

## Method for determining and expressing the grain size of feed meals

### 1. Introduction

The proposed method was established by TECALIMAN based on existing methods (INRA, AFNOR, ASAE). It is used by certain service companies and plants.

On the request of industrial operators, a spreadsheet version of the data processing method has been produced and is available from TECALIMAN.

### 2. The method's principles and limitations

#### 2.1. Principles

The particle structure of a feed meal is assessed by measuring one or more geometric characteristics: length, diameter, volume or surface area, frequently collectively referred to by the generic term "size", of the component particles.

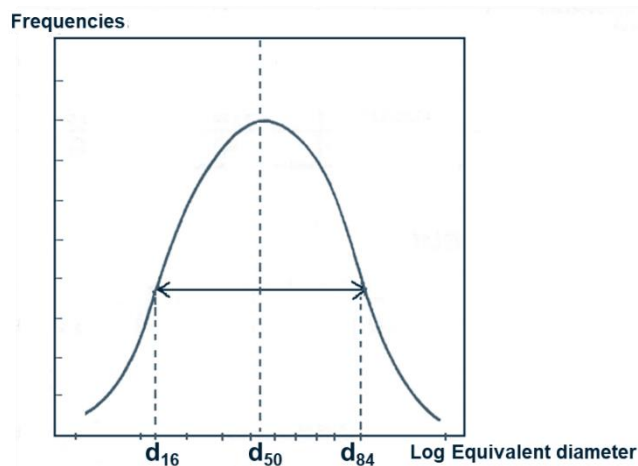
The particle population is therefore classified on the basis of the characteristic chosen using an appropriate technique and the results are most often expressed as a mass.

In animal feed, the most commonly used classification technique is dry sifting and, in this case, the variable that characterises the size of particles is diameter. As a result, particles are treated as spheres, the diameter or *equivalent diameter* of which depends on the sieve mesh (see 5.1).

The graphic representation of the size distribution of particles on semi-logarithmic graph paper reveals that this distribution follows a lognormal distribution pattern (Figure 1).

Consequently, this Gaussian type logarithmic distribution (NF. X 11-635), is characterised by two statistical variables:

a position variable, the *median diameter* "d50" and a dispersal variable, *logarithmic standard deviation* "Sg" or quantile (Figure 1).



**Figure 1: Representation on a semi-logarithmic scale of a lognormal distribution**

The median diameter divides the size of the particle population into two halves of equal sizes, i.e. 50% of the population has an equivalent diameter above or 50% below the median diameter.

Logarithmic standard deviation is equal to the ratio between the median diameter and equivalent diameters with cumulative frequencies of 84.13 and 15.87% (rounded to 84% and 16%):

$$Sg = \frac{d_{84}}{d_{50}} = \frac{d_{50}}{d_{16}}$$

This means that approximately 68 % by mass of particles have an equivalent diameter of between d16 and d84.

#### 2.2. Limitations

The method's limitations relate to the classification technique and the statistical data processing procedure.

Consequently, the proposed method must not be used to determine the grain size of products made up of elongated or flattened particles, such as chopped hay or flaked grains.

Moreover, it only applies if the size distribution of particles is lognormal, which is true for the majority of meals obtained for animal feed (NF. BP X -11-635

### 3. Equipment

#### 3.1. Sieve

A range of sieves, the diameter of which is 200 mm or above (NF X 11-507) and the wire mesh size of which is defined by standard NF X 11-506 (Table 1).

Wire mesh size in $\mu\text{m}$			
6300	2000	630	200
5000	1600	500	160
4000	1250	400	125
3150	1000	315	100
2500	800	250	80

Table 1: Mesh sizes

#### 3.2. Sifter / Screener

The laboratory sifter / screener must be equipped with 10 to 12 sieves with a diameter of 200 mm or above.

#### 3.3. Scales

The scales have a weighing accuracy that is greater than 0.1g.

### 4. Sieving method

#### 4.1. Equipment preparation

##### 4.1.1. Sieve selection and inspection

Depending on the estimated size of the product, select a set of 10 to 12 sieves, the mesh sizes of which are in the order defined by standard NF X 11-506 (Table 1). Check that all the sieves forming part of the set have the same perforated base (metal fabric) and the same mesh shape.

Examine the perforated bases, in order to detect possible imperfections (distortion, broken mesh, clogging).

Replace defective sieves and clean clogged sieves (brushing, hot water with detergent, ultrasound).

##### 4.1.2. Homogenisation of the sample and test specimen

Homogenise the meal sample in advance and take a test specimen of approximately 100 g.

### 4.2. Sieving

#### 4.2.1. General sieving conditions

Place the test specimen on the top sieve and start the sifter / screener after setting the timer.

The sieving duration depends on the equipment used. It is generally between 10 and 15 minutes.

After stopping the sifter / screener, weigh and record the residue collected in each sieve.

The mass of the residue in the top sieve or the passing in the bottom sieve must be less than 10% of the test specimen's mass.

If the sieves become blocked, place ten or so grains of wheat on each sieve or shake the set of sieves once or twice on completion of sieving.

#### 4.2.2. Preliminary test

The aim of this test is to check the theoretical compliance of the selected set of sieves. It is carried out in accordance with the general sieving conditions:

- If the mass of the residue in the top sieve or the passing in the bottom sieve is above 10%, select a new set of sieves and start the preliminary test again.
- If the mass of the residue in the top sieve and the passing in the bottom sieve is below 10%, proceed to actual measurement.

#### 4.2.3. Actual measurement

This is carried out in accordance with the general sieving conditions. It consists of sieving a second and, possibly, a third representative test specimen of the meal sample.

### 5. Data processing

#### 5.1. Graphical method

##### 5.1.1. Data table

Calculate the average residue as a %, by granulometric fraction, and the corresponding equivalent diameter (see the example in Table 2).

##### 5.1.2. Determining the median diameter and logarithmic standard deviation

The cumulative granulometric curve is set out on graph paper, with the X axis being logarithmic and the Y axis being Galtonian. The sieve diameters are plotted along the X axis and the cumulative frequencies for passings on the Y axis (Figure 2).

This method enables the meal's grain size to be represented in the form of a straight line and the median diameter  $d_{50}$  and logarithmic standard deviation  $S_g$  (NF X 11-635 and 636 ) to be geometrically determined.

Formula	VL18-508	Sieve standard	NF X11-501
Operator		Method	dry
Sample reference		Perforated base	200 mm round
Sifter / Screener		Initial mass in g	101

Mesh size µm	Residue in each sieve		Equivalent diameter µm	Cumulative residue %
	Measurement 1 g	Measurement 2 g		
1600	3.2	2.8	1788	100.0
1250	13.7	14.0	1414	97.0
1000	15.0	15.2	1118	83.2
800	14.8	14.2	894	68.2
630	13.4	13.6	710	53.8
500	12.9	13.0	561	40.4
400	8.1	8.0	447	27.5
315	7.7	7.9	355	19.5
250	3.2	3.5	281	11.7
200	3.8	4.0	224	8.4
160	1.8	1.5	179	4.5
125	1.1	1.0	141	2.9
Passing	1.7	2.0	111	1.8
Total	100.4	100.7		

Median diameter (µm)	678	Standard deviation	1.87
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Table 2

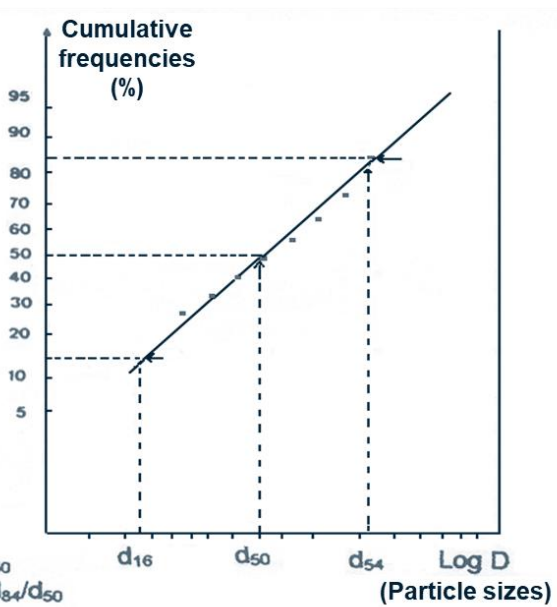


Figure 2: Logarithmic representation. Probability of a lognormal distribution

## 5.2. Method by calculation

The method used is based on that of standard ASAE S 319.2.

### 5.2.1. Equivalent diameters

This is equal to the square root of the product of the sieve mesh from which the residue is collected via the

sieve mesh located immediately above it. The first fraction is equal to the square root of the product of the sieve mesh from which the residue is collected via the sieve mesh theoretically located immediately above it (Table 1). The final fraction or passing from the final sieve is equal to the square root of the product of the final sieve mesh with the sieve mesh theoretically located immediately beneath it (Table 1).

### 5.2.2. Manual calculation

The method is presented in Table 3, where

$$d50 = \log^{-1} \left[ \frac{\sum (P_i \cdot \log d_i)}{\sum P_i} \right]$$

and

$$Sg = \log^{-1} \left[ \frac{\sum P_i \cdot (\log d_i - \log d50)^2}{\sum P_i} \right]^{1/2}$$

### 5.2.3. Calculation software

Based on applications developed using Lotus 1-2-3 and Excel 5.0 spreadsheets and by entering the results by mass of sieving in a data entry table, the calculations are performed automatically.

The software produces:

- a table presenting the distribution as a cumulative % by fraction, median diameter and logarithmic standard deviation
- a graphic representation of the cumulative granulometric spectrum depending on the sieve mesh diameter.

## 6. List of Equipment Suppliers

### Logarithmic-Galtonian graph paper for grain size

Company Guyot Graphco Av. de la république 71210 Montchanin  
 Tel: +33 01.85.78.54.11  
 Fax: +33 01.85.78.08.39

### Sifter / screener and sieve

Company Buhler Tour Aurore 92080 Paris la Défense Cedex 05  
 Tel: +33 01.47.78.61.71  
 Fax: +33 01.47.74.84.14

Company Fritsch, B.P. 78, 91943 Courtaboeuf Cedex  
 Tel: +33 01.69.86.21.21  
 Fax: +33 01.69.86.21.31

Company Haver Boecker, BP 91, 02403 Chateau Thierry  
 Tel: +33 01.23.83.69.97  
 Fax: +33 01.23.69.29.31

Company RetschVeder PA de la Danne, 95160 Eragny  
 Tel: +33 01.34.64.31.11  
 Fax: +33 01.34.64.44.50

Company Tripette et Renaud  
 ZI du Val de la Seine, 20 Av. Marcellin Berthelot 92396 Villeneuve la Garenne  
 Tel: +33 01.47.94.40.21  
 Fax: +33 01.47.98.29.04

## 7. Bibliography

- American Society of Agricultural Engineers, ASAE Standard: ASAE S319.2 Method of determining and expressing fineness of feed materials by sieving
- AFNOR, Recueil de normes francaises, 1990, Granulométrie, tamis, tamisage et autres methods d'analyses granulométriques.
- Standard AFNOR X 11-506, Tamis et tamisage - Toiles métalliques à ouvertures carrées et à fils ronds pour tamisage industriel.
- Standard ISO 2591-1 or AFNOR X 11-507, Analyses granulométriques - Tamisage de contrôle
- Standard AFNOR X 11-632, Granulométrie - Expression des résultats expérimentaux d'analyses granulométriques.
- Standard AFNOR X 11-635, Granulométrie - Représentation des distributions granulométriques - Partie 1 : Modèle de référence.
- Standard AFNOR X 11-636, Granulométrie, Représentation des distributions granulométriques - Partie 2 : Ajustement d'une courbe cumulative expérimentale à un modèle de référence - Cas du tamisage.

Sieve mesh diameter (µm)	Equivalent Diameter di	Log di	Mass g = Pi (a)	Mass % Pi %	Pi * log di (b)	log di - log d50	Pi (log di - log d50) <sup>2</sup> (c)
2500	2806.243	3.448	0	0.00	0.000	0.617	0.000
2000	2236.068	3.349	0	0.00	0.000	0.518	0.000
1600	1788.854	3.253	3	2.98	9.758	0.421	0.533
1250	1414.214	3.151	13.85	13.77	43.635	0.319	1.413
1000	1118.034	3.048	15.1	15.02	46.032	0.217	0.713
800	894.427	2.952	14.5	14.42	42.797	0.120	0.210
630	709.930	2.851	13.5	13.43	38.491	0.020	0.005
500	561.249	2.749	12.95	12.88	35.602	-0.082	0.087
400	447.214	2.651	8.05	8.01	21.337	-0.181	0.263
315	354.965	2.550	7.8	7.76	19.891	-0.281	0.616
250	280.624	2.448	3.35	3.33	8.201	-0.383	0.491
200	223.607	2.349	3.9	3.88	9.163	-0.482	0.905
160	178.885	2.253	1.65	1.64	3.717	-0.579	0.552
125	141.421	2.151	1.05	1.04	2.258	-0.681	0.486
100	111.803	2.048	1.85	1.84	3.790	-0.783	1.133
80	89.443	1.952	0	0.00	0.000	-0.880	0.000
63	70.993	1.851	0	0.00	0.000	-0.980	0.000
<b>Total</b>			<b>100.6</b>	<b>100.0</b>	<b>284.671</b>		<b>7.408</b>

Table 3: ASAE calculation method. S 319.2

$$\log d50 = \frac{\text{total (b)}}{\text{total (a)}} = 2.831 \quad \boxed{D50 = 678 \text{ microns}}$$

$$(\log Sg)^2 = \frac{\text{total (c)}}{\text{total (a)}} = 0.0737 \quad \log Sg = 0.271 \quad \boxed{Sg = 1.87}$$