

Original
(in German)

Aufgabenstellung:

Branche:	Umwelt / Recycling
Material:	<p>Wüstensand; 5 Proben in zweifacher Ausführung Aufgrund der Tatsache, dass nur ein Machbarkeitstest durchgeführt wird und die Vermahlung plus zwischenzeitiges Messen der Korngrößenverteilung zu viel Zeit in Anspruch nehmen würde, wurde nur eine Probe getestet. Die etwas gröbere Probe 2 wurde gewählt. Bei ähnlicher Zusammensetzung/Bruchverhalten der anderen Proben ist ein ähnliches Ergebnis, ggf. mit angepasster Drehzahl, zu erwarten.</p> <p>Probe 2</p>
Aufgabekorngröße:	Probe 2: ca. 1 mm
Aufgabemenge:	Test 1, Trockenvermahlung: 119,67 g = ca. 70 ml Test 2; Nassvermahlung: 117,9 g = ca. 70 ml
Material Spezifikation(en):	trocken, enthält weiche Bestandteile
Kundenforderung:	1 µm, 1000 ml Ich würde gerne 5 unterschiedliche Proben jeweils einmal trocken und einmal nass mahlen lassen, um zu sehen, wie schnell und wie hoch ein Ton-Anteil im Sand erzielt werden kann.
Nachfolgeanalytik:	Korngrößenanalyse und Wasserstau-Fähigkeit des gemahlene Materials

Empfehlung

Ausgewählte(s) Gerät(e):	Planeten-Kugelmühle PM 100	
Konfiguration(en) Artikelnummern:	1 x PM 100, 230 V, 50/60 Hz	205400001
	1 x Mahlbecher EasyFit für Planeten-Kugelmühlen Zirkonoxid 250ml	014620500
	15 x Mahlkugel, Zirkonoxid, Ø 20 mm	053680093
	120 x Mahlkugel, Zirkonoxid, 10 mm ø	053680094
	1 x Mahlkugeln Zirkonoxid, Ø 2 mm, 500 g, ca. 135 ml	053680089
	optional:	
	1 x Sicherheitsverschluss für Mahlbecher EasyFit für Planetenkugelmühlen 250-500ml	228670012

Parameter: Test 1, Trockenvermahlung mit 10 mm Kugeln:
Vorzerkleinerung: 450 U/Min. für 2 Min.
Feinzerkleinerung: 200 U/Min. für 5 Min.; dann 150 U/Min. für 5 Min.
Abbruch, weil verbacken

Test 2; Nassvermahlung:
Vorzerkleinerung; trocken mit 20 mm Kugeln: 350 U/Min. für 8 Min.
Feinzerkleinerung; nass mit 2 mm Kugeln: 450 U/Min. für 5 Std.

Zeit: Test 1, Trockenvermahlung mit 10 mm Kugeln:
Vorzerkleinerung: 2 Min. mit 450 U/Min.
Feinzerkleinerung: 10 Min. mit 200 bzw. 150 U/Min. (5 + 5 Min.)
Abbruch, weil verbacken

Test 2; Nassvermahlung:
Vorzerkleinerung; trocken mit 20 mm Kugeln: 8 Min. mit 350 U/Min.
Feinzerkleinerung; nass mit 2 mm Kugeln: 5 Std. mit 450 U/Min.

**Erreichte(s)
Ergebnis(se):**

Test 1, Trockenvermahlung mit 10 mm Kugeln:

Nach 2 Min. mit 450 U/Min.: nur leichte Anhaftungen

Nach weiteren 5 Min. mit 200 U/Min.: erste Anbackungen

Nach weiteren 5 Min. mit 150 U/Min.: Probe vollständig verbacken

Test 2; Nassvermahlung:

Nach 8 Min. mit 350 U/Min.: überwiegend < 200 - 300 µm

Nach 30 Min. Nassvermahlung mit 2 mm Kugeln:

D90 = 10 µm; D50 = 3,3 µm; D10 = 1 µm

Nach 1 Std. Nassvermahlung mit 2 mm Kugeln:

D90 = 4,4 µm; D50 = 2,5 µm; D10 = 1,2 µm

Nach 1:30 Std. Nassvermahlung mit 2 mm Kugeln:

D90 = 3,2 µm; D50 = 1,9 µm; D10 = 0,8 µm

Nach 2 Std. Nassvermahlung mit 2 mm Kugeln:

D90 = 2,7 µm; D50 = 1,5 µm; D10 = 0,7 µm

Nach 3 Std. Nassvermahlung mit 2 mm Kugeln:

D90 = 2,3 µm; D50 = 1,2 µm; D10 = 0,6 µm

Nach 5 Std. Nassvermahlung mit 2 mm Kugeln:

D90 = 2,1 µm; D50 = 1,1 µm; D10 = 0,6 µm

Bemerkung(en):

Test 1:

Zerkleinerung von 119,67 g = ca. 70 ml der Probe 2 mit der Planeten Kugelmühle PM 100 + 250 ml Mahlbecher aus Zirkonoxid + 120x 10 mm Mahlkugeln.

Die empfohlene Becherfüllung für eine Trockenvermahlung besteht aus 1/3 Kugeln + ca. 1/3 Probe.

Zunächst wurde die Probe für 2 Min. mit einer höheren Drehzahl von 450 U/Min. vorzerkleinert.

Um dann eine möglichst hohe Feinheit zu erzielen und Anbackungen zu vermeiden/hinauszuzögern, wurde die Drehzahl deutlich auf 200 U/Min. reduziert und ein paar Tropfen Ethanol hinzugegeben.

Nach bereits 5 Min. waren die ersten Anbackungen in Becher und am Deckel zu finden zu finden.

Die Probe scheint sehr weiche Bestandteile zu beinhalten, die stark zum Anhaften neigen.

Weitere Reduktion der Drehzahl auf nur 150 U/Min. und Zerkleinerung für 5 Min.

Die vollständige Probe war trichter-/strudelförmig im Mahlbecher verbacken mit den Kugeln in der Mitte.

Eine trockene Feinzerkleinerung scheint mit dieser Probe nicht möglich zu sein.

Die gewünschte Feinheit von 1 µm kann grundsätzlich nicht mit einer Trockenvermahlung erzielt werden.

Hat eine Probe perfekte Brucheigenschaften, ist trocken und neigt nicht bzw. erst spät zum Anbacken, ist trocken eine maximale Feinheit von ca. 10 µm zu erreichen.

Sobald die Probe eher weich ist bzw. weiche Bestandteile enthält, kommt es deutlich früher zu Anbackungen, wie bei dieser Probe festzustellen war.

Test 2:

Um eine höhere Feinheit zu erzielen, wurde die Probe 2 zunächst trocken in der PM 100 + 250 ml Mahlbecher aus Zirkonoxid + 15x 20 mm Mahlkugeln mit 350 U/Min. vorzerkleinert.

Da nach 5 Min. Vorzerkleinerung bereits die ersten Anbackungen an den Kugeln zu sehen waren, wurden für die zusätzlichen 3 Minuten paar Tropfen Ethanol hinzugegeben, was die Anbackungen verhindern/entfernen konnte. Eine Partikelgröße von gefühlt ca. 200 - 300 µm lag vor.

Austausch der 20 mm Kugeln mit 500 g 2 mm Mahlkugeln + 50 ml Wasser + Sicherheitsverschluss.

Für eine Feinst-/Nassvermahlung besteht die Becherfüllung aus 2/3 Kugeln + 1/3 Probe + so viel Flüssigkeit bis eine Viskosität ähnlich Motoröl/Ketchup

erreicht wird.

Bei zu niedriger Viskosität wird der Abrieb der Mahlwerkzeuge erhöht und die Zerkleinerung negativ beeinflusst, ist die Viskosität zu hoch, können sich die kleinen, leichten Kugeln nicht ausreichend gut bewegen =schlechtere Zerkleinerung.

Während der Vermahlung kommt es zu einer Oberflächenvergrößerung, dass sich die Viskosität deutlich erhöhen kann. Deshalb sollte die Viskosität zwischenzeitig kontrolliert und ggf. mehr Wasser nachgefüllt werden.

Zerkleinerung für 30 Min. mit 450 U/Min.

Der Becher war warm und 25 ml Wasser mussten hinzugefügt werden.

Vermahlung für weitere 30 Min. (= 1 Std.)

Der Becher war heiß und 20 ml Wasser wurden hinzugegeben.

Vermahlung für weitere 30 Min. (= 1:30 Std.)

Der Becher war heiß und 10 ml Wasser wurden hinzugegeben.

Vermahlung für weitere 3:30 Std. (= 5 Std.)

Nach einer Gesamt-Nasszerkleinerungsdauer von 30 Min. / 1 Std. / 1:30 Std. / 2 Std. / 3 Std. und 5 Std. wurde die Korngrößenverteilung mit dem Microtrac Sync nass gemessen.

Aufgrund der nur sehr geringen Verbesserung der Feinheit nach 2 zusätzlichen Stunden Zerkleinerung (im Nachkommabereich) wurde der Test nach 5 Std. abgebrochen.

Ggf. kann mit einer höheren Drehzahl schneller eine hohe Feinheit erzielt werden, jedoch geht mit der höheren Drehzahl auch eine deutlich stärkere Erwärmung und ein höherer Innendruck im Becher einher. Somit müsste der Becher nach Beendigung der Vermahlung deutlich länger abkühlen, bevor er sicher geöffnet werden kann (ohne Innendruck und damit Probenverlust = Probe, die raus spritzt).

Um größere Mengen oder mehrere Proben gleichzeitig zu zerkleinern, sind 500 ml Mahlbecher und die PM 300 mit zwei Mahlstationen und die PM 400 mit vier Mahlstationen erhältlich.

Die Zirkoxidmahlbecher wurden verwendet, um einen Stahlabrieb und der damit einhergehenden Grauverfärbung zu vermeiden.

Außerdem ist Zirkonoxid deutlich abriebsfester als Stahl.

Stahlbecher und Kugeln sind jedoch erhältlich.

Empfehlung:

Die Planeten Kugelmühle PM 100 ist zur Zerkleinerung des Probenmaterials unter o.g. Bedingungen geeignet.

Bilder der Probe:

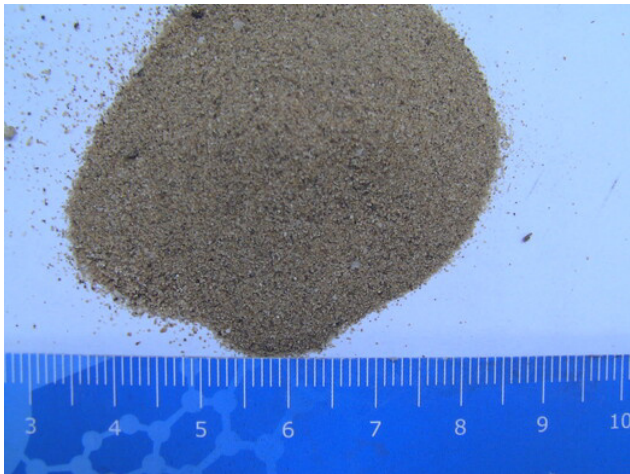


Bild 1: Probe 1, nur für Trocknungsversuch



Bild 2: Probe 2



Bild 3: Trockenvermahlung: 250 ml Mahlbecher aus ZrO₂ + 120x 10 mm Kugeln



Bild 4: Probe 2 nach 2 Min. mit 450 U/Min.



Bild 5: Probe 2; Anbackungen nach weiteren 5 Min. mit 200 U/Min.



Bild 6: Probe 2; Anbackungen nach weiteren 5 Min. mit 200 U/Min.



Bild 7: Probe 2; Verbacken nach weiteren 5 Min. mit 150 U/Min.



Bild 8: Probe 2; Verbacken nach weiteren 5 Min. mit 150 U/Min.



Bild 9: Vorzerkleinerung für Nassvermahlung: 250 ml Mahlbecher aus ZrO₂ + 15x 20 mm Kugeln

Particle Size Analysis Report

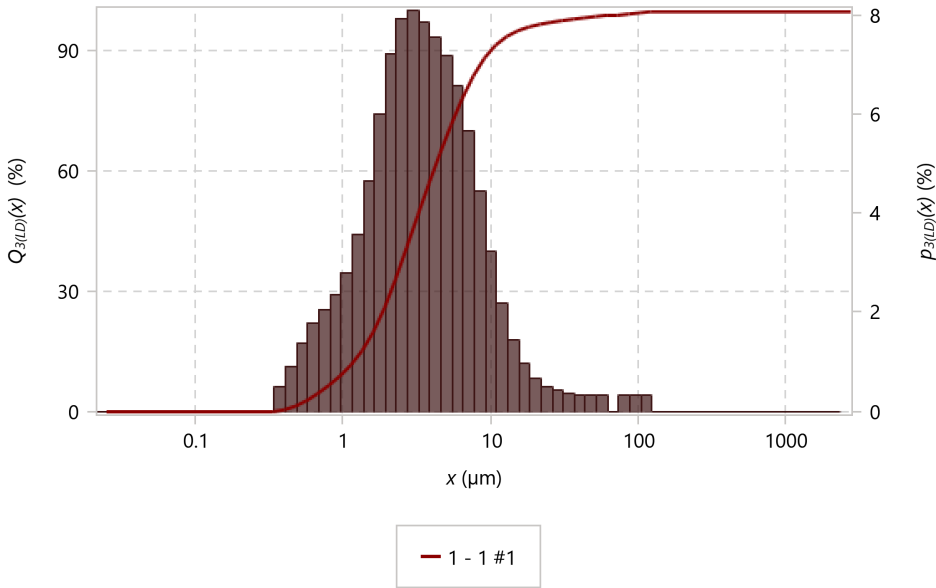
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 30min.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 5.86 μm
Mean area diameter ($M_{3,2}$) 2.29 μm
Mean number diameter ($M_{1,0}$) 0.73 μm
CS 2.63 m^2/cm^3
SD 3.19 μm
Mz 4.19 μm
si 3.78
Ski 0.52

Percentiles & Size Percent

10 % 1.04 μm
50 % 3.34 μm
90 % 10.03 μm

Peak Summary

x	Ratio	Width
3.34 μm	100 %	6.39 μm

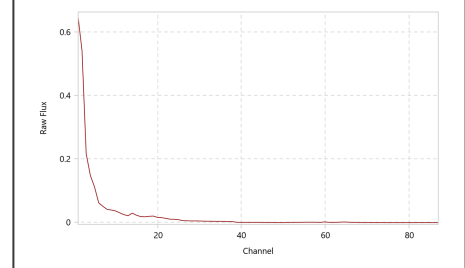
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi run delay	
Delay on first measurement	Disabled
Multi Scan	
Particle name	Wüstensand
Refractive Index red	1.59
Absorption Coefficient red	
Refractive Index blue	
Absorption Coefficient blue	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum Channel Drop	0
Imaging Mode	No Imaging
Number of Rinses	1
Deaeration Cycles	1
Flow Rate	50 %
Ultrasonic Power	100 %
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Probe 2; PM100; nass 30min.
Sample ID 2	
Device type	Sync
Laser Configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	2/19/2025 3:44:10 PM
Recalculated date	
Software Version	2.2.0
Residuals above	0
Residuals below	0
Normal Deconvolution Error	0.67 %
Load factor	0.0515
Transmission	0.910
Transmission L2	
Auto-sequence cycle	
Warnings	
SetZero timestamp	2/19/2025 3:40:42 PM
SetZero warning	

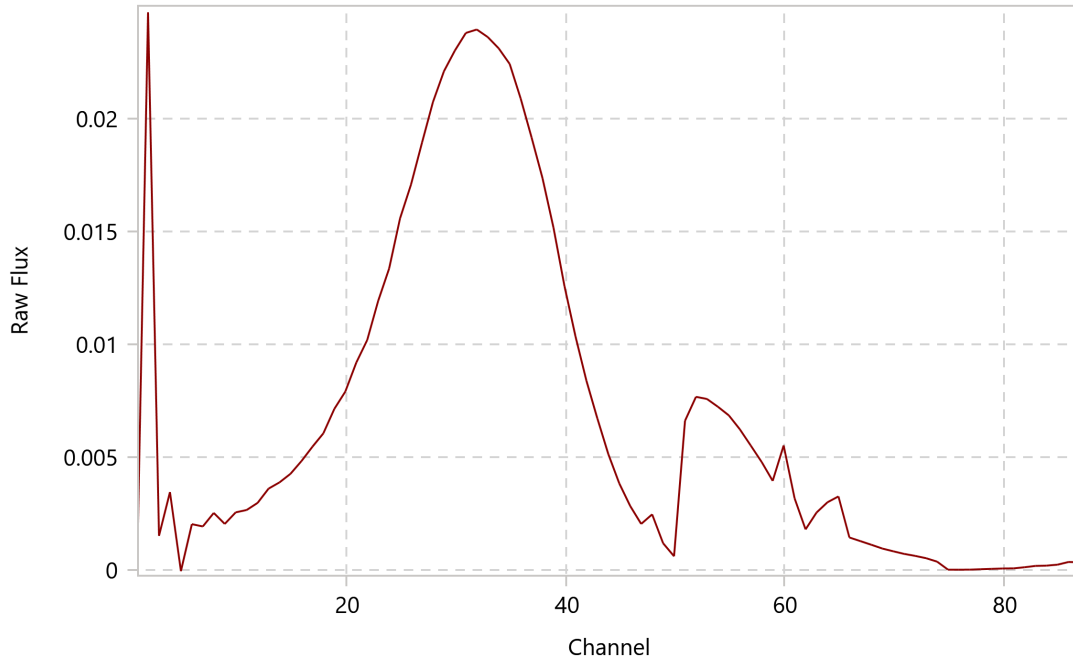
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0.02	0.31
104.6	99.7	0.31	0.02	0.31
88.0	99.4	0.62	0.02	0.31
74.0	99.1	0.93	0	0
62.2	99.1	0.93	0.03	0.31
52.3	98.8	1.24	0.04	0.32
44.0	98.4	1.56	0.05	0.34
37.0	98.1	1.90	0.06	0.37
31.1	97.7	2.26	0.08	0.41
26.2	97.3	2.68	0.12	0.50
22.0	96.8	3.18	0.19	0.66
18.5	96.2	3.84	0.32	0.95
15.6	95.2	4.79	0.58	1.44
13.1	93.8	6.23	1.05	2.19
11.0	91.6	8.42	1.84	3.22
9.25	88.4	11.6	3.02	4.45
7.78	83.9	16.1	4.55	5.65
6.54	78.3	21.7	6.33	6.58
5.50	71.7	28.3	8.15	7.17
4.62	64.5	35.5	10.3	7.55
3.89	57.0	43.0	12.7	7.86

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	49.1	50.9	15.5	8.07
2.75	41.0	59.0	18.1	7.93
2.31	33.1	66.9	19.6	7.20
1.95	25.9	74.1	19.3	5.98
1.64	19.9	80.1	17.9	4.65
1.38	15.3	84.7	16.2	3.55
1.16	11.7	88.3	15.2	2.80
0.97	8.92	91.1	15.2	2.34
0.82	6.58	93.4	15.6	2.05
0.69	4.54	95.5	16.2	1.77
0.58	2.77	97.2	15.0	1.38
0.49	1.38	98.6	11.7	0.90
0.41	0.48	99.5	7.43	0.48
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Particle Size Analysis Report

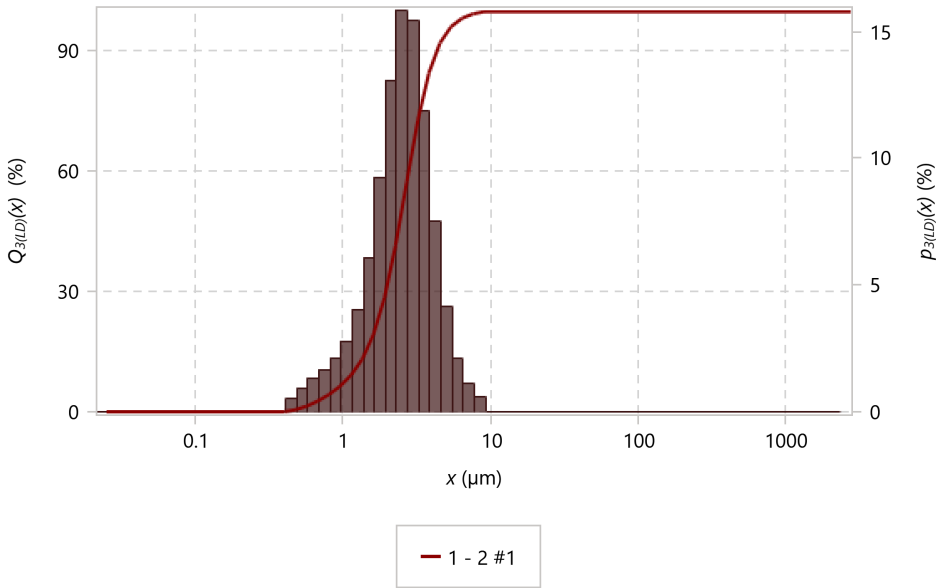
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 1Std.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 2.72 μm
Mean area diameter ($M_{3,2}$) 2.07 μm
Mean number diameter ($M_{1,0}$) 0.98 μm
CS 2.90 m^2/cm^3
SD 1.17 μm
Mz 2.63 μm
si 1.23
Ski 0.17

Percentiles & Size Percent

10 % 1.21 μm
50 % 2.54 μm
90 % 4.36 μm

Peak Summary

x	Ratio	Width
2.54 μm	100 %	2.34 μm

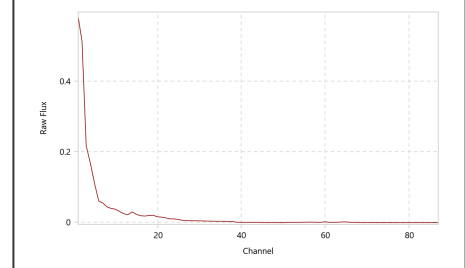
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi run delay	
Delay on first measurement	Disabled
Multi Scan	
Particle name	Wüstensand
Refractive Index red	1.59
Absorption Coefficient red	
Refractive Index blue	
Absorption Coefficient blue	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum Channel Drop	0
Imaging Mode	No Imaging
Number of Rinses	1
Deaeration Cycles	1
Flow Rate	50 %
Ultrasonic Power	100 %
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Probe 2; PM100; nass 1Std.
Sample ID 2	
Device type	Sync
Laser Configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	2/19/2025 3:50:24 PM
Recalculated date	
Software Version	2.2.0
Residuals above	0
Residuals below	0
Normal Deconvolution Error	1.47 %
Load factor	0.0164
Transmission	0.962
Transmission L2	
Auto-sequence cycle	
Warnings	
SetZero timestamp	2/19/2025 3:48:10 PM
SetZero warning	

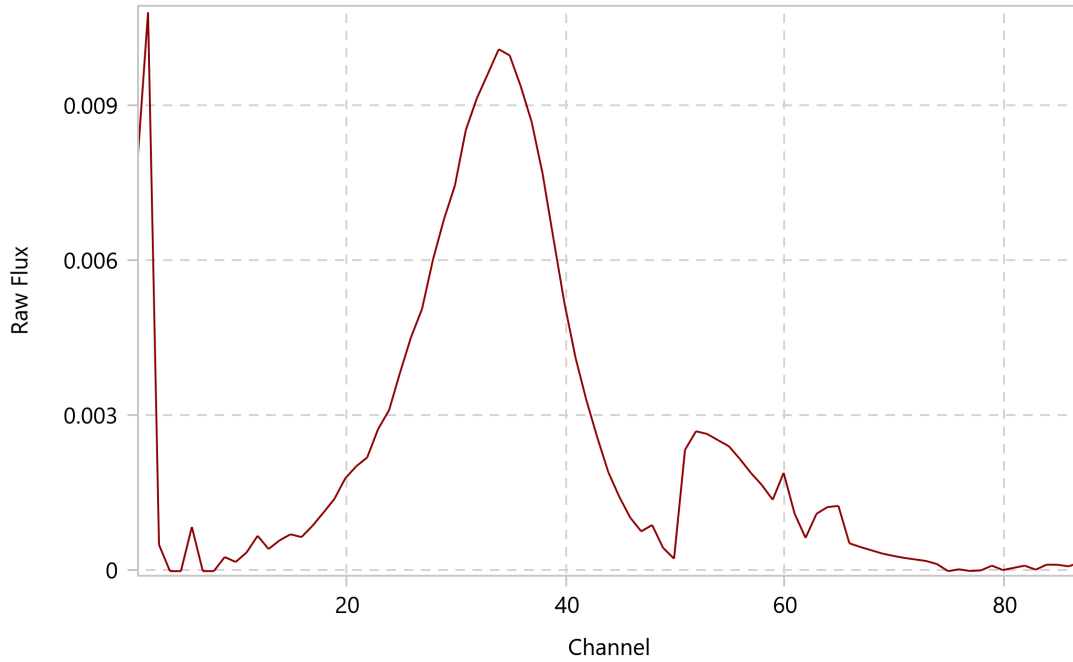
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0.38	0.56
7.78	99.4	0.56	0.87	1.08
6.54	98.4	1.64	2.03	2.11
5.50	96.2	3.75	4.67	4.11
4.62	92.1	7.86	10.3	7.49
3.89	84.7	15.3	19.2	11.9

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	72.8	27.2	29.6	15.4
2.75	57.3	42.7	36.1	15.8
2.31	41.5	58.5	35.6	13.1
1.95	28.5	71.5	29.8	9.25
1.64	19.2	80.8	23.4	6.08
1.38	13.1	86.9	18.3	4.01
1.16	9.12	90.9	15.1	2.78
0.97	6.34	93.7	13.5	2.07
0.82	4.27	95.7	12.5	1.63
0.69	2.64	97.4	11.7	1.27
0.58	1.37	98.6	9.54	0.88
0.49	0.49	99.5	6.34	0.49
0.41	0	100.0	0	0
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Particle Size Analysis Report

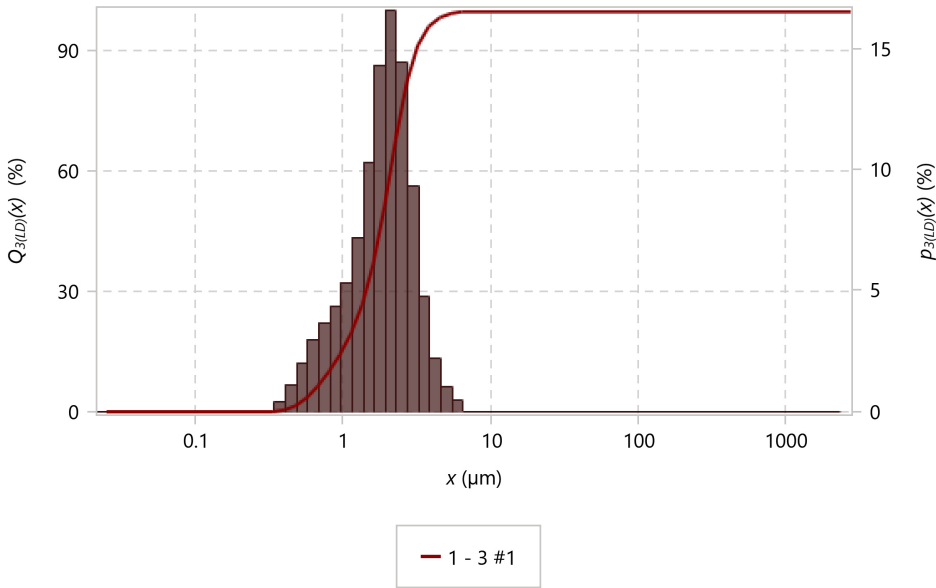
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 1Std30min.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 1.99 μm
Mean area diameter ($M_{3,2}$) 1.52 μm
Mean number diameter ($M_{1,0}$) 0.8 μm
CS 3.94 m^2/cm^3
SD 0.9 μm
Mz 1.92 μm
si 0.91
Ski 0.08

Percentiles & Size Percent

10 % 0.82 μm
50 % 1.92 μm
90 % 3.15 μm

Peak Summary

x	Ratio	Width
1.92 μm	100 %	1.79 μm

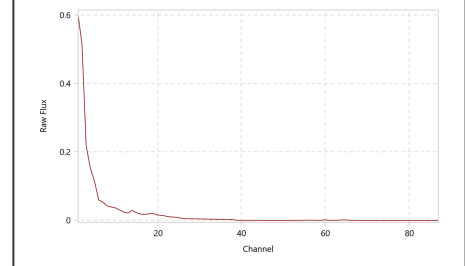
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi run delay	
Delay on first measurement	Disabled
Multi Scan	
Particle name	Wüstensand
Refractive Index red	1.59
Absorption Coefficient red	
Refractive Index blue	
Absorption Coefficient blue	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum Channel Drop	0
Imaging Mode	No Imaging
Number of Rinses	1
Deaeration Cycles	1
Flow Rate	50 %
Ultrasonic Power	100 %
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Probe 2; PM100; nass 1Std30min.
Sample ID 2	
Device type	Sync
Laser Configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	2/19/2025 4:00:50 PM
Recalculated date	
Software Version	2.2.0
Residuals above	0
Residuals below	0
Normal Deconvolution Error	1.36 %
Load factor	0.0098
Transmission	0.972
Transmission L2	
Auto-sequence cycle	
Warnings	
SetZero timestamp	2/19/2025 3:58:42 PM
SetZero warning	

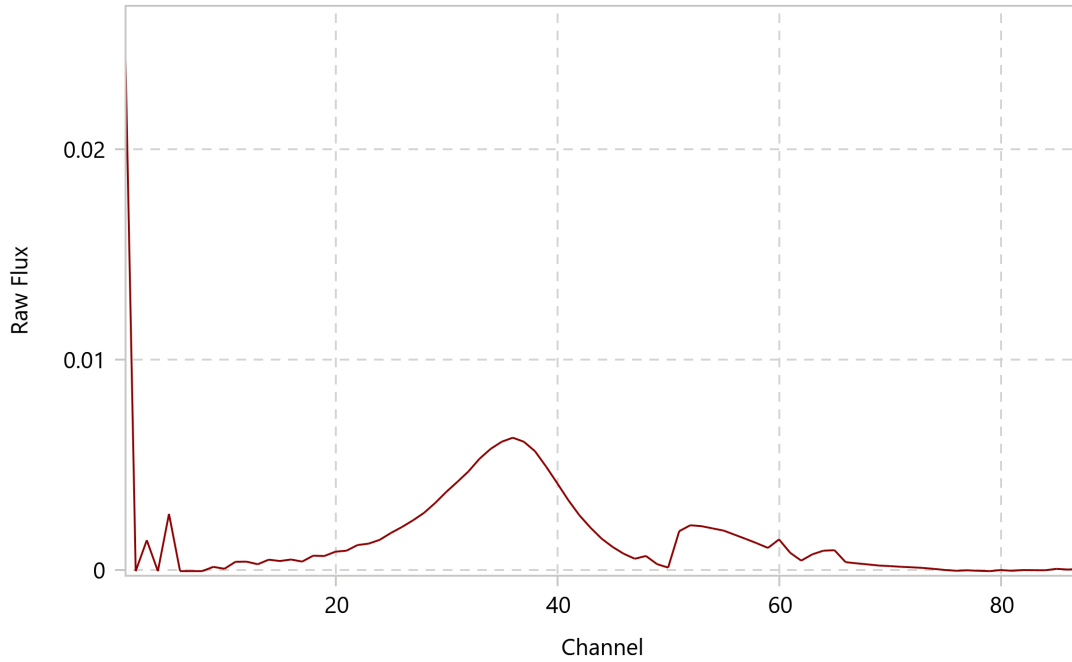
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0.47	0.48
5.50	99.5	0.48	1.14	1.00
4.62	98.5	1.48	3.00	2.19
3.89	96.3	3.68	7.69	4.77

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	91.6	8.44	17.9	9.29
2.75	82.3	17.7	32.9	14.4
2.31	67.9	32.1	45.0	16.5
1.95	51.3	48.7	46.0	14.3
1.64	37.1	62.9	39.6	10.3
1.38	26.8	73.2	32.7	7.16
1.16	19.6	80.4	28.8	5.31
0.97	14.3	85.7	27.9	4.30
0.82	10.0	90.0	27.7	3.63
0.69	6.38	93.6	26.8	2.92
0.58	3.46	96.5	21.7	1.99
0.49	1.47	98.5	13.7	1.05
0.41	0.42	99.6	6.39	0.42
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Particle Size Analysis Report

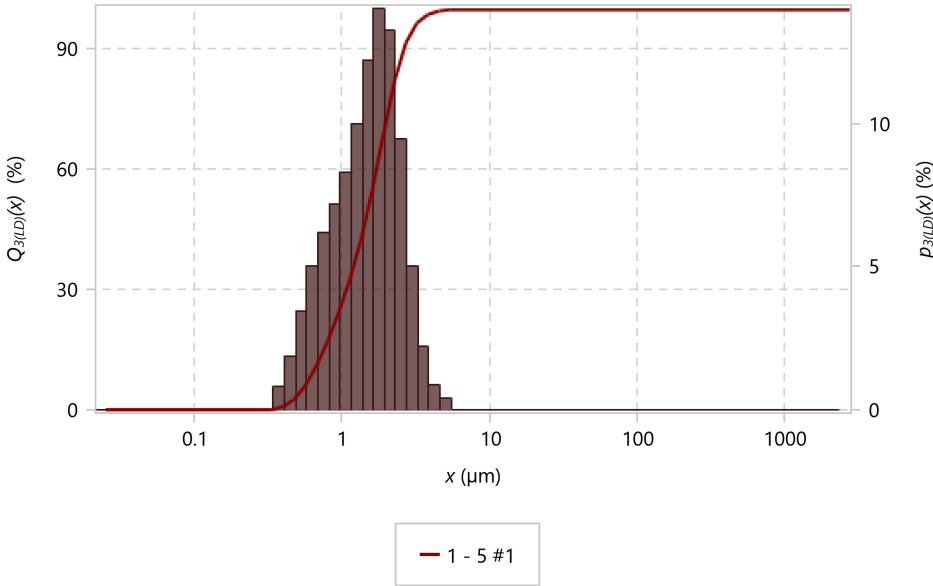
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 2Std
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 1.62 μm
Mean area diameter ($M_{3,2}$) 1.23 μm
Mean number diameter ($M_{1,0}$) 0.72 μm
CS 4.87 m^2/cm^3
SD 0.8 μm
Mz 1.57 μm
si 0.78
Ski 0.14

Percentiles & Size Percent

10 % 0.66 μm
50 % 1.53 μm
90 % 2.66 μm

Peak Summary

x	Ratio	Width
1.53 μm	100 %	1.59 μm

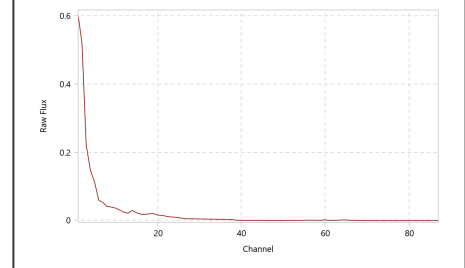
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi run delay	
Delay on first measurement	Disabled
Multi Scan	
Particle name	Wüstensand
Refractive Index red	1.59
Absorption Coefficient red	
Refractive Index blue	
Absorption Coefficient blue	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum Channel Drop	0
Imaging Mode	No Imaging
Number of Rinses	1
Deaeration Cycles	1
Flow Rate	50 %
Ultrasonic Power	100 %
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Probe 2; PM100; nass 2Std
Sample ID 2	
Device type	Sync
Laser Configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	2/19/2025 4:36:46 PM
Recalculated date	
Software Version	2.2.0
Residuals above	0
Residuals below	0
Normal Deconvolution Error	1.79 %
Load factor	0.0053
Transmission	0.981
Transmission L2	
Auto-sequence cycle	
Warnings	Sample Loading Too Low
SetZero timestamp	2/19/2025 4:34:18 PM
SetZero warning	

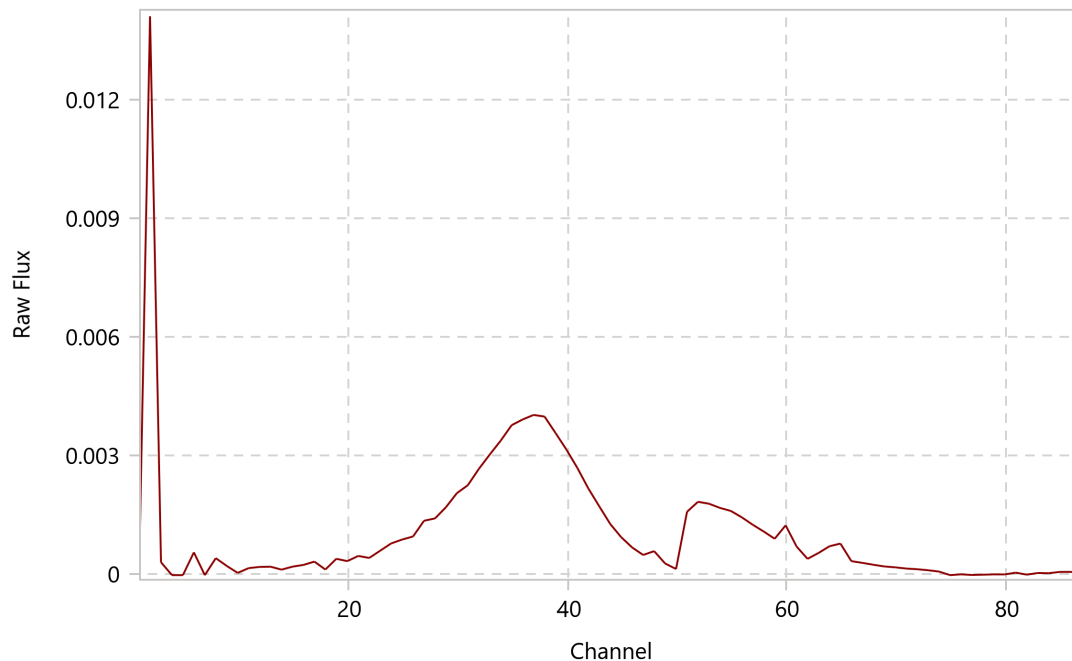
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0.41	0.36
4.62	99.6	0.36	1.19	0.87
3.89	98.8	1.23	3.50	2.17

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	96.6	3.40	9.67	5.03
2.75	91.6	8.43	21.5	9.44
2.31	82.1	17.9	36.1	13.2
1.95	68.9	31.1	45.1	14.0
1.64	54.9	45.1	47.0	12.2
1.38	42.7	57.3	45.4	9.95
1.16	32.7	67.3	44.9	8.27
0.97	24.5	75.5	46.4	7.14
0.82	17.3	82.7	47.3	6.20
0.69	11.1	88.9	46.0	5.01
0.58	6.12	93.9	37.6	3.46
0.49	2.66	97.3	24.3	1.87
0.41	0.78	99.2	12.1	0.78
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Particle Size Analysis Report

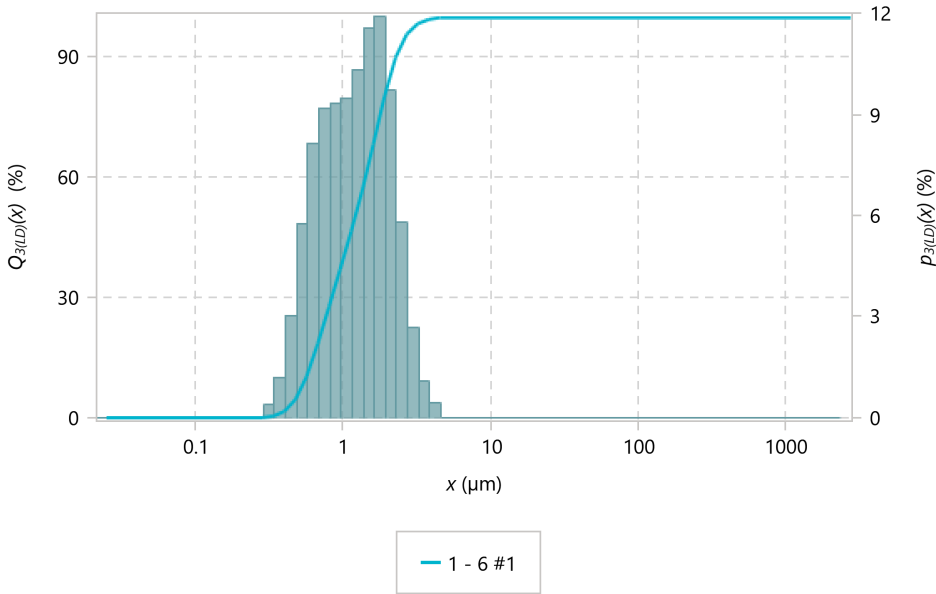
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 3Std.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 1.36 μm
Mean area diameter ($M_{3,2}$) 1.03 μm
Mean number diameter ($M_{1,0}$) 0.64 μm
CS 5.83 m^2/cm^3
SD 0.71 μm
Mz 1.32 μm
si 0.68
Ski 0.25

Percentiles & Size Percent

10 % 0.57 μm
50 % 1.23 μm
90 % 2.31 μm

Peak Summary

x	Ratio	Width
1.23 μm	100 %	1.41 μm

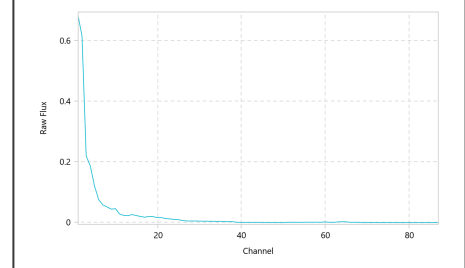
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi run delay	
Delay on first measurement	Disabled
Multi Scan	
Particle name	Wüstensand
Refractive Index red	1.59
Absorption Coefficient red	
Refractive Index blue	
Absorption Coefficient blue	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum Channel Drop	0
Imaging Mode	No Imaging
Number of Rinses	1
Deaeration Cycles	1
Flow Rate	50 %
Ultrasonic Power	100 %
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Probe 2; PM100; nass 3Std.
Sample ID 2	
Device type	Sync
Laser Configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	2/20/2025 6:58:12 AM
Recalculated date	
Software Version	2.2.0
Residuals above	0
Residuals below	0
Normal Deconvolution Error	1.49 %
Load factor	0.0080
Transmission	0.969
Transmission L2	
Auto-sequence cycle	
Warnings	
SetZero timestamp	2/20/2025 6:55:42 AM
SetZero warning	

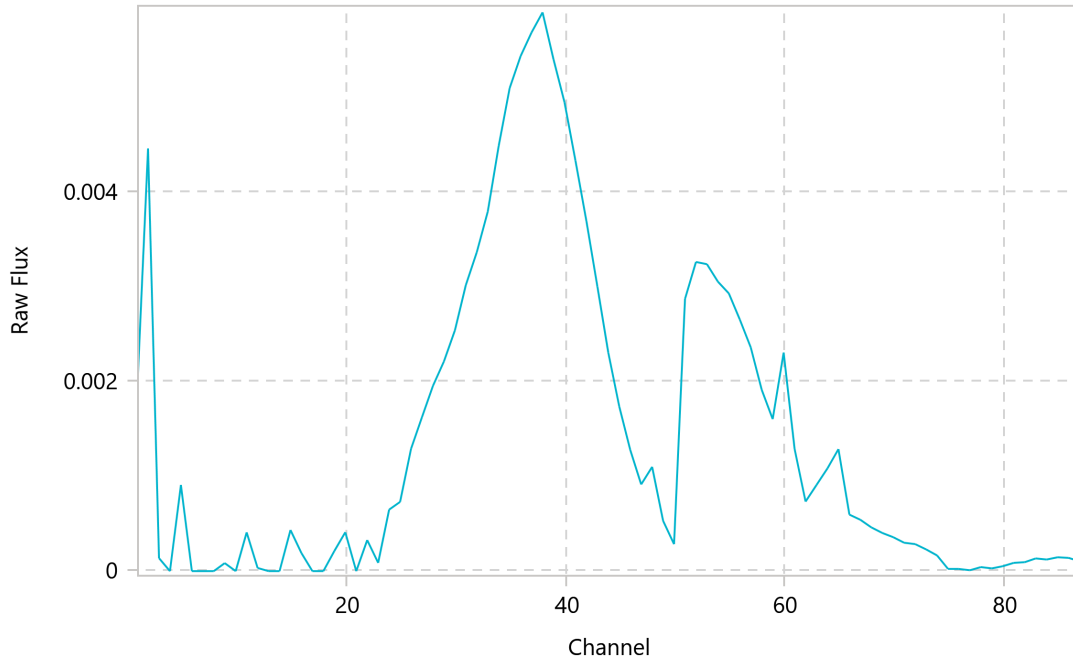
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0	0
4.62	100.0	0	0.62	0.45
3.89	99.5	0.45	1.72	1.07

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	98.5	1.52	5.11	2.66
2.75	95.8	4.18	13.3	5.83
2.31	90.0	10.0	26.5	9.74
1.95	80.3	19.7	38.4	11.9
1.64	68.4	31.6	44.4	11.6
1.38	56.8	43.2	47.1	10.3
1.16	46.5	53.5	51.6	9.50
0.97	37.0	63.0	60.6	9.33
0.82	27.7	72.3	70.2	9.20
0.69	18.5	81.5	74.7	8.14
0.58	10.3	89.7	62.5	5.75
0.49	4.58	95.4	39.0	3.01
0.41	1.58	98.4	18.3	1.19
0.34	0.39	99.6	7.10	0.39
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Particle Size Analysis Report

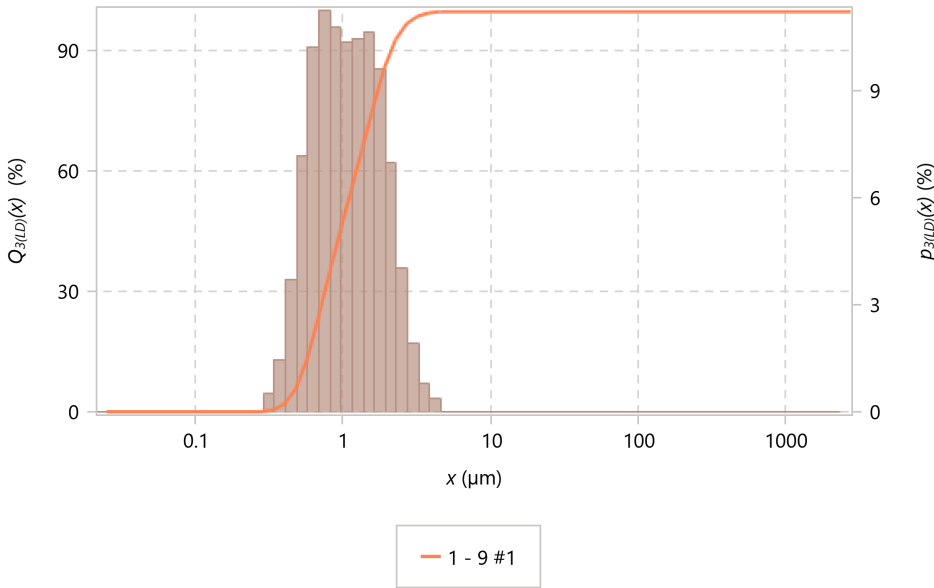
Sample Identification

Sample Name: 33509_Wüstensand
ID 1: Probe 2; PM100; nass 5Std.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Wüstensand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 1.22 μm
Mean area diameter ($M_{3,2}$) 0.94 μm
Mean number diameter ($M_{1,0}$) 0.62 μm
CS 6.40 m^2/cm^3
SD 0.63 μm
Mz 1.18 μm
si 0.62
Ski 0.36

Percentiles & Size Percent

10 % 0.55 μm
50 % 1.06 μm
90 % 2.13 μm

Peak Summary

x	Ratio	Width
0.68 μm	45 %	0.36 μm
1.53 μm	55 %	1.07 μm

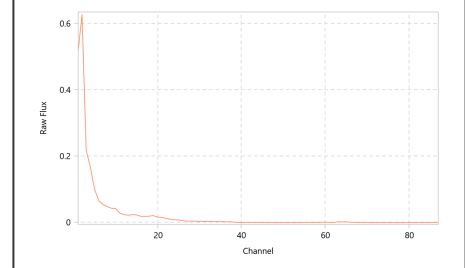
Method

SetZero time 00:00:10
Run time 00:00:10
Number of runs 1
Multi run delay
Delay on first measurement Disabled
Multi Scan
Particle name Wüstensand
Refractive Index red 1.59
Absorption Coefficient red
Refractive Index blue
Absorption Coefficient blue
Transparency Transparent
Shape Irregular
Fluid name Water
Fluid refractive index 1.33
Specific gravity
Progression Standard
Upper edge 2816 μm
Lower edge 0.02148 μm
Include residuals No
Analysis mode Sync
Filter Standard
Blue algorithm
Minimum Channel Drop 0
Imaging Mode No Imaging
Number of Rinses 1
Deaeration Cycles 1
Flow Rate 50 %
Ultrasonic Power 100 %
Ultrasonic Time 00:01:00
Dispersion
Suction

Measurement Info

Sample ID 1 Probe 2; PM100; nass 5Std.
Sample ID 2
Device type Sync
Laser Configuration 3R
Imaging High Range
Serial Number H0293
Sample Cell ID 20029
Module Type Wet
Measurement type Normal
Acquired date 2/20/2025 9:10:56 AM
Recalculated date
Software Version 2.2.0
Residuals above 0
Residuals below 0
Normal Deconvolution Error 1.47 %
Load factor 0.0048
Transmission 0.979
Transmission L2
Auto-sequence cycle
Warnings
SetZero timestamp 2/20/2025 9:04:22 AM
SetZero warning

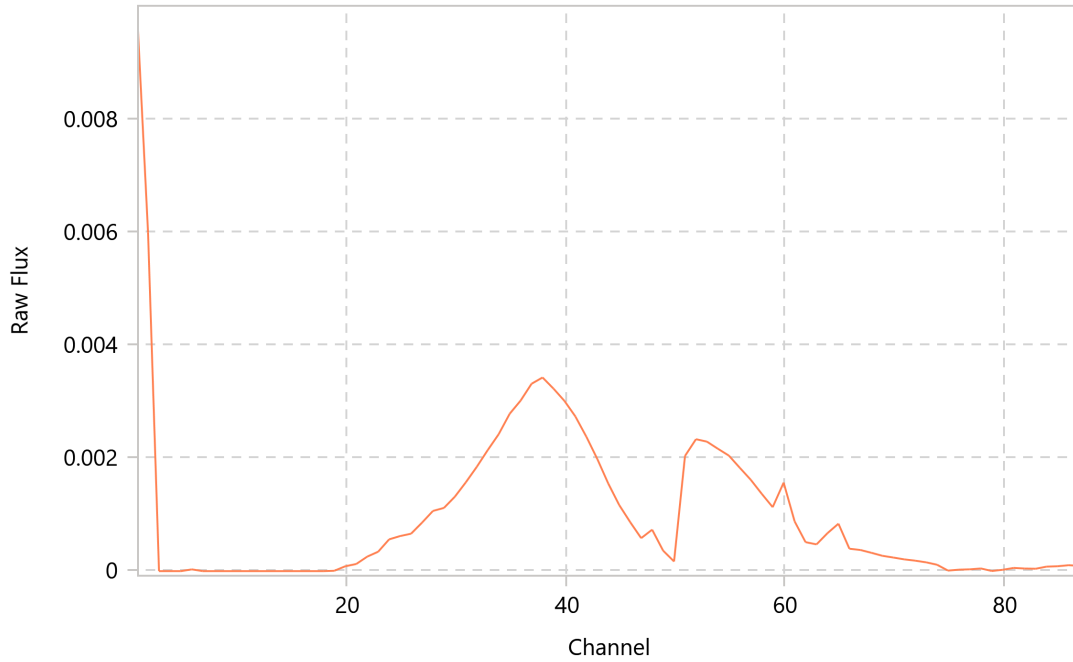
SetZero Graph



Signature

Particle Size Analysis Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0	0
4.62	100.0	0	0.46	0.33
3.89	99.7	0.33	1.28	0.80

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
3.27	98.9	1.13	3.62	1.88
2.75	97.0	3.01	9.13	4.00
2.31	93.0	7.01	19.0	6.99
1.95	86.0	14.0	31.0	9.60
1.64	76.4	23.6	40.8	10.6
1.38	65.8	34.2	47.7	10.5
1.16	55.3	44.7	56.1	10.3
0.97	45.0	55.0	70.0	10.8
0.82	34.2	65.8	85.7	11.2
0.69	23.0	77.0	93.7	10.2
0.58	12.8	87.2	77.9	7.17
0.49	5.60	94.4	47.8	3.68
0.41	1.92	98.1	22.2	1.45
0.34	0.48	99.5	8.72	0.48
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x)(%)
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Translation

(via DeepL,
April 5th, 2026)

Test report no.

Date: 19 February
33509
Author: 2025
MB

Task:

Sector: Environment / Recycling

Material: Desert sand; 5 samples in duplicate
As only a feasibility test was to be carried out and the grinding process plus the interim measurement of the particle size distribution would have taken too much time, only one sample was tested.
The slightly coarser sample 2 was selected. With a similar composition and fracture behaviour of the other samples, a similar result is to be expected, possibly with an adjusted rotational speed.

Sample 2

Feed particle size: Sample2:approx.1mm

Feed quantity: Test 1, dry grinding: 119.67 g = approx. 70 ml
Test 2; wet grinding: 117.9 g = approx. 70 ml

Material specification(s): dry, contains soft components

Customer requirement: 1 µm, 1000 ml
I would like to have 5 different samples ground once each using dry and wet methods to see how quickly and to what extent a clay content can be achieved in the sand.

Follow-up analysis: Particle size analysis and water retention capacity of the ground material

Recommendation

Selected Planetary ball mill PM 100

Equipment: 1x PM 100, 230 V, 50/60 Hz 205400001

Configuration(s) Item numbers: 1x EasyFit grinding jar for planetary ball mills, zirconia, 250 ml 014620500

15 x Grinding ball, zirconia, Ø 20 mm 053680093

120 x Grinding ball, zirconia, 10 mm Ø 053680094

1x Zirconia grinding balls, Ø 2 mm, 500 g, approx. 135 ml 053680089

Optional:

1x Safety cap for EasyFit grinding beakers for planetary ball mills 250–500 ml 228670012

Test report no.

Date: 19 February
33509 2025
Author: MB

Parameters

Test 1, dry grinding with 10 mm balls: Pre-grinding: 450 rpm for 2 mins.
Fine grinding: 200 rpm for 5 min; then 150 rpm for 5 min
Test terminated due to caking

Test 2; wet grinding:

Preliminary grinding; dry with 20 mm balls: 350 rpm for 8 minutes.
Fine grinding; wet with 2 mm balls: 450 rpm for 5 hours.

Time:

Test 1, dry grinding with 10 mm balls: Pre-grinding: 2 mins at 450 rpm
Fine grinding: 10 mins at 200 and 150 rpm respectively (5 + 5 mins).
Aborted due to caking

Test 2; wet grinding:

Pre-grinding; dry with 20 mm balls: 8 mins at 350 rpm. Fine grinding; wet with 2 mm balls: 5 hours at 450 rpm.

Test report no.

Date: 19 February
33509 2025
Author: MB

Result(s)

Test 1, dry grinding with 10 mm balls:

Result(s):

After 2 minutes at 450 rpm: only slight sticking
After a further 5 minutes at 200 rpm: first signs of caking
After a further 5 minutes at 150 rpm: sample completely baked

Test 2; wet grinding:

After 8 minutes at 350 rpm: predominantly < 200–300 µm

After 30 minutes of wet grinding with 2 mm balls:

D90 = 10 µm; D50 = 3.3 µm; D10 = 1 µm

After 1 hour of wet grinding with 2 mm balls:

D90 = 4.4 µm; D50 = 2.5 µm; D10 = 1.2 µm

After 1 hour 30 mins of wet grinding with 2 mm balls:

D90 = 3.2 µm; D50 = 1.9 µm; D10 = 0.8 µm

After 2 hours of wet grinding with 2 mm balls:

D90 = 2.7 µm; D50 = 1.5 µm; D10 = 0.7 µm

After 3 hours of wet grinding with 2 mm balls:

D90 = 2.3 µm; D50 = 1.2 µm; D10 = 0.6 µm

After 5 hours of wet grinding with 2 mm balls:

D90 = 2.1 µm; D50 = 1.1 µm; D10 = 0.6 µm

Test report no.

Date: 19 February
33509 2025
Author: MB

Comments:

Test1:

Grinding of 119.67 g = approx. 70 ml of sample 2 using the PM 100 planetary ball mill + 250 ml zirconia grinding jar + 120 x 10 mm grinding balls.

The recommended beaker filling for dry grinding consists of 1/3 balls + approx. 1/3 sample.

First, the sample was pre-ground for 2 minutes at a higher speed of 450 rpm.

To achieve the finest possible consistency and to prevent or delay caking, the speed was significantly reduced to 200 rpm and a few drops of ethanol were added.

After just 5 minutes, the first signs of sticking were visible in the beaker and on the lid.

The sample appears to contain very soft components that are highly prone to sticking.

Further reduction of the speed to just 150 rpm and grinding for 5 minutes.

The entire sample had caked together in the grinding beaker in a funnel- or swirl-shaped pattern, with the balls in the centre.

Dry fine grinding does not appear to be possible with this sample.

The desired fineness of 1 µm cannot, in principle, be achieved by dry grinding.

If a sample has perfect breaking properties, is dry and does not tend to cake, or only does so at a late stage, a maximum fineness of approx. 10 µm can be achieved in the dry process.

As soon as the sample is relatively soft or contains soft components, sticking occurs much earlier, as was observed with this sample.

Test 2:

To achieve a finer particle size, sample 2 was first pre-ground dry in the PM 100 + 250 ml zirconia grinding jar with 15 x 20 mm grinding balls at 350 rpm.

As the first signs of caking on the balls were already visible after 5 minutes of pre-grinding, a few drops of ethanol were added for the additional 3 minutes, which prevented/removed the caking. The particle size was estimated to be approx. 200–300 µm.

Replacement of the 20 mm balls with 500 g of 2 mm grinding balls + 50 ml water + safety cap.

For ultrafine/wet grinding, the beaker is filled with 2/3 balls + 1/3 sample + enough liquid until a viscosity similar to engine oil or ketchup

Test report no.

Date: 19 February
33509 2025
Author: MB

is achieved.

If the viscosity is too low, wear on the grinding tools increases and the grinding process is adversely affected; if the viscosity is too high, the small, light balls cannot move freely enough, resulting in poorer grinding.

During grinding, the surface area increases, which can cause the viscosity to rise significantly. Therefore, the viscosity should be checked periodically and, if necessary, more water added.

Grinding for 30 mins at 450 rpm.

The beaker was warm and 25 ml of water had to be added. Grinding for a further 30 mins (= 1 hour)

The beaker was hot and 20 ml of water was added. Grinding for a further 30 mins (= 1 hr 30 mins)

The beaker was hot and 10 ml of water was added. Grinding for a further 3 hours 30 minutes (= 5 hours)

After a total wet grinding time of 30 mins / 1 hr / 1 hr 30 mins / 2 hrs / 3 hrs and 5 hrs, the particle size distribution was measured wet using the Microtrac Sync.

Due to the very slight improvement in fineness after 2 additional hours of grinding (in the sub-decimal range), the test was terminated after 5 hours.

It may be possible to achieve a high degree of fineness more quickly at a higher speed, but a higher speed is also accompanied by significantly greater heating and higher internal pressure in the beaker.

Consequently, the beaker would need to cool down for considerably longer after grinding has finished before it can be opened safely (without internal pressure and thus sample loss = sample spurting out).

To grind larger quantities or multiple samples simultaneously, 500 ml grinding jars and the PM 300 with two grinding stations and the PM 400 with four grinding stations are available.

The zirconia grinding bowls were used to prevent steel abrasion and the resulting grey discolouration.

Furthermore, zirconia is significantly more abrasion-resistant than steel. However, steel bowls and balls are available.

Recommendation:

The PM 100 planetary ball mill is suitable for grinding the sample material under the conditions mentioned above.

Images of the sample:

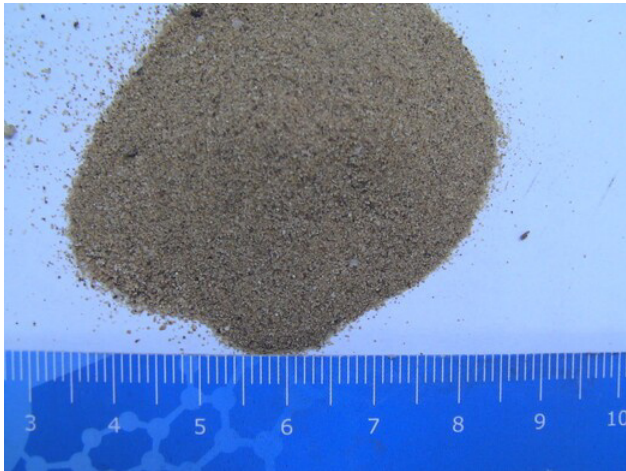


Image 1: Sample 1, for drying test only



Image 2: Sample 2



Image 3: Dry grinding: 250 ml ZrO₂ grinding jar + 120 x 10 mm balls



Image 4: Sample 2 after 2 minutes at 450 rpm



Image 5: Sample 2; caking after a further 5 minutes at 200 rpm



Figure 6: Sample 2; caking after a further 5 minutes at 200 rpm



Figure 7: Sample 2; caking after a further 5 minutes at 150 rpm



Figure 8: Sample 2; caking after a further 5 minutes at 150 rpm



Figure 9: Pre-grinding for wet grinding: 250 ml ZrO₂ grinding beaker + 15 × 20 mm balls

Particle Size Analysis

Report

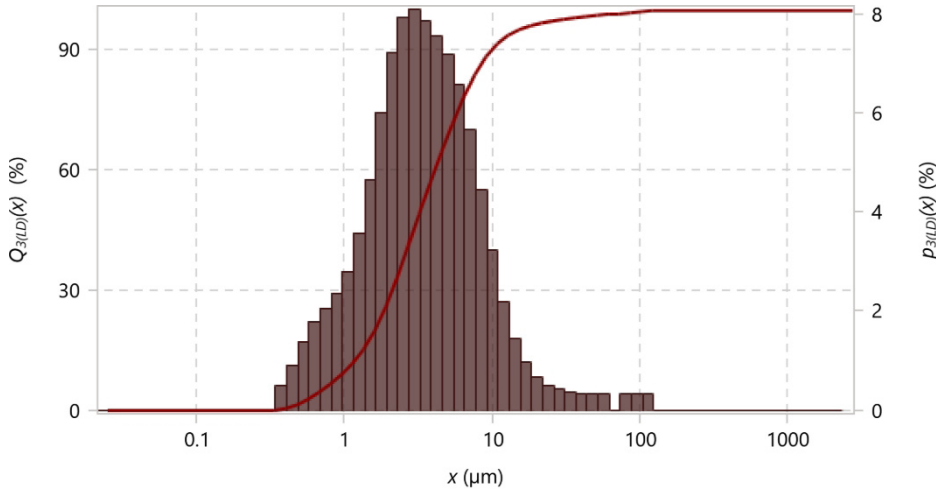
Sample Identification

Sample Name: 33509_Desert sand
ID 1: Sample 2; PM100; wet 30 min.
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



— 1 - 1 #1

Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 5.86 μm
Mean area diameter ($M_{3,2}$) 2.29 μm
Mean number diameter ($M_{1,0}$) 0.73 μm
CS 2.63 m^2/cm^3
SD 3.19 μm
Mz 4.19 μm
si 3.78
Ski 0.52

Percentiles & Size Percent

10% 1.04 μm
50% 3.34 μm
90% 10.03 μm

Peak Summary

x	Ratio	Width
3.34 μm	100%	6.39 μm

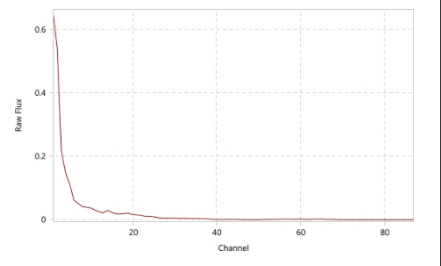
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi-run delay	
Delay on first measurement	Disabled
Multi-scan	
Particle name	Desert sand
Refractive index red	1.59
Absorption coefficient (red)	
Refractive index (blue)	
Absorption coefficient (blue)	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.02148 μm
Include residuals	No
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum channel drop	0
Imaging mode	No imaging
Number of rinses	1
Deaeration cycles	1
Flow Rate	50%
Ultrasonic Power	100%
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement Info

Sample ID 1	Sample 2; PM100; wet 30 min.
Sample ID 2	
Device type	Sync
Laser configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Acquired date	19 February 2025
15:44:10 Recalculated date	
Software version	2.2.0
Residuals above	0
Residuals below	0
Normal deconvolution error	0.67%
Load factor	0.0515
Transmission	0.910
Transmission L2	
Auto-sequence cycle	
Warnings	
SetZero timestamp	19 February 2025 15:40:42
SetZero warning	

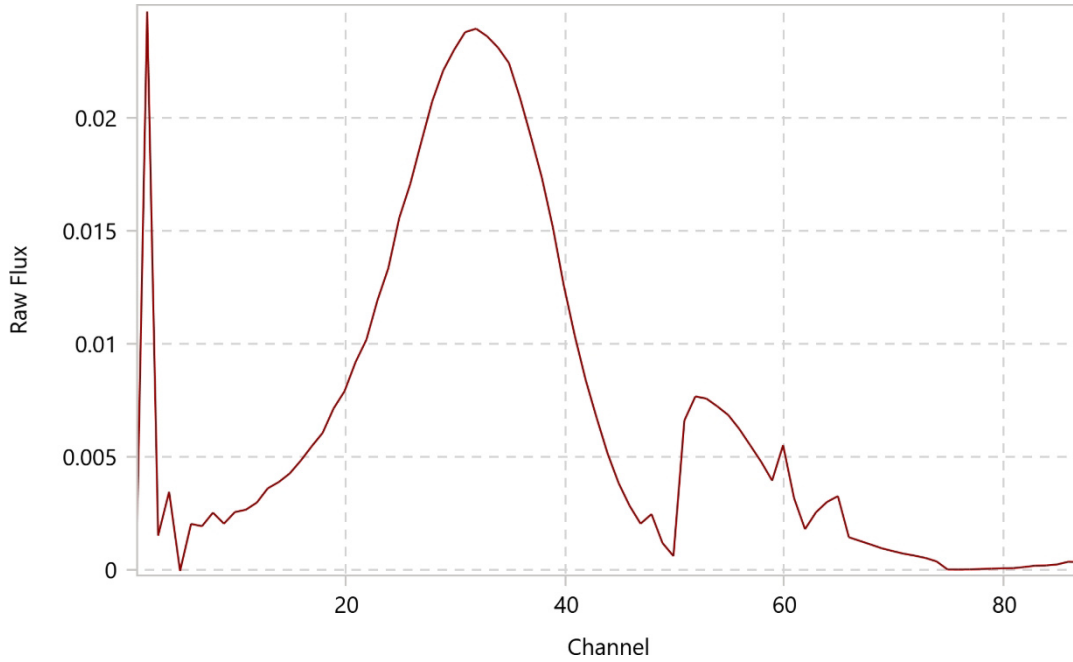
SetZero Graph



Signature

Particle Size Analysis

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0.02	0.31
104.6	99.7	0.31	0.02	0.31
88.0	99.4	0.62	0.02	0.31
74.0	99.1	0.93	0	0
62.2	99.1	0.93	0.03	0.31
52.3	98.8	1.24	0.04	0.32
44.0	98.4	1.56	0.05	0.34
37.0	98.1	1.90	0.06	0.37
31.1	97.7	2.26	0.08	0.41
26.2	97.3	2.68	0.12	0.50
22.0	96.8	3.18	0.19	0.66
18.5	96.2	3.84	0.32	0.95
15.6	95.2	4.79	0.58	1.44
13.1	93.8	6.23	1.05	2.19
11.0	91.6	8.42	1.84	3.22
9.25	88.4	11.6	3.02	4.45
7.78	83.9	16.1	4.55	5.65
6.54	78.3	21.7	6.33	6.58
5.50	71.7	28.3	8.15	7.17
4.62	64.5	35.5	10.3	7.55
3.89	57.0	43.0	12.7	7.86

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	49.1	50.9	15.5	8.07
2.75	41.0	59.0	18.1	7.93
2.31	33.1	66.9	19.6	7.20
1.95	25.9	74.1	19.3	5.98
1.64	19.9	80.1	17.9	4.65
1.38	15.3	84.7	16.2	3.55
1.16	11.7	88.3	15.2	2.80
0.97	8.92	91.1	15.2	2.34
0.82	6.58	93.4	15.6	2.05
0.69	4.54	95.5	16.2	1.77
0.58	2.77	97.2	15.0	1.38
0.49	1.38	98.6	11.7	0.90
0.41	0.48	99.5	7.43	0.48
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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Particle Size Analysis

Report

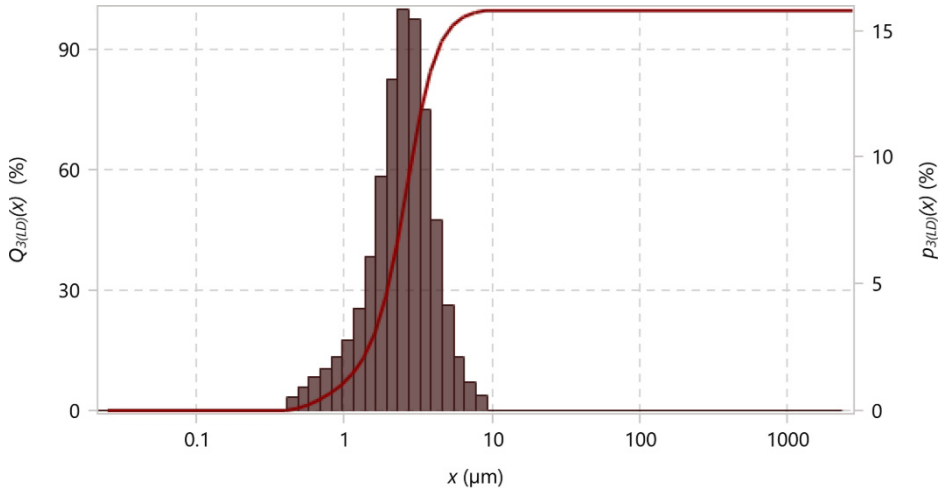
Sample Identification

Sample Name: 33509_Desert Sand
ID 1: Sample 2; PM100; wet 3 hour
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 2.72 μm
Mean area diameter ($M_{3,2}$) 2.07 μm
Mean number diameter ($M_{1,0}$) 0.98 μm
CS 2.90 m^2/cm^3
SD 1.17 μm
Mz 2.63 μm
si 1.23
Ski 0.17

Percentiles & Size Percent

10% 1.21 μm
50% 2.54 μm
90% 4.36 μm

Peak Summary

x	Ratio	Width
2.54 μm	100%	2.34 μm

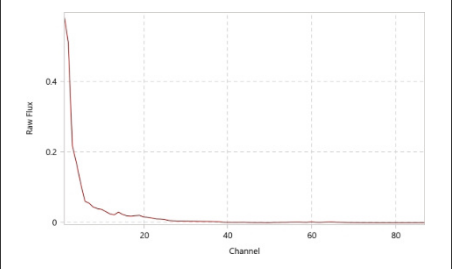
Method

SetZero time 00:00:10
Run time 00:00:10
Number of runs 1
Multi-run delay
Delay on first measurement Disabled
Multi-scan
Particle name Desert sand
Refractive index red 1.59
Absorption coefficient (red)
Refractive index (blue)
Absorption coefficient (blue)
Transparency Transparent
Shape Irregular
Fluid name Water
Fluid refractive index 1.33
Specific gravity
Progression Standard
Upper edge 2816 μm
Lower edge 0.02148 μm
Include residuals No
Analysis mode Sync
Filter Standard
Blue algorithm
Minimum channel drop 0
Imaging Mode No imaging
Number of Rinses 1
Deaeration Cycles 1
Flow Rate 50 %
Ultrasonic Power 100%
Ultrasonic Time 00:01:00
Dispersion
Suction

Measurement Info

Sample ID 1 Probe 2; PM100; wet 1 hr.
Sample ID 2
Device type Sync
Laser configuration 3R
Imaging High Range
Serial Number H0293
Sample Cell ID 20029
Module Type Wet
Measurement type Normal
Date acquired Date 19/02/2025 15:50:24
recalculated Software
version 2.2.0
Residuals above 0
Residuals below 0
Normal deconvolution error 1.47 %
Load factor 0.0164
Transmission 0.962
Transmission L2
Auto-sequence cycle
warnings
SetZero timestamp 19 February 2025
15:48:10 SetZero warning

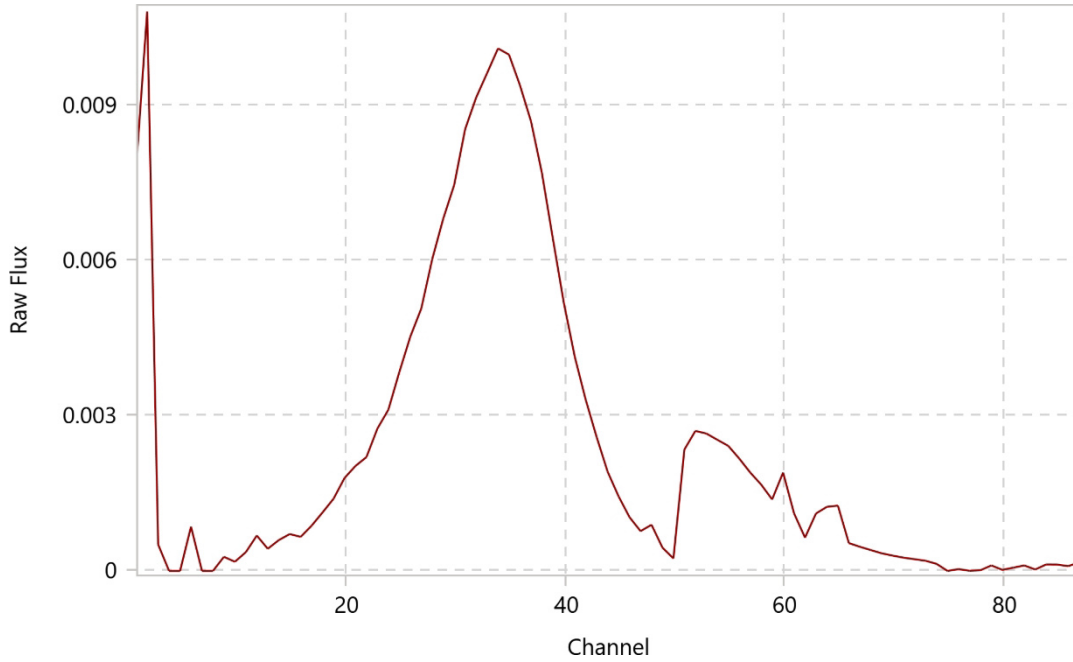
SetZero Graph



Signature

Particle Size Analysis

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0.38	0.56
7.78	99.4	0.56	0.87	1.08
6.54	98.4	1.64	2.03	2.11
5.50	96.2	3.75	4.67	4.11
4.62	92.1	7.86	10.3	7.49
3.89	84.7	15.3	19.2	11.9

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	72.8	27.2	29.6	15.4
2.75	57.3	42.7	36.1	15.8
2.31	41.5	58.5	35.6	13.1
1.95	28.5	71.5	29.8	9.25
1.64	19.2	80.8	23.4	6.08
1.38	13.1	86.9	18.3	4.01
1.16	9.12	90.9	15.1	2.78
0.97	6.34	93.7	13.5	2.07
0.82	4.27	95.7	12.5	1.63
0.69	2.64	97.4	11.7	1.27
0.58	1.37	98.6	9.54	0.88
0.49	0.49	99.5	6.34	0.49
0.41	0	100.0	0	0
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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Particle Size Analysis

Report

Sample Identification

Sample Name: 33509_Desert Sand

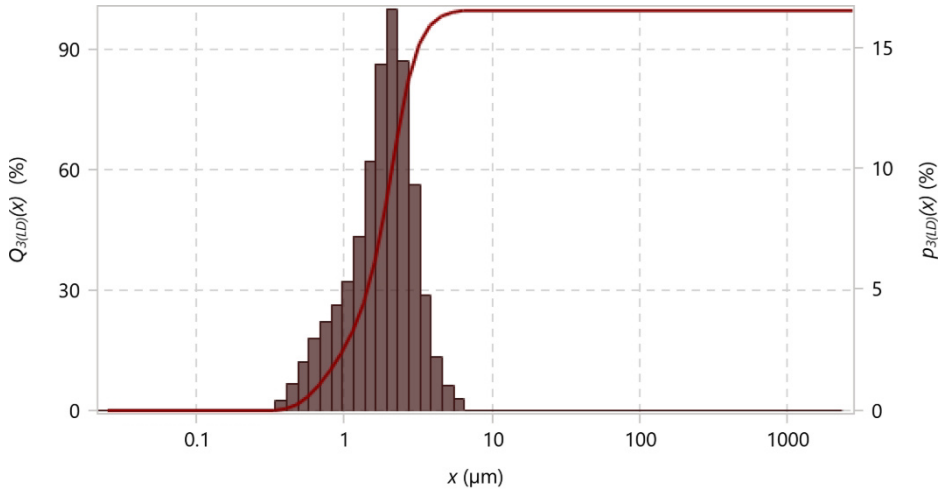
ID 1: Sample 2; PM100; wet 1 hr 30 min.

ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



Summary

Data tolerance

Mean volume diameter ($M_{4,3}$) 1.99 μm

Mean area diameter ($M_{3,2}$) 1.52 μm

Mean number diameter ($M_{1,0}$) 0.8 μm

CS 3.94 m^2/cm^3

SD 0.9 μm

Mz 1.92 μm

si 0.91

Ski 0.08

Percentiles & Size Percent

10% 0.82 μm

50% 1.92 μm

90% 3.15 μm

Peak Summary

x	Ratio	Width
1.92 μm	100%	1.79 μm

Method

SetZero time 00:00:10

Run time 00:00:10

Number of runs 1

Multi-run delay

Delay on first measurement Disabled

Multi-scan

Particle name Desert sand

Refractive index red 1.59

Absorption coefficient (red) Refractive index (blue) Absorption coefficient (blue)

Transparency Transparent

Shape Irregular

Fluid name Water

Fluid refractive index 1.33

Specific gravity

Progression Standard

Upper edge 2816 μm

Lower edge 0.02148 μm

Include residuals No

Analysis mode Sync

Filter Standard

Blue algorithm

Minimum channel drop 0

Imaging mode No imaging

Number of rinses 1

Deaeration cycles 1

Flow Rate 50%

Ultrasonic Power 100%

Ultrasonic Time 00:01:00

Dispersion

Suction

Measurement Info

Sample ID 1 Probe 2; PM100; wet 1 hr 30 min. Sample ID 2

Device type Sync

Laser configuration 3R

Imaging High Range

Serial Number H0293

Sample Cell ID 20029

Module Type Wet

Measurement type Normal

Acquired date 19 February 2025

16:00:50 Recalculated date

Software version 2.2.0

Residuals above 0

Residuals below 0

Normal deconvolution error 1.36%

Load factor 0.0098

Transmission 0.972

Transmission L2

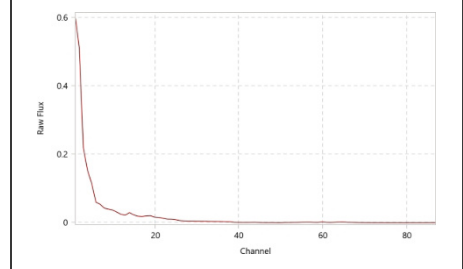
Auto-sequence cycle

Warnings

SetZero timestamp 19 February 2025

3:58:42 pm SetZero warning

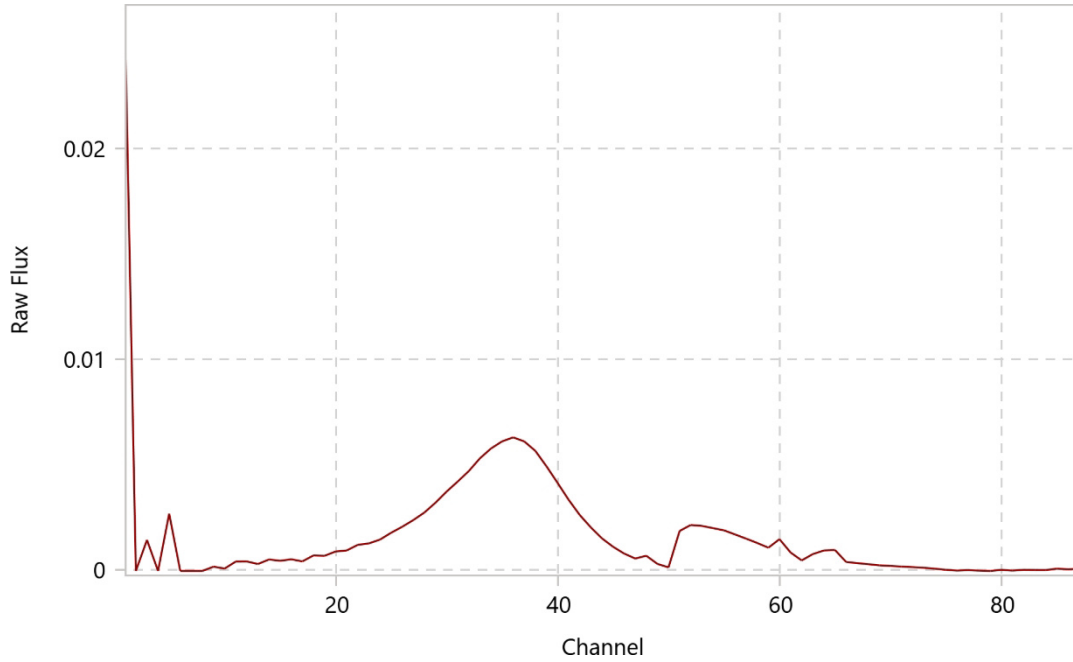
SetZero Graph



Signature

Particle Size Analysis

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0.47	0.48
5.50	99.5	0.48	1.14	1.00
4.62	98.5	1.48	3.00	2.19
3.89	96.3	3.68	7.69	4.77

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	91.6	8.44	17.9	9.29
2.75	82.3	17.7	32.9	14.4
2.31	67.9	32.1	45.0	16.5
1.95	51.3	48.7	46.0	14.3
1.64	37.1	62.9	39.6	10.3
1.38	26.8	73.2	32.7	7.16
1.16	19.6	80.4	28.8	5.31
0.97	14.3	85.7	27.9	4.30
0.82	10.0	90.0	27.7	3.63
0.69	6.38	93.6	26.8	2.92
0.58	3.46	96.5	21.7	1.99
0.49	1.47	98.5	13.7	1.05
0.41	0.42	99.6	6.39	0.42
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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Particle Size Analysis

Report

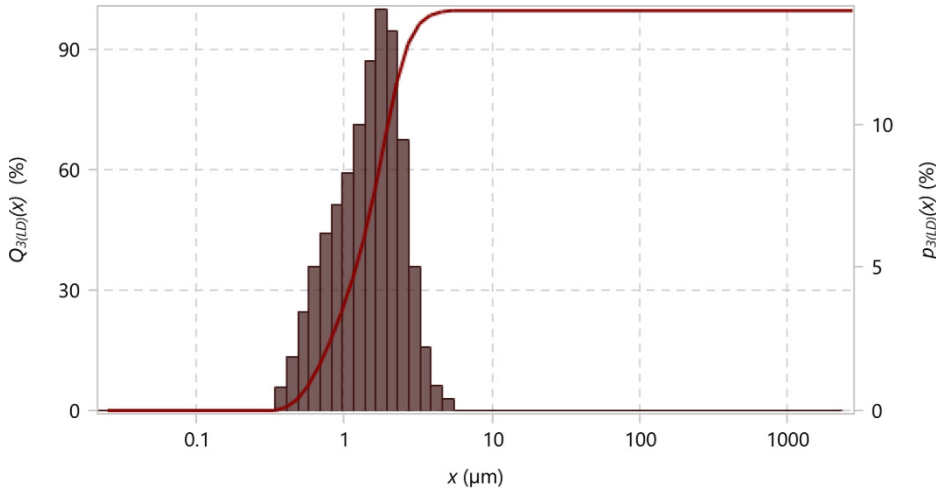
Sample Identification

Sample Name: 33509_Desert Sand
ID 1: Sample 2; PM100; wet 2 hours
ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



Summary

Data tolerance
Mean volume diameter ($M_{4,3}$) 1.62 μm
Mean area diameter ($M_{3,2}$) 1.23 μm
Mean number diameter ($M_{1,0}$) 0.72 μm
CS 4.87 m^2/cm^3
SD 0.8 μm
Mz 1.57 μm
si 0.78
Ski 0.14

Percentiles & Size Percent

10% 0.66 μm
50% 1.53 μm
90% 2.66 μm

Peak Summary

x	Ratio	Width
1.53 μm	100%	1.59 μm

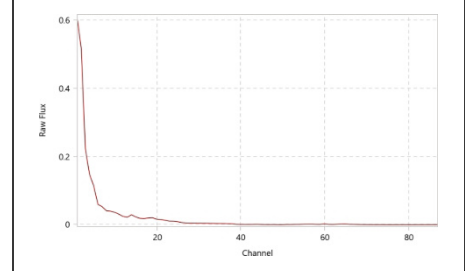
Method

SetZero time	00:00:10
Run time	00:00:10
Number of runs	1
Multi-run delay	
Delay on first measurement	Disabled
Multi-scan	
Particle name	Desert sand
Refractive index red	1.59
Absorption coefficient (red) Refractive index (blue) Absorption coefficient (blue)	
Transparency	Transparent
Shape	Irregular
Fluid name	Water
Fluid refractive index	1.33
Specific gravity	
Progression	Standard
Upper edge	2816 μm
Lower edge	0.2148 μm
Residuals	0
Analysis mode	Sync
Filter	Standard
Blue algorithm	
Minimum channel drop	0
Imaging mode	No Imaging
Number of rinses	1
Deaeration cycles	1
Flow Rate	50%
Ultrasonic Power	100%
Ultrasonic Time	00:01:00
Dispersion	
Suction	

Measurement information

Sample ID 1	Sample 2; PM100; wet 2-
hour Sample ID 2	
Device type	Sync
Laser configuration	3R
Imaging	High Range
Serial Number	H0293
Sample Cell ID	20029
Module Type	Wet
Measurement type	Normal
Date acquired	19 February 2025 16:36:46
Recalculated date	2.2.0
Software version	
Residuals above	0
Residuals below	0
Normal deconvolution error	1.79 %
Load factor	0.0053
Transmission	0.981
Transmission L2	
Auto-sequence cycle	
Warnings	Sample loading too low
SetZero timestamp	19 February 2025 4:34:18 pm
SetZero warning	

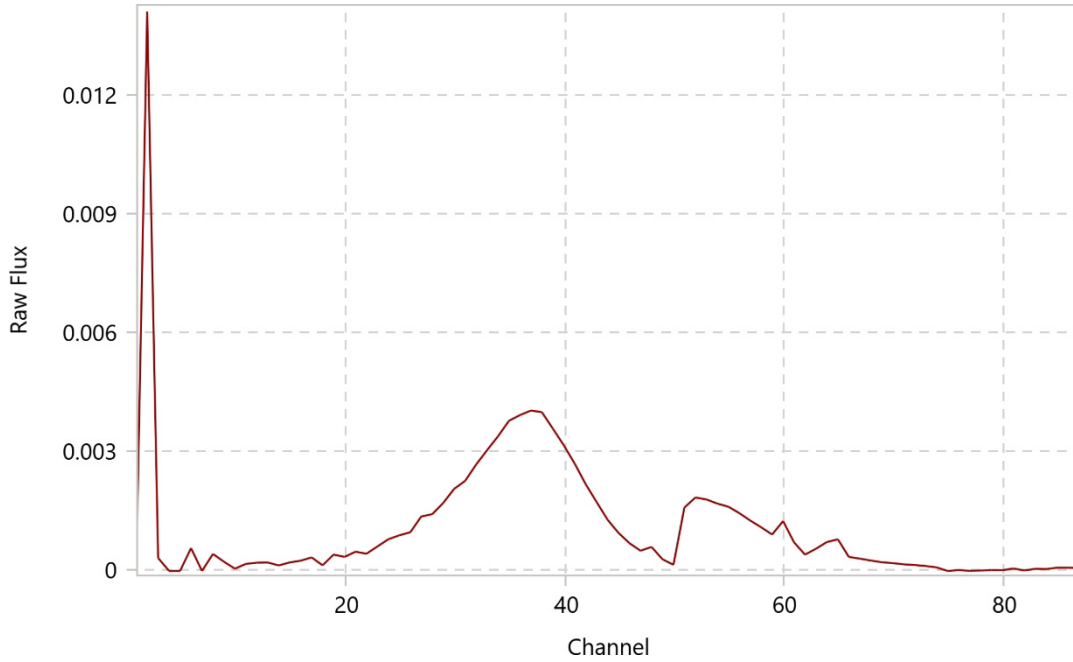
SetZero graph



Signature

Particle Size Analysis

Raw data graph



Tabular data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0.41	0.36
4.62	99.6	0.36	1.19	0.87
3.89	98.8	1.23	3.50	2.17

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	96.6	3.40	9.67	5.03
2.75	91.6	8.43	21.5	9.44
2.31	82.1	17.9	36.1	13.2
1.95	68.9	31.1	45.1	14.0
1.64	54.9	45.1	47.0	12.2
1.38	42.7	57.3	45.4	9.95
1.16	32.7	67.3	44.9	8.27
0.97	24.5	75.5	46.4	7.14
0.82	17.3	82.7	47.3	6.20
0.69	11.1	88.9	46.0	5.01
0.58	6.12	93.9	37.6	3.46
0.49	2.66	97.3	24.3	1.87
0.41	0.78	99.2	12.1	0.78
0.34	0	100.0	0	0
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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Particle Size Analysis

Report

Sample Identification

Sample Name: 33509_Desert Sand

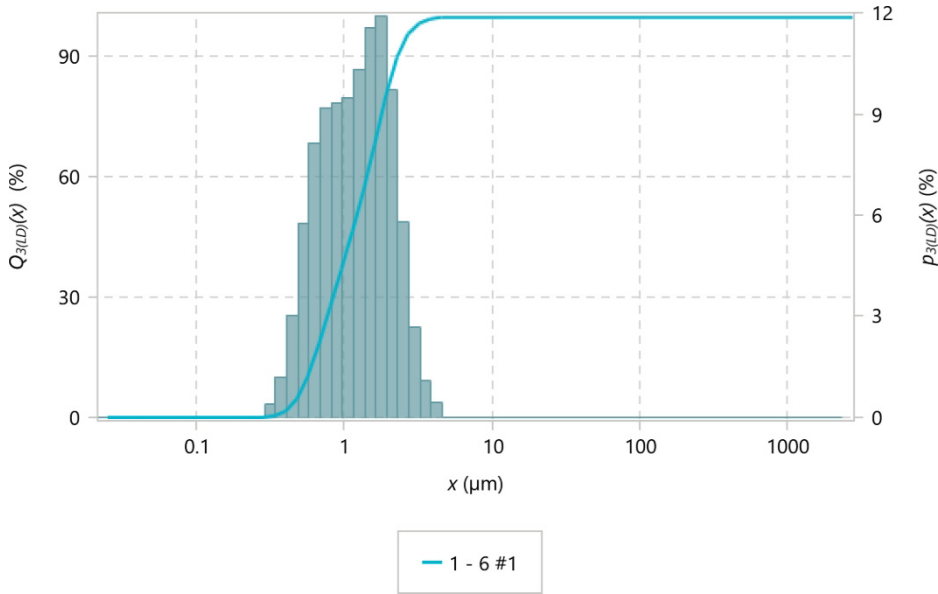
ID 1: Sample 2; PM100; wet 3 hours

ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



Summary

Data tolerance

Mean volume diameter ($M_{4,3}$) 1.36 μm

Mean area diameter ($M_{3,2}$) 1.03 μm

Mean number diameter ($M_{1,0}$) 0.64 μm

CS 5.83 m^2/cm^3

SD 0.71 μm

Mz 1.32 μm

si 0.68

Ski 0.25

Percentiles & Size Percent

10% 0.57 μm

50% 1.23 μm

90% 2.31 μm

Peak Summary

x	Ratio	Width
1.23 μm	100%	1.41 μm

Method

SetZero time 00:00:10

Run time 00:00:10

Number of runs 1

Multi-run delay

Delay on first measurement Disabled

Multi-scan

Particle name Desert sand

Refractive index red 1.59

Absorption coefficient (red)

Refractive index (blue)

Absorption coefficient (blue)

Transparency Transparent

Shape Irregular

Fluid name Water

Fluid refractive index 1.33

Specific gravity

Progression Standard

Upper edge 2816 μm

Lower edge 0.02148 μm

Include residuals No

Analysis mode Sync

Filter Default

Blue algorithm

Minimum channel drop 0

Imaging Mode No imaging

Number of Rinses 1

Deaeration Cycles 1

Flow Rate 50 %

Ultrasonic Power 100%

Ultrasonic Time 00:01:00

Dispersion

Suction

Measurement Info

Sample ID 1 Probe 2; PM100; wet 3 hours. Sample ID 2

Device type Sync

Laser configuration 3R

Imaging High Range

Serial Number H0293

Sample Cell ID 20029

Module Type Wet

Measurement type Normal

Date acquired Date 20/02/2025 06:58:12

recalculated Software version 2.2.0

Residuals above 0

Residuals below 0

Normal deconvolution error 1.49%

Load factor 0.0080

Transmission 0.969

Transmission L2

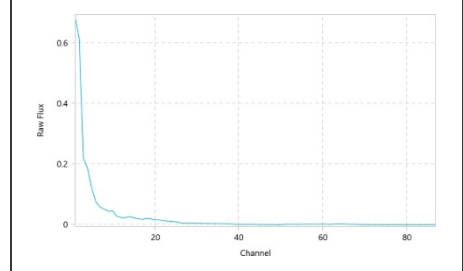
Auto-sequence cycle

warnings

SetZero timestamp 20 February 2025

6:55:42 am SetZero warning

SetZero Graph

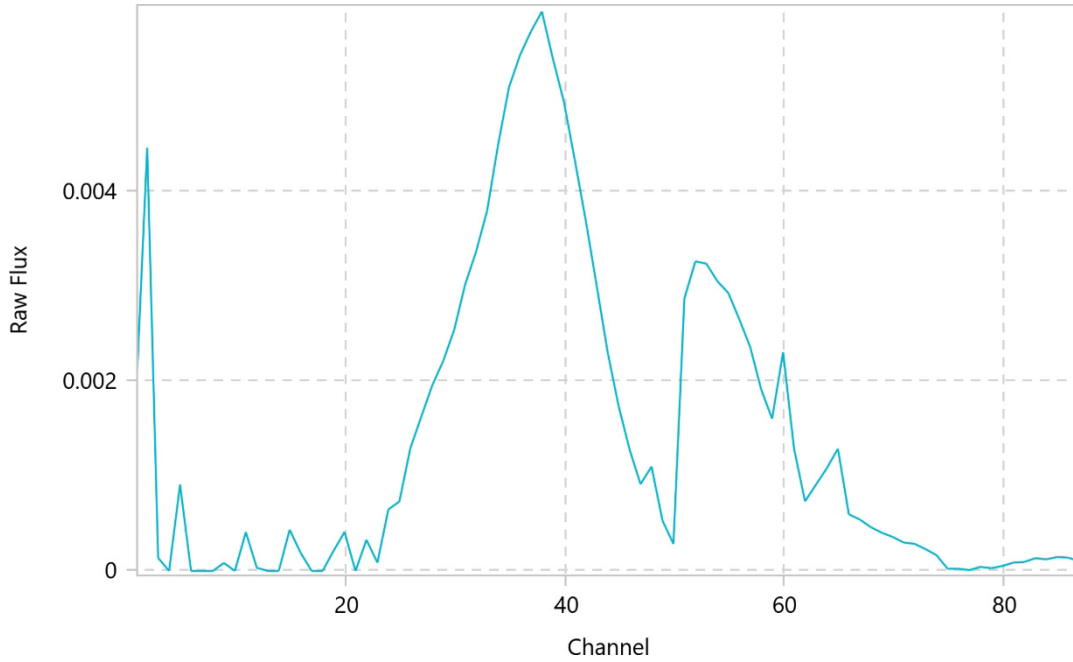


Signature

Particle Size Analysis

Report

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0	0
4.62	100.0	0	0.62	0.45
3.89	99.5	0.45	1.72	1.07

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	98.5	1.52	5.11	2.66
2.75	95.8	4.18	13.3	5.83
2.31	90.0	10.0	26.5	9.74
1.95	80.3	19.7	38.4	11.9
1.64	68.4	31.6	44.4	11.6
1.38	56.8	43.2	47.1	10.3
1.16	46.5	53.5	51.6	9.50
0.97	37.0	63.0	60.6	9.33
0.82	27.7	72.3	70.2	9.20
0.69	18.5	81.5	74.7	8.14
0.58	10.3	89.7	62.5	5.75
0.49	4.58	95.4	39.0	3.01
0.41	1.58	98.4	18.3	1.19
0.34	0.39	99.6	7.10	0.39
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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Particle Size Analysis

Report

Sample Identification

Sample Name: 33509_Desert Sand

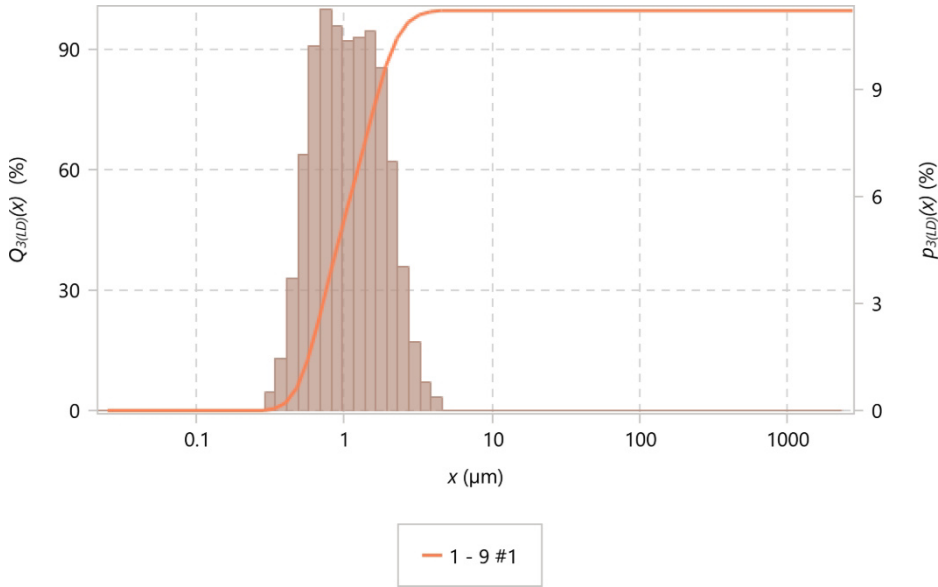
ID 1: Sample 2; PM100; wet 5 hours

ID 2:

Notes:

C:\Microtrac\Dimensions LS 2.2.0.0\Databases\33509_Desert_Sand.smdb

Measurement Graph



Summary

Data tolerance

Mean volume diameter ($M_{4,3}$) 1.22 μm

Mean area diameter ($M_{3,2}$) 0.94 μm

Mean number diameter ($M_{1,0}$) 0.62 μm

CS 6.40 m^2/cm^3

SD 0.63 μm

Mz 1.18 μm

si 0.62

Ski 0.36

Percentiles & Size Percent

10% 0.55 μm

50% 1.06 μm

90% 2.13 μm

Peak Summary

x	Ratio	Width
0.68 μm	45%	0.36 μm
1.53 μm	55%	1.07 μm

Method

SetZero time 00:00:10

Run time 00:00:10

Number of runs 1

Multi-run delay

Delay on first measurement Disabled

Multi-scan

Particle name Desert sand

Refractive index red 1.59

Absorption coefficient (red)

Refractive index (blue)

Absorption coefficient (blue)

Transparency Transparent

Shape Irregular

Fluid name Water

Fluid refractive index 1.33

Specific gravity

Progression Standard

Upper edge 2816 μm

Lower edge 0.02148 μm

Include residuals No

Analysis mode Sync

Filter Standard

Blue algorithm

Minimum channel drop 0

Imaging Mode No imaging

Number of Rinses 1

Deaeration Cycles 1

Flow Rate 50 %

Ultrasonic Power 100%

Ultrasonic Time 00:01:00

Dispersion

Suction

Measurement Info

Sample ID 1 Probe 2; PM100; wet 5 hours. Sample ID 2

Device type Sync

Laser configuration 3R

Imaging High Range

Serial Number H0293

Sample Cell ID 20029

Module Type Wet

Measurement type Normal

Date acquired Date 20 February 2025 9:10:56 am

recalculated Software version 2.2.0

Residuals above 0

Residuals below 0

Normal deconvolution error 1.47 %

Load factor 0.0048

Transmission 0.979

Transmission L2

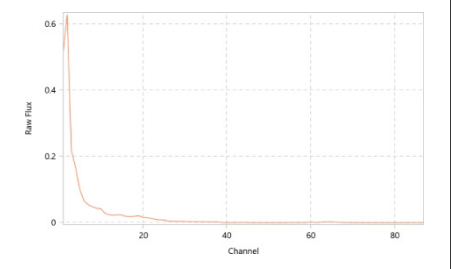
Auto-sequence cycle

warnings

SetZero timestamp 20 February 2025

09:04:22 SetZero warning

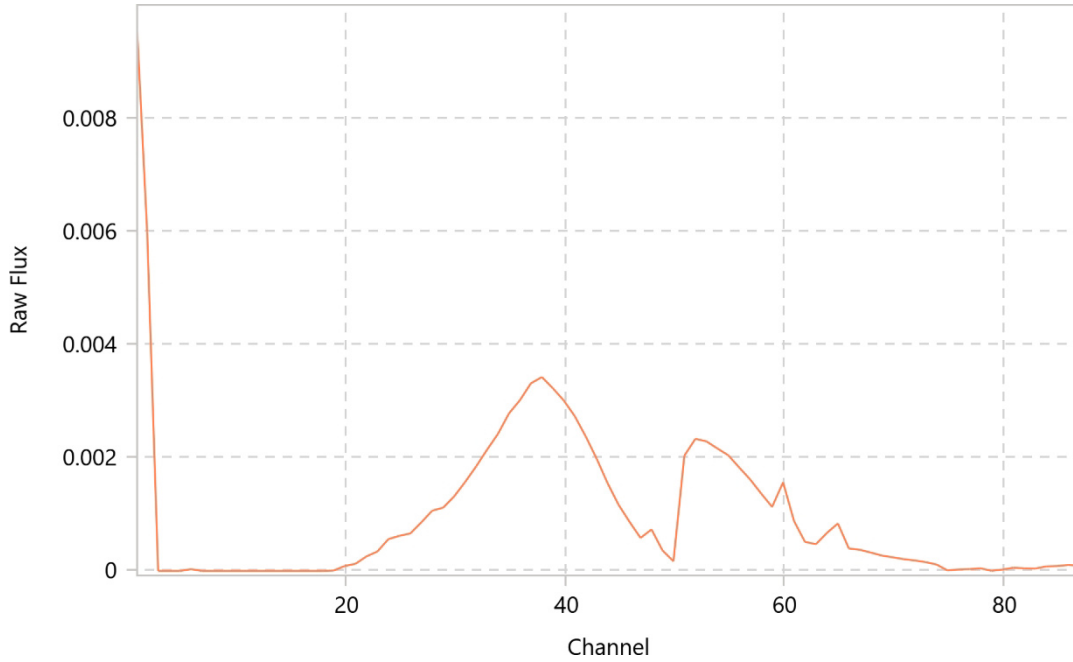
SetZero Graph



Signature

Particle Size Analysis

Raw data graph



Tabular Data

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
1	1	1	1	1
2,816.0	100.0	0	0	0
2,368.0	100.0	0	0	0
1,991.0	100.0	0	0	0
1,674.0	100.0	0	0	0
1,408.0	100.0	0	0	0
1,184.0	100.0	0	0	0
995.6	100.0	0	0	0
837.2	100.0	0	0	0
704.0	100.0	0	0	0
592.0	100.0	0	0	0
497.8	100.0	0	0	0
418.6	100.0	0	0	0
352.0	100.0	0	0	0
296.0	100.0	0	0	0
248.9	100.0	0	0	0
209.3	100.0	0	0	0
176.0	100.0	0	0	0
148.0	100.0	0	0	0
124.5	100.0	0	0	0
104.6	100.0	0	0	0
88.0	100.0	0	0	0
74.0	100.0	0	0	0
62.2	100.0	0	0	0
52.3	100.0	0	0	0
44.0	100.0	0	0	0
37.0	100.0	0	0	0
31.1	100.0	0	0	0
26.2	100.0	0	0	0
22.0	100.0	0	0	0
18.5	100.0	0	0	0
15.6	100.0	0	0	0
13.1	100.0	0	0	0
11.0	100.0	0	0	0
9.25	100.0	0	0	0
7.78	100.0	0	0	0
6.54	100.0	0	0	0
5.50	100.0	0	0	0
4.62	100.0	0	0.46	0.33
3.89	99.7	0.33	1.28	0.80

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
3.27	98.9	1.13	3.62	1.88
2.75	97.0	3.01	9.13	4.00
2.31	93.0	7.01	19.0	6.99
1.95	86.0	14.0	31.0	9.60
1.64	76.4	23.6	40.8	10.6
1.38	65.8	34.2	47.7	10.5
1.16	55.3	44.7	56.1	10.3
0.97	45.0	55.0	70.0	10.8
0.82	34.2	65.8	85.7	11.2
0.69	23.0	77.0	93.7	10.2
0.58	12.8	87.2	77.9	7.17
0.49	5.60	94.4	47.8	3.68
0.41	1.92	98.1	22.2	1.45
0.34	0.48	99.5	8.72	0.48
0.29	0	100.0	0	0
0.24	0	100.0	0	0
0.20	0	100.0	0	0
0.17	0	100.0	0	0
0.14	0	100.0	0	0
0.12	0	100.0	0	0
0.10	0	100.0	0	0
0.09	0	100.0	0	0
0.07	0	100.0	0	0
0.06	0	100.0	0	0
0.05	0	100.0	0	0
0.04	0	100.0	0	0
0.04	0	100.0	0	0
0.03	0	100.0	0	0
0.03	0	100.0	0	0

x (µm)	Q3(x) (%)	1-Q3(x) (%)	q3(x) (%/µm)	p3(x) (%)
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