where f_F, f_o and f_u are functions of the mass flow rates of the feed material, oversize product and undersize product streams, respectively. If the separation process is 100% efficient, then all oversize material will end up in the oversize product stream and all undersize material will end up in the undersize product stream. Invariably, industrial particle separation processes produce an incomplete separation, so that some undersize material is retained in the oversize stream and some oversize material may find its way into the undersize stream.

Considering the oversize material, a given powder feed stream will contain a certain proportion of true oversize material, δ_F; the outgoing oversize product stream will contain a fraction, δ_o, of true oversize particles, and the undersize product stream will contain a fraction, δ_u, of true oversize material (Fig. 10.16). The efficiency of the separation of oversize material can be determined by considering the relationship between mass flow rates of feed and product streams and the fractional contributions of true size grade in the streams. For example, the efficiency E_o of a size separation process for oversize material in the oversize stream is given by:

$$E_o = \frac{f_o \delta_o}{f_F \delta_F} \tag{10.8}$$

and the separation efficiency for undersize material in the undersize stream is given by:

$$E_u = \frac{f_u (1-\delta_o)}{f_F (1-\delta_F)} \tag{10.9}$$

The total efficiency, E_t, for the whole size separation process is given by:

$$E_t = E_u \square E_o \tag{10.10}$$

Separation efficiency determination can be applied to each stage of a complete size classification and is often referred to as *grade efficiency*. In some cases, knowledge of grade efficiency is insufficient, for example where a precise particle size cut is required. A *sharpness index* can be used to quantify the sharpness of cut-off in a given size range. A sharpness index, S, can be determined in several

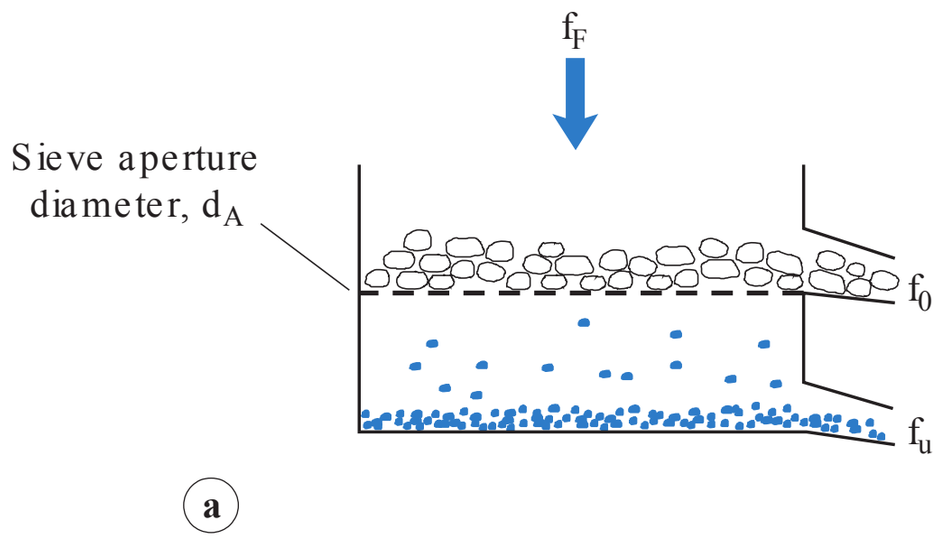

Fig. 10.16 • Size separation efficiency determination. **(a)** Separation operation. **(b)** Size distributions of feed, oversize and undersize material to obtain values for d_o, d_f and d_u.

different ways, for example by taking the percentage values from a grade efficiency curve at the 25% and 75% levels (L_{25} and L_{75}, respectively):

$$S_{25/75} = \frac{L_{25}}{L_{75}} \tag{10.11}$$

or at other percentile points, for example at the 10% and 90% levels:

$$S_{10/90} = \frac{L_{10}}{L_{90}} \tag{10.12}$$