

approximate to a sphere: some property of the particle is measured and related to a sphere, the diameter of which can be quoted. Because the measurement is then based on a hypothetical sphere, which represents only an approximation to the true size and shape of the particle, the dimension is referred to as the *equivalent sphere diameter* or *equivalent diameter* of the particle.

Equivalent sphere diameters

It is possible to generate more than one sphere which is equivalent to a given irregular particle shape. Figure 9.2 shows the two-dimensional projection of a particle with two different diameters constructed about it.

The *projected area diameter* is based on a circle of equivalent area to that of the projected image of a particle; the *perimeter diameter* is based on a circle having the same perimeter as the particle. Unless the particles are unsymmetrical in three dimensions then these two diameters will be independent of particle orientation.

This is not true for *Feret's* and *Martin's* diameters (Fig. 9.3), the values of which are dependent on

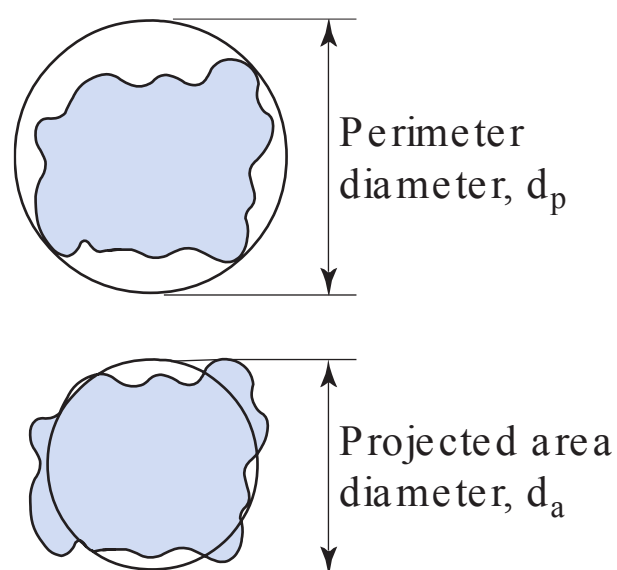


Fig. 9.2 • Different equivalent diameters constructed around the same particle.

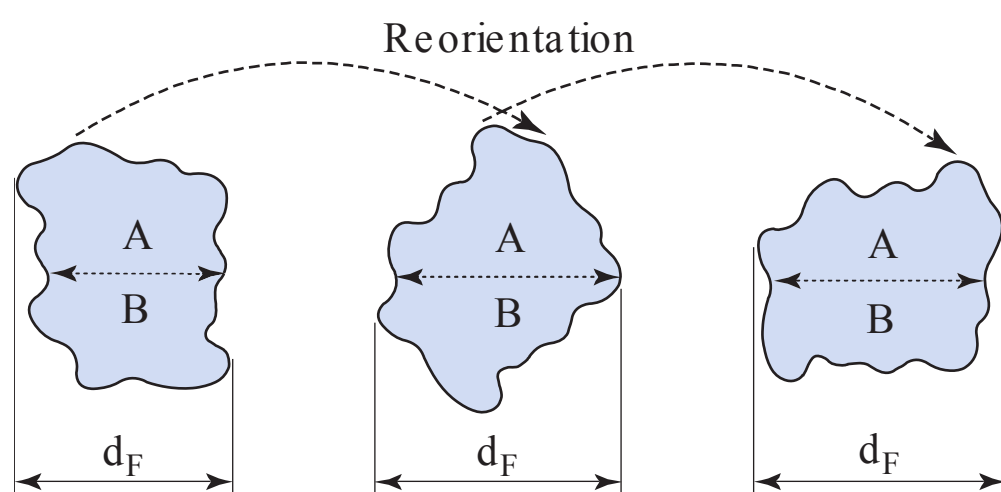


Fig. 9.3 • Influence of particle orientation on statistical diameters. The change in Feret's diameter is shown by the distances, d_F ; Martin's diameter d_M corresponds to the dotted lines in the mid-part of each image.

both the orientation and the shape of the particles. These are statistical diameters which are averaged over many different orientations to produce a mean value for each particle diameter. Feret's diameter is determined from the mean distance between two parallel tangents to the projected outline of the particle. Martin's diameter is the mean chord length of the projected particle perimeter, which can be considered as the boundary separating equal particle areas (A and B in Fig. 9.3).

It is also possible to determine the equivalent sphere diameters of particles based on other factors such as volume, surface, sieve aperture, sedimentation characteristics, etc. Some of the more commonly used equivalent sphere diameters are defined in Table 9.1; there are others. In general, the method used to determine particle size dictates the type of equivalent diameter that is measured. This is explained for each particle size analysis method described later in this chapter. Inter-conversion of the various equivalent particle sizes may be carried out and this can be done mathematically or automatically as part of the size analysis.

Particle size distribution

A particle population which consists of spheres or equivalent spheres of the same diameter is said to be *monodispersed* or *monosized*, and its characteristics can be described by a single diameter or equivalent sphere diameter.

However, it is unusual for particles to be completely monodispersed and such a sample will rarely, if ever, be encountered in a pharmaceutical system. Most powders contain particles with a range of different equivalent diameters, i.e. they are *polydispersed* or *heterodispersed*. In order to be able to define a size distribution or compare the characteristics of two or more powders consisting of particles with many different diameters, the size distribution can be broken down into different size ranges, which can be presented in the form of a histogram plotted from data such as those in Table 9.2.

Such a histogram presents an interpretation of the particle size distribution and enables the percentage of particles having a given equivalent diameter to be determined. A histogram allows different particle size distributions to be compared. For example, the histogram in Figure 9.4a is a representation of particles that are *normally distributed* symmetrically about a central value.