

Complete removal of a certain constituent would be rated as "100 per cent efficient" cleaning, no matter how extravagant might be the consumption of energy. Recognizing the need for a better expression for this measure of performance, some engineers have used the terms *per cent collection*, *per cent removal*, *per cent recovery*, *per cent retention*, *arrestance*, among others. In this discussion, "effectiveness" is the preferred term, and the rating of performance on a 100-point scale will be stated directly as "per cent" or "percentage."

The proportion of material escaping or passing through the separating mechanism is sometimes identified as *per cent passage* or *per cent penetration*.

B. SEPARATION DEGREE

In view of the increasing necessity of high-quality air-cleaning equipment operating in the range of 95 to 100 per cent separation, it is the opinion of the writer that a logarithmic scale of rating is in order. A mass transmission degree scale has been devised for use in the correlation of data on performance of separation processes.⁵

Separation degree is defined here as the base-10 logarithm of the ratio of incoming concentration to outgoing concentration:

$$\text{Separation degree} = \log \frac{\text{incoming concentration}}{\text{outgoing concentration}}$$

Separation degree may also be determined from per cent effectiveness:

$$\text{Separation degree} = \log \frac{100}{100 - E}$$

One-degree separation is defined as 90 per cent reduction in the concentration of air-borne matter from inlet to outlet of the air-cleaning device, or an outgoing concentration $1/10$ that of the incoming concentration. The relation between separation degree and per cent effectiveness may be indicated by a tabulation. The symbol $\oplus$ has been adopted for separation degree.

Effectiveness, in per cent	Separation, degrees	Concentration, in/out
50	0.3 $\oplus$	2/1
90	1 $\oplus$	10/1
95	1.3 $\oplus$	20/1
99	2 $\oplus$	100/1
99.9	3 $\oplus$	1000/1
99.99	4 $\oplus$	10,000/1
99.999	5 $\oplus$	100,000/1

⁵ W. N. Witheridge, *Fundamental Concepts in Gas Cleaning* (Ph.D. thesis, University of Michigan). University Microfilms, Ann Arbor, Michigan, 1951.

The advantages of a logarithmic scale of rating equipment performance are many, mathematical and graphical. Correlation studies may be reported and analyzed with convenient straight lines on logarithmic graphs, using separation degrees as one of the scales. It is particularly helpful for reports of the performance of multistage separating mechanisms, such as highly effective multiple-layer filters or sequential systems, represented by the cascade impactor. For example, if we assume that air is filtered through a multiple-layer filter having identical construction in each layer, or stage, and that the air contains submicron particles of absolutely uniform size removed to the extent of 50 per cent in each layer of the filter, then it would take 10 layers to produce, theoretically, a total percentage separation of 99.9, which is 3 degrees of separation: 50 per cent = 0.3 degree per layer; 10 times 0.3 = 3.0 degrees total; 3 degrees = 99.9 per cent separation.

C. REFERENT DIFFICULTY OF SEPARATION

Table 1 indicates the effectiveness of various air-cleaning mechanisms against contaminants arranged roughly according to particle size. For this purpose, referent difficulty of separation has been selected, and the value chosen is one degree, or 90 per cent separation. This is the ability of a cleaner to deposit

TABLE 1
Effectiveness of Air Cleaners

Type of cleaner	Contaminants	Particle size, in microns, 90 per cent removed (one degree separation ^a)
Gravity settling chambers	Dust, mist	50-100
Chamber	Dust, mist	20-50
Bag filter	Dust, mist	20-50
High speed centrifugal	Dust, mist	5-10
High speed centrifugal, dry	Dust	5-20
High speed centrifugal cones	Dust	10-20
High speed scrubbers	Dust, mist, pollen, vapors, gases	5-20
Wet tower scrubbers	Dust, mist, pollen, vapors, gases	2-10
Wet venturi scrubbers	Mist, fog, vapor, gas	1-5
Wet venturi scrubbers	Dust, fog, fume, gas	0.1-2
Wet venturi scrubbers	Dust, fume, vapor, gas	0.1-1
High speed filters, viscous	Dust, mist, pollen	5-10
High speed filters	Dust, fume, spores, bacteria	0.5-2
High speed filters	Dust, fume, spores, bacteria	0.2-1
High speed filters	Dust, fume, spores, bacteria	0.01-0.1
High speed filters	Dust, fume, fog, spores, bacteria	0.01-10
High speed filters	Dust, fume, fog, spores, bacteria	0.01-10
High speed filters	Vapor, gas, odor	Molecular