TEXTE
120/2024

Annex

HP 14 Classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German ‘Recommendations for the ecotoxicological characterization of wastes’

Sampling protocols

by:
Ralf Ketelhut
Stoffstromdesign, Neumünster

publisher:
German Environment Agency

German Environment Agency

Umwelt Bundesamt

TEXTE 120/2024

Ressortforschungsplan of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

Project No. (FKZ) 3721 34 305 0
FB001439/ANH,ENG

Annex

HP 14 Classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German ‘Recommendations for the ecotoxicological characterization of wastes’

Sampling protocols

by

Ralf Ketelhut

Stoffstromdesign, Neumünster

On behalf of the German Environment Agency

Imprint

Publisher
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
buergerservice@uba.de
Internet: www.umweltbundesamt.de

Report performed by:
ECT Oekotoxikologie GmbH
Böttgerstraße 2-14
65439 Flörsheim/Main
Germany

Report completed in:
May 2024

Edited by:
Section III 1.5
Mareike Röhreich

Publication as pdf:
http://www.umweltbundesamt.de/publikationen

ISSN 1862-4804

Dessau-Roßlau, August 2024

Table of content

List of figures

List of tables

1 Flue-gas dust (10 09 09*) from iron and steel casting: batch 1

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018)[1], requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 1: Sampling

Waste code	10 09 09* (Flue-gas dust containing hazardous substances)
Identification	Flue-gas dust from iron and steel casting: batch 1
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 July 2022, 10:00 a.m. to 10:20 a.m.
Weather conditions	Sunny, 19°C, 54% relative humidity
Relevant background for the sampled waste	Flue-gas dusts are mainly produced during the cleaning of furnace exhaust gases, process exhaust air from the waste sand treatment, casting part removal and post-processing and, to a small extent, exhaust air from the casting process as well as mould construction. They are generally removed from exhaust air with fabric filters. Dusts from the cleaning of furnace exhaust contain predominantly iron oxide, oxides of other metals used, ash of fuel, impurities adhering to the input material and unburnt aggregates.[2] Here: Kupolo oven dust, approx. 85% grey cast iron, approx. 15% lamellar casting. Generally, huge fluctuations in chemical analysis.
Sampling point	Foundry in western Germany
Material description	Very fine-grained, grey
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.

[1] All references are included in the reference list (section 8) of the main report.

[2] See information portal waste assessment, waste sheet 1009 iron and steel foundries (https://www.abfallbewertung.org)

Specific information	The intended separation into grey cast iron and lamellar cast iron could not be realised. Therefore, two batches were sampled: older material (storage period >4 weeks) and fresh material (storage period <4 weeks). Here: batch 1 (aged material, storage period >4 weeks)		
Batch size	A total of 7 big bags of approx. 1 m³ or 5 Mg (estimated)		
Mass flow	Not known		
Bulk density	ρ_B = 0.7 kg/dm³ (estimated)		
Raw density	ρ_R = 2.8 kg/dm³ (estimated)		
Particle dimension	d_{95} = 2 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.003 kg d_{95}: Nominal screen size of particles [cm], here 0.2 cm ρ_p: Particle density [g/cm³], here 2.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10%[a 3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples (CS):	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	≤2 mm	0.5 dm³	1 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 17	$M_{CS} = V_{CS} \bullet \rho_B$
	0.0002 dm³	0.004 dm³	0.003 kg
Type of sampling according to CEN/TR 15310-1	Systematic sampling. 14 individual samples were taken with a 50 mm sampling pipe from 7 big bags. Real sample: approx. 7.3 dm³, 5.1 kg		
Storage	None		
Transport at, start	None		
Sample preparation site	Foundry in western Germany		

[3] Fraction (proportion) of particles with a certain characteristic (the characteristic to be determined). Generally, p is not known in advance. In addition, p is different for each active component. Therefore, p is usually assumed to be 10%.

Figure 1: Photographic documentation for flue-gas dust (10 09 09*) from iron and steel casting: batch 1 (aged material, storage period >4 weeks)

Big bags with old material, recognizable by deposits and standing water on the big bags
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 2: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	14 July 2022, 10:20 a.m.
End	14 July 2022, 10:40 a.m.
Place of treatment	Foundry in western Germany
Weather conditions	Sunny, 20°C
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample.
Sieve curve for original material and approximate distribution	The particle size distribution is speculative. The total sample can be almost completely rubbed through the 4 mm sieve.

Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	5,125.0	99.99%	99.99%
<5 mm	0,8	0.01%	100.00%
Sample pretreatment	Small, possibly metallic contaminant particles are contained.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	5,126.8	100.0%
	Sample <4 mm	5,125.0	99.65%
	Oversized particles	0.8	0.015%
	Losses	1.0	0.020%
Storage	None		
Transport, start	14 July 2022, 12:15 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	15 July 2022, 8:30 a.m.		
Recipient	ECT Oekotoxikologie GmbH		

Figure 2: Photographic documentation for flue-gas dust (10 09 09*) from iron and steel casting: batch 1 (aged material, storage period >4 weeks)

Above: impurities >4 mm, bottom: material <4 mm after screening
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

2 Flue-gas dust (10 09 09*) from iron and steel casting: batch 2

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 3: Sampling

Waste code	10 09 09* (Flue-gas dust containing hazardous substances)
Identification	Flue-gas dust (10 09 09*) from iron and steel casting: batch 2
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 July 2022, 10:45 a.m. to 11:15 a.m.
Weather conditions	Sunny, 19°C, 54% relative humidity
Relevant background for the sampled waste	Flue-gas dusts are mainly produced during cleaning of furnace exhaust gases, process exhaust air from waste sand treatment, casting part removal and post-processing and, to a small extent, exhaust air from the casting process as well as mould construction. They are generally removed from exhaust air with fabric filters. Dusts from the cleaning of furnace exhaust contain predominantly iron oxide, oxides of the other metals used, ash of fuel, impurities adhering to the input material and unburnt aggregates.[4] Here: Kupolo oven dust, approx. 85% grey cast iron, approx. 15% lamellar cast iron. Generally, huge fluctuations in chemical analysis.
Sampling point	Foundry in western Germany.
Material description	Very fine-grained, grey
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.
Specific information	The intended separation into grey cast iron and lamellar cast iron could not be realised. Therefore, two batches were sampled: older material

[4] See information portal waste assessment, waste sheet 1009 iron and steel foundries (https://www.abfallbewertung.org)

	(storage period >4 weeks) and fresh material (storage period <4 weeks). Here: batch 2 (fresh material, storage period <4 weeks)		
Batch size	A total of 25 big bags of approx. 1 m^3 or 17.5 Mg (estimated)		
Mass flow	Not known		
Bulk density	ρ_B = 0.7 kg/dm^3 (estimated)		
Raw density	ρ_R = 2.8 kg/dm^3 (estimated)		
Particle dimension	d_{95} = 2 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.003 kg d_{95}: Nominal screen size of particles [cm], here 0.2 cm ρ_p: Particle density [g/cm^3], here 2.8 g/cm^3 g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	≤2 mm	0.5 dm^3	1 dm^3
Sample size according to CEN/TR 15310-1	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 17	$M_{CS} = V_{CS} \bullet \rho_B$
	0.0002 dm^3	0.0035 dm^3	0.0024 kg
Type of sampling according to CEN/TR 15310-1	Systematic sampling. 16 individual samples with a 50 mm sampling pipe distributed over 16 big bags. Weight of the individual sample approx. 0.410 kg Real sample: approx. 9.3 dm^3, 6.5 kg		
Storage	None		
Transport at, start	None		
Sample preparation site	Foundry in western Germany		

Figure 3: Photographic documentation for flue-gas dust (10 09 09*) from iron and steel casting: batch 2 (fresh material, storage period <4 weeks)

Big bags with fresh material
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 4: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	14 July 2022, 11:20 a.m.		
End	14 July 2022, 11:45 a.m.		
Place of treatment	Foundry in western Germany		
Weather conditions	Sunny, 20°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample.		
Sieve curve original material and approximate distribution	The particle size distribution is speculative. The total sample can be almost completely rubbed through the 4 mm sieve.		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	6,527.0	99.99%	99.99%
<5 mm	0.8	0.01%	100.00%
Sample pretreatment	The sample contains small, possibly metallic contaminant particles.		

Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	6,529.8	100.0%
	Sample <4 mm	6,527.0	99.97%
	Oversized particles	0.81	0.013%
	Losses	1.1	0.017%
Storage	None		
Transport	14 July 2022, from 12:15 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	15 July 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 4: Photographic documentation for flue-gas dust (10 09 09*) from iron and steel casting: batch 2 (fresh material, storage period <4 weeks)

Above: impurities >4 mm, bottom: material <4 mm after screening
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

3 Flue-gas dust (10 09 10) from iron and steel casting: plant A

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 5: Sampling

Waste code	10 09 10 (Flue-gas dust other than those mentioned in 10 09 09
Identification	Flue-gas dust from iron and steel casting: plant A
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 June 2022, 10:00 a.m. to 10:20 a.m.
Weather conditions	Sunny, 17°C, 60% relative humidity
Relevant background for the sampled waste	Flue-gas dusts are mainly produced during the cleaning of furnace exhaust gases, process exhaust air from waste sand treatment, casting part removal and post-processing and, to a small extent, exhaust air from casting process as well as mould construction. They are generally removed from exhaust air with fabric filters. Dusts from cleaning of furnace exhaust contain predominantly iron oxide, oxides of other metals used, ash of fuel, impurities adhering to the input material and unburnt aggregates.[5]
Sampling point	Reserve area of the Cröbern Central Landfill in Saxony. Deferred, opened big bag (approx. 1 m^3) from one delivery.
Material description	Very fine-grained
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.
Specific information	Very small batch size (deferral of one big bag)
Batch size	Piles of 1 m^3 or 1.3 Mg (estimated)

[5] See information portal waste assessment, waste sheet 1009 iron and steel foundries (https://www.abfallbewertung.org)

Mass flow	Not known		
Bulk density	ρ_B = 1.3 kg/dm³ (estimated)		
Raw density	ρ_R = 2.8 kg/dm³ (estimated)		
Particle dimension	d_{95} = 2 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.003 kg d_{95}: Nominal screen size of particles [cm], here 0.2 cm ρ_p: Particle density [g/cm³], here 2.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	≤2 mm	0.5 dm³	1 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.0002 dm³	0.002 dm³	0.003 kg
Type of sampling according to CEN/TR 15310-1	Simple random sampling. 40 Individual samples with a 50 mm sampling pipe were taken, distributed over the total sample. Real sample: approx. 3.9 dm³, 5.0 kg.		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	14 June 2022, 10:20 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Arrival at the sample preparation site	14 June 2022, 10:40 a.m.		

Figure 5: Photographic documentation for flue-gas dust (10 09 10) from iron and steel casting: plant A

Above: deferred big bag with marking, below: detail

Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 6: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	14 June 2022, 10:30 a.m.		
End	14 June 2022, 11:15 a.m.		
Place of treatment	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Weather conditions	Sunny, 20°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample.		
Sieve curve original material and approximate distribution	The particle size distribution is speculative. The total sample was completely rubbed through the 4 mm sieve.		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	5,000.0	100.0%	100.0%
Sample pretreatment	No interfering material contained.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	5,000.0	100.0%
	Sample <4 mm	4,983.0	99.7%
	Oversized particles	0.0	0.0%
	Losses	17.0	0.3%
Storage	None		
Transport	14 June 2022, from 12:15 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	15 June 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 6: Photographic documentation for flue-gas dust (10 09 10) from iron and steel casting: plant A

Material <4 mm after screening
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

4 Flue-gas dust (10 09 10) from iron and steel casting: plant B

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 7: Sampling

Waste code	10 09 10 (Flue-gas dust other than those mentioned in 10 09 09)
Identification	Flue-gas dust from iron and steel casting: plant B
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	19 October 2022, 1:10 to 2:00 p.m.
Weather conditions	Clouded, 6°C, 80% relative humidity
Relevant background for the sampled waste	Flue-gas dusts are mainly produced during cleaning of furnace exhaust gases, process exhaust air from waste sand treatment, casting part removal and post-processing and, to a small extent, exhaust air from the casting process as well as mould construction. They are generally removed from exhaust air with fabric filters. Dusts from the cleaning of furnace exhaust contain predominantly iron oxide, oxides of other metals used, ash of fuel, impurities adhering to the input material and unburnt aggregates.[6]
Sampling point	Reserve area of the Cröbern Central Landfill in Saxony. Deferred batch from a delivery of 21 big bags.
Material description	Very fine, dark, slightly greasy
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.
Specific information	None
Batch size	A total of 21 big bags of 1 m^3 or 32.5 Mg (estimated)

[6] See information portal waste assessment, waste sheet 1009 iron and steel foundries (https://www.abfallbewertung.org)

Mass flow	Not known		
Bulk density	ρ_B = 1.3 kg/dm³ (estimated)		
Raw density	ρ_R = 2.8 kg/dm³ (estimated)		
Particle dimension	d_{95} = 2 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.003 kg d_{95}: Nominal screen size of particles [cm], here 0.2 cm ρ_p: Particle density [g/cm³], here 2.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	≤2 mm	0.5 dm³	1 dm³
Sample size according to CEN/TR 15310-1	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.0002 dm³	0.002 dm³	0.003 kg
Type of sampling according to CEN/TR 15310-1	Stratified random sampling. 16 individual samples with a 50 mm sampling pipe distributed over 16 of the 21 big bags. Total composite sample approx. 6.3 kg		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	19 October 2022, 1:45 p.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Arrival at the sample preparation site	19 October 2022, 2:00 p.m.		

Figure 7: Photographic documentation for flue-gas dust (10 09 10) from iron and steel casting: plant B

Deferred big bags with marking, below: detail of a single sampling
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 8: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	19 October 2022, 2:00 p.m.		
End	19 October 2022, 2:30 p.m.		
Place of treatment	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Weather conditions	Clouded, 7°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample.		
Sieve curve original material and approximate distribution	The particle size distribution is speculative. The total sample can be completely rubbed through the 4 mm sieve.		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	6,309.0	100.0%	100.0%
Sample pretreatment	No interfering materials contained.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	6,337.0	100.0%
	Sample <4 mm	6,309.0	99.6%
	Oversized particles	0.0	0.0%
	Losses	28.0	0.4%
Storage	None		
Transport	19 October 2022, from 4:15 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	20 October 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 8: Photographic documentation for flue-gas dust (10 09 10) from iron and steel casting: plants B

Material <4 mm after screening
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

5 Soil and stones (17 05 03*): excavated geogenic material

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 9: Sampling

Waste code	17 05 03* (Soil and stones containing hazardous substances)
Identification	Excavated geogenic material
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 June 2022, 10:20 to 10:50 a.m.
Weather conditions	Sunny, 17°C, 60% relative humidity
Relevant background for the sampled waste	The excavated geogenic material originates from an open-cast lignite mine. The material has a pH in the acidic range. In the past, it was shown to contain increased levels of nickel. Since the pH of waste has proven to be a relevant parameter with regard to effects in bioassays, the geogenic material appeared of interest for the present study.
Sampling point	Reserve area of the Cröbern Central Landfill in Saxony. Between stockpiles of approx. 30 m³ from a very large population.
Material description	Soil material without vegetation
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low
Specific information	Experience has shown that pH is between 2 and 3
Batch size	Pile of 30 m³ or 36 Mg (estimated)
Mass flow	Not known
Bulk density	ρ_B = 1.2 kg/dm³ (estimated)
Raw density	ρ_R = 1.8 kg/dm³ (estimated)
Particle dimension	d_{95} = 20 mm (estimated)

Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 1.7 kg d_{95}: Nominal screen size of particles [cm], here 2 cm ρ_p: Particle density [g/cm³], here 1.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to ≤20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 7	$M_{CS} = V_{CS} \bullet \rho_B$
	0.22 dm³	1.4 dm³	1.7 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). No wheel loader available. The pile indicates sufficient mixing during the accumulation process. 20 Individual samples were taken with a 100 mm piercing tube. Real sample: 3.9 dm³, 4.7 kg		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	14 June 2022, 10:30 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Arrival at the sample preparation site	14 June 2022, 10:40 a.m.		

Figure 9: Photographic documentation for excavated geogenic material (17 05 03)

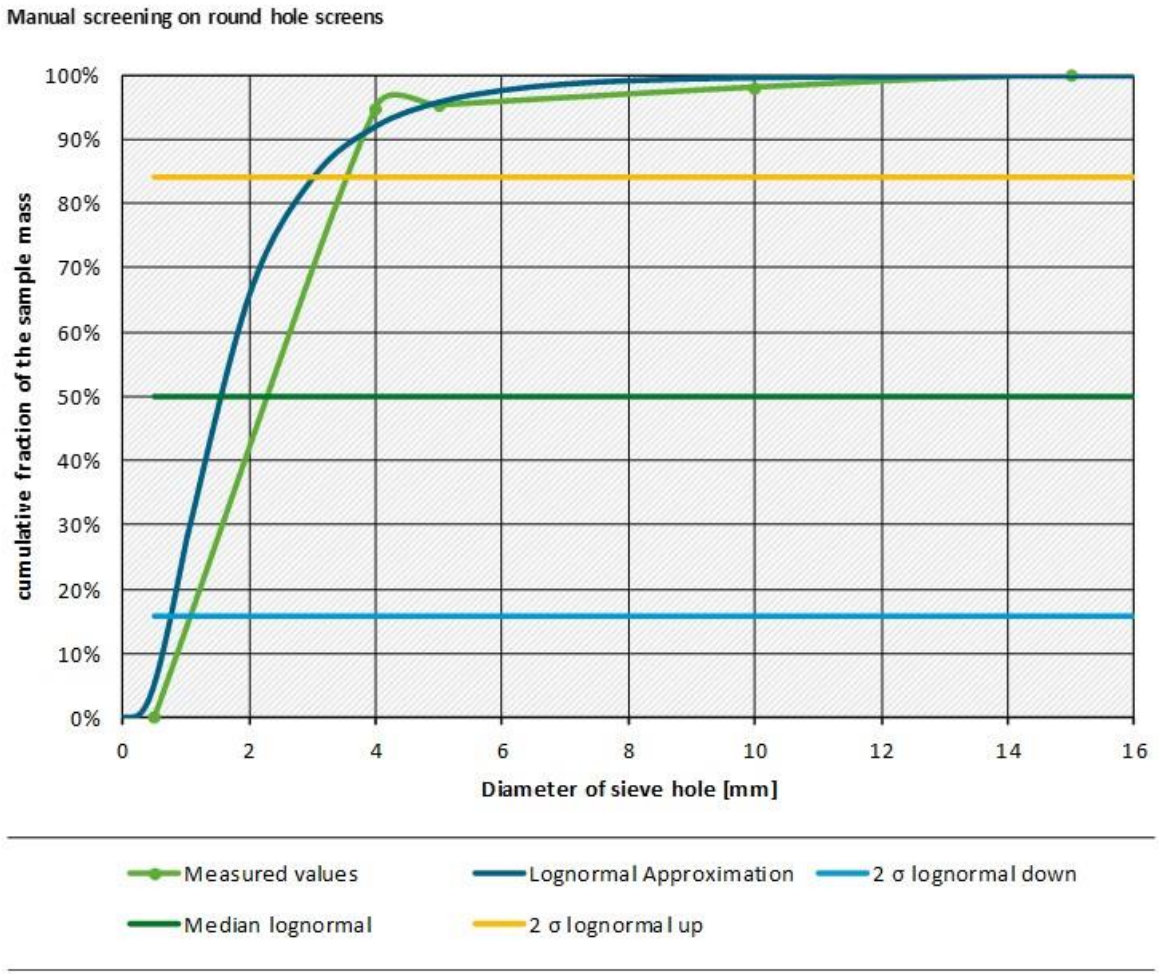
Deferred heap with marking, right: detail
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 10: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	14 June 2022, 11:15 a.m.		
End	14 June 2022, 12:00 a.m.		
Place of treatment	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Weather conditions	Sunny, 20°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample. Oversized particles and interfering material were separated, as no jaw crusher was available on site.		
Sieve curve original material and approximate distribution	The particle size of the soil is approximately lognormally distributed. The median is approx. 1.5 mm. The d_{95} is approx. 4 mm (see also Figure 10).		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	4.310,0	94.7%	94.7%
<5 mm	22,0	0.5%	95.2%
<10 mm	126,0	2.8%	98.0%
<15 mm	92,0	2.0%	100.0%
Sample pretreatment	It can be expected that some drying of the material will take place. No interfering materials contained.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	4,700.0	100.0%
	Sample <4 mm	4,310.0	91.7%
	Oversized particles	240.0	5.1%
	Losses	150.0	3.2%
Storage	None		

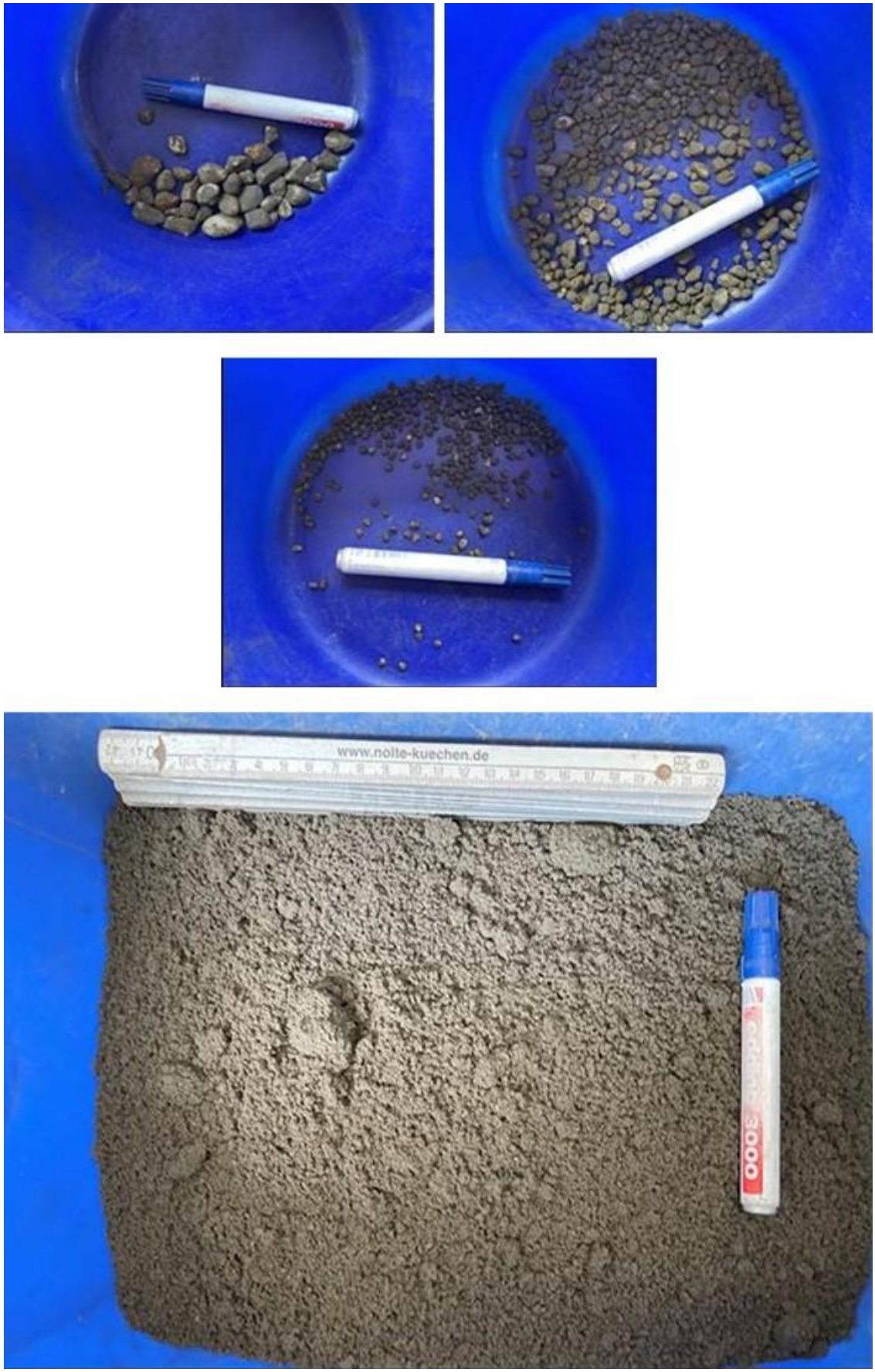
Beginning	14 June 2022, 11:15 a.m.
Transport	14 June 2022, from 12:15 p.m.
Transport container	PE bag in cooled 60-liter PP barrel in a car
Transport by	Ralf Ketelhut
Handover	15 June 2022, 8:30 a.m.
Recipients	ECT Oekotoxikologie GmbH

Figure 10: Sieve curve for excavated geogenic material (17 05 03*)



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 11: Photographic documentation for excavated geogenic material (17 05 03)



Top left: >15 mm; top right: >10 mm, center: >4/<5 mm, bottom: <4 mm

Source: own illustration, Ralf Ketelhut, Stoffstromdesign

6 Soil and stones (17 05 03*): material from the side verges of a federal road

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 11: Sampling

Waste code	17 05 03* (Soil and stones containing hazardous substances)
Identification	Material from the side verges of a federal road
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	19 October 2022, 7:20 a.m. to 7:35 a.m.
Weather conditions	Cloudy, 6°C, 80% relative humidity
Relevant background for the sampled waste	In the side verge area, impurities and deposits from vegetation residues and road dirt accumulate. Depending on the traffic volume, direct material input from traffic emissions as well as abrasion of tires, roadways and brakes are to be expected. In addition, road salt residues may be relevant. The side verge is periodically peeled off at a width of about 80 cm with a layer thickness of 3-10 cm approximately every 3-8 years. Here, the removal was carried out on both sides of a busy federal road to prepare for the use of an asphalt milling machine.
Sampling point	Storage space for excavated side verge material in northern Germany. Intermediate stockpile of approx. 45 m³ from a main unit of approximately 1,000 m³ over a period of several months.
Material description	Older floor material with significant vegetation cover
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.
Specific information	The material is classified as Z2 according to LAGA soil analysis. This means that the material may only be disposed of or installed to a limited extent. Reasons for classification according to LAGA and for classification as hazardous are not known.

Batch size	Pile of 45 m³ or 40 Mg (estimated)		
Mass flow	None		
Bulk density	ρ_B = 0.92 kg/dm³ (estimated)		
Raw density	ρ_R = 1.8 kg/dm³ (estimated)		
Particle dimension	d_{95} = 20 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 1.7 kg d_{95}: Nominal screen size of particles [cm], here 2 cm ρ_p: Particle density [g/cm³], here 1.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	12	3	3
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to ≤20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.22 dm³	1.8 dm³	1.7 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). No wheel loader available. The pile indicates a sufficient mixing by accumulation. Since it is a guarded heap, superficial influence by erosion can be expected. Therefore, approximately 10 cm of surface material is taken and then 20 individual samples are taken with a 100 mm piercing tube. Real sample: approx. 15.4 dm³, 14.2 kg.		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	19 October 2022, 7:40 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Arrival at the sample preparation site	19 October 2022, 2:00 p.m.		

Figure 12: Photographic documentation for material from the side verges of a federal road (17 05 03*)

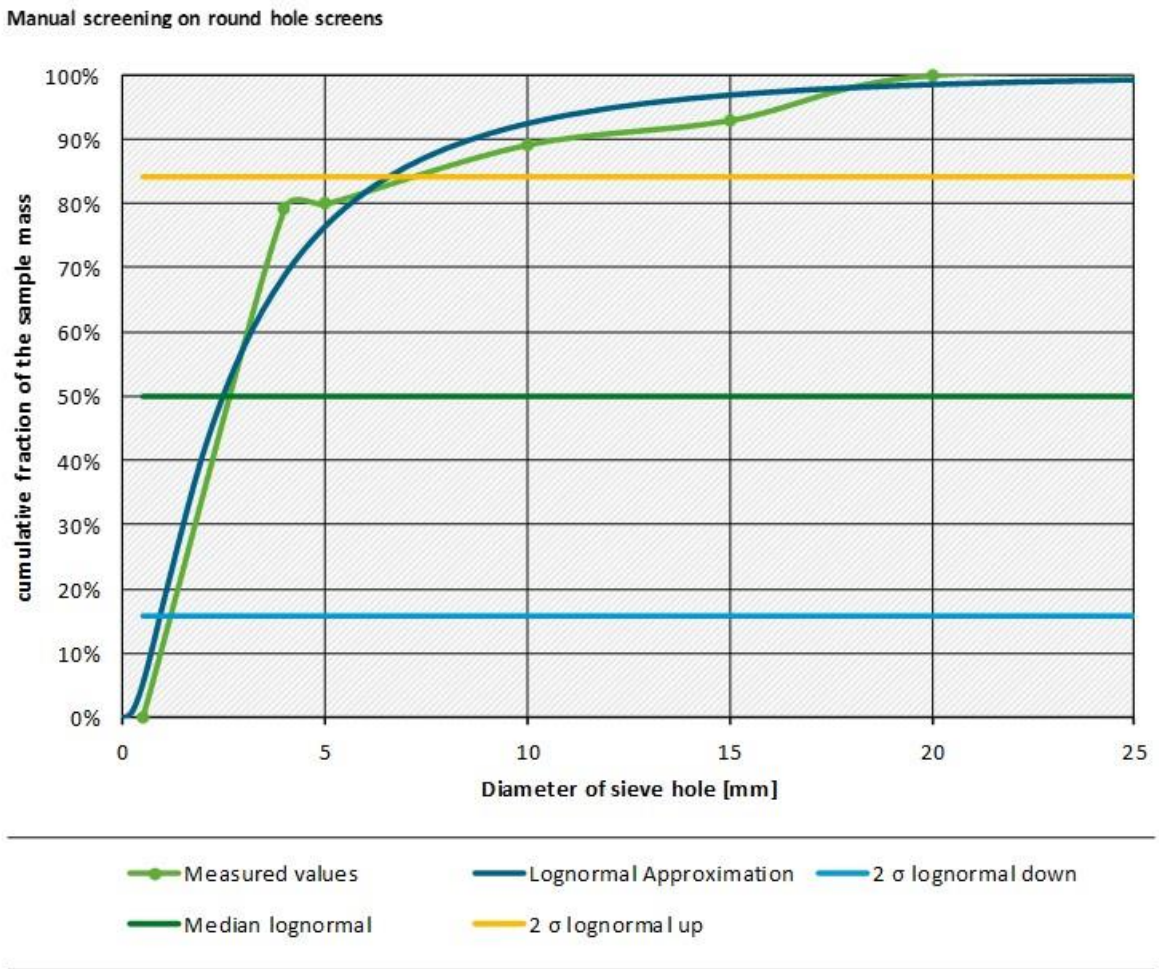
Left: heap with vertical breakline, right: detail of the breakline
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 12: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	19 October 2022, 2:30 p.m.		
End	19 October 2022, 4:00 p.m.		
Place of treatment	Westsächsische Entsorgungs- und Verwertungsgesellschaft mbH, Cröbern		
Weather conditions	Clouded, 10°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Screen cut <4 mm round-hole sieve represents the laboratory sample. Oversized particles and interfering material were removed, as no jaw crusher was available on site.		
Sieve curve original material and approximate distribution	The particle size of the soil is approximately lognormally distributed. The median is approx. 3 mm. The d_{95} is approx. 18 mm (see also Figure 14).		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	11,210	79.2%	79.3%
<5 mm	93	0.7%	79.9%
<10 mm	1,307	9.2%	89.1%
<15 mm	540	3.8%	93.0%
<20 mm	995	7.0%	100.0%
Sample pretreatment	It can be expected that some drying of the material will take place. No metallic material is included. As contaminants, there are few organic plant parts. There are larger amounts of clay particles that escape hand screening by agglomeration. They are separated as oversized particles. The proportion of clay in the separated material >10 mm is 84%. Whether and to what extent is found in the sample material <4 mm clay is unknown.		

Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	14,203.0	100.0%
	Sample <4 mm	11,210.0	78.9%
	Biogenic material	10.0	0.1%
	Oversized particles	2,925.0	20.6%
	Losses	58.0	0.4%
Storage	None		
Transport	19 October 2022, from 4:30 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	20 October 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 13: Sieve curve for material from the side verges of a federal road (17 05 03*)



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 14: Photographic documentation for material from the side verges of a federal road (17 05 03)

Top left: >10 mm; top right: >5/<10 mm, center left: >4/<5 mm, center right: impurities, below: <4 mm
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

7 Soil and stones (17 05 04): material from the side verges of a secondary road

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 13: Sampling

Waste code	17 05 04 (Soils and stones other than those mentioned in 17 05 03)
Identification	Material from the side verges of a secondary road
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	17 May 2022, 7:05 a.m. to 7:30 a.m.
Weather conditions	Light rain, 13°C, 60% relative humidity
Relevant background for the sampled waste	In the side verge area, impurities and deposits from vegetation residues and road dirt accumulate. Depending on the traffic volume, direct material input from traffic emissions as well as abrasion of tires, roadways and brakes are to be expected. In addition, road salt residues may be relevant. The side verge is periodically peeled off at a width of about 80 cm with a layer thickness of 3-10 cm approximately every 3-8 years. Here the removal was carried out on both sides of a district road to prepare for the use of an asphalt milling machine.
Sampling point	Storage space for excavated side verge material in northern Germany. Intermediate stockpile of approx. 100 m^3 from a main unit of about 400 m^3 over a period of several weeks.
Material description	The heap has a limited vegetation cover.
Variability	No specific spatial heterogeneity to be expected, large number of small influences, particulate heterogeneity rather low.
Specific information	The material is classified as Z2, but not hazardous, according to LAGA soil analysis. This means that the material may only be disposed of or installed to a limited extent. The reasons for the classification according to LAGA are PAKs according to the information provided by the waste producer.

Batch size	Pile of 100 m³ or 92 Mg (estimated)		
Mass flow	None		
Bulk density	ρ_B = 0.92 kg/dm³ (estimated)		
Raw density	ρ_R = 1.8 kg/dm³ (estimated)		
Particle dimension	d_{95} = 20 mm (estimated)		
Particle type	Grainy		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 1.7 kg d_{95}: Nominal screen size of particles [cm], here 2 cm ρ_p: Particle density [g/cm³], here 1.8 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	16	4	4
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to ≤20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.22 dm³	1.8 dm³	1.7 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). No wheel loader available. The pile indicates a sufficient mixing by accumulation. Since it is an overgrown heap, superficial influence due to erosion can be expected. Therefore, approximately 10 cm of surface material is taken away and 16 individual samples are taken with a 50 mm piercing tube. Real sample: 16.6 dm³, 15.3 kg		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	17 May 2022, 7:30 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	CTL Luers, Bremen		
Arrival at the sample preparation site	17 May 2022, 2:00 p.m.		

Figure 15: Photographic documentation for material from the side verges of a secondary road (17 05 04)

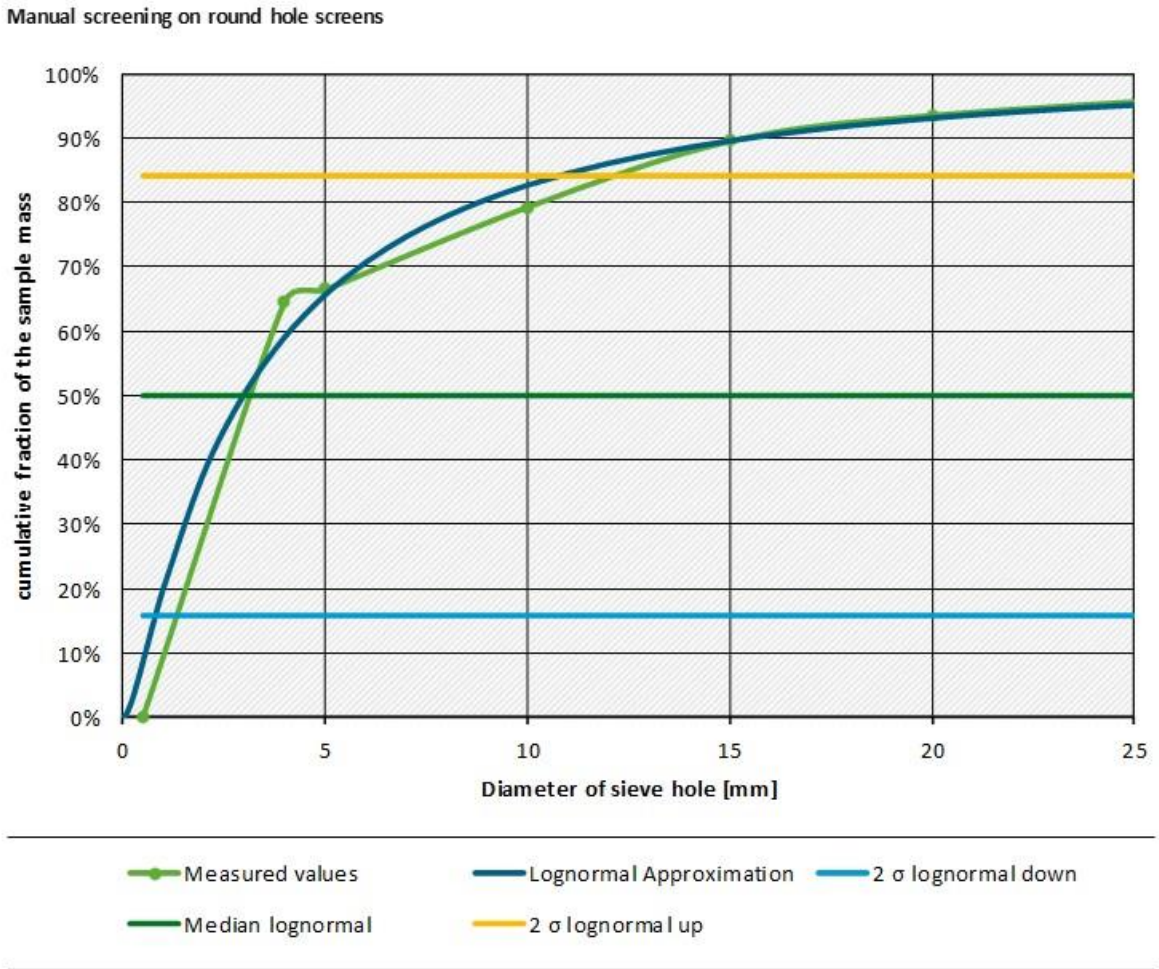
Sampled piles from two different perspectives
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 14: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	17 May 2022, 2:20 p.m.		
End	17 May 2022, 4:20 p.m.		
Place of treatment	CTL Luers, Bremen		
Weather conditions	Clouded, 17°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Sieve opening <4 mm round-hole screen. Oversized particles were repeatedly broken using a jaw crusher (Retsch type BB 1A). Interfering material was removed.		
Sieve curve original material and approximate distribution	The particle size of the soil is approximately lognormally distributed. The median is approx. 3 mm. The d_{95} is approx. 25 mm (see also Figure 16).		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	9,570.0	64.6%	64.6%
<5 mm	282.0	1.9%	66.5%
<10 mm	1,901.8	12.8%	79.3%
<15 mm	1,517.9	10.2%	89.6%
<20 mm	594.8	4.0%	93.6%
<30 mm	567.0	3.8%	97.4%
<40 mm	386.3	2.6%	100.0%
Sample pretreatment	It can be expected that some drying of the material will take place. The sample does not include metallic material. As contaminants, there are few organic plant parts.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	15,260.0	100.0%

Beginning	17 May 2022, 2:20 p.m.		
	Sample <4 mm	14,780.0	96.9%
	Biogenic material	12.6	0.1%
	Losses	467.4	3.1%
Storage	None		
Transport	17 May 2022, from 4:30 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	18 May 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 16: Sieve curve for material from the side verges of a secondary road (17 05 04)



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 17: Photographic documentation for material from the side verges of a secondary road (17 05 04)

Top left: >20 mm, top right: >10 mm, center left: >4 mm, center right: impurities, below: sample <4 mm
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

8 Fluff-light fraction and dust (19 10 04): material (sieved to <10 mm) from plant A, batch 1

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 15: Sampling

Waste code	19 10 04 (Fluff-light fraction and dust other than those mentioned in 19 10 03)
Identification	Fluff-light fraction (material sieved to <10 mm) from plant A, batch 1
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	17 May 2022, 9:30 a.m. to 10:30 a.m.
Weather conditions	Cloudy, light rain, 14°C, 60% relative humidity
Relevant background for the sampled waste	Fluff-light fractions are considered an extreme example of heterogeneous waste material. In modern plants, material recycling is significantly improved by automated sorting technology. This results in waste with a d_{95} ≤10 mm.
Sampling point	Premises of a metal recycler in Germany
Material description	Continuously occurring material (<10 mm) from processing of fluff-light fractions from Fe metals processing. Heterogeneous mixture of metal, mineral, biogenic and synthetic materials.
Variability	Temporal-spatial heterogeneity is possible. Particular heterogeneity is very high but reduced by sieving.
Specific information	The sample covers an operating time of about 2 h. It has, therefore, random sample characteristics.
Batch size	Collection containers with a filling of 20 m^3 or 12 Mg (estimated)
Mass flow	Not known
Bulk density	ρ_B = 0.6 kg/dm^3 (estimated)

Raw density	ρ_R = 1.2 kg/dm³ (estimated)		
Particle dimension	d_{95} = 15 mm (estimated)		
Particle type	Heterogeneous		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.5 kg d_{95}: Nominal screen size of particles [cm], here 1.5 cm ρ_p: Particle density [g/cm³], here 1.2 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to 20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.09 dm³	0.8 dm³	0.5 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). Sampling of 4 subsamples of approx. 50 dm³ with grabbed excavator. Mixing and spreading. Collection of 30 individual samples of approx. 0.4 dm³ (0.25 kg) with a 50 mm piercing tube. Real sample approx. 12 dm³, 7.2 kg		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	17 May 2022, 10:30 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	CTL Luers, Bremen		
Arrival at the sample preparation site	17 May 2022, 2:00 p.m.		

Figure 18: Photographic documentation for fluff-light fraction from plant A, batch 1 (19 10 04)

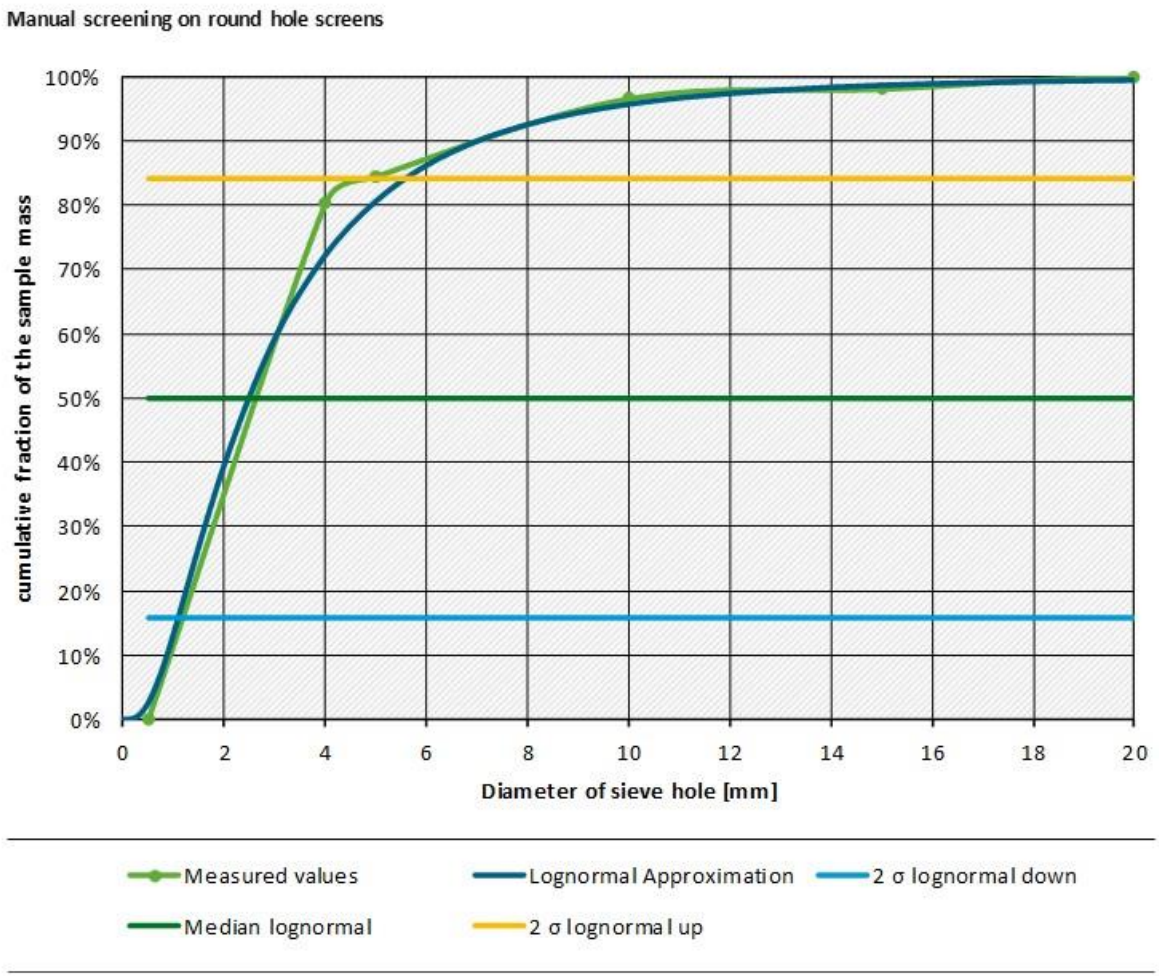
Original material before sample pretreatment
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 16: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	17 May 2022, 4:30 p.m.		
End	17 May 2022, 5:45 p.m.		
Place of treatment	CTL Luers, Bremen		
Weather conditions	Clouded, 17°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Jaw crushers and cutters were available, but not suitable for the material.		
Sieve curve original material and approximate distribution	The particle size of the material is approximately lognormally distributed. The median is approx. 2.5 mm. The d_{95} is approx. 9 mm (see also Figure 19).		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	5,700.0	80.4%	80.4%
<5 mm	293.0	4.1%	84.5%
<10 mm	860.7	12.1%	96.6%
<15 mm	105.5	1.5%	98.1%
<20 mm	132.1	1.9%	100.0%
Sample pretreatment	No shredding of the oversized particles. The material is fibrous and fluffy, so that – within the time available – shredding is not feasible. Material >4 mm is discarded as oversized particles.		

Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	7,160.0	100.0%
	Sample <4 mm	5,700.0	79.6%
	Impurities	60.0	0.8%
	Oversized particles >4 mm	1,391.3	19.4%
	Losses	8.7	0.1%
Storage	None		
Transport	17 May 2022, from 5:45 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	18 May 2022, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 19: Sieve curve for fluff-light fraction (19 10 04) from plant A, batch 1



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 20: Photographic documentation for fluff-light fraction (19 10 04) from plant A, batch 1

Top left: >20 mm, top right: >15 mm, center left: 10 mm, center right: 4 mm, bottom left: impurities, lower right: sample <4 mm

Source: own illustration, Ralf Ketelhut, Stoffstromdesign

9 Fluff-light fraction and dust (19 10 04): material (sieved to <10 mm) from plant A, batch 2

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 17: Sampling

Waste code	19 10 04 (Fluff-light fraction and dust other than those mentioned in 19 10 03)
Identification	Fluff-light fraction (material sieved to <10 mm) from plant A, batch 2
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 February 2023, 8:30 a.m. to 8:45 a.m.
Weather conditions	Cloudy, 3°C, 80% relative humidity
Relevant background for the sampled waste	Fluff-light fractions are considered an extreme example of heterogeneous waste material. In modern plants, material recycling is significantly improved by automated sorting technology. This results in waste with a d_{95} ≤10 mm.
Sampling point	Premises of a metal recycler in Germany
Material description	Continuous removal from fluff-light fraction and dust from the processing of Fe metals. Heterogeneous mixture of metals, minerals, biogenic and synthetic materials.
Variability	A temporal-spatial heterogeneity is possible. The partial heterogeneity is very high but is reduced by the sieve opening.
Specific information	The sample covers an operating time of about 2 hours. It has, therefore, random sample characteristics.
Batch size	Collection containers with a filling of 12 m^3 or 7.2 mg (estimated)
Mass flow	Not known
Bulk density	ρ_B = 0.6 kg/dm^3 (estimated)

Raw density	ρ_R = 1.2 kg/dm³ (estimated)		
Particle dimension	d_{95} = 10 mm (estimated from preliminary investigation batch 1)		
Particle type	heterogeneous		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.14 kg d_{95}: Nominal screen size of particles [cm], here 1 cm ρ_p: Particle density [g/cm³], here 1.2 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	8	2	2
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to ≤20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 9	$M_{CS} = V_{CS} \bullet \rho_B$
	0.03 dm³	0.24 dm³	0.14 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). Sampling of 12 individual samples of approx. 1 dm³ (0.6 kg) with a shovel from the container. Real sample: approx. 12 dm³, 7.3 kg.		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	14 February 2023, 8:45 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Wookerkamp 61, 24536 Neumünster		
Arrival at the sample preparation site	17 May 2022, 12:00		

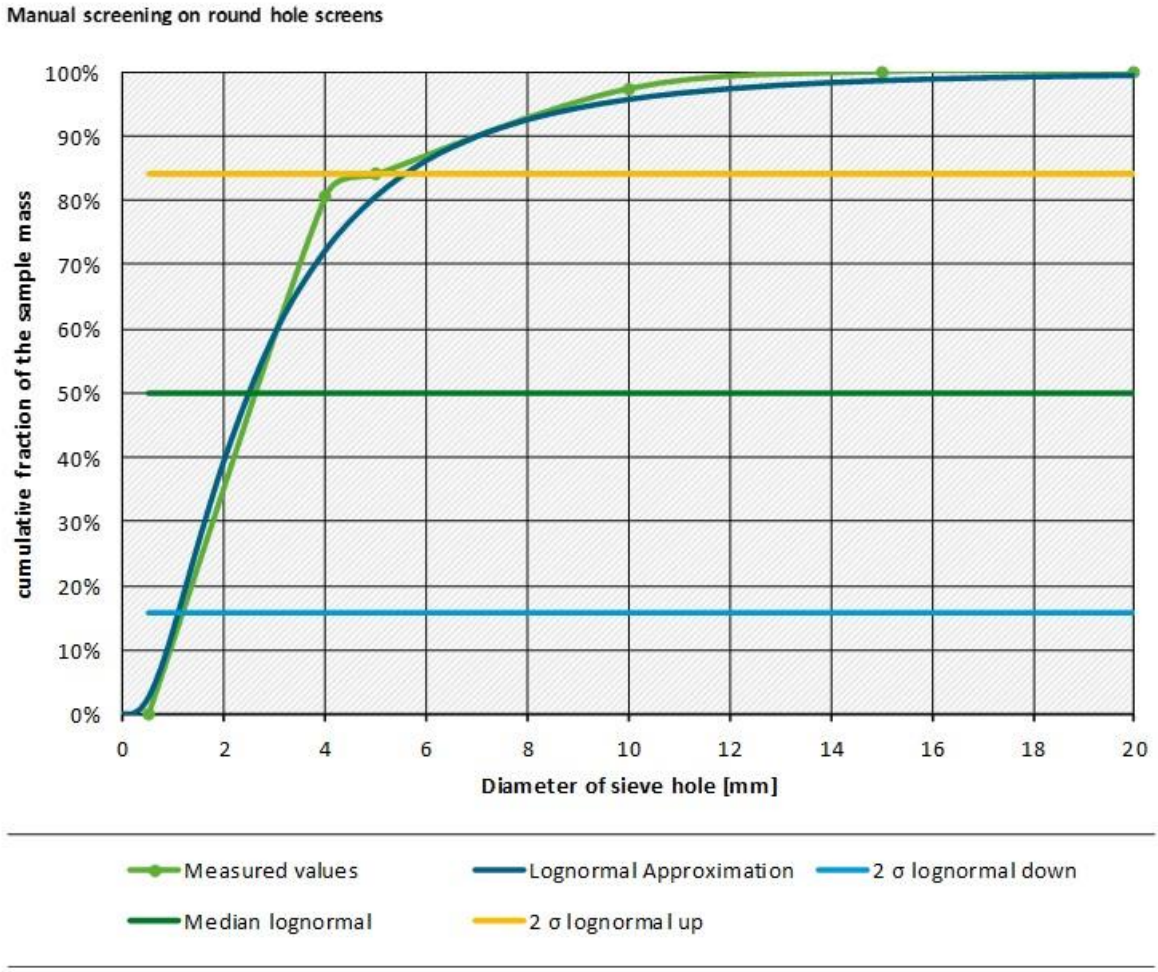
Figure 21: Photographic documentation for fluff-light fraction from plant A, batch 2 (19 10 04)

Original material before sample pretreatment, above: in the container, below: detail of the sample
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 18: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

Beginning	14 February 2023, 1:00 p.m.		
End	14 February 2023, 1:45 p.m.		
Place of treatment	Ralf Ketelhut, Wookerkamp 61, 24536 Neumünster		
Weather conditions	Cloudy, 4°C		
Sample preparation	Sieve curve made using original material and hand screening on round-hole screens. Sieve opening <4 mm round-hole screen. Removal of oversized particles and interfering material.		
Sieve curve original material and approximate distribution	The particle size of the material is approximately lognormally distributed. The median is approx. 2.3 mm. The d_{95} is approx. 8 mm (see also Figure 22).		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	5.828,0	80.6%	80.6%
<5 mm	245,0	3.4%	84.0%
<10 mm	866,5	13.4%	97.4%
<15 mm	191,0	2.6%	100.0%
Sample pretreatment	No shredding of the oversized particles. The material is fibrous and fluffy, so that – within the time available – shredding is not feasible. Material >4 mm is discarded as oversized particles.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	7.258,0	100.0%
	Sample <4 mm	5.828,0	80.3%
	Impurities	0,0	0.0%
	Oversized particles >4 mm	1.402,5	19.3%
	Losses	27,5	0.4%
Storage	None		
Transport	14 February 2023, from 2:00 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	15 February 2023, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 22: Sieve curve for fluff-light fraction from plant A, batch 2 (19 10 04)



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 23: Photographic documentation for fluff-light fraction from plant A, batch 2 (19 10 04)

Top left: >10 mm, top right: >5 mm, center left: >4 mm, bottom: sample <4 mm

Source: own illustration, Ralf Ketelhut, Stoffstromdesign

10 Fluff-light fraction and dust (19 10 04): material (sieved to <10 mm) from plant B

In accordance with the requirements of European standardisation in the framework of CEN/TC 292 (characterization of waste), careful sampling planning is required for the sampling of waste for physical, chemical or ecotoxicological characterization. This accompanying protocol on sampling and sample preparation is based on data provided by the waste owner and the sampler's assessments in the light of the recommendations of the 'Commission notice on technical guidance on the classification of waste' (EU 2018), requirements of CEN/TR 15310-1 (2006a), DIN EN 14735 (2022), LAGA PN 98 (2019), and the 'Recommendations for the ecotoxicological characterization of wastes' of the UBA (2013).

Table 19: Sampling

Waste code	19 10 04 (Fluff-light fraction and dust other than those mentioned in 19 10 03)
Identification	Fluff-light fraction (material sieved to <10 mm) from plant B
Sponsor	German Environment Agency/ECT Oekotoxikologie GmbH
Project	HP 14 classification of mirror entries in the List of Wastes – elaboration of proposals for further developing the German 'Recommendations for the ecotoxicological characterization of wastes'
Overall objective	Collection of a probabilistic sample and preparation for ecotoxicological testing
Waste owner	Is known to the sampler
Project management	ECT Oekotoxikologie GmbH
Sampler	Ralf Ketelhut Stoffstromdesign
Sampling date, time	14 February 2023, 10:40 a.m. to 11:00 a.m.
Weather conditions	Cloudy, 4°C, 80% relative humidity
Background to the waste sample	Fluff-light fractions are considered an extreme example of heterogeneous waste material. In modern plants, material recycling is significantly improved by automated sorting technology. This results in waste with a d_{95} ≤10 mm.
Sampling point	Premises of a metal recycler in Germany
Material description	Discontinuous removal from the processing of fluff-light fraction and dust from the processing of Fe metals. Heterogeneous mixture of metallic, mineral, biogenic and synthetic materials.
Variability	A temporal-spatial heterogeneity is possible but reduced by sieving. The partial heterogeneity is very high but is also reduced by sieving.
Specific information	The material is produced by discontinuous screening with a mobile rotary screen.
Batch size	Collection pile of approx. 100 m³ or 80 mg (estimated)
Mass flow	Not known
Bulk density	ρ_B = 0.8 kg/dm³ (estimated)

Raw density	ρ_R = 1.2 kg/dm³ (estimated)		
Particle dimension	d_{95} = 10 mm (estimated)		
Particle type	Heterogeneous		
Minimum sample mass according to CEN/TC 292 CEN/TR 15310-1, Annex D	The European working group on the characterization of waste (CEN/TC 292) states that an estimate of the minimum sample size can be obtained according to the equation indicated in Figure 13 of the report. The calculation was performed using the following values: M_{SAM}: Minimum sample size [kg], here: M_{SAM} = 0.14 kg d_{95}: Nominal screen size of particles [cm], here 1 cm ρ_p: Particle density [g/cm³], here 1.2 g/cm³ g: Correction factor for particle size, here g = 0.25, since d_{95}/d_{05} >4 p: Fraction of particles with a certain characteristic, if not known, then p = 10% [3] CV: Coefficient of variation, if not known, then CV = 10%		
Sample numbers according to LAGA PN 98	Number of individual samples (RS):	Number of composite samples:	Number of laboratory samples (LS):
	16	4	4
Minimum sample size according to LAGA PN 98	d_{95}:	Volume of RS:	Volume of LS:
	>2 to ≤20 mm	1 dm³	2 dm³
	No sample size reduction of the composite samples to laboratory samples was made to avoid increasing the variance of the samples. The sample mass was increased to obtain sufficient material.		
Sample size according to CEN/TR 15310-1	$V_{RS} = (3 \bullet d_{95})^3$	V_{CS} = (number of RS • V_{RS}) Number of RS: 7	$M_{CS} = V_{CS} \bullet \rho_B$
	0.02 dm³	0.18 dm³	0.14 kg
Type of sampling according to CEN/TR 15310-1	Restricted random sampling (*judgmental sampling 1*). Sampling of 16 individual samples of approx. 0.4 dm³ (0.3 kg) sampling pipe 50 mm. Real sample: approx. 6.6 dm³, 5.3 kg.		
Storage	Transfer to PE bag and then cooled 60-liter PP barrel with clamping ring closure.		
Transport at, start	14 February 2023, 11:00 a.m.		
Transport by	Ralf Ketelhut		
Sample preparation site	Wookerkamp 61, 24536 Neumünster		
Arrival at the sample preparation site	17 May 2022, 12:00		

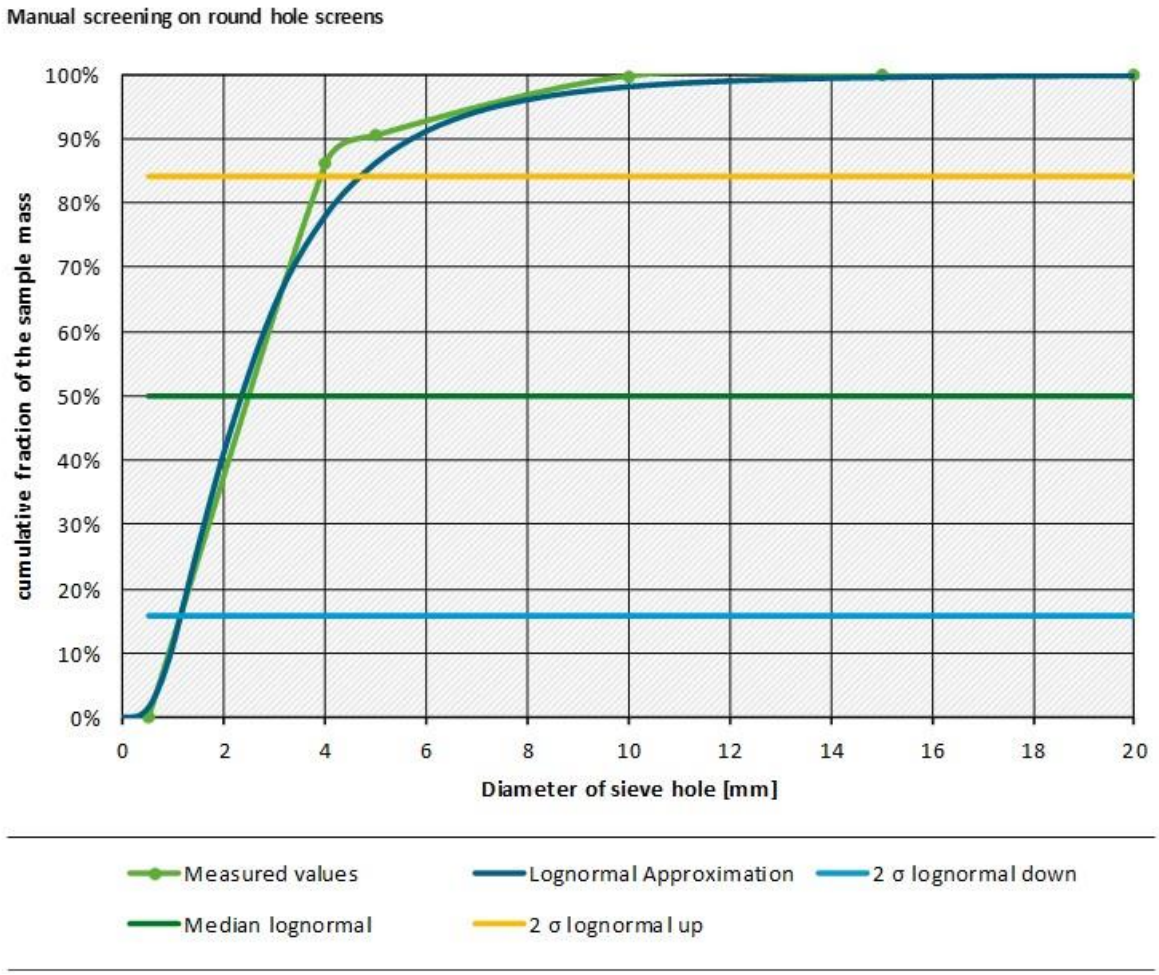
Figure 24: Photographic documentation for fluff-light fraction from plant B (19 10 04)

Original material before sample pretreatment, above: original heap, below: detail sample before pre-treatment
Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Table 20: Sample pretreatment and sample preparation according to DIN 19747 (2009a)

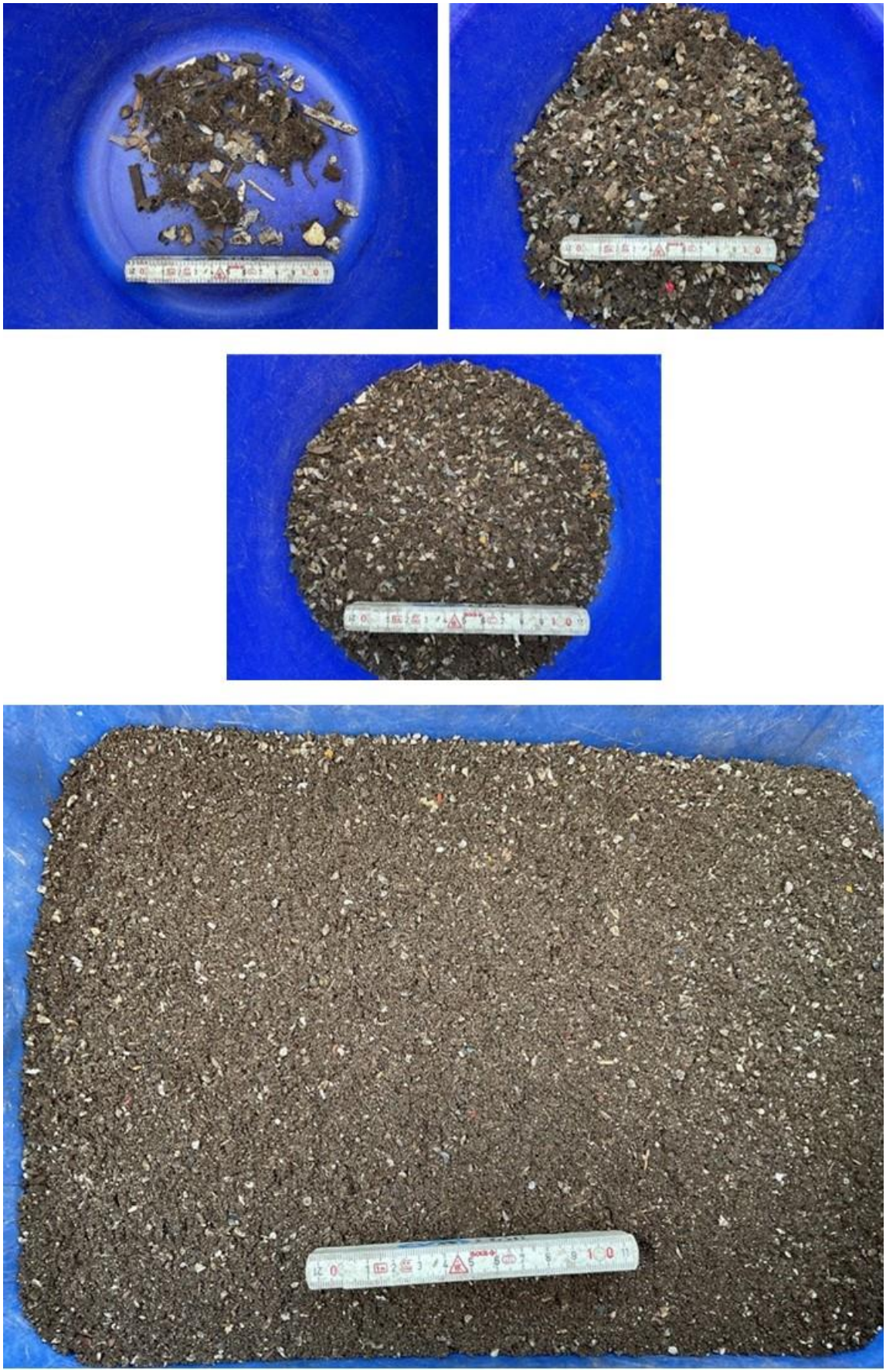
Beginning	14 February 2023, 12:00		
End	14 February 2023, 1:00 p.m.		
Place of treatment	Ralf Ketelhut, Wookerkamp 61, 24536 Neumünster		
Weather conditions	Cloudy, 4°C		
Sample preparation	Creation of a sieve line using original material with hand screening on round-hole screens. Sieve opening <4 mm round-hole screen. Removal of oversized particles and interfering material.		
Sieve curve original material and approximate distribution	The particle size of the material is approximately lognormally distributed. The median is approx. 2.3 mm. The d_{95} is approx. 7.5 mm.		
Data on the sieve curve	Weight [g]	Percentage by weight [%]	Cumulative percentage by weight [%]
<4 mm	4,524.5	86.1%	86.1%
<5 mm	231.5	4.4%	90.5%
<10 mm	485.0	9.2%	99.7%
<15 mm	14.5	0.3%	100.0%
Sample pretreatment	No shredding of the oversized particles. The material is fibrous and fluffy, so that – within the time available – shredding is not feasible. Material >4 mm is discarded as oversized particles.		
Mass balance of pre-treatment	Factions	Weight [g]	Share [%]
	Input	5,277.5	100.0%
	Sample <4 mm	4,524.5	85.7%
	Impurities	0.0	0.0%
	Oversized particles >4 mm	731.0	13.9%
	Losses	22.0	0.4%
Storage	None		
Transport	14 February 2023, from 2:00 p.m.		
Transport container	PE bag in cooled 60-liter PP barrel in a car		
Transport by	Ralf Ketelhut		
Handover	15 February 2023, 8:30 a.m.		
Recipients	ECT Oekotoxikologie GmbH		

Figure 25: Sieve curve for fluff-light fraction from plant B (19 10 04)



Source: own illustration, Ralf Ketelhut, Stoffstromdesign

Figure 26: Photographic documentation for fluff-light fraction from plant B (19 10 04)



Top left: >10 mm, top right: >5 mm, center: >4 mm, bottom: sample <4 mm

Source: own illustration, Ralf Ketelhut, Stoffstromdesign