Filter aids are a special type of filter medium. Ideally, the filter aid forms a fine surface deposit that screens out all solids, preventing them from contacting and plugging the supporting filter medium. Usually, the filter aid acts by forming a highly porous and noncompressible cake that retains solids, as does any depth filter. The duration of a filtration cycle and the clarity attained can be controlled as density, type, particle size, and quantity of the filter aid are varied.

The quantity of the filter aid greatly influences the filtration rate. If too little filter aid is used, the resistance offered by the filter cake is greater than if no filter aid is used, because of added thickness to the cake. On the other hand, if high amounts of filter aid are added, the filter aid merely adds to the thickness of the cake without providing additional cake porosity.

Figure 7-1 is a typical plot of filter aid concentration versus permeability. In the figure, flow rate and permeability are directly proportional to each other.

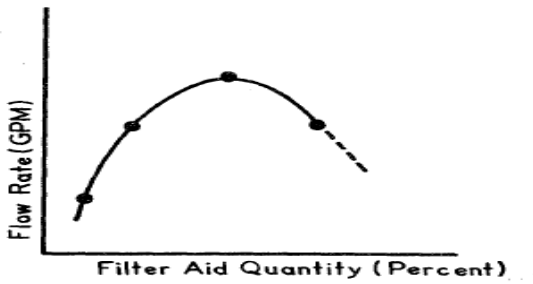

FIG. 7-1. *Experimental determination of flow rate as a function of filter aid quantity discloses correct operating level.*

At low concentrations of filter aid, the flow rate is slow because of low permeability. As the filter aid concentration increases, the flow rate increases and peaks off. Beyond this point, *the* flow rate decreases as the fllter aid concentration is increased.

The ideal filter aid performs its functions physically or mechanically; no absorption or chemical action is involved in most cases. The important characteristics for filter aids are the following:

1. It should have a structure that permits formation of pervious cake.

2. It should have a particle size distribution suitable for the retention of solids, as required.

3. It should be able to remain suspended in the liquid.

4. It should be free of impurities.

5. It should be inert to the liquid being filtered.

6. It should be free from moisture in cases where the addition of moisture to the fluid would be undesirable.

The particles must be inert, insoluble, incompressible, and irregularly shaped. Filter aids are classified from low flow rate (fine: mean size in the range of 3 to 6 microns) to fast flow rate (coarse: mean size in the range of 20 to 40 microns).

Clarity of the filtrate is inversely proportional to the flow rate, and selection requires a balance between these factors. Filter aids are considered to be equivalent in performance when they produce the same flow rate and filtered solution clarity under the same operating conditions when filtering a standard sugar solution.

Table 7-2 lists the advantages and disadvantages of filter aid material.

Diatomite **(diatomaceous earth) is the most important filter aid. Processed from fossilized diatoms, it has an irregularly shaped porous particle that forms a rigid incompressible cake.**

Since diatomite is primarily silica, it is relatively inert and insoluble. *Perlite*, an aluminum silicate, forms filter cakes that are 20 to 30% less dense than diatomic cakes. Perlite is not a porous incompressible particle, but it has· an economic advantage over diatomite.

https://www.google.com/search?q=Perlite&tbm=isch&ved=2ahUKEwj86YmVje_wAhUFZRoKHf4SA40Q2-cCegQIABAA&oq=Perlite&gs_lcp=CgNpbWcQDDICCAAyAggAMgIIADICCAAyAggAMgIIADICCAAyAggAMgIIADICCAA6BwgjEOoCECdQw-gtWJn2LWCSmi5oAXAAeAOAAfwLiAGKJpIBBTctMy4xmAEAoAEBqgELZ3dzLXdpei1pbWewAQrAAQE&sclient=img&ei=1E-yYPyvN4XKaf6ljOgI&bih=730&biw=1517&hl=en

Cellulose, *asbestos*, and *carbon* filter aids are also commercially available. Cellulose is highly compressible and costs two to four times more than diatomite or perlite. It is reserved for applications where the liquids may be incompatible with silica compounds. Cellulose is used as a coarse precoat. It is available in high-purity material and has excellent chemical resistance.

Asbestos has good retention on coarse screens, but has limited application because of high cost, and because of concern over its toxicity should the fibers carry over into the filtrate. Asbestos filters may be used in pharmaceutical industry if their application is followed by a membrane filter.

Nonactivated carbons that are not suitable for decolorization or absorption are rarely used in pharmaceutical applications because of cleanliness problems. They may be used for filtering strong alkaline solutions.

Commercial blends of various filter aids are common, and these specialities, particularly those intended as water scavengers in oil filtrations, must be considered in selection of a filter aid.

Filter aids may be applied by *precoating* or *body-mix* techniques.

Precoating requires suspending the filter aid in a liquid and recirculating the slurry until the filter aid is uniformly deposited on the filter septum. The quantity varies from 5 to 15 pounds per 100 square feet of filter area, or that sufficient to deposit a cake 1/16 to 1/8 inches thick. The liquid is preferably a portion of the feed or retained filtrate from a prior cycle, since the physical properties of the precoat liquid must approximate those of the material to be filtered. Precoating should proceed at the same flow rates and pressures to be used in final filtration, and the transition from precoat liquid to regular feed must be rapid to prevent disruption of the cake.

Body mix (direct addition of filter aid to the filter feed) is more common in batch pharmaceutical operations.

The filter aid, 1 to 2 pounds per pound of contaminant, or 0.1 to 0.5% of total batch weight, is mixed into the feed tank. This slurry is recirculated through the filter until a clear filtrate is obtained; filtration then proceeds to completion.

The body-mix method minimizes equipment requirements and cross-contamination potentials.

Filter aids are chosen by trial and error in either laboratory or plant. Within ranges previously indicated, the filter aid is usually selected to give acceptable filtrate at the highest flow rate; however, in pharmaceutical operations in which quality is a primary consideration, the selection usually favors the fine grades, which yield low flow rates. The most important pharmaceutical factor is inertness. A filter aid may have such extensive absorption properties that desired colored substances and active principles are frequently removed. The total quantity of any ingredient absorbed may be small, but it may be a considerable portion of the original concentration.

Filtration efficiency also may be affected by changes in temperature, since there is an inverse relationship of flow rate to viscosity. The viscosities of most liquids decrease with increase in temperature. According to the "hole theory," there are vacancies in a liquid, and there is a continuous movement of the molecules into these vacancies, thus causing vacancies to move around. This movement of vacancies permits flow, but requires energy. This energy is the activation energy with which a molecule has to move into a vacancy. The activation energy is more readily available at higher temperatures than at lower temperatures. Thus, the liquid can flow more easily at higher temperatures than at lower temperatures. Table 7-3 lists the viscosities of some common liquids at different temperatures. Equation (5) represents the relationship of the coefficient of viscosity to temperature.

$$\eta = Ae^{E/RT} \qquad (5)$$

where:

η = coefficient of viscosity of the liquid

E = activation energy

R = ideal gas constant

T = absolute temperature

A = pre-exponential factor

TABLE 7-3. *Viscosity of Liquids in Centipoise*

Liquid	*Temperature (°C)*			
	0	25	50	75
Water	1.793	0.895	0.549	0.380
Ethanol	1.79	1.09	0.698	—
Benzene	0.9	0.61	0.44	—

From Daniels, F., and Alberty, R. A.: Irreversible processes in solution. In Physical Chemistry. 3rd Ed. Edited by F. Daniels and R.A. Alberty. John Wiley and Sons, New York, 1966.

According to the "hole theory," the viscosity of a liquid increases as the pressure is increased. Since the number of holes is reduced, it is more difficult for molecules to move around. Increasing the temperature of heavy pharmaceutical syrups lowers the viscosity and increases filtration rates. Most liquids must be maintained at a high temperature during filtration to prevent the formation of crystals.

The filtration of cosmetic products at low temperatures, approximately 5°C, is also common. The consequent reduction in flow rate is tolerated, since the goal is reduced solubility of contaminants or perfume oils, resulting in their more effective removal. Filtration at room temperature would yield a liquid that might cloud at the lower temperatures encountered by the product under field conditions.

Filter Selection

In designing or selecting a system for filtration, the specific requirements of the filtration problem must be defined. The following questions should be answered before any assistance is requested from the manufacturers of filtration
equipment.

1. What is to be filtered-liquid or gas?
2.What liquid or gas is to be filtered?
3. What is the pore size required to remove the smallest particle?
4. What is the desired flow rate?
5. What will the operating pressure be?
6. What are the inlet and outlet plumbing (pipes) connections?
7. What is the operating temperature?
8. Can the liquid to be filtered withstand the special temperature required?
9. What is the intended process-clarification or filtration?
10. Will the process be a sterilizing filtration?
11. Will the process be a continuous or batch filtration?
1'2. What is the volume to be filtered?
13. What time constraints will be imposed, if any?

In general, a pore size smaller than the smallest particle to be removed is selected. The optimum system often requires use of a series of filters in a single multilayered filter containing layers of various pore sizes or a prefilter followed by a final filter.

Optimum performance is obtained when the filters in a series exhaust their dirt-holding capacities at the same time. When the flow resistance across each filter in the series approaches the limiting pressure drop, the dirt-holding capacity of the system is considered expended. Figures 7-2 through 7-5 illustrate the prefilters with adequate and inadequate *dirt* holding capacity.

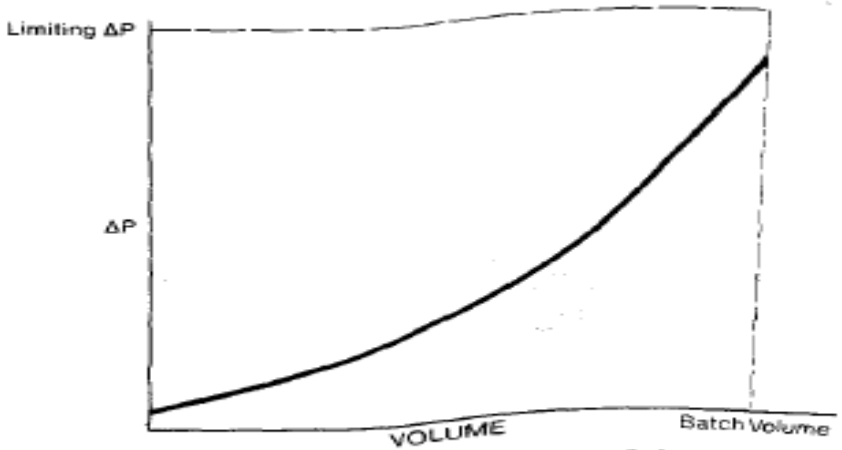

FIG. 7-2. *Ideal filtration system.* (From Cole, J. C., and Shumsky, R.: Pharm. Tech., 1:39, 1977.)

In Figure 7-3, the coarse prefilter does not provide sufficient retention efficiency, thus causing the poorly protected final filter to *clog* prematurely.

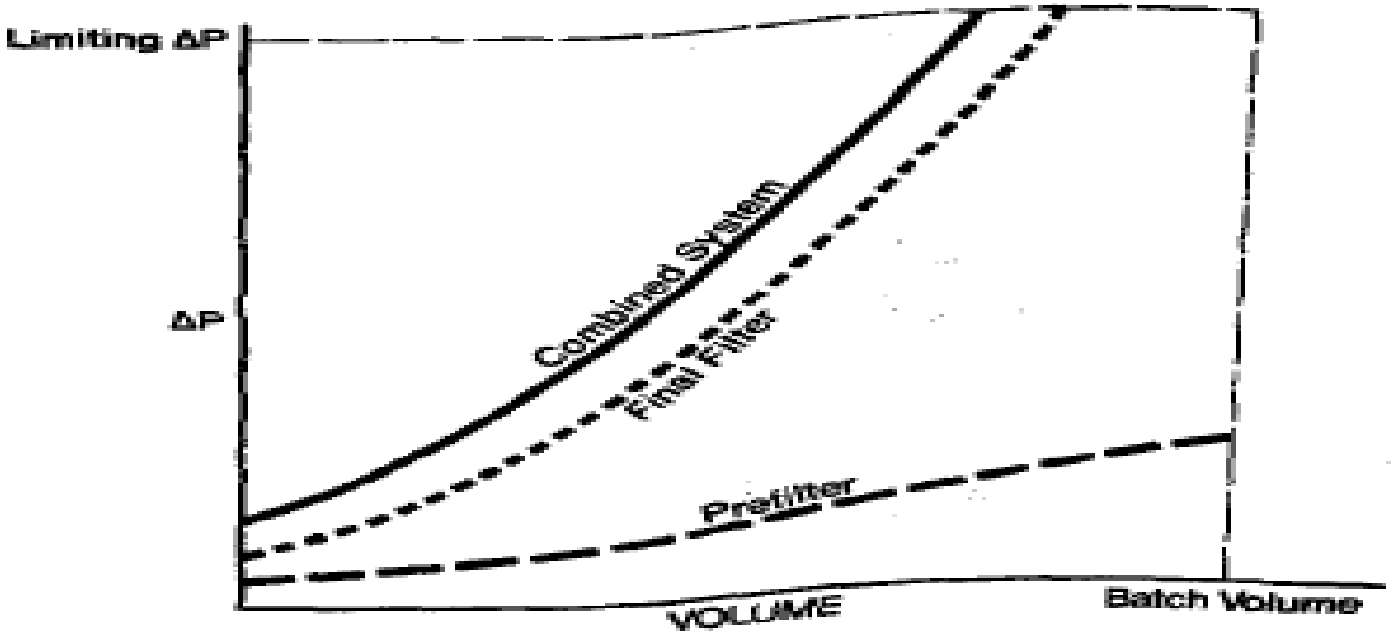

FIG. 7-3. *Filtration system with inadequate prefilter—too coarse. (From Cole, J. C., and Shumsky, R.: Pharm. Tech., 1:39, 1977.)*

Too fine a filter, on the other hand, has enough retention efficiency but insufficient dirt-holding capacity, and it plugs very quickly, as illustrated in Figure 7-4.

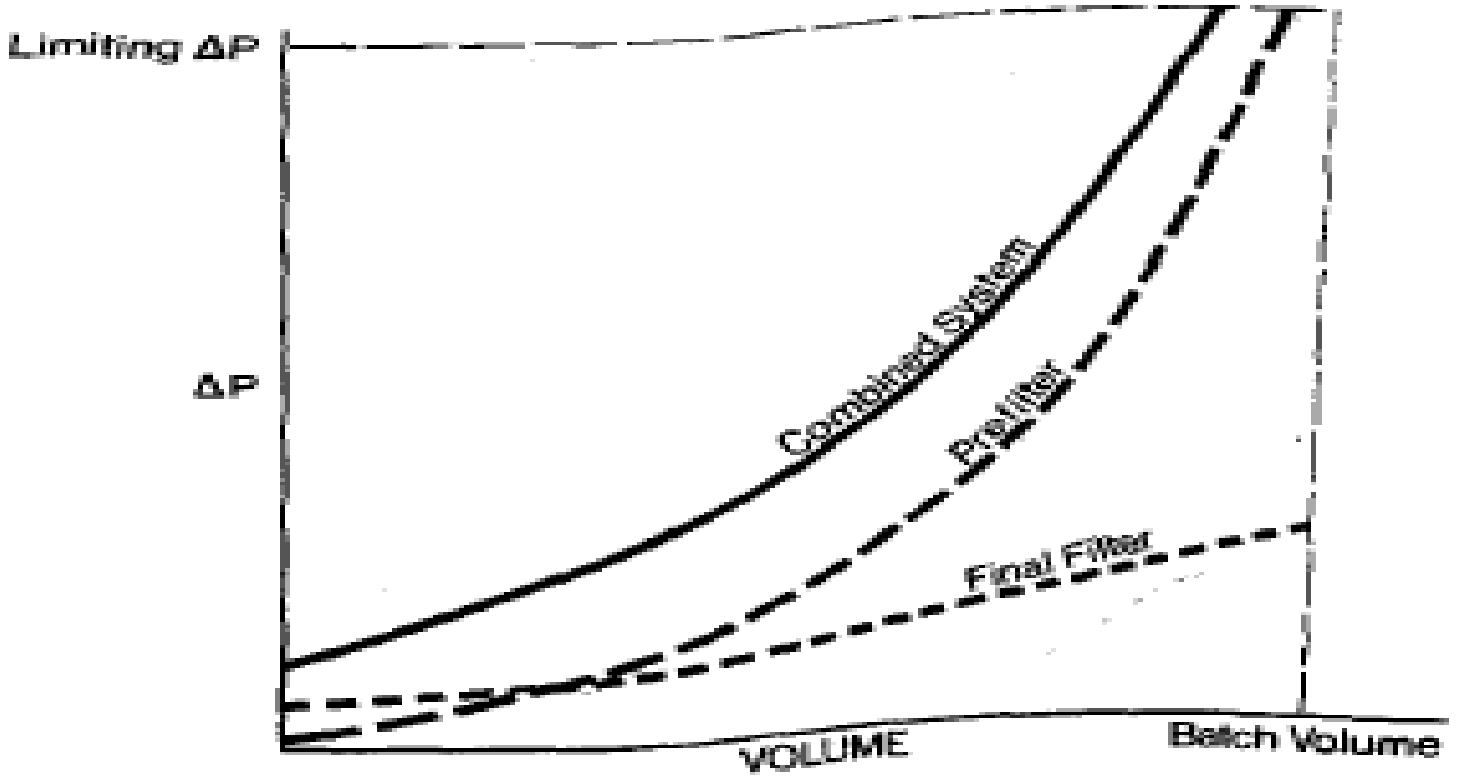

FIG. 7-4. *Filtration system with adequate retentive prefilter but inadequate dirt-holding capacity. (From Cole, J. C., and Shumsky, R.: Pharm. Tech., 1:39, 1977.)*

As shown in Figure 7-5, both filters-the final filter and the "correct" prefilter-will have almost expended their dirt-holding capacities as the last of the batch is filtered.

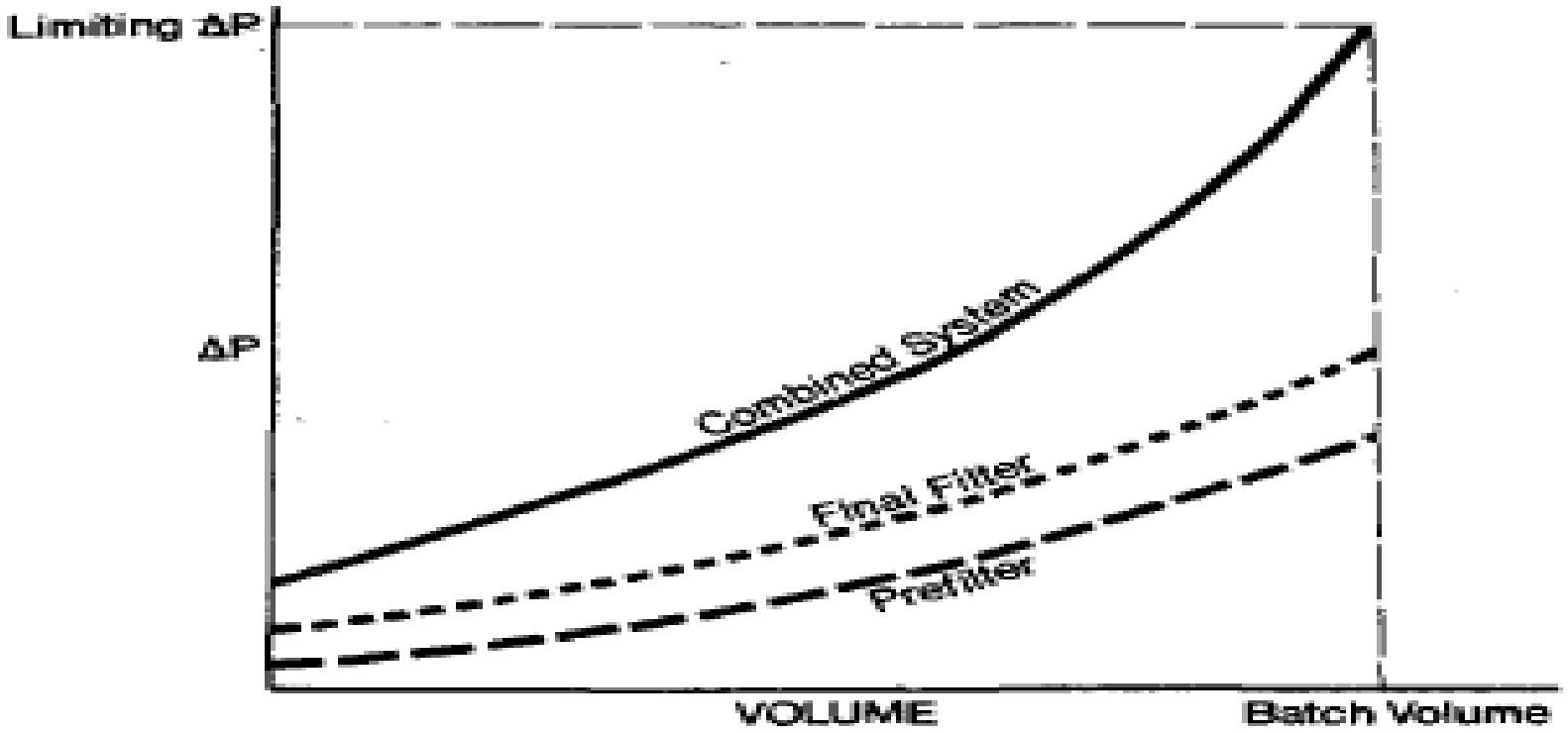

FIG. 7-5. *Filtration system with adequate prefilter. (From Cole, J. C., and Shumsky, R.: Pharm. Tech., 1:39, 1977.)*

A final filter that is not protected by prefilter has a short filter life.

When a prefilter is used in combination with a final filter, the efficiency of the prefilter is maximum. In these cases, it is important that the 0-ring seal sits directly on the membrane itself and not on the prefilter. Therefore, the diameter of the disc prefilter selected should be somewhat smaller than the diameter of the final filter.

Table 7-4 lists the diameter of the filter and the diameter of the prefilter when used in combination.

Seating the 0-ring on the prefilter often fails to produce a seal, thus causing the filtration system to leak. This leakage may result in the filtrate being exposed to contamination.

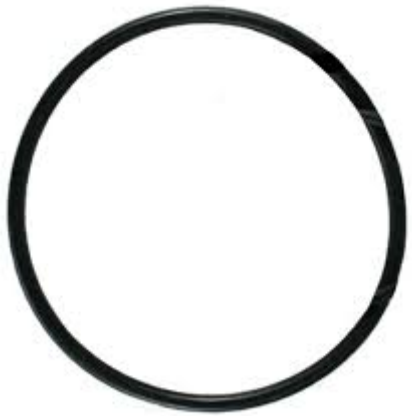

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TABLE 7-4. *Diameter of Filter and Corresponding Prefilter When Used in Combination*

Filter Size (mm)	*Prefilter Size (mm)*
25	22
47	35
90	75
142	124
293	257

Nonsterile Operations

For nonsterile polish filtrations, the quality level must be established prior to choice of media.

Particulate matter above 30- to 40-micron particles may be noticeable. Most pharmaceutical filtrations therefore aim for removal of particles of 3 to 5 microns or less.

A nephelometer, an instrument that measures the degree of light scattering (Tyndall effect) in dilute suspensions, is an excellent tool for assessing effectiveness in this range.

The nephelometer gives a quantitative value to the formulator's quality specification of Sparkling clear. This value may be used to compare results using different filtration media.

Figure 7-6 shows a typical curve obtained from filtration of an elixir through disposable cartridges and standard kraft paper. If an existing process is to be shifted from paper on a filter press to cartridges, this curve permits selection of an element that gives comparable performance. The technique also may be applied to assessment of filter aid effectiveness by determining transmittance as a function of filter-aid type, quantity, or method of use.

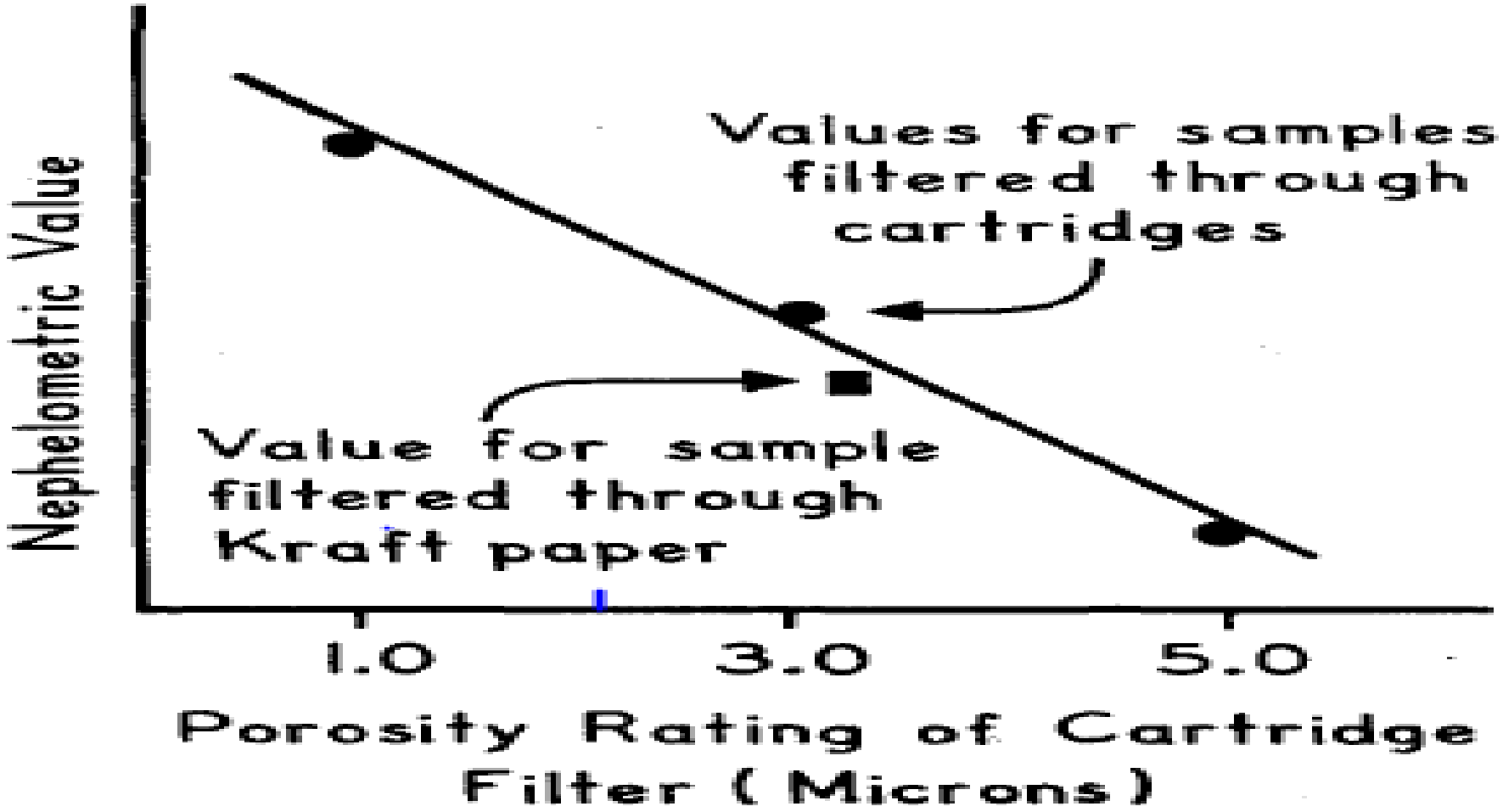

FIG. 7-6. *A nephelometer reading of a filtrate provides data that may be used to compare performance of different media.*

The question of time for a filtration cycle is resolved by determining total volume versus time during a test run at pressures approximating normal operating conditions. Flow rate decreases with time as the media plugs or as the cake builds up. Plotting log total volume per unit area versus log time usually gives a straight line suitable for limited extrapolation (Fig. 7 -7). If the filter area of production equipment is fixed, the time to filter a given batch size may be estimated.

Alternately, the filter area required to complete the process within an allotted time period may be established.

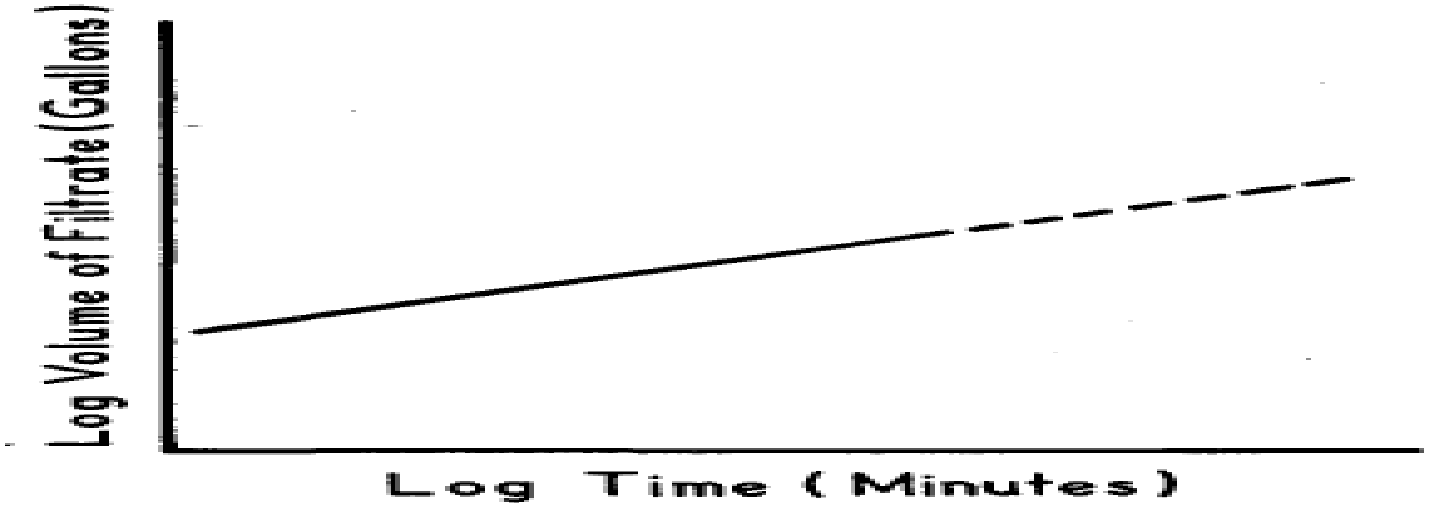

FIG. 7-7. *Extrapolation of filtrate volume produced in a given time can be made from log-log plots of experimental data.*