General practice in trickling-filter design has been to use empirical relationships to find the required filter volume for a desired degree of wastewater treatment. Several of these associations have been developed from operational data collected at existing treatment plants. One of the first evolved was the National Research Council (NRC) formula, based on data collected from filter plants at military installations in the United States in the early 1940s [9].

The NRC formula for a single-stage trickling filter is

$$E = \frac{100}{1 + 0.0561\,(w/VF)^{0.5}} \tag{12.42}$$

where E = BOD removal at 20°C, %
w = BOD load applied, lb/day
V = volume of filter media, $ft^3 \times 10^{-3}$
F = recirculation factor
w/V = BOD loading, lb/1000 ft^3/day

The recirculation factor is calculated from the formula

$$F = \frac{1 + R}{(1 + 0.1R)^2} \tag{12.43}$$

where R is the recirculation ratio (ratio of recirculation flow to raw-wastewater flow).

The NRC formula for the second stage of a two-stage filter is

$$E_2 = \frac{100}{1 + [0.0561/(1 - E_1)](w_2/VF)^{0.5}} \tag{12.44}$$

where E_2 = BOD removal of the second stage at 20°C, percent
E_1 = fraction of BOD removed in the first stage
w_2 = BOD load applied to the second stage, lb/day
w_2/V = BOD loading, lb/1000 ft^3/day

The effect of wastewater temperature on stone-filled trickling-filter efficiency may be expressed as follows:

$$E = E_{20}1.035^{T-20} \tag{12.45}$$

where E = BOD removal efficiency at temperature T in °C
E_{20} = BOD removal efficiency at 20°C

The BOD removal efficiencies computed by the NRC formulas include final settling of the filter effluent. In the empirical development of these formulas, the field procedure used in collecting data sampled the filter influent and final clarifier effluent. Therefore, in evaluating the efficiency of a trickling-filter secondary, the overflow rate and detention time of the final clarifier should be examined for adequacy of design.

For a two-stage filter secondary without an intermediate settling tank (Fig. 12.23), the NRC formulas cannot be used to determine the efficiency of the first stage. In this case it is common to assume that the first-stage efficiency is 50% and find the efficiency of the second stage from Eq. 12.44.

TF-2