Formula Sheet for all Wastewater Operator Exams
Revised 3/17

F001

$$\text{Surface area of a pond, acres} = \frac{\text{Length, ft} \times \text{Width, ft}}{43560}$$

F002

$$\text{Volume of a pond, MG} = \left[\frac{(\text{Surface area, sf}) \times (\text{Bottom area, sf})}{2}\right] \times (\text{Depth, ft}) \times \left(\frac{7.48}{1{,}000{,}000}\right)$$

F004

$$\text{BOD removal efficiency, \%} = \left(\frac{\text{Influent BOD, mg/L} - \text{Effluent BOD, mg/L}}{\text{Influent BOD, mg/L}}\right) \text{ X } 100\%$$

F008

$$\text{Theoretical detention time of a pond, days} = \frac{\text{Volume of the pond, MG}}{\text{Flow rate, MGD}}$$

F011

$$\text{Removal efficiency, \%} = \left(\frac{\text{Influent concentration} - \text{Effluent concentration}}{\text{Influent concentration}}\right) \times 100\%$$

F012

Solids, lbs= (Volume, MG) x (MLSS, mg/L) x (8.34)

F016

$$\text{Average flow rate, MGD} = \frac{\text{(Final flow, MG) - (Initial flow, MG)}}{\text{Time elapsed, days}}$$

F017

BOD loading, lbs/day = (Flow rate, MGD) x (BOD, mg/L) x 8.34

F018

$$\text{TSS removal efficiency, \%} = \left(\frac{\text{Influent TSS} - \text{Effluent TSS}}{\text{Influent TSS}}\right) \times 100\%$$

F020

$$\text{Volume of sample needed for a BOD test bottle, mL} = \frac{1200}{\text{Estimated BOD of the sample, mg/L}}$$

F021

$$\text{BOD, mg/L} = \frac{\text{(Initial D.O., mg/L - Final D.O., mg/L) x 300 mL}}{\text{Sample volume, mL}}$$

F022

Chlorine feed rate, lbs/day = (Flow, MGD) x (Dosage, mg/L) x (8.34)

F023

$$\text{TSS test results, mg/L} = \left(\frac{\text{Net dry weight, mg}}{\text{Sample volume, mL}}\right) \text{X } 1000 \text{ mL/L}$$

Or

$$\text{TSS test results, mg/L} = \left(\frac{\text{Net dry weight, g}}{\text{Sample volume, mL}}\right) \text{X } 1{,}000{,}000 \text{ mL/L}$$

F030

$$\text{Pump capacity, gpm} = \frac{\text{(Width, ft) x (Length, ft) x (Draw-down, ft) x 7.48}}{\text{Time of draw-down in minutes}}$$

F030B

$$\text{Increased flow} = \frac{\text{(New pipe diameter, inch)}^2}{\text{(Old pipe diameter, inch)}^2}$$

F030C

Flow rate in a pipe, gpd =

$$\left[\frac{(\text{Pipe diameter, inches})^2}{(12 \text{ in/ft})^2}\right] \times 0.785 \times (\text{Velocity, ft/sec}) \times 60 \text{ sec/min} \times 1440 \text{ min/day} \times 7.48 \text{ gal/cf}$$

F032

Desired suspended solids, lbs = (Sludge age, days) x (Primary effluent solids, lb/day)

F033

$$\text{Volume per stroke, gal/stroke} = \left[\frac{(0.785) \times (\text{Diameter, inches})^2}{12^2}\right] \times \left[\frac{(\text{Stroke, inches}) \times (7.48)}{12}\right]$$

F034

$$\text{Total dry solids, lbs} = \frac{\text{(Raw sludge, gal) x (Total solids, \%) x (8.34)}}{100\%}$$

F035

MLSS, lbs = (Aeration volume, MG) x (MLSS conc, mg/L) x (8.34)

F037

$$\text{Digestion time, days} = \frac{\text{Digester volume, gal}}{\text{Flow, gpd}}$$

F038

Phosphorus (P) removal, % = $\left(\frac{\text{Influent P, mg/L} - \text{Effluent P, mg/L}}{\text{Influent P, mg/L}}\right)$ x 100%

F039

Sludge applied, gal = $\frac{\text{(Area, sf) x (Depth of application, in) x (7.48)}}{\text{12 in/ft}}$

F040

Pollutant emission rate, lbs/day = $\frac{\text{(Flow, gpd) x (Pollutant conc., mg/L) x (3.785 L/gal)}}{\text{453,600 mg/lb}}$

F043

Chemical application rate, lbs/day = (Flow, MGD) x (Chemical dosage, mg/L) x 8.34

F045

Flux, gpd/sf = $\frac{\text{(Flow rate, gpm) x (60 min/hr) x (24 hr/day)}}{\text{Surface area of membrane, sf}}$

F047

New, or actual, WAS flow rate, MGD = $\frac{\text{(Calculated WAS flow, MGD) x (24hr/day)}}{\text{Actual hours of sludge wasting, hr/day}}$

F048

Solids produced, lbs/day = (BOD removed, lbs/day) x (Yield factor)

F050

Primary sludge, lbs/day = (Flow rate, MGD) x (Inflow SS, mg/L - Effluent SS, mg/L) x 8.34

F052

Hydraulic loading of a DAF unit, gpd/sf = $\frac{\text{(Inflow rate, gpm) x (1440)}}{\text{Liquid surface area, sf}}$

F053

Solids loading to a centrifuge, lbs/hr = $\frac{\text{(Sludge flow rate, gal/hr) x (Sludge conc \%) x 8.34 lbs/gal}}{\text{100\%}}$

F054

Efficiency of solids removal, % = $\left(\frac{\text{Influent SS, \%} - \text{Effluent SS, \%}}{\text{Influent SS, \%}}\right)$ x 100%

F055

$$\text{Dry polymer, lbs} = (\text{Volume of solution, gal}) \times \left(\frac{\text{Polymer concentration, \%}}{100\%} \right) \times (8.34 \text{ lb/gal})$$

F058

$$\text{Pumping rate, gpm} = \frac{\text{(Volume, cf) x (7.48 gal/cf)}}{\text{Time, min}}$$

F061

$$\text{Surface loading, gpd/sf} = \frac{\text{Flow, gpd}}{\text{Surface area, sf}}$$

F062

$$\text{Solids loading, lbs/day/sf} = \frac{\text{(Flow, MGD) x (TSS, mg/L) x (8.34)}}{\text{Surface area, sf}}$$

F063

$$\text{Sludge age} = \frac{\text{TSS in aerator, lbs}}{\text{TSS in primary effluent, lbs/day}}$$

F064

$$\text{F/M} = \frac{\text{lbs BOD/day to aeration tank}}{\text{lbs of MLVSS under aeration}}$$

F065

$$\text{Waste sludge pumping rate, MGD} = \text{Current pump rate, MGD} + \left[\frac{(\text{Difference in aerator sludge inventory, lbs})}{(\text{RAS concentration, mg/L}) \times 8.34} \right]$$

F066

$$\text{MCRT, days} = \frac{\text{MLSS in aeriationtion tank, lbs}}{(\text{TSS wasted, lbs/day}) + (\text{TSS in effluent, lbs/day})}$$

F068

$$\text{MLVSS, mg/L} = \frac{\text{BOD Loading from primary, lbs/day}}{(\text{F/M Ratio}) \times (\text{Aerator volume, MG}) \times (8.34)}$$

F069

$$\text{Return sludge rate, MGD} = \frac{\text{Settled solids, mL x (Flow, MGD)}}{\text{(1000 mL - Settled solids, mL)}}$$

F073

$S0_2$ feed, lbs/day =(Flow, MGD) x (Residual chlorine, mg/L + SO_2 overdose, mg/L) x (8.34)

F074
Chlorine demand, mg/L = (Chlorine dose, mg/L) - (Chlorine residual, mg/L)

F076
$$\text{Polymer dose, mg/L} = \frac{\text{(Polymer delivery rate, gpm) x (Polymer, lbs/gal) x (1,000,000)}}{\text{(Flow, gpm) x (8.34)}}$$

F077
$$\text{Polymer dose, mg/L} = \frac{\text{(Polymer feed rate, lbs/day) x (1,000,000)}}{\text{(Flow, gpm) x (1440) x (8.34)}}$$

F078
Volume of seed sludge, gal = (Volume of digester, gal) x (% seed)

F081
Total settleable solids to pump to digester, gpd = (Sludge removed, mL) x (Flow, MGD) x (1000)

F082
$$\text{\% reduction of volatile matter, \%} = \frac{\text{(In - Out) x (100)}}{\text{In - [(In) x (Out)]}}$$ *("in" and "out" in fraction, not in %)*

F083
$$\text{\% reduction of volatile matter, \%} = \left[\frac{(\text{Initial volatile matter, lbs}) - (\text{Final volatile matter, lbs})}{\text{Initial volatile matter, lbs}}\right] \times 100\ \%$$

F087
$$\text{Seed correction per 1.0 mL of seed} = \frac{\text{Initial D.O. – Final D.O.}}{\text{mL of seed in bottle}}$$

and

$$\text{BOD}_5\text{, mg/L} = \left\{\frac{[(\text{Initial DO, mg/L}) - (\text{Final DO, mg/L})] - (\text{Seed correction, mg/L})}{\text{Sample volume, mL}}\right\} \times 300\ \text{mL}$$

F088
$$\text{Volume diluted, mL} = \frac{\text{(Target normality) x (Target volume, mL)}}{\text{Stock acid normality}}$$

F091
$$\text{Sludge flow, MGD} = \frac{\text{(Thickener loading, lbs/day/sf) x (Surface area, sf)}}{\text{(8.34) x (10,000) x (\% solids)}}$$

F092
Desired lbs of solids in aeration tank = (Daily solids addition, lbs/day) x (Sludge age, days)

F094

New digestion time, days = $\frac{\text{(Digester volume, gal)x(Increase in sludge conc,\%-Initial sludge conc,\%)}}{\text{(Initial sludge flow, gpd) x (Initial sludge conc, \%)}}$

F096

Volume of working solution, mL = $\frac{\text{(Beaker volume, mL) x (Dosage, mg/L)}}{\text{(Stock solution conc, \%) x (10,000)}}$

F097

Chemical feed rate, gph = $\frac{\text{(Flow, MGD) x (Dosage, mg/L) x 100\%}}{\text{(Solution strength, \%) x (24 hr/day)}}$

F098

Surface loading rate, gpd/sf = $\frac{\text{(Flow rate, MGD) x (1,000,000 gal/MG)}}{\text{(Diameter, ft)}^2 \text{ x (0.785)}}$

F099

Polymer dosage, mg/L = $\frac{\text{(Polymer pumping rate, gpm) x (Polymer conc. lbs/gal) x (1,000,000)}}{\text{(Sludge flow rate, gpm) x (8.34 lbs/gal)}}$

F100

Retention % = $\frac{(\text{Retentate conc., mg/L}) - (\text{Permeate conc., mg/L})}{\text{Retentate conc., mg/L}} \times 100\%$

F101

Average transmembrane pressure, psi =

$$\frac{\text{(Inlet pressure, psi + Outlet pressure, psi)} - \text{Permeate pressure, psi}}{2}$$

F103

RAS, MGD = $\frac{\text{(Settled volume, mL/L) x (Influent flow rate, MGD)}}{\text{(1000 mL/L) - (Settled volume, mL/L)}}$

F105

Sludge age, days = $\frac{(\text{Tank volume, MG}) \times (\text{MLSS, mg/L})}{(\text{Inflowrate, MGD}) \times (\text{Primary effluent SS, mg/L})}$

F106

F/M, lb COD/day per lb MLVSS = $\frac{(\text{Flow, MGD}) \times (\text{COD, mg/L}) \times (\text{8.34 lbs/gal})}{(\text{Solids under aeration, lbs}) \times (\text{Volatile fraction})}$

F108

Phosphorus to be added, lbs/day = [BOD lbs/day x P/BOD (desired ratio)] – (P in wastewater, lbs)

F110
Desired COD loading, lbs/day = (COD loading rate, lbs COD/lbs VS) x (VS, lbs)

F111
Sludge produced, lbs/day =
(Flow, MGD) x (Influent BOD, mg/L - Effluent BOD, mg/L) x (8.34 x yield factor)

F112

$$\text{Thickened sludge volume, gal/day} = \left(\frac{\text{Sludge, lbs/day}}{8.34\ \text{lbs/gal}}\right) \times \left(\frac{100\%}{\text{Sludge solids concentration, \%}}\right)$$

F114

$$\text{Solids loading, lbs/hr/sf} = \frac{\text{(Flow, gpm) x (60) x (8.34 lbs/gal) x (SS\%)}}{\text{(Liquid surface area, sf) x (100\%)}}$$

F115

$$\text{Air to solids ratio} = \frac{(\text{Air supply rate, cfm}) \times (0.075\ \text{lb/cf}) \times (100\%)}{(\text{Solids feed rate, gpm}) \times (\text{Sludge conc, \%}) \times (8.34\ \text{lbs/gal})}$$

F116

$$\text{Feed time to a centrifuge, min} = \frac{\text{(Storage volume, cf) x (Basket sludge conc, \%) x (62.4 lbs/cu ft)}}{\text{(Flow, gpm) x (Influent solids, \%) x (8.34 lbs/gal)}}$$

F117

$$\text{Increase of detention time, days} = \frac{(\text{Aerobic digester volume, gal}) \times (\text{Increase in sludge conc., \%})}{(\text{Initial sludge flow, gpd}) \times (\text{Initial sludge conc., \%})}$$

F122

$$\text{Polymer dosage, lbs/ton} = \frac{\text{(Polymer solution conc, \%) x (Polymer added, gpm) x (2,000 lbs/ton)}}{\text{(Sludge conc, \%) x (Sludge flow rate, gpm)}}$$

F123

$$\text{Vacuum filter yield, lbs/hr/sq ft} = \frac{\text{Sludge loading, lbs/day} \times \left(\frac{\text{Recovery, \%}}{100\%}\right)}{(\text{Duration of filter operation, hr/day}) \times (\text{Filter area, sf})}$$

F124

$$\text{Required filter run time, hr/day} = \frac{\text{Sludge solids loading, lbs/day x Solids recovery, \%}}{\text{(Filter yield, lbs/hr/sf) x (Filter area, sf) x (100\%)}}$$