10} m

Mesh: Number of (sieve) openings per linear inch, starting with a ruler zeroed on the center of any wire

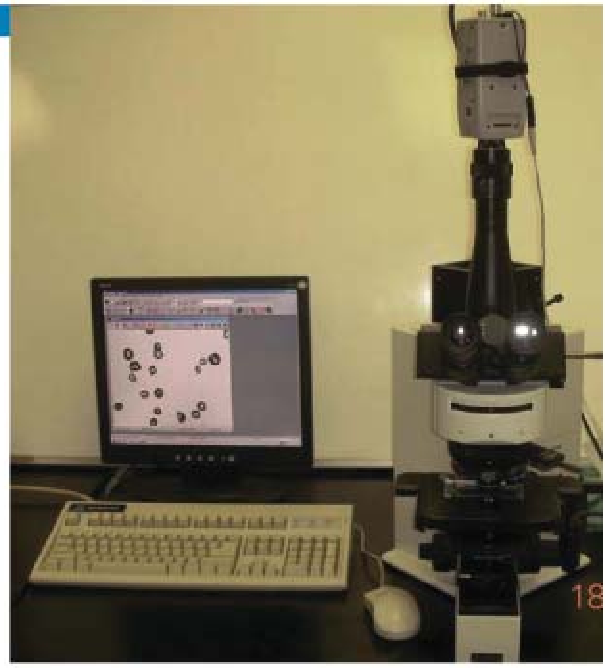
Accuracy: Measure of how close a measured value is to the true value

Precision: Measure of the variation in repeated measurements (same instrument & operator)

Resolution: Measure of the minimum detectable differences between features in a size distribution or the capability of the equipment to resolve or separate adjacent narrow peaks that differ in size.

Reproducibility: Measure of the variation between different instruments, operators and sample preparation

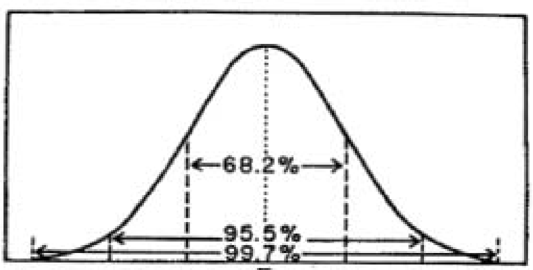
Mean: The mean is determined by adding a group of measured values, then dividing the total by the number of measurements in the group: X = $\sum Xi/n$. The mean value is related to accuracy or systematic error. The mean value for a control material provides an estimate of the central tendency of the distribution that is expected if method performance remains stable. Any change in accuracy, such as schematic shift or drift, would be reflected in change in mean value of the control, which would be shown by a shift or drift of the distribution of control results.



OPTICAL MICROSCOPY IMAGE ANALYZER

Standard Deviation: Standard deviation is determined by first calculating the mean, then taking the difference of each control result from the mean, squaring that difference, dividing by n-1, then taking the square root: _ = $\sqrt{[\sum (Xi - X)^2 / (n-1)]}$. The standard deviation is a measure of the distribution and is related to imprecision or random error. The bigger the standard deviation, the wider the distribution, the greater the random error, and the poorer the precision of the method; the smaller the standard deviation, the narrower and sharper the distribution, the smaller the random error, and the better the precision of the method. For a measurement procedure, it is generally expected that the distribution of control results will be normal or Gaussian. For a Gaussian distribution, the percentage of results that are expected with certain limits can be predicted. For example, for control results that fit a Gaussian distribution, it would be expected that 68.2% of observed results will be within $\pm 1\sigma$ of the mean; 95.5% within $\pm 2\sigma$ of the mean and 99.7% within $\pm 3\sigma$ of the mean.

Control Limits: Given the mean and standard deviation for a control material, control limits are calculated as the mean plus a certain multiple (n) of the standard deviation, such as 2σ or 3σ. Upper control limit (UCL) = Mean + $n\sigma$. Lower control limit (LCL) = Mean - $n\sigma$



Sub-sieve size diamond and CBN powders - Conformance to ANSI B74.20: Nominal standard particle size distributions and acceptability limits for those distributions are summarized in Table 6.0 – Specification for particle size distribution of sub-sieve diamond and CBN powders - ANSI B74.20-2004. Standard definitions for each of the columns in the table are listed below:

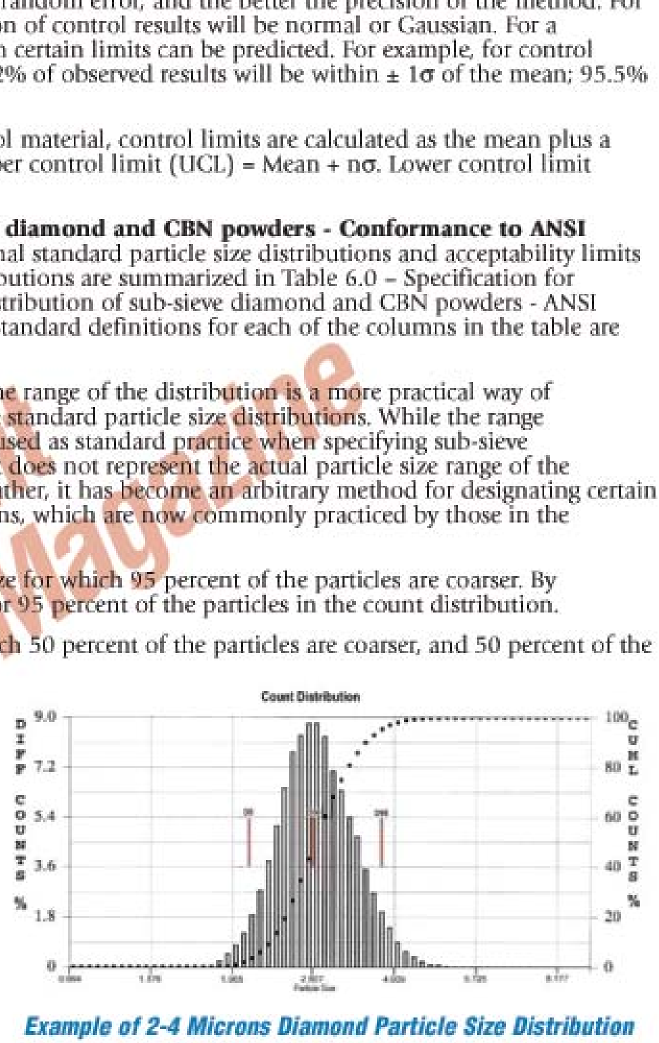
Size Range: The range of the distribution is a more practical way of designating the standard particle size distributions. While the range designation is used as standard practice when specifying sub-sieve distributions, it does not represent the actual particle size range of the distribution. Rather, it has become an arbitrary method for designating certain size distributions, which are now commonly practiced by those in the industry.

D5 (Minimum): The D5 (Minimum) value represents the particle size for which 95 percent of the particles are coarser. By specifying a minimum value, the standard specifies a "lower limit" for 95 percent of the particles in the count distribution.

D50 & Tolerance: The D50 value represents the particle size for which 50 percent of the particles are coarser, and 50 percent of the particles are finer. The tolerance on the D50 value represents the permissible deviation from the number that will be allowed and while still conforming to this standard.

D95 (Maximum): The D95 (Maximum) value represents the particle size, for which 95 percent of the particles are finer. By specifying a maximum value, the standard specifies an "upper limit" for 95 percent of the particles in the count distribution.

D99.9 (Largest Particle): The D99.9 (Largest Particle) value represents the particle size, for which no particles coarser are present. By specifying a largest IMAGE particle value, the standard specifies an "upper threshold" for the entire population of particles in the distribution. The D99.9 figure is read as the last channel of measurable particles. Confirmation of oversize particles should be made by microscopy.



Example of 2-4 Microns Diamond Particle Size Distribution

APPENDIX 2

USA Grit Size (Mesh)	Approximate Particle Size (µm)	Number of Particles in One Carat
GRIT or SIEVE SIZES		
8/10	2380-2000	4.2-7
10/12	2000-1680	7-12
12/24	1680-1410	12-20
14/16	1410-1190	20-33
16/18	1190-1000	35-57
18/20	1000-840	57-97
20/25	840-710	97-160
25/30	750-590	160-282
30/35	590-500	282-460
35/40	500-420	460-770
40/45	420-350	770-1334
45/50	350-297	1,334-2,080
50/60	297-250	2,080-3,240
60/80	250-177	3,240-10,400
80/100	177-149	10,400-17,140
100/120	149-125	17,140-20,920
120/140	125-105	20,920-49,400
140/170	105-88	49,400-82,400
170/200	88-74	82,400-140,000
200/230	74-62	140,000-252,000
230/270	62-33	252,000-384,000
270/325	33-44	384,000-660,000
325/400	44-37	660,000-1,120,000
MICRON OR SUB-SIEVE SIZES		
400-500	60-40	1,120,000-1,580,000
500/600	50-25	1,580,000-2,046,000
600/700	37-22	~ 2,046,000
700/800	36-40	~ 9,503,000
1200	18-12	~ $1.696*10^{7}$
1800	12-8	~ $1.696*10^{7}$ – $2.62*10^{8}$
2200	10-6	~ $7.86*10^{7}$
3000	8-4	~ $2.62*10^{8}$
6000	6-2	~ $8.82*10^{8}$
8000	4-2	~ $2.05*10^{9}$
12000	3-1	~ $2.05*10^{9}$ – $6.2*10^{10}$
15000	2-0	~ $6.2*10^{10}$
25000	1-0	$6.2*10^{10}$

APPENDIX 3 – Part 1

STANDARDS FOR CALIBRATION OF TEST EQUIPMENT
PART 1, STANDARD REFERENCE MATERIALS FOR SIEVE CALIBRATION

PRIMARY STANDARDS – Standard Reference Materials (SRM) National Institute for Standards and Technology (NIST) has developed Standard Reference Materials (SRM) for sieve calibration that are certified for dimension by electron and optical microscopy methods. SRM 8010 is a three bottle set of different sands (A, C and D), intended for use in sieving only, and covers the sieve size range from 30 mesh to 325 mesh, as follows:

SRM	Description	Particle Diameter Distribution	Unit Size
8010A	Sand	30 to 100 mesh	130g
8010C	Sand	70 to 200 mesh	130g
8010C	Sand	110 to 325 mesh	130g

SRMs 1003c, 1004b, 1017b, 1018b and 1019b each consist of soda-lime glass beads covering a particular size distribution (PSD) range.

SRM	Description	Particle Diameter Distribution	Unit Size
1003c	Glass Beads	10 to 60 µm / 600 to 325 mesh	25g
1004b	Glass Beads	40 to 150 µm / 270 to 120 mesh	43g
1017b	Glass Beads	100 to 400 µm / 140 to 45 mesh	70g
1018b	Glass Beads	220 to 750 µm / 60 to 25 mesh	87g
1019b	Glass Beads	750 to 2450 µm / 20 to 10 mesh	200g

APPENDIX 3 – Part 2

STANDARDS FOR CALIBRATION OF TEST EQUIPMENT PART 2

STANDARDS FOR CALIBRATION OF PARTICLE SIZE DISTRIBUTION ANALYZERS PRIMARY STANDARDS – STANDARD REFERENCE MATERIALS (SRM) NIST has developed various standards, available as SRMs, for calibration and performance evaluation of particle size distribution analyzers. Following SRMs are recommended for the calibration of the laser diffraction instruments:
– SRMs 1690, 1691, 1692, 1963 and 1964 are commercially manufactured mono-disperse latex particles in a water suspension.
– SRMs 1960 and 1961 are mono-disperse latex particles in a water suspension produced by the National Aeronautics and Space Administration (NASA).
– SRM 1965 consists of two different groupings of the SRM 1960 particles mounted on a microscope slide.

Following SRMs are recommended for the calibration of instruments based on gravitational sedimentation:
– SRM 659 consists of equiaxed silicon nitride particles measured using sedimentation.
– SRM 1978 consists of granular, irregular shaped zirconium oxide particles measured using sedimentation.
– SRM 1982 consists of spherical particles measured using scanning electron microscopy, laser scattering, and sieving.

SRM	Description	Particle Diameter Distribution	Unit Size
659	Silicon Nitride	0.2 to 10 µm	2.5g
1978	Zirconium Oxide	0.33 to 2.19 µm	5g
1982	Zirconium Oxide	10 to 150 µm	10g
1984	Tungsten Carbide/Cobalt	9 to 30 µm	14g
1985	Tungsten Carbide/Cobalt	18 to 55 µm	14g

SECONDARY STANDARDS – NIST TRACEABLE POLYMER SPHERES SIZE STANDARDS In addition to the NIST Standard Reference Materials, numerous secondary standards are available from NIST, as well as, from instrument manufacturers and vendors of scientific supplies. These secondary standards are all calibrated against primary standards developed by international standards accreditation agencies.

SRM	Description	Particle Diameter Distribution	Unit Size
1690	Polystyrene Spheres (1 µm)	0.895 µm	5 ml vial
1691	Polystyrene Spheres (0.3 µm)	0.269 µm	5 ml vial
1692	Polystyrene Spheres (3.0 µm)	2.982 µm	5 ml vial
1961	Polystyrene Spheres (30 µm)	29.64 µm	5 ml vial
1963a	Polystyrene Spheres (0.1 µm)	0.1018 µm	5 ml vial
1964	Polystyrene Spheres (0.06 µm)	0.0639 µm	5 ml vial
1965	Polystyrene Spheres (10 µm) (on slide)	9.94 µm (hexagonal array) 9.89 (unordered clusters)	1 slide

DEFINITIONS

Reference Material Certificate – Document accompanying a certified reference material stating one or more property values and their uncertainties, and confirming that the necessary procedures have been carried out to ensure their validity and traceability. (ISO Guide 30: 1992)

NIST Standard Reference Material® (SRM) - A CRM issued by NIST that also meets additional NIST-specific certification criteria and is issued with a certificate or certificate of analysis that reports the results of its characterizations and provides information regarding the appropriate use(s) of the material (NIST SP 260-136). Note: An SRM is prepared and used for three main purposes: (1) to help develop accurate methods of analysis; (2) to calibrate measurement systems used to facilitate exchange of goods, institute quality control, determine performance characteristics, or measure a property at the state-of-the-art limit; and (3) to ensure the long-term adequacy and integrity of measurement quality assurance programs. The terms "Standard Reference Material" and the diamond-shaped logo that contains the term "SRM," are registered with the United States Patent and Trademark Office.

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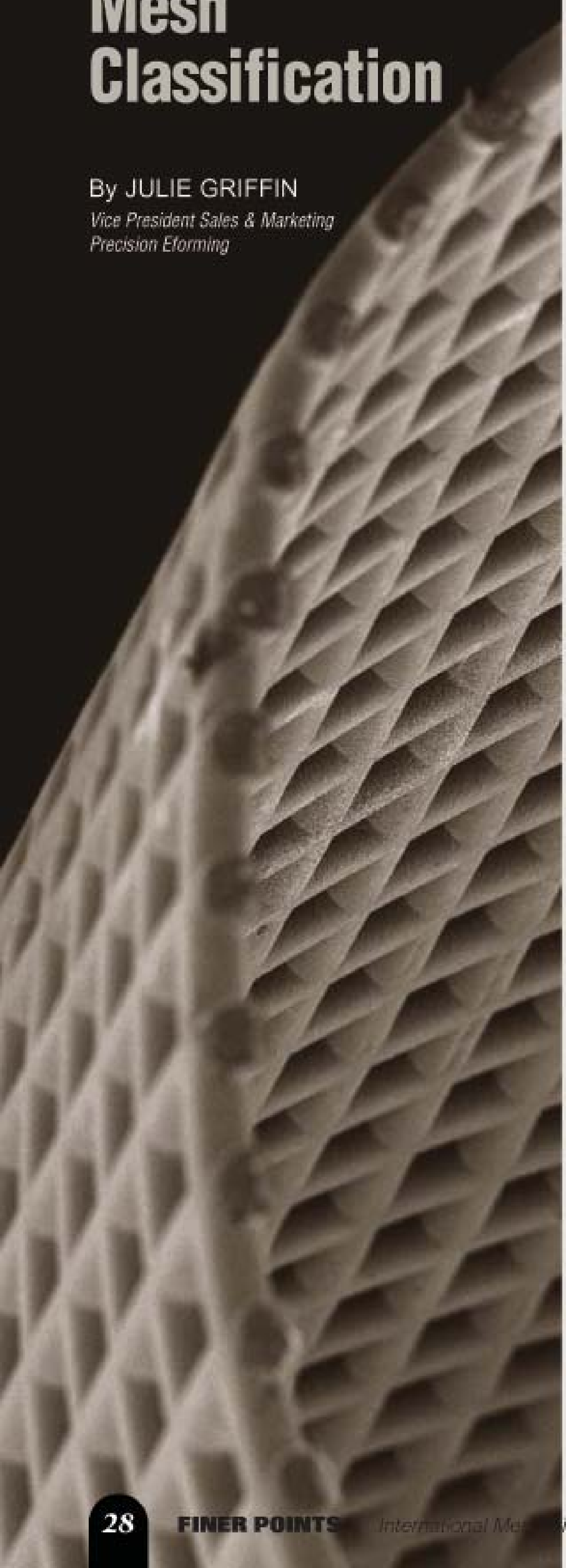
NIST Certificate of Traceability – Document stating the purpose, protocols, and measurement pathways that support claims by an NTRM to specific NIST standards or stated references. No NIST certified values are provided, but rather the document references a specific NIST report of analysis, bears the logo of the U.S. Department of Commerce, the name of NIST as a certifying body, and the name and title of the NIST officer authorized to accept responsibility for its contents.

Standards for calibration should also be developed from the powders being measured on a regular basis. In addition, it is critical to compare the material used as "standard" against a traceable primary standard. It is also recommended to develop protocols for sample preparation, analysis and data interpretation, particular to the material investigated and the instrument used.

The Technology And Application Of Sieves For Superabrasives Mesh Classification

By JULIE GRIFFIN
Vice President Sales & Marketing
Precision Eforming



ELECTROFORMED NICKEL SIEVES ARE PRECISE INSTRUMENTS

Electroplated Sieves

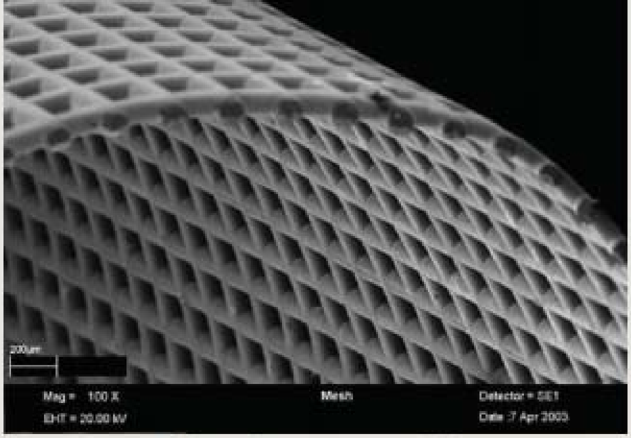
Sieving is a reliable technique for determining particle size and shape, important factors in the quality of many products in a number of industries including diamond powder and abrasives to eliminate the possibility of oversized grains that result in scratched surfaces. Electroformed sieves are used for sorting, sifting, screening and classifying materials. Sieves are precise instruments and are widely used in manufacturing applications, as well as laboratory environments. Electroformed sieves offer a number of advantages. The greatest advantage is achieving and holding precise hole sizes. Certified sieve materials are available within the range from three to two thousand microns, at the single micron increment and are not subject to the limitations of woven wire sieves. Electroformed nickel materials commonly contain apertures that are square or round, but the ability to produce custom geometries exists. Electroformed nickel sieves comply with FEPA, ISO 3310 and ASTM E-161-87 standards. The certification process requires that all sieves be measured on a non-contact automated measuring system. Each manufactured sieve is subjected to crucial measurements and the data is supplied on a histogram analysis along with a certification of compliance. These sieves are manufactured with extremely precise apertures, to very close tolerances. They are produced from electroformed nickel mesh with a planer surface approximately .001" thick and are supplied in stainless steel frames or in sheet form. The mesh can be supported by a square etched grid made of nickel-plated stainless steel. A support grid of 5 lines per inch is standard, however, for sieves with 90 micron apertures or finer, 14 lines per inch is also available. The support grid may be either on the top or the bottom of the sieving material. Standard electroformed nickel sieve products have tolerances of +/-2um and Ultra Precision Sieves meet tolerances of +/-1um. Sieves can be acrylic framed and unmounted sieve materials can be mounted to custom equipment of up to 29".

ELECTROFORMED NICKEL MORE PRECISE THAN WOVEN WIRE SIEVES

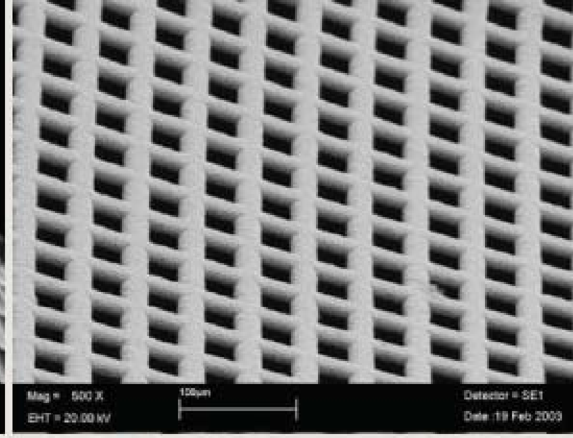
As stated above, Electroformed Nickel Sieves are not subject to the limitations of woven wire sieves such as clogging, particle entrapment and imprecise tolerances. In addition, their flat, smooth surface simplifies cleaning. Wire woven materials are commonly sold by mesh count, disguising true aperture size, as the wires may not be evenly spaced. Due to the woven method itself, it is impossible for the apertures to be of a perfect square configuration, while the electroforming process can produce true apertures repeatedly. Initial test results also show that electroformed nickel materials wear slower than stainless steel materials in certain aggressive applications involving abrasive materials like diamond and cbn, improving efficiency for users in these industries.

SIEVING SUPERABRASIVES CRITICAL TO PERFORMANCE

The importance of accuracy in grain content in Micro-Diamond Powder is widely understood in the superabrasives industry. It is of extreme importance not to inject oversized grains into micro-powder, because this results in the scratching of the polished surface. Accuracy in initial sorting is critical and lends to efficiency for the end-user. It assists in producing smooth, even surfaces – not leaving scratches or grooves that will need to be removed. For years, sieves have been widely used to sort superabrasive materials. The most commonly known type of sieve is the wire woven type. The wire woven sieve is offered in Mesh size, with limited selection in aperture size. Less known is the electroformed nickel sieve, which far exceeds other materials in accuracy and reliability. The electroformed nickel sieve is a non-woven material available at the single micron increment, ranging from 3 to 2000um. Along with guaranteed tolerances of +/-2um, openings are available in square, round, slotted and other custom apertures. The attributes of the electroformed nickel sieve allow users to sieve materials very precisely at the exact micron opening desired, eliminating the possibility of oversized and odd-shaped grains.



Sieve Aperatures at 100X



Nickel Sieve Aperature at 500X

THE ELECTROFORMING PROCESS DELIVERS EXCEPTIONAL RESULTS

The photo-electroforming process produces an exact copy of a phototool in metal onto a base material called a mandrel. The mandrel surface has subsequently been prepared with a highly sensitive photoresist. The process is additive in that the production of base material is accomplished by deposition of metal instead of removal of material as exists in traditional photoetching. The mandrel is placed into a special electroforming tank where nickel is electrodeposited over it under very tightly controlled conditions. During the process, pure nickel is deposited onto a stainless steel mandrel. When the electroforming process is finished, the mandrel is removed from the plating solution and the electroformed part is carefully separated from the mandrel. This material is then bonded to a support grid and the finished aperture size achieved. Some of the advantages of electroforming are ultra precise hole sizes, flat material, burr free edges, sharp edge definition and exceptional repeatability. These advantages combined with fine process control result in unmatched capabilities that guarantee superabrasive crystals meet the proper standards for size and shape in industrial applications. ■

Maintaining the proper standards for size and shape of superabrasive crystals is dependent on the quality and precision of the sieves used in the classification process.

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