YOUR FREE READER'S COMPANION

The Operator Exam Cram Pack

A companion to The Wastewater Treatment Operator Certification Study Guide · by Dale Rourke

Thanks for picking up the study guide. This companion is the part you carry with you: fold it into your notebook, tape it inside your locker, or read it in the parking lot before you walk in to test. It pulls the formulas, the highest-yield numbers, ten worked problems, and a fast recall quiz into a few pages you can drill in an afternoon. Every value here matches the book and the ABC need-to-know, so nothing here contradicts what you studied.

Most people who fail the operator exam do not fail on theory. They fail on the math and on a handful of ranges they never quite memorized. Get the pounds formula automatic, know your F:M and MCRT windows cold, and keep your units straight, and you have already answered most of the questions that sink everyone else. Carry this, drill it, and walk in calm. — Dale

Operator Math Formula Sheet

Every formula you need, in one compact list. Keep your units straight: concentration in mg/L, flow in MGD unless noted, volume and area in the units the formula names.

The pounds formula (the workhorse)

- Pounds per day = Concentration (mg/L) x Flow (MGD) x 8.34
- Rearranged: mg/L = Pounds per day / (MGD x 8.34)
- Rearranged: MGD = Pounds per day / (mg/L x 8.34)
- 8.34 is pounds per gallon. Used for BOD load, TSS load, chemical feed, solids, and oxygen demand.

Flow and velocity

- Q = A x V (flow = cross-sectional area x velocity). Area in ft2, velocity in ft/s gives Q in cfs.
- Rectangular area = Width x Depth (ft2)
- Circular area = 0.785 x Diameter squared (ft2); 0.785 is pi divided by 4
- Circular perimeter (weir length) = 3.14 x Diameter (ft)

Detention time

- Detention time = Volume / Flow. Keep volume and flow in matching units (gallons and gpd give days; gallons and gpm give minutes).

Clarifier and filter loadings

- Surface overflow rate = Flow (gpd) / Surface area (ft2). Units gpd/ft2.
- Weir overflow rate = Flow (gpd) / Weir length (ft). Units gpd/ft.
- Solids loading rate = (Flow + RAS) MGD x MLSS (mg/L) x 8.34 / Surface area (ft2). Units lb/day/ft2.
- Hydraulic loading rate = Flow (gpd) / Surface area (ft2). Units gpd/ft2.
- Organic loading rate = Pounds BOD per day / Media volume (in 1,000 ft3 units). Units lb BOD/day per 1,000 ft3.

Activated sludge process control

- F:M = Pounds BOD applied per day / Pounds MLVSS under aeration (dimensionless; the 8.34 cancels top and bottom).
- MCRT (SRT) = Pounds of solids in system / Pounds of solids leaving per day. Solids in = MLSS x aeration volume (MG) x 8.34; solids leaving = WAS pounds + effluent TSS pounds.
- Sludge age (Gould) = Pounds MLSS under aeration / Pounds TSS applied per day (uses solids IN, not solids OUT).
- RAS ratio: RAS flow / Influent flow = MLSS / (RAS concentration - MLSS)
- SVI = (Settled sludge volume, mL/L after 30 min / MLSS, mg/L) x 1,000. Units mL/g. Do not forget

the x 1,000.

Removal and disinfection

- Percent removal = ((In - Out) / In) x 100. In and Out in the same units.
- Chlorine dose = Demand + Residual (all mg/L)
- Chlorine feed = Dose (mg/L) x Flow (MGD) x 8.34 (lb/day)
- CT = Residual concentration (mg/L) x Contact time (minutes). Contact time = basin volume / flow (convert flow to gpm so gallons/gpm gives minutes).

Solids and digestion

- Dry solids per day = Sludge flow (gpd) x 8.34 x (Percent solids / 100). Also: 1 percent = 10,000 mg/L.
- Volatile solids loading = Pounds VS per day / Digester volume (ft3). Units lb VS/day/ft3.

Pumping horsepower

- Water horsepower (WHP) = (Flow, gpm x Head, ft) / 3,960
- Brake horsepower (BHP) = WHP / Pump efficiency (decimal)
- Motor horsepower = BHP / Motor efficiency (decimal)

Dilution

- C1 x V1 = C2 x V2 (concentration x volume is conserved; solve for the unknown)

Key conversion factors

Convert	Equals
1 cubic foot of water	7.48 gallons
1 gallon of water	8.34 pounds
1 cubic foot of water	62.4 pounds
1 day	1,440 minutes
1 MGD	694.4 gpm = 1.55 cfs
1 cfs	448.8 gpm = 0.6463 MGD
1 acre	43,560 square feet
1 acre-foot	43,560 ft3 = 325,829 gallons
1 percent solids	10,000 mg/L

Key Numbers to Memorize

The highest-yield values the exam loves. Learn them cold; they answer direct recall questions and set the sanity check for your math.

Universal constants

- 8.34 = pounds per gallon of water; 7.48 = gallons per cubic foot; 1 MGD = 694 gpm; 1,440 minutes per day

Wastewater strength (typical medium domestic)

- BOD5 about 200 mg/L; COD about 400 to 450 mg/L; TSS about 210 mg/L; total N about 40 mg/L; total P about 7 mg/L
- COD-to-BOD5 ratio about 2 to 2.5 (over 3 suggests industrial input); VSS about 70 to 80 percent of TSS

Lab test conditions

- BOD5: 5 days, 20 degrees C, in the dark; valid dilution needs 2.0 mg/L depletion and 1.0 mg/L residual DO
- GGA check standard: 198 plus or minus 30.5 mg/L
- TSS dried at 103 to 105 degrees C; VSS ignited at 550 degrees C
- Alkalinity titrated to pH 4.5 endpoint; fecal coliform incubated at 44.5 degrees C for 24 hours

Preliminary and primary

- Horizontal grit chamber velocity about 1 ft/s; aerated grit detention about 2 to 5 minutes
- Primary SOR about 800 to 1,200 gpd/ft2; detention about 1.5 to 2.5 hours
- Primary removal: BOD about 25 to 40 percent; TSS about 50 to 65 percent
- Weir overflow rate about 10,000 to 20,000 gpd/ft

Activated sludge and clarification

- DO setpoint: 1.5 to 2.0 mg/L conventional; 2.0 to 3.0 mg/L nitrifying
- MLSS: 1,500 to 3,000 mg/L conventional; MLVSS/MLSS ratio 0.7 to 0.8
- F:M: 0.2 to 0.5 conventional (target 0.2 to 0.4); 0.05 to 0.15 extended aeration
- Sludge age (MCRT): 5 to 15 days conventional; at least 8 to 10 days to nitrify; 20 to 30+ extended aeration
- RAS about 20 to 40 percent of influent; WAS about 1.5 to 4 percent of RAS flow
- SVI: 80 to 120 mL/g good; up to 150 acceptable; above 150 to 250 = bulking; very low = pin floc
- Secondary SOR 400 to 800 gpd/ft2; SLR 12 to 30 lb/day/ft2; secondary detention 2 to 4 hours

Fixed-film and ponds

- Trickling filter organic loading: low-rate 5 to 25, high-rate 25 to 100 lb BOD/day/1,000 ft3
- Recirculation ratio about 0.5:1 to 3:1; RBC disks about 40 percent submerged, 1 to 1.6 rpm
- Facultative pond loading about 15 to 35 lb BOD/day/acre; MBR MLSS about 8,000 to 12,000 mg/L

Nutrient removal

- Nitrification: 7.14 lb alkalinity (as CaCO3) and 4.6 lb oxygen per lb NH3-N; DO at or above 2.0 mg/L; pH 7.0 to 8.0
- Denitrification: recovers about 3.57 lb alkalinity per lb NO3-N; about 2.86 lb BOD per lb NO3-N
- Nutrient balance for the biology: BOD:N:P about 100:5:1

Disinfection and effluent

- Chlorine dose = demand + residual; typical secondary dose 5 to 20 mg/L; contact time about 30 minutes at average flow
- Breakpoint about 7.6 parts chlorine per part ammonia-N; dechlorination about 0.9 mg SO2 per mg chlorine
- UV dose about 30 to 100+ mJ/cm2; want UVT above about 55 to 65 percent
- Secondary standard (40 CFR 133): 30 mg/L BOD5 and 30 mg/L TSS (30-day average), 85 percent removal, pH 6.0 to 9.0
- Bacterial benchmarks: fecal coliform near 200 per 100 mL; E. coli near 126 per 100 mL (geometric means)

Solids and digestion

- Gravity thickening about 6 to 10 percent; DAF (WAS) about 4 to 6 percent solids
- Anaerobic digestion: mesophilic 95 to 98 degrees F; thermophilic 122 to 131 degrees F; detention 15 to 30 days
- Volatile solids reduction 40 to 60 percent; 38 percent VS reduction meets vector attraction reduction
- Digester pH 6.8 to 7.2; alkalinity 2,000 to 5,000 mg/L; volatile-acids-to-alkalinity ratio near 0.1 or below
- Biogas 60 to 65 percent methane; Class B geometric mean below 2,000,000 MPN/g

Safety (know these cold)

- Confined space oxygen: 19.5 to 23.5 percent (below is deficient, above is enriched)
- Flammable gas: below 10 percent of the LEL to enter; methane LEL about 5 percent
- Hydrogen sulfide: rotten-egg odor, heavier than air; olfactory fatigue and IDLH about 100 ppm; OSHA PEL 20 ppm ceiling; 500 to 700 ppm rapidly fatal
- Chlorine: PEL 1 ppm ceiling, IDLH 10 ppm, heavier than air; wear SCBA at or above IDLH
- Records retained at least 3 years; report an SSO or bypass often within 24 hours

Ten Worked Math Problems

Cover the answer, work it on scratch paper, then check your setup against mine. The setup matters more than the arithmetic; if your setup is right, a calculator finishes the job.

1. Convert gpm to MGD. A pump runs 350 gpm. What is that in MGD?

Setup: 350 gpm x 1,440 min/day = 504,000 gpd. Then 504,000 / 1,000,000 = 0.504 MGD.

2. Tank volume in gallons. A rectangular tank is 80 ft long, 20 ft wide, 12 ft deep.

Setup: 80 x 20 x 12 = 19,200 ft3. Then 19,200 x 7.48 = 143,616 gallons (about 143,600).

3. BOD load. Influent BOD 180 mg/L, flow 2.5 MGD.

Setup: 180 x 2.5 x 8.34 = 3,753 lb/day of BOD.

4. Solids load. TSS 220 mg/L, flow 3.6 MGD.

Setup: 220 x 3.6 x 8.34 = about 6,605 lb/day.

5. Chlorine feed rate. Dose 8 mg/L, flow 1.5 MGD.

Setup: 8 x 1.5 x 8.34 = about 100 lb/day of chlorine.

6. Percent removal. Influent BOD 200 mg/L, effluent BOD 18 mg/L.

Setup: (200 - 18) / 200 x 100 = 182 / 200 x 100 = 91 percent removal.

7. Detention time. A clarifier holds 150,000 gallons; flow is 1.0 MGD.

Setup: 1.0 MGD = 1,000,000 gpd. Detention = 150,000 / 1,000,000 = 0.15 day. Times 24 = 3.6 hours.

8. Surface overflow rate. A circular clarifier is 60 ft across; flow is 1.8 MGD.

Setup: Area = 0.785 x 60 x 60 = 2,826 ft2. SOR = 1,800,000 gpd / 2,826 ft2 = about 637 gpd/ft2.

9. F:M ratio. BOD applied 3,000 lb/day; MLVSS under aeration 12,000 lb.

Setup: F:M = 3,000 / 12,000 = 0.25. In the target conventional window.

10. SVI. 30-minute settled volume 220 mL/L; MLSS 2,500 mg/L.

Setup: SVI = (220 / 2,500) x 1,000 = 88 mL/g. Good settling.

Rapid-Fire Recall Quiz

Read the question, say the answer out loud, then uncover it. Do the whole set the night before and again the morning of. If you miss one, flag the chapter and reread that section.

Question	Answer
Pounds per day equals what?	mg/L x MGD x 8.34
What does 8.34 represent?	Pounds in one gallon of water
Gallons in one cubic foot?	7.48
Minutes in a day?	1,440
BOD5 test conditions?	5 days, 20 degrees C, in the dark
TSS drying temperature?	103 to 105 degrees C
VSS ignition temperature?	550 degrees C
Alkalinity titration endpoint?	pH 4.5
Typical domestic BOD5?	About 200 mg/L
Conventional DO setpoint?	1.5 to 2.0 mg/L
DO to nitrify?	At or above 2.0 mg/L
Conventional MLSS range?	1,500 to 3,000 mg/L
MLVSS to MLSS ratio?	0.7 to 0.8
Conventional F:M target?	0.2 to 0.4
Extended aeration F:M?	0.05 to 0.15
Conventional MCRT range?	5 to 15 days
MCRT needed to nitrify?	At least 8 to 10 days
Good SVI range?	80 to 120 mL/g
SVI that signals bulking?	Above 150
Typical RAS as percent of flow?	20 to 40 percent
Primary clarifier detention?	1.5 to 2.5 hours
Primary BOD removal?	25 to 40 percent
Primary TSS removal?	50 to 65 percent
Secondary SOR range?	400 to 800 gpd/ft2
Chlorine dose equation?	Demand + residual
CT equals what?	Residual x contact time (minutes)
Chlorine contact time at average flow?	About 30 minutes

Alkalinity used per lb ammonia nitrified?	7.14 lb as $CaCO_3$
Oxygen per lb ammonia nitrified?	4.6 lb
BOD:N:P balance for the bugs?	100:5:1
Secondary effluent BOD and TSS limit?	30 mg/L each, 30-day average
Required removal for secondary treatment?	85 percent
Mesophilic digestion temperature?	95 to 98 degrees F
Anaerobic digester pH?	6.8 to 7.2
Biogas methane content?	60 to 65 percent
Safe confined-space oxygen range?	19.5 to 23.5 percent
Methane LEL?	About 5 percent
H_2S IDLH?	About 100 ppm
Chlorine IDLH?	10 ppm
How long to keep records?	At least 3 years

That is the whole pack. Drill the formula sheet until the setups are automatic, memorize the ranges, and trust your sanity checks. You have done the work. Walk in and pass. — Dale