Revised January 2002

Illinois Environmental Protection Agency
Bureau of Water
Operator-In-Training Study Guide
Wastewater Operator Certification

The purpose of this study guide is to explain the testing process and to help you prepare for the Operator-In-Training (O.I.T.) wastewater operator certification examinations.

There are three O.I.T. exam levels - Basic, Intermediate, and Advanced. Detailed information regarding the eligibility requirements for each O.I.T. exam level is contained in 35 Ill. Adm. Code Part 380, Procedures for the Certification of Operators of Wastewater Treatment Works.

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 process of panel review. 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 process of validation has taken several years. It is an ongoing 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 O.I.T. exam question is related back to one of the following subject categories:

1. Activated Sludge
2. Chemical Addition
3. Digesters
4. Disinfection
5. Electrical
6. Flow Measurement
7. General Information
8. Laboratory
9. Maintenance
10. Math
11. Motors
12. Preliminary Treatment
13. Primary Treatment
14. Pumps and Pumping
15. Recordkeeping
16. Rules and Regulations
17. Safety and Health
18. Secondary Sedimentation
19. Sludge Drying Beds
20. Sludge Handling
21. Tertiary Treatment

Each O.I.T. exam version has 100 multiple choice questions taken from any combination of the above categories.

When you take an O.I.T. exam, you are given one exam booklet 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 nonprogrammable 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 completions, 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:

CATEGORY	NUMBER OF QUESTIONS	NUMBER CORRECT	NUMBER INCORRECT	% CORRECT IN CATEGORY
FLOW MEASUREMENT	3	0	3	0%
PRELIM TREATMENT	2	1	1	50%
DIGESTERS	10	5	5	50%
LABORATORY	8	4	4	50%
SLUDGE HANDLING	5	3	2	60%
SECONDARY SEDIMENTATION	6	4	2	67%
ACTIVATED SLUDGE	22	16	6	73%
PRIMARY TREATMENT	4	3	1	75%
DISINFECTION	4	3	1	75%
MAINTENANCE	8	7	1	88%
GENERAL INFORMATION	8	7	1	88%
MATH	10	9	1	90%
ELECTRICAL	1	1	0	100%
PUMPS AND PUMPING	2	2	0	100%
SAFETY	5	5	0	100%
SLUDGE DRYING BEDS	2	2	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 Flow Measurement (0%), Preliminary Treatment (50%), Digesters (50%) and Laboratory (50%) but lost the most points on Activated Sludge (6 points). It would be wise to review all five subject categories. Notice how the category list progresses from lowest percent correct (Flow measurement 0%) to highest percent correct (Sludge Drying Beds 100%). This category list would appear in different orders for various examinees, depending on each examinee's area(s) of weakness.

If you score less than 70%, you may reschedule the O.I.T. exam, without submitting another application, by returning the exam scheduling form provided with your results. 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 10 of this study guide.

The following is a list of the main subject areas that may be covered on the O.I.T. 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 activated sludge systems

Example Question:

The Kraus process is used when the:

a) settleable solids fraction in raw wastewater is very high
b) nitrogen content in raw wastewater is high
c) ratio of carbonaceous to nitrogenous material is higher than normal
d) sludge digestion works poorly

II. Pumps and Pumping

A. Types of pumps and motors and their application

B. Operation and maintenance

1. Pumps

2. Motors

3. Controls for motors and pumps

Example Question:

A centrifugal pump is operating but at reduced discharge pressure. Which of the following would probably not cause reduced pressure?

a) partially clogged impeller
b) stuck discharge check valve
c) excessive clearance of wearing rings
d) pump is air-bound

III. <u>Flow Measurement</u>

A. Purpose

B. Process controls

Example Question:

Flow is measured in a Venturi meter by measuring pressure head:

a) at a point just after the converging section and at the throat
b) at a point of equal distance before the converging section and before the throat
c) midway through the converging section and midway through the throat
d) at a point just before the converging section and at the throat

IV. <u>Preliminary Treatment</u>

A. Purpose

B. Operation and Maintenance

1. Bar screens

2. Barminutors

3. Comminutors

4. Grit chambers

Example Question:

A lab analysis indicates that an aerated grit chamber is removing 20% of the volatile solids of the incoming influent. An operator should:

a) do nothing
b) reduce velocity of wastewater through grit chamber
c) increase velocity of wastewater through grit chamber
d) decrease aeration

V. <u>Primary Treatment</u>

A. Purpose

B. Operation and maintenance of primary clarifiers

Example Question:

Which of the following parameters is not significantly affected in a clarifier?

a) BOD
b) bacteria
c) suspended solids
d) pH

VI. Secondary Treatment

A. Theory of secondary treatment

B. Operation and maintenance of activated sludge units

Example Question:

If a mixed liquor sample is taken from an aeration tank and, after 30 minutes, solids settle to the bottom and then float to the top, what should you do?

a) reduce BOD loading
b) reduce aeration rate
c) add coagulant
d) increase nitrate concentration by adding sodium nitrate to the aeration tank

VII. Sludge Handling

A. Theory of sludge handling and disposal

B. Operation and maintenance

1. Anaerobic digesters

2. Aerobic digesters

3. Sludge disposal

Example Question:

Which of the following would be the most useful to an operator to avoid anaerobic digester upsets?

a) pH
b) percent of volatile solids
c) alkalinity
d) volatile acids/alkalinity ratio

VIII. Tertiary Treatment

A. Theory of tertiary treatment

B. Operation and maintenance

1. Polishing ponds

2. Intermittent sand filters

3. Rapid sand filters

Example Question:

The amount of filter aid needed in a tertiary filter:

a) increases with lower water temperature
b) increases with higher flow rates through the filter
c) increases with a higher turbidity in the influent to the filter
d) all of the above

IX. Disinfection

A. Theory of disinfection

B. Operation and maintenance

1. Gas chlorination systems

2. Hypochlorite systems

Example Question:

The point of maximum chlorine demand beyond which the residual rises in proportion to the dose is called the:

a) breakpoint
b) hyposaturation point
c) saturation point
d) solution end-point

X. Laboratory Testing

A. Purpose of Testing

B. Process control testing

1.	pH	7.	Volatile solids
2.	DO	8.	Volatile acids
3.	Settleable solids	9.	Alkalinity
4.	BOD	10.	F/M ration
5.	TSS	11.	Sludge age
6.	SVI		

C. NPDES testing

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

Example Question:

Which of the following chemicals can be used for dechlorination?

a) sodium bisulfite
b) sodium thiosulfate
c) activated carbon
d) all of the above

XI. Safety and Health

A. Clothing and apparel

B. Machinery

C. Chemical handling including chlorine

D. Laboratory

E. Collection systems

Example Question:

If an operator's eyes have been exposed to chlorine gas, one should:

a) keep patient's eyes closed, cover eyes with bandage, rush to hospital
b) apply weak solution of boric acid to eyes for 5 minutes
c) flush eyes with a small amount of water and cover them
d) flush eyes with a large amount of water for at least 15 minutes

XII. Recordkeeping

A. Plant operations

B. Laboratory data

C. Financial data

D. Maintenance data

E. Accident data

Example question:

According to NPDES permits, generally speaking, how long must records of your treatment facility be retained?

a) 1 year
b) 3 years
c) 5 years
d) must be kept for the life of the facility

XIII. Rules and Regulations

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

B. NPDES

C. Local ordinances

Example Question:

Industrial waste ordinances do not usually contain specific limits on:

a) pH
b) DO
c) grease and oils
d) toxics

XIV. Mathematics

A. General math

B. Process control math

C. Laboratory math

Example Question:

Given the following data, calculate the primary effluent BOD.
Data: F/M = 0.4, Influent flow = 1.0 MGD, MLVSS = 3,000 lbs

a) 112 mg/l
b) 128 mg/l
c) 144 mg/l
d) 162 mg/l

The formulas which will be provided for your use on the examination are attached at the end of the study guide.

LIST OF SUGGESTED READING

1. MOP 1 Safety and Health in Wastewater Systems

2. MOP 5 Aeration in Wastewater Treatment

3. MOP 11 Operation of Wastewater Treatment Plants

4. MOP 16 Anaerobic Sludge Digestion

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

6. MOP OM-7 Operation of Extended Aeration Package Plants

7. Wastewater Biology: The Microlife

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

The preceding eight publications are available through:

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

9. Manual of Wastewater Treatment

Available through:

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

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

    a. Volume I
    b. Volume II

11. Advanced Waste Treatment, A Field Study Training Program

12. Operation and Maintenance of Wastewater Collection Systems, a Field Study Training Program

    a. Volume I
    b. Volume II

The correspondence courses and/or texts for items 10, 11 and 12 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 Univ.
Edwardsville, IL 62026-1075
(618) 650-2030

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

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

Items 13 and 14 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

15. Math Review for Wastewater Certification

16. Guide to Microscopic Evaluation for Sewage Treatment Operations

Items 15 and 16 are available through:

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

17. WPCF/ABC Studyguide for Wastewater Treatment and Collection System Personnel (Order NO. E0-376) by the Water Pollution Control 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

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

$^oF = 9/5\ ^oC + 32$ $^oC = 5/9\ (^oF - 32)$ $^oK = {^oC} + 273$

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

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

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

MISCELLANEOUS

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

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

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

Application Rate = Concentration x Flow x Conversion Factor

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

LABORATORY

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

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

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

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

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

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

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

CLARIFIER

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

$$\text{Weir Overflow Rate} = \frac{\text{Flow}}{\text{Length}}$$

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

PROCESS CONTROL

$$F/M = \frac{\text{lbs of BOD}}{\text{lbs of MLSS}}$$

$$(Q + RQ)\ \text{MLSS} = RQ \times \text{RAS}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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