Q and H are at maximum efficiency for a given speed N, Q, is in cumec, H is in meters and N and N_s in r.p.m.

2. The work done by the pump in lifting Q cumecs of water by a head

\[ H = wQH \]

where \( w = \) unit weight of water in kg/m^3
\( Q = \) discharge to be pumped in m^3/sec

3. The water horse power

\[ \text{W.H.P.} = \frac{wQH}{75} \]

4. B.H.P. = \[ \frac{\text{WHP}}{75\eta} = \frac{wQH}{75\eta} \]

Economic diameter of pipe, \( D = 0.97 \) to \( 1.22 \sqrt{Q}. \)

WATER TREATMENT

1. \( V = \frac{Q}{BH} \)

where \( Q = \) discharge entering in basin
\( B = \) width of the basin
\( H = \) depth of water in tank.

2. \( V_s = \frac{Q}{BL} \)

3. Detention time \( t \) for a rectangular tank

\[ t = \frac{BH}{Q} \]

4. Detention time for a circular tank

\[ t = \frac{d^2 (0.011d + 0.785H)}{Q} \]

Frictional loss in pipe (\( h_f \));

\[ h_f = \frac{f'IV^2}{2gd} \]

\( f' = \) coefficient of friction
\( l = \) Total length of pipe line

13. WATER AND WASTE

WATER QUALITY

1. \( Y_t = L \left[ 1 - (10)^{-k_D \cdot t} \right] \)

where \( Y_t \) is the oxygen absorbed in \( t \) days \( i.e. \) BOD of \( t \) days and \( L \) is the ultimate B.O.D.

\[ K_D = \text{speed of BOD reaction}. \]

2. \( K_D(T^o) = K_D(20^o)^{1.0477 - 20^o} \)

\( K_D(20^o) = \text{deoxygenation constant at 20^oC} \)

\( K_D(T^o) = \text{deoxygenation constant at temperature T^oC} \)

3. Standard BOD (5 days) of industrial sewage

\( = \) standard BOD (5 days) of domestic sewage per person per day x population equivalent

The standard BOD of 5 days of domestic sewage is generally 0.08 kg/day/person.

\[ \therefore \text{The population equivalent} = \frac{\text{total standard BOD (5 days) of city or industry in kg / day}}{0.08} \]

4. Relative stability,

\[ S = 100 \left[ 1 - (0.794)^{(t/20)} \right] \]

\[ S = 100 \left[ 1 - (0.630)^{(t/20)} \right] \]

5. BOD of sewage = loss of oxygen \times \text{dilution factor}

6. \[ C = \frac{C_S Q_S + C_R Q_R}{Q_S + Q_R} \]

where \( C_S = \) concentration of sewage
\( Q_S = \) rate of sewage
\( C_R = \) concentration of river
\( Q_R = \) rate of flow of river

7. Oxygen deficit (\( D \))

\[ = \text{saturation (DO) – actual (DO)} \]

8. \[ D_t = \frac{K_D L}{K_R - K_D} (10)^{-k_D t} - (10)^{-k_R t} \]

\( + \left[ (D_0 \times (10)^{-k_R t}) \right] \]

where \( D_t = \) the DO deficit in mg/litre after \( t \) days
\( L = \) ultimate first stage BOD
\( D_o = \) initial oxygen deficit
\( D_D = \) de-oxygenation coefficient
\( K_R = \) re-oxygenation coefficient

\( K_R(T) = K_R(20^o)^{1.0167 - 20^o} \)

\( K_D(T) = K_D(T)^{1.0477 - 20^o} \)

9. Critical or maximum oxygen deficit,

\[ D_C = \frac{K_D L}{K_R} (10)^{-k_D t} \]
where \( \frac{K_R}{K_D} = f \) (self purification factor)

10. \( t_c = \frac{1}{K_D (f - 1)} \log \left[ \left( 1 - (f - 1) \frac{D_c}{L} \right) f \right] \)

11. \( \left( \frac{1}{D_o f} \right)^{f - 1} = f \left[ \left( 1 - (f - 1) \frac{D_c}{L} \right) \right] \)

WATER AND WASTE WATER TREATMENT

1. Modified Shield formula for grit chamber;
   \[ V_H = 3 \text{ to } 4.5 \sqrt{gd(S_s - 1)}. \]

2. Surface area required for skimming tank
   \[ A = 0.00622 \frac{q}{V_r} \]
   \( q = \) rate of flow of sewage
   \( V_r = \) minimum rising velocity of greasy material
   = 0.25 m/minute

3. Modified Hazen’s equation for transmission zone;
   \[ V_S = 60.6 (S_S - 1) d \left( \frac{3T + 70}{100} \right) \]
   For particles both 0.1 and 1 mm
   For inorganic solid, \( V_n = d(3T + 70) \)
   For organic solid, \( VS_{(O)} = 0.12 d(3T + 70) \)

4. \[ V_S = \frac{Q}{BL} \]

5. Detention time \( t \) for rectangular tank
   \[ = \frac{\text{volume of the tank}}{\text{rate of flow}} = \frac{BLH}{Q} \]

6. Detention period for a circular tank
   \[ = d^2 (0.011d + 0.785H) \frac{Q}{Q} \]

7. \[ V = V_1 \left[ \frac{(100 - P_1)}{(100 - P)} \right] \]
   \( P_1 = \) certain moisture content of any sludge
   \( P = \) reduced moisture content
   \( V_1 = \) volume of sludge when moisture content = \( P_1 \)

\[ V = \text{new volume at moisture content } P. \]

8. Capacity of digestion tank
   \[ = \left[ V_1 - \frac{2}{3} (V_1 - V_2) \right] \]
   \( V_1 = \) volume of raw sewage produced daily
   \( V_2 = \) equivalent volume of daily sludge
   \[ = \frac{V_1}{3} \]
   \( t = \) digestion period in days

9. Efficiency of conventional trickling filter,
   \[ \eta = \frac{100}{1 + 0.0044\sqrt{u}} \]
   \( u = \) organic loading in kg/ha-m/day.

10. Recirculation factor (High rate filters),
    \[ F = \frac{1 + \frac{R}{I}}{\left[ 1 + 0.1 \frac{R}{I} \right]^2} \]
    \( R/I = \) recirculation ratio

11. Efficiency of single stage high rate trickling filter,
    \[ \eta' = \frac{100}{1 + 0.0044\sqrt{u}} \]
    \( u = \) unit organic loading

12. Final efficiency of two stage filter
    \[ \eta = \frac{100}{1 + \frac{0.044}{\sqrt{u}} \left( 1 - \eta' \right).} \]

13. Aeration tank capacity,
    \[ V = Q \frac{T}{24} \]
    \( Q = \) volume of flow of sewage in m³/day
    \( T = \) aeration period (4 to 8 hours).

14. Volumetric BOD loading = \( \frac{Q Y_0 (gm)}{V (m^3)} \)
    \( Y_0 = \) BOD₅ in mg/lt or gm/m³
    \( V = \) aeration tank volume.

15. Food (F) to micro-organism (M) ratio
    \[ \frac{F}{M} \text{ ratio} = \frac{Q Y_0}{VX_t} \]
16. Total solid removal from the system per day
   \[ Q_w X_R + (Q - Q_w) X_E \]
where \( Q_w \) = volume of wasted sludge per day
\( X_R \) = concentration of solid in return sludge
\( Q_1 \) = sewage inflow per day
\( X_E \) = concentration of solids in effluent in mg/litre

17. Sludge age, \( Q_x = \frac{V X_t}{Q_w X_R + (Q - Q_w) X_E} \)
\( X_t \) = concentration of solid in the reactor (MLSS).

18. Sludge volume Index (SVI) = \( \frac{V}{X} \) ml/mg.

19. Rate of return sludge,
   \[ Q_R = Q \left[ \frac{X_t}{10^6 \left( \frac{SVI}{X} - X_t \right)} \right] \]

20. Detention in days in oxidation pond
   \[ = \frac{1}{K_D} \log_{10} \left( \frac{L}{L - Y} \right) \]
\( L = \text{BOD of effluent entering the pond} \)
\( Y = \text{BOD removal say 90 to 95\% of } L \).