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Illinois Environmental Protection Agency
Bureau of Water
Class 3 Study Guide
Wastewater Operator Certification

The purpose of this study guide is to explain the testing process and to help you prepare for the Class 3 wastewater operator certification examination.

If this is your first exam attempt, a short history of the current exam development should be of interest. The exam questions were developed by experts in the wastewater field. Each question has been validated through a panel review process. The panel is comprised of 8 experts who have worked for many years in the wastewater field. Every question with each of the four answer selections has been examined for content, readability, accuracy and relation to the Task Analysis.

The validation process has taken several years. It is an on-going process with new questions being developed and reviewed each year. You might say the job is never finished since existing validated questions must also prove reliable; that is they must test what they are supposed to test. Reliability can only be established from statistical evidence, which takes a minimum question repetition of 100 times. If statistics show a question to be unreliable, it is removed from the question bank. Unreliable questions are sent back to the review panel for restructuring.

Each exam question is related back to a major subject category; Class 3 subject categories include:

1. Chemical Addition
2. Collection Systems
3. Digesters
4. Disinfection
5. Electrical
6. Flow Measurement
7. General Information
8. Imhoff Tanks
9. Intermittent Sand Filters
10. Laboratory
11. Lagoons
12. Maintenance
13. Management
14. Math
15. Motors
16. Preliminary Treatment
17. Primary Treatment
18. Pumps and Pumping
19. RBC's
20. Recordkeeping
21. Rules and Regulations
22. Safety and Health
23. Secondary Sedimentation
24. Sludge Drying Beds
25. Sludge Handling
26. Tertiary Treatment
27. Trickling Filters

Each Class 3 exam version has 100 multiple choice questions taken from any combination of these twenty-seven categories.

When you take the Class 3 exam, you are given one exam book-let containing questions, formulas and conversion factors, one answer sheet, two sheets of scratch paper and two pencils. The only item you may bring to the exam site is your calculator which must be non-programmable and incapable of storing alpha-numeric data. You are allowed a maximum of three hours to complete the exam. A copy of the conversion factors and formulas are provided at the back of this study guide. If you familiarize yourself with the format, it should cut down your referencing time during the examination.

Usually within two weeks of exam completion, your results are sent to your home. Whether or not you passed the exam, you receive a detailed breakdown of your performance as shown below:

	NUMBER OF QUESTIONS	NUMBER CORRECT	NUMBER INCORRECT	% CORRECT IN CATEGORY
ELECTRICAL	1	0	1	0%
TRICKLING FILTERS	10	3	7	30%
FLOW MEASUREMENT	1		2	33%
PRELIM TREATMENT	5	2	3	40%
RBC'S	5	2	3	40%
LAGOONS	4	2	2	50%
DISINFECTION	4	2	2	50%
LABORATORY	5	3	2	60%
MAINTENANCE	3	2	1	67%
MATH	10	7	3	70%
PRIMARY TREATMENT	4	3	1	75%
COLLECTION SYTEMS	10	9	1	90%
PUMPS AND PUMPING	4	4	0	100%
IMHOFF TANKS	4	4	0	100%
DIGESTERS	10	10	0	100%
SECONDARY CLARIFIERS	2	2	0	100%
SAFETY	7	7	0	100%
INTERMITTENT S.F.	2	2	0	100%
SLUDGE DRYING BEDS	4	4	0	100%
MOTORS	3	3	0	100%
TOTAL	100	72	28	72%

Should you fail to achieve a score of 70%, you can use these results to determine the areas to study.

In the preceding example, the examinee scored the lowest percent correct on Electrical (0%), Trickling Filters (30%), Flow Measurement (33%), Preliminarty Treatment (40%) and RBC's (40%) but lost the most points on Trickling Filters (7 points), Preliminary Treatment (3 points), RBC's (3 points) and Math (3 points). It would be wise to review all six subject categories. Notice how the category list progresses from lowest percent correct (Electrical 0%) to highest percent correct (Motors 100%). This category list would appear in different orders for various examinees, depending on an examinee's area(s) of weakness.

If you score less than 70%, you may reschedule for the Class 3 exam by simply completing and returning the exam scheduling form provided with your results, since submission of another completed application is not required for retesting. When you do retest, the number of questions per category or the categories themselves may differ on the exam you are given. If you find a need for additional technical information, there is a list of suggested reading on page 12 of this study guide.

The following is a list of the main subject areas that may be covered on the Class 3 examination. The questions are provided to show you the type of questions that one might expect to see on the examination; however, these exact questions do not appear on the examination.

I. General Information

A. Characteristics of wastewater

B. Basic Steps of treatment

C. Wastewater terminology relating to fixed film systems

Example Question:

It is most likely that zoogleal films will be found in:

a) vacuum filters
b) primary clarifiers
c) trickling filter media
d) digested sludge

II. Collection Systems

A. Purposes and types of collection systems

B. Collection system components

C. Routine operation and maintenance procedures

D. Sewer installation inspections

E. Troubleshooting collection systems

Example Question:

A new collection system should be tested using either water or air to determine the ability of the system to withstand the infiltration of ground water or exfiltration of wastewater:

a) before backfilling is completed
b) after backfilling is completed
c) after backfilling and compacting is completed
d) after backfilling, compaction, and the surface is restored

III. Pumps and Pumping

A. Types of pumps and motors and their application

B. Operation and maintenance of pumps

C. Operation and maintenance of motors

D. Operation and maintenance of pump controls

Example Question:

A plunger type pump should be started after:

a) opening suction valve and closing discharge valve
b) opening air vent and closing suction valve
c) closing suction valve and opening discharge valve
d) opening suction valve and opening discharge vlave

IV. Flow Measurement

A. Instruments

1. Venturi tubes

2. Parshall flumes

3. Weirs

B. Process controls

Example Question:

A U-tube manometer is used to measure what type of pressure?

a) vapor
b) differential
c) absolute
d) atmospheric

V. Preliminary Treatment

A. Purpose of preliminary treatment

B. Operation and maintenance

1. Bar screens

2. Barminutors

3. Comminutors

4. Grit Chambers

Example Question:

Which of the following machines is used to cut and shred solids in wastewater?

a) centrifuge
b) comminutor
c) rotator
d) detritor

VI. Primary Treatment

A. Purpose of primary treatment

B. Operation and maintenance

1. Primary clarifiers

2. Imhoff tanks

Example Question:

Sludge gasification in a primary clarifier may be the result of:

a) hydraulic overloading
b) low influent BOD concentrations
c) infrequent pumping of sludge
d) too short of detention time

VII. Secondary Treatment

A. Purpose of secondary treatment

B. Operation and maintenance

1. Trickling filters

2. RBC's

3. Slow sand filters

4. Lagoons

5. Secondary sedimentation

Example Question:

Ponding of a trickling filter may not be corrected by:

a) flooding the filter and keeping the media submerged for 24 hours
b) dosing the filter with chlorine at a rate of 5 mg/l for several hours
c) shutting off the filter for several hours allowing the filter growth to dry
d) decreasing the hydraulic loading to the filter for several hours allowing the ponded water to seep into the filter media

VIII. Sludge Handling

A. Purpose of sludge handling

B. Operation and maintenance of anaerobic digesters

C. Operation and maintenance of Imhoff tanks

D. Sludge disposal

Example Question:

A sludge thickened from 1% to 4% solids will be reduced in volume by how much?
a) no more than 4% of original volume
b) approximately 17% of original volume
c) approximately 25% of original volume
d) more information is needed

IX. Tertiary Treatment

A. Purpose of tertiary treatment

B. Operation and maintenance

1. Polishing ponds

2. Intermittent sand filters

3. Rapid sand filters

Example Question:

Which of the following is a true statement concerning the operation of intermittent sand filters?

a) Significantly reduces the total phosphorus concentration of wastewater
b) nitrification is not significant
c) has a large impact on effluent temperature
d) anaerobic conditions will significantly reduce the effluent quality

X. Disinfection

A. Purpose of disinfection

B. Operation and maintenance of chlorination systems

1. Hypochlorite systems

2. Gas chlorine systems

Example Question:

What is the percentage of available chlorine in sodium hypochlorite:

a) 15 - 25%
b) 45 - 55%
c) 60 - 70%
d) 80 - 90%

XI. Laboratory Testing

A. Purpose of testing

B. Process control testing

1. pH
2. DO
3. Settleable solids
4. Volatile solids
5. Volatile acids
6. Alkalinity

C. NPDES testing

1. BOD
2. TSS
3. Ammonia
4. pH
5. DO
6. Chlorine residual

Example Question:

A pH reading of 9.7 for the influent to a trickling filter facility indicates:

a) the oxygen demand of the wastewater will increase
b) The wastewater is acidic and may interfere with the normal operation of the trickling filter
c) the wastewater is alkaline and may have sufficient alkalinity for nitrification
d) is of no concern as a trickling filter is not affected by pH

XII. Safety and Health

A. Clothing and apparel

B. Machinery

C. Chemical handling including chlorine

D. Laboratory

E. Collection systems

Example Question:

An operator should not enter an enclosed structure if the percentage of oxygen in the air is less than:

a) 19.5%
b) 23.5%
c) 27.2%
d) 32.5%

XIII.Recordkeeping

A. Plant operations

B. Laboratory data

C. Financial data

D. Maintenance data

Example Question:

An operator has 8 pH samples to summarize on a monthly NPDES Discharge Monitoring Report. The pH readings were 6.9, 7.3, 7.1, 7.6, 7.2, 6.8, 7.4, and 7.3. He should report the pH findings as:

a) 7.2
b) 6.8
c) 7.6
d) 6.8 - 7.6

XIV. Rules and Regulations

A. 35 Ill. Adm. Code, Subtitle C: Water Pollution

B. 35 Ill. Adm. Code Part 391 (Design Criteria for Sludge Application on Land)

C. NPDES requirements

D. Local sewer use ordinance

Example Question:

A Notice of Non-Compliance must be submitted to the Agency when:
a) bypassing occurs
b) 30 day average of effluent samples exceeds effluent limitations
c) upset of plant due to industrial shock loads resulting in excursions of effluent limitations
d) all of the above

XV. Mathematics

A. General math

B. Process control math

C. Laboratory math

Example Question:

The influent flow to a trickling filter plant has a BOD of 220 mg/l and a SS concentration of 190 mg/l. Primary processes remove 35% of the applied BOD and 35% of the applied SS. Secondary processes remove 80% of the applied BOD and 68% of the applied SS. The tertiary process removes 20% of the applied BOD and 28% of the applied SS. What is the final effluent BOD?

a) 0
b) 15 mg/l
c) 22.8 mg/l
d) 28.6 mg/l

LIST OF SUGGESTED READING

1. MOP 1 Safety and Health in Wastewater Systems

2. MOP OM-10 Operation and Maintenance of Trickling Filters, RBC's, and Related Processes

3. MOP 11 Operation of Municipal Wastewater Treatment Plants (3 Volumes)

4. MOP 16 Anaerobic Sludge Digestion

5. Standard Methods for the Examination of Water and Wastewater - Latest Edition

6. MOP OM-8 Operation and Maintenance of Sludge Dewatering Systems

The preceding six publications are available through:

Water Environment Federation
Publications Order Department
601 Wythe Street
Alexandria, VA 22314-1994
(800) 666-0206

7. Manual of Wastewater Treatment

Available through:

Texas Water Utilities Association
1106 Clayton Lane, Suite 101-E
Austin, TX 78723-1033

8. Operation of Wastewater Treatment Plants, a Field Study Training Program

    a. Volume I
    b. Volume II

9. Advanced Waste Treatment, A Field Study Training Program

10. Operation & Maintenance of Wastewater Collection Systems, a Field Study Training Program

The correspondence courses and/or texts for items 8, 9, and 10 are available through:

Kenneth Kerri
Department of Civil Engineering
California State Univ., Sacramento
6000 J Street
Sacramento, CA 95819

and

Correspondence Course Coordinator
Environmental Resources Training Center
Campus Box 1075 - Southern Illinois University
Edwardsville, IL 62026-1075
(618) 650-2030

11. Aerobic Biological Wastewater Treatment Facilities, USEPA 430/9-77-006, SN/055-001-01071-1

12. Anaerobic Sludge Digestion, USEPA 430/9-76-001

Items 11 and 12 are available through:

ORD Publications
P.O. Box 19962
Cincinnati, OH 45219
(513) 569-7562

or

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

13. Math Review for Wastewater Certification

14. Stabilization Pond Filtration

15. Guide to Microscopic Evaluation for Sewage Treatment Operations

The preceding items 13, 14 and 15 are available through:

Environmental Resources Training Center
Campus Box 1075 - Southern Illinois University
Edwardsville, IL 62026-1075
(618) 650-2030

16. WPCF/ABC Studyguide for Wastewater Treatment and Collection System Personnel, Order No. E0376PC by the Water Environment Federation and the Association of Boards of Certification

Available through:

Water Environment Federation
Publications Order Department
601 Wythe Street
Alexandria, VA 22314-1994
(800) 666-0206

17. Design Criteria for Sludge Application on Land (35 Ill. Adm. Code 391)

Available through:

Illinois Environmental Protection Agency
DWPC/Permit Section/Watershed Unit #15
P.O. Box 19276
Springfield, IL 62794-9276
(217) 782-1696

FORMULA SHEETS

CONVERSION FACTORS

Pi (π) = 3.14
1 gallon of water = 8.34 pounds
1 gallon of water = 4 quarts = 8 pints = 3.785 liters
1 Population Equivalent (PE) = 0.17 pounds BOD/capita/day
" = 0. 20 pounds SS/capita/day
" = 100 gallons water/capita/day
1 day = 24 hours = 1440 minutes
1 square foot (ft^2) = 144 square inches (in^2)
1 square yard (yd^2) = 9 square feet (ft^2)
1 cubic foot (ft^3) = 7.5 gallons = 1728 cubic inches (in^3)
1 cubic yard (yd^3) = 27 cubic feet (ft^3)
1 acre = 43560 square feet (ft^2)
1 horsepower (HP) = 33,000 foot-pounds/minute (ft-lb/min) = 746 watts = 0.746 kilowatts (kw)
1 foot of water = 0.433 pounds/square inch (psi)
1 pound/square inch (psi) = 2.31 feet of water

VOLUMES, AREAS, & PERIMETERS

GIVEN: V = Volume, L = Length, H = Height, W = Width, r = radius, d = diameter, π = Pi, b = base, P = Perimeter, C = Circumference

VOLUMES

Rectangular Solid: $V = L \times W \times H$

Cylinder: $V = \pi r^2 H = \frac{\pi d^2}{4} H = 0.785\ d^2 H$

Sphere: $V = 4/3\ \pi r^3$

Cone: $V = 1/3\ \pi r^2 H$

Pyramid: $V = 1/3\ L \times W \times H$

PERIMETER

Polygon: $P = L_1 + L_2 + L_3 + \ldots\ldots + L_n$

Circle: $C = \pi d$

AREA

Rectangle: $A = L \times W$

Triangle: $A = 1/2\ b \times H$

Circle: $A = \pi r^2 = \frac{\pi d^2}{4} = 0.785\ d^2$

Trapezoid: $A = 1/2\ (b_1 + b_2)\ H$

PROCESS FORMULAS

TEMPERATURE

$^{o}F = 9/5\ ^{o}C + 32$ $^{o}C = 5/9\ (^{o}F - 32)$ $^{o}K = ^{o}C + 273$

FLOW MEASUREMENT

90^{o} V-notch weir: $Q = 2.5H^{2.5}$ Sharp-crested weir: $Q = 3.33LH^{1.5}$

Cippolletti weir: $Q = 3.367LH^{1.5}$ Proportional weir: $Q = 7.57mH$

Parshall flume: $Q = 4WH^{1.52W^{0.026}}$

ELECTRICITY

Power = Current x Voltage Voltage = Current x Resistance

$$\text{Average Current} = \frac{\text{Line 1 Current + Line 2 Current + Line 3 Current}}{3}$$

$$\text{Current Imbalance} = \frac{\text{Average Current - Maximum Deviation}}{\text{Average Current}} \times 100$$

MISCELLANEOUS

$$\text{Efficiency} = \frac{\text{(In - Out)}}{\text{In}} \times 100\% \qquad \text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

Application Rate = Concentration x Flow x Conversion Factor

$$\text{Loading Rate} = \frac{\text{Concentration x Flow x Conversion Factor}}{\text{Area}}$$

LABORATORY

$$BOD_5\ (mg/l) = (\text{Initial DO - Final DO}) \times \frac{\text{Bottle Volume}}{\text{Sample Volume}}$$

$$\text{SS Concentration } (mg/l) = \frac{\text{Weight of Solids (g)}}{\text{Amount of Sample (ml)}} \times \text{Conversion Factor(s)}$$

$$\% \text{ Capture} = \frac{\text{Sludge SS - RAS SS}}{\text{Wet Sludge}} \times 100 \qquad \% \text{ Solids} = \frac{\text{Dry Sample}}{\text{Wet Sample}} \times 100$$

$$\% \text{ Moisture} = \frac{\text{Wet Sludge - Dry Solids}}{\text{Wet Sludge}} \times 100$$

$$\% \text{ Volatile Solids} = \frac{\text{Dry Sample - Ash}}{\text{Dry Sample}} \times 100$$

$$\% \text{ Reduction in Volatile Matter} = \frac{\text{In - Out}}{\text{In - (In x Out)}} \times 100$$

CLARIFIER

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}} \qquad \text{Weir Overflow Rate} = \frac{\text{Flow}}{\text{Length}}$$

$$\text{Surface Settling Rate} = \frac{\text{Flow}}{\text{Surface Area}}$$

PROCESS CONTROL

$$\text{F/M} = \frac{\text{lbs of BOD}}{\text{lbs of MLSS}} \qquad (Q + RQ)\,\text{MLSS} = RQ \times \text{RAS}$$

$$\text{MLSS (mg/l)} = \frac{\text{MLSS (lbs)}}{\text{Volume x Conversion Factor(s)}}$$

$$\text{SDI} = \frac{\text{MLSS (mg/l)}}{\text{Settled Sludge Volume (ml) (30 minutes) x 10}} \text{ or } \frac{100}{\text{SVI}}$$

$$\text{SVI} = \frac{\text{Settled Sludge Volume (ml) (30 minutes)}}{\text{MLSS (mg/l)}} \times 1000$$

$$\text{Gould's Sludge Age} = \frac{\text{lbs of MLSS [Aeration Tank(s)]}}{\text{lbs of TSS (Influent)}}$$

$$\text{MCRT} = \frac{\text{lbs of MLSS (Aeration Tank) + lbs of Solids (Clarifier)}}{[(\text{RAS(mg/l)} \times \text{WAS Flow}) + (\text{Effluent SS(mg/l)} \times \text{Flow})] \times \text{Conversion Factor}}$$

$$\text{Mixed Concentration} = \frac{(\text{Upstream Flow} \times \text{Upstream Concentration}) + (\text{Effluent Flow} \times \text{Effluent Concentration})}{\text{Downstream Flow}}$$

SLUDGE LAND APPLICATION

lb/ton = mg/l x 0.002 1 mg/kg = 0.002 lbs/ton

$$\text{gal/acre} = \frac{\text{wet tons}}{\text{acre}} \times \frac{2000 \text{ lbs}}{\text{ton}} \times \frac{1 \text{ gal}}{8.34 \text{ lbs}}$$

$$\text{mg/l (dry)} = \text{mg/l (wet)} \times \frac{100}{\% \text{ Total Solids}}$$

$$\text{Dry Tons} = \text{Wet Tons} \times \frac{\% \text{ Total Solids}}{100}$$

Plant Available Nitrogen(PAN)(mg/kg) = Ammonia Nitrogen(mg/kg) + Organic Nitrogen(mg/kg)

Organic Nitrogen(mg/kg) = Total Kjeldahl Nitrogen(TKN)(mg/kg) - Ammonia Nitrogen(mg/kg)

WEST PROCESS CONTROL METHOD FOR ACTIVATED SLUDGE

$F = 31.2\ lbs/ft^3 \times H^2 \times L$

$$R_Q = \frac{\frac{MLSS}{RAS} \times Q}{1 - \frac{MLSS}{RAS}}$$

$$R_Q = \frac{Q \times M}{\frac{1{,}000{,}000}{SVI} - M}$$

$$WCR = \frac{MLTSS}{ATC}$$

$$SLU = \frac{Volume \times Centrifuged\ Concentration}{100}$$

$$SSC = \frac{1000 \times ATC}{SSV}$$

$$CFP = \frac{ATC}{(RSC - ATC}$$

$$ATC = \frac{CFP \times RSC}{CFP + 1.0}$$

$$RSC = ATC + \frac{(ATC)}{CFP}$$

$$ASU = \frac{AV \times ATC}{100}$$

$$RSU = \frac{RSF \times RSC}{100}$$

$$ADT\ @\ AFI = \frac{AV \times 24}{AFI}$$

$$ADT\ @\ TFL = \frac{AV \times 24}{AFI + RSF}$$

$$CFP = \frac{ATC - FEC}{RSC - ATC}$$

$$ATC = \frac{(CFP \times RSC) + FEC}{CFP + 1.0}$$

$$RSC = \frac{ATC + (ATC - FEC)}{CFP}$$

$$RSP = \frac{ATC - PEC}{RSC - ATC}$$

$$ATC = \frac{(RSP \times RSC) + PEC}{RSP + 1.0}$$

$$RSC = \frac{ATC + (ATC - PEC)}{RSP}$$

$$CSU = \frac{BLV \times CSC}{100}$$

$$CDT = \frac{CV \times 24}{CFI}$$

$$CSDT = \frac{CSU}{CSUO}$$

$$OFR = \frac{CFO}{CFA}$$

$$SAH = \frac{ADT \times 24}{ADT + CSDT}$$

$$AGE = \frac{ASU + CSU}{TXU/day}$$

$$CSFD = \frac{RSF \times (RSC - ATC)}{SSC - ATC}$$

$$AAG = \frac{AGE \times SAH}{24}$$

$$SCR = \frac{SSC60}{RSC}$$

AAG - Aeration Age
ADT - Aeration Tank Detention Time
AFI - Aeration Tank Wastewater Flow(In)
AGE - Sludge Age
ASU - Aeration Tank Sludge Units
ATC - Aeration Tank Concentration
AV - Aeration Tank Volume
BLV - Sludge Blanket Volume
CDT - Final Clarifier Detention Time
CFA - Final Clarifier Area
CFI - Final Clarifier Flow(In)
CFO - Final Clarifier Flow(Out)
CFP - Final Clarifier Sludge Flow Percentage
CSC - Final Clarifier Sludge Concentration
CSDT - Final Clarifier Sludge Detention Time
CSF - Final Clarifier Sludge Flow
CSFD - Final Clarifier Sludge Flow Demand
CSU - Final Clarifier Sludge Units
CSUO - Final Clarifier Sludge Units Out of Clarifier
CV - Final Clarifier Volume
FEC - Final Effluent Solids Concentration
MCRT - Mean Cell Residence Time
MLSS - Mixed Liquor Suspended Solids
MLTSS - Mixed Liquor Total Suspended Solids
MLVSS - Mixed Liquor Volatile Suspended Solids
OFR - Final Clarifier Surface Overflow Rate
PEC - Primary Effluent Concentration
RAS - Return Activated Sludge
RSC - Return Sludge Concentration
RSF - Return Sludge Flow
RSP - Return Sludge Percentage
RSU - Return Sludge Units
SAH - Sludge Aeration Hours
SCR - Sludge Concentration Ratio
SLU - Sludge Units
SSC - Settled Sludge Concentration
SSV - Settled Sludge Volume
SVI - Sludge Volume Index
TFL - Total Flow
TXU - Total Excess Sludge Units to Waste
VSS - Volatile Suspended Solids
WAS - Waste Activated Sludge
WCR - Sludge Weight to Concentration Ratio
XFP - Excess Sludge Flow
XSC - Excess Sludge Concentration
XSF - Excess Sludge Flow to Waste
XSU - Total Excess Sludge Units to Waste