Kongter

OPC-500 Online Particle Counter

The **OPC-500** online particle counter, also known as a contamination sensor or cleanliness sensor, is a compact fluid particle counter designed based on the light obscuration (light-blocking) principle. It can be installed and operated in real time to measure the contamination levels of various liquids such as hydraulic oils and lubricants. The device outputs cleanliness grades according to standards like NAS1638, ISO4406, GJB420A, GJB420B, or other relevant criteria. With its small, robust design, the OPC-500 is ideally suited for monitoring oil conditions in industrial equipment used in hydraulics, lubrication systems, and more—making it a reliable tool for preventive maintenance and advanced manufacturing applications.

Key Features

- High-precision laser and photoelectric transceiver components ensure measurement accuracy
- Suitable for various liquids, real-time monitoring of cleanliness levels 24/7
- Ensures safe operation of hydraulic and lubrication systems, preventing excessive contamination
- Optional online detection of oil moisture saturation level for enhanced diagnostics
- Internal storage of up to 3,000 test records
- Compact, robust, durable, intelligent, and easy to integrate
- Built-in flow estimation function ensures measurement accuracy
- Detects abnormal contamination and wear to safeguard asset operation
- Continuous and interval measurement modes are freely configurable
- Fast response with adjustable accumulation and measurement cycles
- Excellent chemical resistance and high-pressure tolerance
- Dual certification for EMC and explosion protection, ensuring long-term stable operation in harsh environments
- No moving parts or consumables, designed for a 10-year service life
- 2.5 kV isolated RS485 Modbus communication

Only 10 grams of test dust (MTD) is required to degrade the cleanliness of 10,000 liters of perfectly clean fluid (0/0/0) to ISO 19/17/14, a level at which failures may occur.

Suitable for liquids

Hydraulic oil, lubricating oil, insulating oil, turbine oil, engine oil, aviation kerosene, diesel fuel, ethylene glycol fire-resistant hydraulic fluid, phosphate ester hydraulic fluid, cooking oil, cutting fluids, ultrapure water, pharmaceutical solutions.

Applicable Industries

Aviation, aerospace, defense, oil, chemicals, power generation, energy, metallurgy, steel, transportation, ports, oil filtration, engineering, machinery, hydraulics, automotive, pharmaceuticals, electronics, semiconductors, research, laboratories and so on.

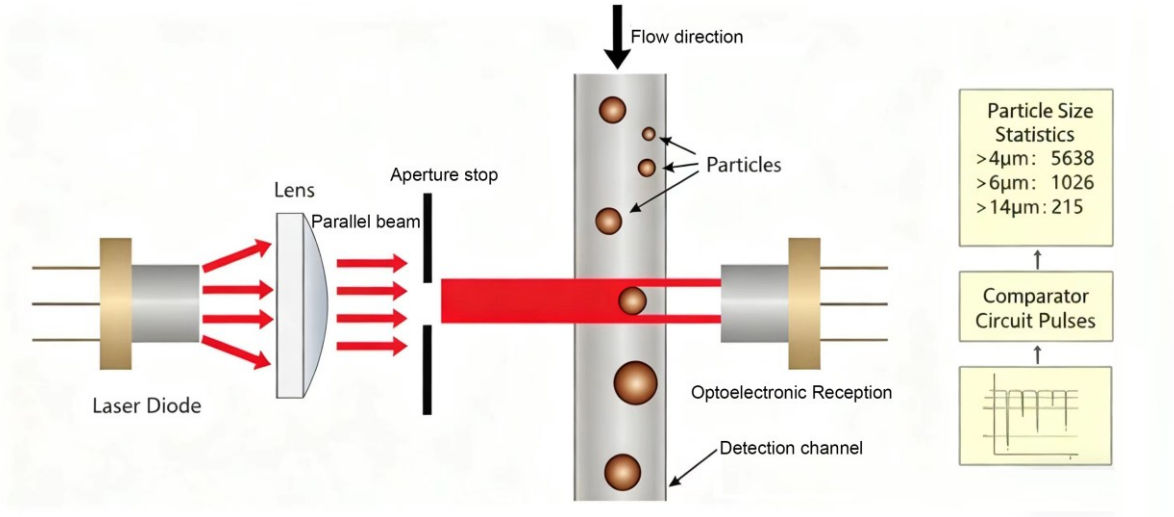
Technical specifications

Measurement Principle	Light Extinction Method (Optical Blockage)
Sensing Element	Semiconductor laser, photodetector
Detection Range	1–100 μm (ISO 4402), 4–70 μm(c) (ISO 11171, GB/T 18854)
Detection Channels (8 channels)	ISO 4402: 1, 2, 5, 10, 15, 25, 50, 100 μm or ISO 11171: 4(c), 4.6(c), 6(c), 10(c), 14(c), 21(c), 38(c), 70 μm(c)
Sensitivity	ISO 4402: 1 μm ISO 11171: 4 μm(c)
Calibration Standard	ISO 4402 (ACFTD, GBW(E)120017) ISO 11171 (ISO MTD, GBW(E)120083)
Built-in Standards	ISO 4406: Grades 0–28 NAS 1638: Grades 00–12 GJB 420A, GJB 420B: Grades 000–12 GB/T 14039: Grades 0–28 SAE AS4059: Grades 000–12 GOST 17216: Grades 00–17
Measurement Accuracy	±0.5 cleanliness code (depends on flow stability)
Permissible Flow Rate	10–500 mL/min optimal at 25 mL/min)
Fluid Viscosity	≤680 cSt
Coincidence Error Limit	20,000 particles/mL
Maximum Allowable Oil Pressure	0–3 MPa (continuous), up to 5 MPa (transient peak); up to 42 MPa with optional pressure-reducing valve
Oil Line Connection	M10×1.0 mm internal thread
Digital Output	RS485 Modbus RTU, 2 kV isolation voltage
Operating Power Supply	DC 10–28 V, <60 mA @ DC 24 V, Max 2 W

Applicable Fluids	Lubricating oil, hydraulic oil, kerosene, reagents, water-based fluids, etc.(Phosphate ester fluids available on request)
Fluid Temperature	-20 °C to 85 °C
Ambient Temperature	-20 °C to 60 °C
Storage Temperature	-40 °C to 85 °C
Housing Material	Stainless steel (explosion-proof version) or anodized aluminum (industrial version), polycarbonate
Wetted Materials	NBR, FKM, glass, stainless steel, aluminum alloy
Dimensions	80 × 80 × 60 mm (L × W × H)
Weight	<800 g
Protection Rating (IP Rating)	IP66
Connection Cable	2 m long 5-core cable, M12×1.5-5 pin connector or M12 cable gland
Electromagnetic Compatibility (EMC)	EN 61000, EN 61326-1, EN 61326-2, EN 61326-4
Vibration Resistance	2 g
Explosion Protection Rating (Optional)	Ex ib IIC T6 Gb
Trace Moisture (Optional)	0–5000 ppm (calibrated per oil sample), accuracy ±10%
Water Activity (Optional)	0–1 aw (equivalent to 0–100% RH moisture saturation), accuracy ±3%
Oil Temperature (Optional)	-40 °C to 85 °C, accuracy ±0.5 °C

Measurement Principle

The OPC-500 online particle counter uses the light obscuration (light-scattering) principle and is calibrated using standard reference materials such as MTD (ISO Medium Test Dust, ISO 11171) or ACFTD (Air Cleaner Fine Test Dust, ISO 4402).



OPC-500 features a high-performance semiconductor laser that, via a collimating lens, directs a parallel beam into the oil detection channel inside the counter. Paired with a high-efficiency PIN photodetector serving as the signal-receiving unit, it enables real-time monitoring of particle count and contamination levels.

When no particles pass through the liquid, the detection circuit outputs a constant voltage. However, as particles move through the detection channel, they block the light beam, causing the photocurrent to weaken. Consequently, the photoelectric signal received by the photodetector also diminishes, triggering the detection circuit to output a pulse signal. Since the detection channel is narrow enough to ensure that particles in the liquid pass through one by one in sequence, each pulse detected corresponds to a single particle passing through the channel. By counting the number of pulses generated, you can accurately determine how many particles have traveled through the detection area.

The amplitude of the negative pulse is related to the particle size according to the following equation. This enables counting solid particles in oil and, based on different standards, facilitates real-time online detection and classification of liquid contamination levels.

$$E = \frac{E_0}{S} A = \frac{E_0}{S} \times \frac{\pi d^2}{4}$$

E —— represents the voltage pulse value, in millivolts, generated as particles pass through the detection area，mV

E_0 —— The voltage reference value, in mV, generated by the photoelectric detector when no particles pass through the detection area，mV

A —— Effective receiving area of the photoelectric detector，μm^2 ;

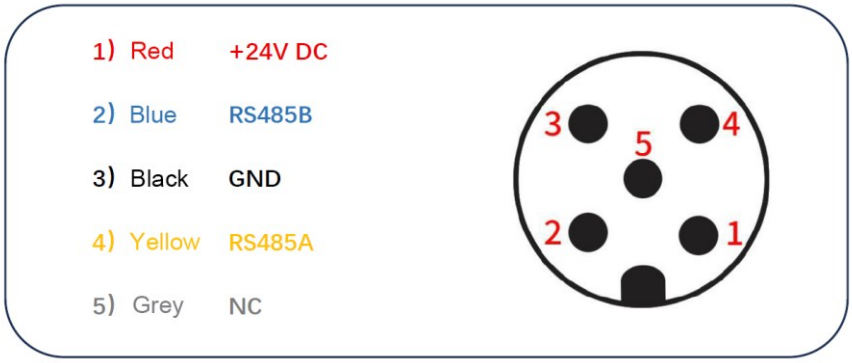
S —— The projected area of the particle in the direction of the light beam，μm^2 ;

d —— When the particle is spherical, it represents the particle diameter, in μm.

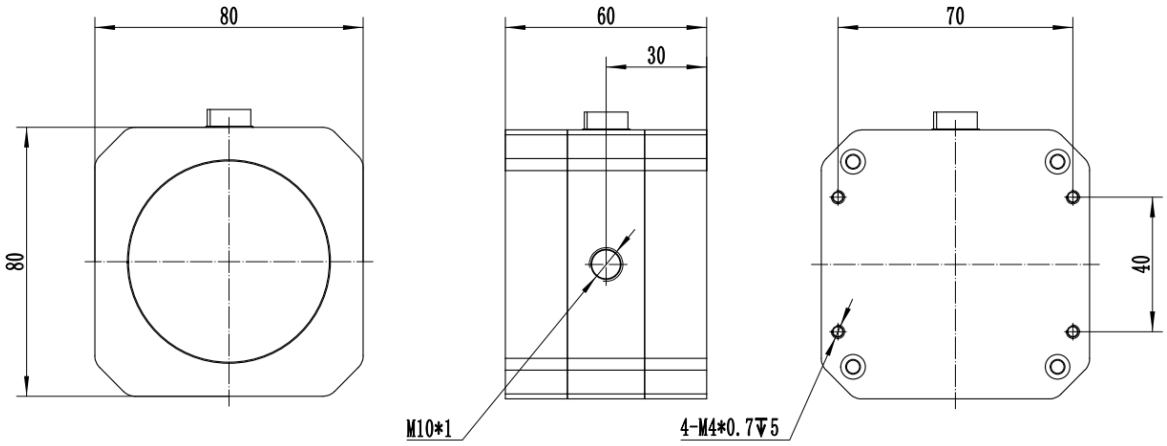
The product also offers optional features for measuring dissolved moisture content (expressed in ppm), water activity (aw, moisture saturation RH%), and temperature. It is available under the model number OPC-500-W.

OPC-500-W measures water activity by integrating high-performance polyimide film capacitors, paired with a PT100 platinum resistance sensor, enabling real-time detection of dissolved moisture in oil. Leveraging its built-in multiple calibration coefficients for water solubility, the device accurately monitors both dissolved moisture levels in parts per million (ppm) and water activity (aw), ensuring at all times that oil moisture remains below the saturation point—and providing you with comprehensive diagnostic insights to safeguard your valuable equipment.

Interface Definition (M12 Female Flange Mount View)

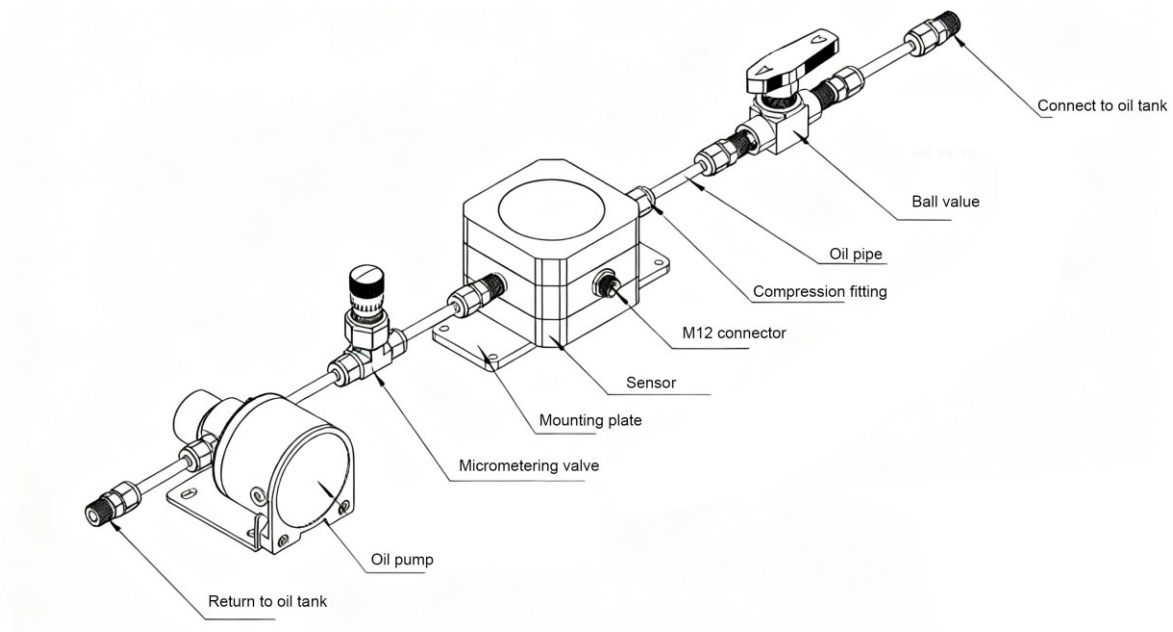


Structural dimensions (mm)



Note: Stainless steel casing (anti-bulk-buy model), aluminum alloy anodized casing (industrial-grade model)

Installation Example



Note: The image above is for illustrative purposes only; measurement circuit components can be

selected based on the actual application.

Important Notes

- The sensor shall be installed in series in the circulating oil line, with oil entering through the port on the side with the filter mesh.
- The sensor shall be installed at a location in the oil circulation loop where pressure is stable, and the pressure must not exceed 3 MPa.
- A stable fluid flow through the sensor must be ensured. A flow rate of 25 mL/min is recommended, and a regulating valve may be used for flow adjustment.
- The sensor shall be installed away from vibration sources, heat sources, and strong electromagnetic interference sources such as inverters, motors, pumps, and transformers.
- The sensor's oil inlet and outlet ports should be installed as vertically perpendicular to the ground as possible to prevent air from accumulating or remaining inside the sensor.
- If the measurement result is excessively high, even reaching the maximum level, it may be due to the presence of bubbles or free water droplets in the liquid.
- If the measurement result is excessively low, even reaching the minimum level, it may be caused by liquid not flowing through the sensor, insufficient flow rate, or clogged filter mesh.
- If the liquid is opaque, detection will not be possible, affecting the sensor's measurement capability.
- After a period of use, if abnormal data is observed, the filter mesh can be removed and cleaned with petroleum ether (90–120).

Contamination Level

ISO 4406:2021 Hydraulic fluid power-Fluids-Method for coding the level of contamination by solid particles
Unit: Number of solid particles per 1 ml

Number of particles per 1 ml		ISO4406 Level
>	≤	
0.00	0.01	0
0.01	0.02	1
0.02	0.04	2
0.04	0.08	3
0.08	0.16	4
0.16	0.32	5
0.32	0.64	6
0.64	1.3	7
1.3	2.5	8
2.5	5	9
5	10	10
10	20	11
20	40	12
40	80	13
80	160	14
160	320	15
320	640	16

1. When the count is less than 8, the repeatability is affected by the actual number of particles in the sample. The original count should be greater than 20 particles.

2. Under certain conditions, the symbols "*" (indicating too many particles to count) or "-" (indicating counting is not required) may be used in the report to represent codes.

For example:
*/19/14 indicates that the number of particles ≥4μm(c) in the fluid is too high to count.
-/19/14 indicates that counting particles ≥4μm(c) in the fluid is not required.

640	1,300	17
1,300	2,500	18
2,500	5,000	19
5,000	10,000	20
10,000	20,000	21
20,000	40,000	22
40,000	80,000	23
80,000	160,000	24
160,000	320,000	25
320,000	640,000	26
640,000	1,300,000	27
1,300,000	2,500,000	28
2,500,000		> 28

ISO 4406 is a three-digit code, representing the total number of particles per milliliter at ≥4 μm(c), ≥6 μm(c), and ≥14 μm(c) respectively. The contamination grade is determined by comparing these particle counts with the values in the table.

For example: 22/18/13

- "22" indicates that the number of particles with a diameter ≥4 μm(c) per milliliter of fluid is between 20,000 and 40,000 (inclusive of 40,000).
- "18" indicates that the number of particles with a diameter ≥6 μm(c) per milliliter of fluid is between 1,300 and 2,500 (inclusive of 2,500).
- "13" indicates that the number of particles with a diameter ≥14 μm(c) per milliliter of fluid is between 40 and 80 (inclusive of 80).

Note: The particle count statistics for ≥4 μm(c) include particles of ≥6 μm(c) and ≥14 μm(c).

NAS1638 Cleanliness Requirements of Parts Used in Hydraulic Systems
Unit: Number of particles per 100 ml

Contamination Level	5-15μm	15-25μm	25-50μm	50-100μm	>100μm
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1000	178	32	6	1
3	2000	350	63	11	2
4	4000	712	126	22	4
5	8000	1425	253	45	8
6	16000	2850	506	90	16
7	32000	5700	1012	180	32
8	64000	11400	2025	360	64
9	128000	22800	4050	720	128
10	256000	45600	8100	1440	256
11	512000	91200	16200	2880	512
12	1024000	182400	32400	5760	1024

The table above shows the number of particles within different size ranges per 100 milliliters of fluid. For example, under NAS6 level, the number of particles in each specified range must be lower than the maximum particle count allowed per 100 milliliters of fluid as listed in the table for NAS6 level.

Typically, users select a NAS-grade output, where the contamination level in NAS1638 corresponds to the grade associated with the highest particle count among its five channels.

NAS1638 is more commonly used and accepted in practical applications and among customer groups, although it was replaced by SAE AS 4059 in 2001.

The test results of NAS1638 and ISO 4406 can be roughly converted using the table below:

NAS	ISO	NAS	ISO
0	12/10/7	8	19/17/14
2	13/11/8	9	20/18/15
3	14/12/9	10	21/19/16
4	15/13/10	11	22/20/17
5	16/14/11	12	23/21/18
6	17/15/12	＞12	24/22/19
7	18/16/13		

GJB420A Solid Contamination Classification for Hydraulic Fluids in Aircraft Hydraulic Systems
Unit: Number of particles per 100 ml.

Contamination Level	Particle Size Range (/ μm)				
	>2	>5	>15	>25	>50
000	164	76	14	3	1
00	328	152	27	5	1
0	656	304	54	10	2
1	1310	609	109	20	4
2	2620	1220	217	39	7
3	5250	2430	432	76	13
4	10500	4860	864	152	26
5	21000	9730	1730	306	53
6	42000	19500	3460	612	106
7	83900	38900	6920	1220	212
8	168000	77900	13900	2450	424
9	336000	156000	27700	4900	848
10	671000	311000	55400	9800	1700
11	1340000	623000	111000	19600	3390
12	2690000	1250000	222000	39200	6780

GJB420B-2015 Solid Contamination Classification for Aerospace Hydraulic Fluids
Unit: Number of particles per 100 ml.

Size	A	B	C	D	E	F
Contaminatio	>1μm	>5μm	>15μm	>25μm	>50μm	>100μm

n Level	>4μm(c)	>6μm(c)	>14μm(c)	>21μm(c)	>38μm(c)	>70μm(c)
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1560	609	109	20	4	1
2	3120	1220	217	39	7	1
3	6250	2430	432	76	13	2
4	12500	4860	864	152	26	4
5	25000	9730	1730	306	53	8
6	50000	19500	3460	612	106	16
7	100000	38900	6920	1220	212	32
8	200000	77900	13900	2450	424	64
9	400000	156000	27700	4900	848	128
10	800000	311000	55400	9800	1700	256
11	1600000	623000	111000	19600	3390	512
12	3200000	1250000	222000	39200	6780	1020

GB/T14039 Solid Particle Contamination Grade for Hydraulic Fluids in Fluid Power Systems
Unit: Number of solid particles per 1 ml.

Number of particles		Code
>	≤	
0.00	0.01	0
0.01	0.02	1
0.02	0.04	2
0.04	0.08	3
0.08	0.16	4
0.16	0.32	5
0.32	0.64	6
0.64	1.3	7
1.3	2.5	8
2.5	5	9
5	10	10
10	20	11
20	40	12
40	80	13
80	160	14
160	320	15
320	640	16

640	1300	17
1300	2500	18
2500	5000	19
5000	10000	20
10000	20000	21
20000	40000	22
40000	80000	23
80000	160000	24
160000	320000	25
320000	640000	26
640000	1300000	27
1300000	2500000	28
2500000		>28

SAE AS 4059F Aerospace Fluid Power – Contamination Classification for Hydraulic Fluids
Unit: Number of solid particles per 100 ml.

ACFTD	>1um	>5um	>15um	>25um	>50um	>100um
ISO MTD	>4 um(c)	>6 um(c)	>14 um(c)	>21 um(c)	>38 um(c)	>70 um(c)
Contamination Level	A	B	C	D	E	F
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1560	609	109	20	4	1
2	3120	1217	217	39	7	1
3	6250	2432	432	76	13	2
4	12500	4864	864	152	26	4
5	25000	9731	1731	306	53	8
6	50000	19462	3462	612	106	16
7	100000	38924	6924	1224	212	32
8	200000	77849	13849	2449	424	64
9	400000	155698	27698	4898	848	128
10	800000	311396	55396	9796	1696	256
11	1600000	622792	110792	19592	3392	512
12	3200000	1245584	221584	39184	6784	1024

Example：A6/B6/C5/D5/E4/F3

Different components, cleanliness requirements (ISO 4406)

Pumps	
Axial Piston Pump	21/18/15
Radial Piston Pump	21/18/15
Gear Pump	21/18/15
Vane Pump	20/17/14
Valves	
Directional Control Valve (Solenoid Valve)	21/18/15
Pressure Valve	21/18/15
Flow Control Valve	21/18/15
Check Valve	21/18/15
Proportional Valve	20/17/14
Servo Valve	17/14/11
Motors	
Axial Piston Motor	21/18/15
Radial Piston Motor	21/18/15
Gear Motor	21/18/15
Vane Motor	20/17/14
Cylinders	21/18/15

By improving the fluid cleanliness within the equipment system, the lifespan of hydraulic and lubrication systems can be extended.

System Type	Initial ISO Code	Target ISO Code	Service Life Extension Factor
Hydraulic	-/19/17	-/14/11	4 times
Lubrication	-/21/19	-/15/12	3 times

Calibration Standards and Reference Materials

Use dimensions calibrated according to ISO MTD (ISO Medium Test Dust, ISO 11171, domestic standard GB/T 18854) or measured via scanning electron microscopy, based on the projected area equivalent diameter, expressed in micrometers as μm(c). The "(c)" following μm indicates certification by an automated particle counter.

ISO MTD offers international certified reference materials, including NIST SRM 2806, while domestically, we have GBW(E)120082 to 120085.

Calibrated using ACFTD (Air Cleaner Fine Test Dust, ISO 4402) or measured with an optical microscope, dimensions are given in micrometers (μm).

Reference Material	ISO MTD (ISO Medium Test Dust, ISO11171)	ACFTD (Air Cleaner Fine Test Dust, ISO4402)
Particle Size Definition	Particle size is defined by the diameter of the equivalent circle of the particle's projected area	Particle size is defined by the length of the particle's longest chord
Unit	μm(c)	μm

Measurement Method	1μm—50μm(c)	1μm—100μm
Measurement Method	Measured using electrical sensing zone technology (e.g., Coulter Multisizer)	Measured using RoLa (Light Obstruction) analyzers or laser diffraction to determine the average volume-based particle size distribution per batch
Conversion	4μm(c)	2μm
	6μm(c)	5μm
	14μm(c)	15μm
	21μm(c)	25μm
	38μm(c)	50μm
	70μm(c)	100μm

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