**Particle size distribution:**

|  |  |  |
| --- | --- | --- |
| xarea | **Particle diameter** calculated by the area of particle projection  xarea =   Diameter of the area equivalent circle with a volume of a sphere with the diameter of xarea | |
| xc min | Width, Breadth  particle diameter which is the shortest chord of the measured set of maximum chords of a particle projection (for results close to screening/sieving) | |
| xMa min | Width, Breadth  particle diameter, which is the shortest Martin diameter, which is dividing the area of the particle projection into two halves (for diameter of extrudates) | |
| xFe min | Width, Breadth  particle diameter which is the shortest Feret diameter of the measured set of Feret diameter of a particle projection | |
| xFe max | Length  particle diameter which is the longest Feret diameter of the measured set of Feret diameter of a particle (for results close to microscopy) | |
| xlength | Length  particle size, which is calculated from the longest Feret-diameter and the smallest chord or Martin– diameter of each particle projection    (suitable for distributions of cylinders, which are orientated by a guidance sheet e.g. to substitute slower optical measurement systems like light table, calliper, microscope or static image analysis systems). Smallest xlength is limited to xMa min of this particle image. |
| xlength2 | Length  particle size, which is calculated from the longest Feret-diameter xFe max and the smallest of all maximum chords xc min diameter of each particle projection |
| xlength3 | Length    Like xlength2  but smallest xlength 3 is limited to the xc min of this particle image |
| xstretch | Length  particle size, which is calculated from the area of the particle projection of each particle divided by the smallest diameter (smallest Martin diameter) of the particle projection, interesting for bended extrudates and short extrudates. Smallest xStretch is limited to xMa min of this particle |
| xstretch2 | Length  particle size, which is calculated from the area of the particle projection of each particle divided by the smallest diameter (smallest of all maximum chords xc min) of the particle projection, interesting for bended extrudates and short extrudates |
| Q3(x) | **Cumulative distribution (% passing)**, based on volume:  volume proportion of particles smaller than x in proportion to the total volume | |
| 1-Q3(x) | **Cumulative distribution of residue** 1-Q3(x), based on volume | |
| p3(x1,x 2) | **Fractions** p3 (x1,x2) – volume proportion of particles in the range (x1,x2): | |
| q3(x) | **Density distribution** q3(x) based on volume:  1. Derivative of Q3(x) | |
| Q0(x) | **Cumulative distribution** Q0(x), based on number of particles:  number of particles smaller than x in proportion to the total number of particles | |
| 1-Q0(x) | **Cumulative distribution of residue** 1-Q0(x), based on number of particles | |
| p0(x1,x2) | **Fractions** p0(x1,x2) - number of particles in the range (x1,x2): | |
| q0(x) | **Density (frequency) distribution** q0(x), based on number of particles:  1. Derivative of Q0(x) | |

**Characteristics:**

|  |  |
| --- | --- |
| Q3(x) | **Q3 value**, where at a given particle diameter x is reached, based on volume |
| x (Q3) | **x value** whereat which a given Q3 value is reached, based on volume |
| SPAN3 | **Span value, based on volume:**    Here the first index indicates that the values are based on volume. In the program the first index has been left off, since for SPAN3 and SPAN0 the same Q(x) values are used. |
|  |  |
| U3 | **Non-uniformity**, based on volume:    x10: x value for Q3 = 10 %  x60: x value for Q3 = 60 % |
| Q0 (x) | **Q0 value**, where at a given particle diameter x is reached, based on number |
| x(Q0) | **x value**, where at a given Q0 value is reached, based on number |
| SPAN0 | Span value, based on number of particles    Here the first index indicates that values are based on the number of particles.  In the program the first index was left off as for SPAN3 and SPAN0 the same Q values are used. |
| U0 | Non-uniformity, based on number of particles    x10: x value for Q0 = 10 %  x60: x value for Q0 = 60 % |

**Indirect determination of the specific surfaces Sv and Sm:**

|  |  |
| --- | --- |
| SV | Specific surface |
| Sm | **Specific surface** for a given specific density |

**RRSB characteristics:**

|  |  |
| --- | --- |
| n | Slope of the RRSB line |
| d' | **x value, where at the line reaches a value of 0.632** |
| correlation | **Correlation** between the RRSB line and Q(x) in the range between Q1 and Q2 |

**Shape characteristics:**

|  |  |
| --- | --- |
| xFe  xFe max  xFe min | **Feret diameter** xFe  Distance between two tangents placed perpendicular to the measuring direction. For a convex particle the mean Feret diameter (mean value of all directions) is equal to the diameter of a circle with the same circumference.    xFe max  The longest Feret diameter out of the measured set of Feret diameters.  The shortest Feret diameter out of the measured set of Feret diameters. |
| xMa    xMa min | **Martin diameter** xMa  Length of the area bisector in the measuring direction    A/2  xMa min  A/2  The shortest Martin diameter out of the measured set of Martin diameters. |
| xc  xc min | **maximum chord** xc in measuring direction    xc min  The shortest chord out of the measured set of max. chords xc.  = breadth/width, which is very close to sieving. |
| SPHT0,2,3 | **Sphericity**  = Circularity2 (ISO 9276-6)  P – measured perimeter/circumference of a particle projection  A – measured area covered by a particle projection  For an ideal sphere SPHT is expected to be as 1.  Otherwise it is smaller than 1. |
| C | **Circularity**  = (ISO 9276-6) |
| Compct | **Compactness**  (ISO 9276-6) |
| Symm0,2,3 | **Symmetry**  r1 und r2 are distances from the centre of area to the borders in the measuring direction. For asymmetric particles Symm is < 1.  If the centre of area is outside the particle i.e.  Symm is < 0.5  “Symm” is minimum value of measured set of symmetry values from different directions |
| b/l0,2,3 | **Aspect ratio**  ;  xc min and xFe max  out of the measured set of xc and xFe values |
| (b/l)rec 0,2,3 | ; min quotient of perpendicular xc and xFe out of the measured set of xc and xFe values. |
| B/L0,2,3 | ; xFe min and xFe max out of the measured set of xFe values |
| (B/L)rec 0,2,3 | ; min quotient of perpendicular xFe1 and xFe2 out of the measured set of xFe values. |
| xp= xmean | The Feret diameter, the Martin diameter, the max. chord and the sphericity for the various size classes are determined by calculating a **mean value, based on the number of particles within a size class**:  As the objects within a class can be distributed unevenly, the mean equivalent diameter of circles equal in area, xp, should be used as reference value for class-related information. |
| PD0, PD3 | Number of **p**article **d**etections, measure of the statistical reliability of the shape characteristics. The larger PD the more reliable is the value of xFe, xMa, xc and SPHT. |
| Sigma(v)0 | Standard deviation of the ratio    with the ratio  of the particle no. i,  in which the measuring directions of the Feret diameter and the maximal chord are perpendicular to each other. |
| Q0(SPHT)= NSP0  Q3(SPHT)= NSP3 | **Proportion of non-spherical particles**, whose sphericity is smaller than a given threshold; based on number of particles or on volume |
| Q0/2/3; Symm; b/l, (b/l)(rec) B/L, etc. | **Proportion of particles or volume**, whose symmetry, or various b/l-ratios is smaller than a given threshold |
| Mv0/2/3(x) | **Mean value** of a chosen characteristic, weighted; x1,r = ∑ x qr(x) Δx |
| Sigma(x) | **Standard deviation** σ(x) from the mean value Mv(x) |
| Conv0/2/3 | **Convexity** = (square root) ratio of real area of the particle projection and convex area of particle projection (as if a rubber band was put around the particle projection) |
| Trans0/2/ 3  Transa0/2/ 3  Transb0/2/ 3  Q0/2/3(trans)  Q0/2/3(transa)  Q0/2/3(transb) | **Trans(parency)** = ratio of the bright area within the particle projection divided by complete filled particle projection  **Q(Transparency)** = amount of sample below a threshold of the ratio between bright area of particle projection divided by complete filled particle projection. Characteristic “Trans”  A= Area of the filled particle projection (without pixels at the edge of the projection). A1= Area within the particle projection which has a brightness larger than “Thresh1”. Thresh1 = Imin + 0.25 (Imax – Imin) Characteristic “Trans a”  A= Area of the particle projection (without pixels at the edge of the projection). A2= Area within the particle projection which has a brightness larger than “Thresh2”. Thresh2 = Imin + 0.5 (Imax – Imin) Characteristic “Trans b”  A= Area of the particle projection (without pixels at the edge of the projection). A3= Area within the particle projection which has a brightness larger than “Thresh3”. Thresh3 = Ifix + 0.25 (Imax – Ifix)  Imin = minimum brightness within particle  Imax = maximum brightness of particle  Ifix = minimum brightness of the camera  Trans and Trans a are depending on the brightness of the particle projection. Calculation of Transparency is done with the histogram of the particle brightness and the brightness of the surrounding area. |

|  |  |
| --- | --- |
| **Optional characteristics:** | |
| rD | **relative Density**, mass of sample divided by the volume of the sample measured with the CAMSIZER® |
| AFS (ISO)  AFS (ASTM)  GFN | (**A**merican **F**oundry **S**ociety) **number** (**G**rain **F**ineness **N**umber), GFN or AFS number is a sand specific requirement and it is a figure that results in one number for a measured sample.  The formula for this number is:  Where: p3i is the fraction of the material in the class i and M3 is a fixed multiplication factor for each class. There is a connection between the ASTM Mesh number and this M3 multiplication factor (we do not know it).  Example:   |  |  |  |  | | --- | --- | --- | --- | | Class | Fraction p3 | Multiplication  factor M3 | P3 \* M3 | | 1 – 0,71 | - | 15 | - | | 0,71 – 0,5 | 0,75 | 25 | 19 | | 0,5 – 0,355 | 8,70 | 35 | 305 | | 0,355 – 0,25 | 28,60 | 45 | 1287 | | 0,25 – 0,18 | 30,05 | 60 | 1803 | | 0,18 – 0,125 | 5,90 | 81 | 478 | | 0,125 – 0,09 | 1,00 | 118 | 118 | | 0,09 – 0,063 | 0,30 | 164 | 49 | | 0,063 – 0,02 | 0,35 | 275 | 96 | |  | 75,65 |  | 4155 | |
| SGN | Size Guide Number Calculated diameter of the “average particle”, expressed in millimeters and multiplied with 100 (for example: d50 = 0.123 mm => SGN = 12.3)  with  in mm  The calculation of SGN is based on the following size classes:  0.212, 0.300, 0.425, 0.600, 0.850, 1.18, 1.70, 2.36, 3.35, 4.75, 6.70mm  If x50 falls into one of these size classes, than x50 is an interpolated value from the Q3 value of the next lower and the next higher sieve. If x50 lies beyond 0.212 mm or 6.7 mm than x50 is the actual value determined by the CAMSIZER and is not interpolated. |
| UI | Uniformity Index ratio of the size of “SMALL PARTICLES” to “LARGE PARTICLES” in the sample, expressed in percentage; UI is the ratio, times 100, of the two extreme sizes in the range of large particles at the 90% Q3 level and fine particles at the 5% Q3 level. UI =100 means that the particles have the same size, perfectly uniform; UI = 50 means that the small particles are half the size of the large particles in the sample with ,  The determination of x5 and x90 follows the determination of x50 for the calculation of SGN |
| CV | **C**oefficient of **V**ariation (see also **\***)  the coefficient of variation is the standard deviation (SD) of the size distribution divided by the average; it is dimensionless. CV is common in the *Sugar Industry*.  with , ,  **\* C**oefficient of **V**ariation = => |
| MA | **M**ean **A**perture = D50 value = Median Diameter x50 |
| PI | **P**olydispersity **I**ndex PI(Q1,Q2) |
| Q1(V) | **Q1 value**, where at a **given particle volume** is reached, **based on volume** |
| Q0(V) | **Q0 value**, where at a **given particle volume** is reached, **based on number** |
| DM-CECA | **Sum of linear mean values of particle sizes in the specific size classes. The calculation works as follows:**    **where  are the size limits.**  **if  is, then leave x1 out, this means the formula is then** |

**RDNS\_C** (Krumbein Roundness or Waddell Roundness) is the average curvature radius of all relevant corners divided by the largest inscribed circle radius. The lower limit for detection is 20 pixels of the relevant camera.

**SPHT\_K** is the box ratio (B/L)rec (see above)   
adjusted to Krumbein chart from the original book, API and ISO standards => optional available with 3D => 2D correlation to get results like from microscopy

**Ellipse** is the ellipticity deviation between the real particle image and a Legendre ellipse with the same area and the same aspect ratio.