

**WEF Operations Challenge  
Process Control Event  
2016**

**Team Name:** \_\_\_\_\_

**Team Number:** \_\_\_\_\_

**Team Captain:** \_\_\_\_\_

**Test points awarded:** \_\_\_\_\_

**Simulator points awarded:** \_\_\_\_\_

**Total event points:** \_\_\_\_\_

Multiple choice section

5 pages  
30 total questions  
10 to 20 points per question

Extended multiple choice section

2 pages  
10 total questions  
25 to 50 points per question

Math multiple choice section

2 pages  
10 total questions  
Up to 50 points per question  
50% partial credit possible  
**0 points if work not shown**

Process scenarios section

**Questions may have differing point values**  
up to 180 points per correct answer and work shown  
50% partial credit possible  
**0 points if work not shown**

**Remember that you may be penalized if you don't show your work, even if the answer is correct!**

All team members must participate

### Multiple Choice

Circle the **best** answer for each question from the choices provided.

**Each correct answer on this page is worth 10 points**

For grader's use	
Points	Proper answer

#	Question	Choices	
1	The typical operation depth for digesters is approximately how many feet?	A	5 ft (1.5 m)
		<input checked="" type="radio"/> B	20 ft (6 m)
		C	50 ft (15 m)
		D	80 ft (24 m)
2	Screening devices are designed to remove _____.	A	dissolved solids
		B	grit particles
		<input checked="" type="radio"/> C	trash solids
		D	settleable solids
3	The adverse effect a substance has on a living entity defines that substance's _____.	<input checked="" type="radio"/> A	toxicity
		B	alkalinity
		C	acidity
		D	demand
4	How is phosphorus removed from wastewater?	A	air stripping
		B	breakpoint chlorination
		C	methanol addition
		<input checked="" type="radio"/> D	chemical addition and sedimentation/filtration
5	If a hazardous gas has a specific gravity of 1.5, where is this gas likely to be found if it leaks from a container in a room?	<input checked="" type="radio"/> A	near the floor
		B	equally distributed throughout the space
		C	near the ceiling
		D	in a cloud right around the leak
6	Waste activated sludge is typically _____ raw primary sludge.	A	thicker than
		<input checked="" type="radio"/> B	thinner than
		C	the same as
		D	more dense than

10    B

10    C

10    A

10    D

10    A

10    B

### Multiple Choice

Circle the **best** answer for each question from the choices provided.

**Each correct answer on this page is worth 10 points**

For grader's use	
Points	Proper answer

#	Question	Choices	
7	Ultraviolet disinfection is becoming more popular because UV systems	A	Create disinfection byproducts
		B	Conserve energy
		C	Require no maintenance
		<input checked="" type="radio"/> D	Eliminate safety concerns about handling chlorine
8	Ultraviolet lamps contain which of the following hazardous substances?	A	Hydrogen sulfide
		B	Chlorine gas
		<input checked="" type="radio"/> C	Mercury vapor
		D	Methane
9	What name is given to the material floating on the surface of clarifiers and other settling tanks?	A	grit
		<input checked="" type="radio"/> B	scum
		C	trash
		D	screenings
10	The vertical distance through which a liquid is to be pumped is referred to as _____.	A	specific speed
		B	displacement
		C	pressure
		<input checked="" type="radio"/> D	head
11	The gas produced in an anaerobic digester that can be used as a fuel is _____.	<input checked="" type="radio"/> A	methane
		B	ethane
		C	carbon dioxide
		D	propane
12	Most of the major odorous gases contain which element?	A	iron (Fe)
		<input checked="" type="radio"/> B	sulfur (S)
		C	magnesium (Mg)
		D	iodine (I)

10     D

10     C

10     B

10     D

10     A

10     B

### Multiple Choice

Circle the **best** answer for each question from the choices provided.

**Each correct answer on this page is worth 10 points**

For grader's use	
Points	Proper answer

#	Question	Choices	
13	When it comes to hazards of a specific chemical, the best source of information is _____.	A	Your safety officer
		B	An OSHA representative
		<input checked="" type="radio"/> C	SDS (Safety Data Sheet) formerly MSDS
		D	your supervisor
14	What document is intended to regulate discharges into waterways?	A	Comprehensive Environmental Response, Compensation & Liability Act (CERCLA)
		<input checked="" type="radio"/> B	National Pollutant Discharge Elimination System (NPDES)
		C	Material Safety Data Sheet (MSDS)
		D	Occupational Safety and Health Act (OSHA)
15	In anaerobic digestion, what explosive gas is formed?	A	carbon dioxide
		B	ammonia
		C	hydrogen sulfide
		<input checked="" type="radio"/> D	methane
16	Nitrogen and _____ are essential nutrients for microbial growth.	A	chlorine
		<input checked="" type="radio"/> B	phosphorus
		C	sulfur
		D	boron
17	When sludge does not settle properly, the condition is typically referred to as _____.	A	denitrification
		B	nitrification
		<input checked="" type="radio"/> C	bulking
		D	blowdown
18	A limiting factor for digester loading is _____.	A	sludge color
		B	pathogen type
		C	pathogen content
		<input checked="" type="radio"/> D	hydraulic detention time

10    C

10    B

10    D

10    B

10    C

10    D

### Multiple Choice

Circle the **best** answer for each question from the choices provided.

**Each correct answer on this page is worth 20 points**

For grader's use	
Points	Proper answer

#	Question	Choices	
19	Which of the following is NOT an inorganic conditioner?	A	ferric chloride
		B	calcium oxide
		<b>C</b>	polymer
		D	calcium hydroxide
20	Most gas piping systems are rated for _____ service.	A	700 kPa (100 psi)
		<b>B</b>	1050 kPa (150 psi)
		C	350 kPa (50 psi)
		D	1500 kPa (200 psi)
21	In an extended aeration activated sludge process, the solids retention time (SRT) is _____ ?	A	40 - 60 days
		B	2 - 8 days
		C	8 - 15 days
		<b>D</b>	15 - 40 days
22	What is the typical cause of ponding on a trickling filter?	<b>A</b>	excessive biological growth on the media
		B	foreign material
		C	insufficient filter wetting
		D	insufficient ventilation
23	A pH drop in an aerobic digester can be caused by _____	A	organic underloading
		<b>B</b>	nitrification or CO <sub>2</sub> buildup
		C	clogging of diffusers
		D	hydraulic overloading
24	The maximum rate for withdrawing gaseous chlorine from a 1-ton tank at room temperature (70F or 21C).	A	7 lbs/hr (3 kg/hr)
		B	10 lbs/hr (4.5 kg/hr)
		<b>C</b>	15 lbs/hr (7 kg/hr)
		D	20 lbs/hr (9 kg/hr)

20    C

20    B

20    D

20    A

20    B

20    C

*NOT 11*

**Multiple Choice**

Circle the **best** answer for each question from the choices provided.

**Each correct answer on this page is worth 20 points**

For grader's use	
Points	Proper answer

#	Question	Choices	
25	The destabilization of sludge particles by decreasing the repulsive forces between particles is called _____.	A	equalization
		B	flocculation
		C	neutralization
		<input checked="" type="radio"/> D	coagulation
26	In an aerated lagoon, the minimum dissolved oxygen level that must be maintained is _____ ?	<input checked="" type="radio"/> A	1 mg/L
		B	2 mg/L
		C	3 mg/L
		D	4 mg/L
27	The two design configurations typically available for solid-bowl centrifuges are _____.	A	horizontally and vertically opposed
		B	gravity and high-pressure
		C	recessed plate and diaphragm
		<input checked="" type="radio"/> D	<sup>con</sup> current and countercurrent
28	The wavelength of UV light used to disinfect wastewater effluent is _____.	<input checked="" type="radio"/> A	253.7 nm
		B	274.9 nm
		C	286.5 nm
		D	225.2 nm
29	If involved in a fire, which one of the following chemicals would be considered a Class D fire?	A	Paper
		B	Oil
		C	Electrical Equipment
		<input checked="" type="radio"/> D	Magnesium
30	If your RAS flow is too high, what is typically the primary result?	A	aeration in the basin would increase
		B	anaerobic conditions would develop in your secondary clarifier
		C	the solids level to the final effluent decreases
		<input checked="" type="radio"/> D	solids could overload the clarifier

20     D

20     A

20     D

20     A

20     D

20     D

# Extended Multiple Choice

Each correct answer on this page is worth **25** points

Enter the letter corresponding to the **best** answer in the box provided for each question

125  
250  
375

75  
50  
125

For grader's use	
Points (25)	Proper answer

Choices	
A	acid and water at the same time
B	acid into a container containing water
C	activated sludge
D	anaerobiasis
E	ashing
F	bulking
G	clarifier
H	colloids
I	disinfection system
J	double stack
K	filter
L	fluidized bed
M	induced draft
N	It does not matter
O	multiple-hearth
P	overland flow
Q	rotating biological contactors
R	screen
S	trickling filters
T	water into a container containing acid.

#	Question	Answer
1	When diluting acids with water the proper technique is to pour _____.	B
2	What type of treatment process typically includes aeration basins and mixed liquor?	C
3	Before wastewater treatment begins, flow typically passes through a _____.	R
4	Which type of incinerator uses graded silica?	L
5	An excessive amount of small, light particles floating on the surface of a secondary clarifier is referred to as _____.	E

25    B

25    C

25    R

25    L

25    E

# Extended Multiple Choice

150  
75  
225

Each correct answer on this page is worth **50** points

Enter the letter corresponding to the **best** answer in the box provided for each question

For grader's use	
Points (50)	Proper answer

Choices	
A	aeration basins
B	anaerobic conditions within the filter
C	coagulation
D	dechlorination
E	digestion
F	dilution
G	disinfection
H	dissolved air flotation
I	gravity thickening
J	odor control
K	pH control
L	polishing ponds
M	primary sedimentation
N	rotating biological contactors
O	sand filtration
P	sterilization
Q	the clogging of distributor arm orifices
R	the presence of the Psychoda fly
S	too much recirculation
T	trickling filtration

#	Question	Answer
6	An aerobic pond with a detention time of 3 days would provide treatment comparable to _____.	M
7	Potassium permanganate is typically used for _____ in wastewater treatment.	J
8	Which treatment unit is dependent on suspended bacteria for efficiency?	A (E)
9	A "rotten egg" odor near a trickling filter generally indicates _____.	B
10	The destruction of the larger portion of microorganisms with the probability that all pathogens are killed is called _____.	G

50 M

50 J

50 A, E

50 B

50 G

Team number:

# Math Multiple Choice

You must show your work (i.e. formulas, intermediate calculations, etc.) to receive full credit even if the answer is correct.

Each correct answer on this page is worth 30 points

For grader's use	
Points (15/30)	Proper answer

#	Question	Choices
1	A clarifier is 50 ft. (15.2 m) in diameter and 12 feet (3.6 m) deep. How many gallons (liters) does it hold? (ignore the sloped bottom) $\left(\frac{50}{2}\right)^2 \pi \times 12 \times 7.48 = 176243 \text{ gal}$ $\left(\frac{15.2}{2}\right)^2 \pi \times 3.6 \times 1000 = 653250 \text{ L}$	A 195000 gal (740000 liters)
		B 700000 gal (2650000 liters)
		<input checked="" type="radio"/> C 175000 gal (650000 liters)
		D 56000 gal (210000 liters)
2	An operator knows that the plant must remove at least 85% of the BOD coming in. If the influent BOD is 189 mg/l, what must the effluent BOD be less than? $189 \times 0.85 = 160.65$ $189 - 160.65 = 28.35$	<input checked="" type="radio"/> A 28 mg/l
		B 160 mg/l
		C 20 mg/l
		D 104 mg/l
3	The BOD level of the wastewater entering an aeration tank is 220 mg/L. If the flow to the tank is 1.65 MGD (72.3 l/s), what is the lbs/day (kg/day) of BOD loading? $220 \times 8.34 \times 1.65 = 3027.42 \text{ lbs}$ $\frac{72.3 \times 60 \times 60 \times 24 \times 220}{1,000,000} = 1374.2784 \text{ kg}$	A 3596 lbs/day (1631 kg/day)
		B 4515 lbs/day (2048 kg/day)
		C 5299 lbs/day (2403 kg/day)
		<input checked="" type="radio"/> D 3027 lbs/day (1374 kg/day)
4	1 cu ft/sec is equal to _____ $1 \times 7.48 \times \frac{60}{24} = 448.8 \text{ gpm}$ $\frac{448.8 \times 60}{24 \times 1000,000} = 0.646 \text{ MGD}$	A 0.72 mgd
		B 500 gpm
		C 30024 gph
		<input checked="" type="radio"/> D 0.65 mgd
5	If a solids sample is 5% solids, what is the concentration in mg/L? $5\% \times 10,000 = 50,000$	A 500 mg/L
		B 5,000 mg/L
		C 50 mg/L
		<input checked="" type="radio"/> D 50,000 mg/L

30      C

30      A

30      D

30      D

30      D

# Math Multiple Choice

You must show your work (i.e. formulas, intermediate calculations, etc.) to receive full credit even if the answer is correct.

Each correct answer on this page is worth 50 points

For grader's use	
Points (25/50)	Proper answer

#	Question	Choices
6	A magnetic flow meter measured 5000 gal (19000 liters) of raw solids pumped. The solids pumped were 6.1% total solids. How many pounds (kg) of dry solids were handled? $0.005 \times 8.34 \times 6.1 \times 10,000 = 2543.7 \text{ lb}$ $\frac{19000 \times 6.1 \times 10,000}{10,000} = 1159 \text{ kg}$	A 1581 lb (717 kg)
		B 2281 lb (1035 kg)
		<input checked="" type="radio"/> C 2544 lb (1159 kg)
		D 3657 lb (1659 kg)
7	A plant has a 90 foot (27.5 m) diameter sludge tank with a side-wall depth of 20 feet (6.1 m). The tank also has a conical bottom that is 8 feet (2.4 m) deep. The tank has a sludge level of 15 feet (4.6 m) (SWD). How many gallons (liters) of sludge liquid are in the tank? $(\frac{90}{2})^2 \times \frac{1}{11} \times (15 + \frac{8}{3}) \times 7.48 = 840650 \text{ gal}$ $(\frac{27.5}{2})^2 \times \frac{1}{11} \times (4.6 + \frac{2.4}{3}) = 320737 \text{ m}^3$	A 587,000 gals (2220 m <sup>3</sup> )
		B 713,000 gal (2700 m <sup>3</sup> )
		<input checked="" type="radio"/> C 840,000 gal (3210 m <sup>3</sup> )
		D 1,094,000 gal (4140 m <sup>3</sup> )
8	What approximate horsepower (kW) motor is required for a pump discharge of 1000 gpm (63 l/sec) at 110 psi (758 kPa)? Assume the pump and motor are 100% efficient. $\frac{1000 \times (110 \times 2.31)}{3960} = 64.16 \text{ hp}$ $\frac{63 \times 60 \times 758}{60,000} = 47.4 \text{ kW}$	A 25 HP (15 kW)
		B 50 HP (40 kW)
		<input checked="" type="radio"/> C 75 HP (50 kW)
		D 100 HP (75 kW)
9	A total chlorine dosage of 6.9 mg/L is required for disinfection. If the effluent flow is 3.1 MGD (136 l/sec) and the hypochlorite used has 65% available chlorine, how many pounds /day (kg/day) of hypochlorite will be required? $\frac{3.1 \times 8.34 \times 6.9}{0.65} = 274.4 \text{ lbs}$ $\frac{136 \times 60 \times 1440}{1,000,000} \times 6.9 \times \frac{1}{0.65} = 124.7 \text{ kg}$	A 512 lbs/day (232 kg/day)
		B 158 lbs/day (71.7 kg/day)
		<input checked="" type="radio"/> C 274 lbs/day (125 kg/day)
		D 395 lbs/day (179 kg/day)
10	A 250 foot (76 m) long pipe 12 inches (300 mm) in diameter holds how many gallons (liters) of water when full? $(\frac{12}{2})^2 \times \frac{1}{11} \times 250 \times 7.48 = 1468.69 \text{ gal}$ $(\frac{0.300}{2})^2 \times \frac{1}{11} \times 76 \times 1000 = 5372 \text{ L}$	A 196 gal (742 liters)
		<input checked="" type="radio"/> B 1470 gal (5370 liters)
		C 5870 gal (22200 liters)
		D 1640 gal (6210 liters)

50 C

50 C

50 C

50 C

50 B

Bourbon Street Wastewater Treatment Plant is a 50 MGD ( $131.4 \text{ m}^3/\text{min}$ ) design, trickling filter (TF) plant. The plant has primary clarifiers ahead of 4 separate trains of a two stage TF system. Each two stage TF train has a roughing filter for the first pass followed by a high rate filter capable of nitrification. Each TF train has recirculation capabilities where effluent from the high rate filter is designed for recirculation rate of up to a 1:1 ratio (in relation to influent flow) to the influent pump station of the roughing filter. All TFs are identical in size at 100' ( $30.5 \text{ m}$ ) diameter and 20' ( $6.1 \text{ m}$ ) media depth each with a 4 arm distributor mechanism. The roughing filters contain plastic media with a surface area of 31 sq ft/cu ft ( $102 \text{ m}^2/\text{m}^3$ ) of media with a design BOD loading of 150 lbs/day/1000 cu ft ( $2.4 \text{ kg}/\text{m}^3/\text{d}$ ) while the high rate filter's plastic media is 48 sq ft/cu ft ( $157.5 \text{ m}^2/\text{m}^3$ ) of media with a design BOD loading of 25 lbs/day/1000 cu ft ( $0.4 \text{ kg}/\text{m}^3/\text{d}$ ). Primary effluent data is measured at the confluence of the primary clarifier launders.

Plant Operating Information	
Daily flow	30 MGD ( $113,560 \text{ m}^3/\text{d}$ )
Influent BOD	240 mg/l
Influent TSS	225 mg/l
Influent NH <sub>3</sub>	25 mg/l
Primary Effluent BOD	135 mg/l
Primary Effluent TSS	90 mg/l
Primary Effluent NH <sub>3</sub>	30 mg/l
Final Effluent BOD	8 mg/l
Final Effluent TSS	12 mg/l
Final Effluent NH <sub>3</sub>	0.5 mg/l
Current Recycle Ratio	0.5
TF Trains on line	3

TABLE 1A (Standard Units)		TABLE 1B (Metric Units)	
BOD5 loading - lbs/day/1000 cu ft	Design SK rate range (mm/pass)	BOD5 loading kg/day/m <sup>3</sup>	Design SK rate range (mm/pass)
< 25	15-40	<0.41	15-40
50	25-75	0.8	25-75
75	40-120	1.2	40-120
100	50-150	1.6	50-150
120	60-180	1.9	60-180
150	75-225	2.4	75-225

C-B-C-B

### Scenario #1: Tricking Filters

Use the scenario information for all questions and circle the correct answer for each.

You must show your work to receive full credit even if the answer is correct.

<p>Maximum point value for this question: <b>90</b></p>	<p><b>A</b> 47.8 lbs BOD/1000 cu ft (0.77 kg/m<sup>3</sup>)</p>
<p>Under plant operating conditions and assuming an equal flow split from the primary clarifiers and considering primary effluent data, what is the organic loading on the roughing filters?</p> <p><math>\left(\frac{100}{2}\right)^2 \times \frac{1}{11} \times 20 = 157079 \text{ ft}^3 \text{ each}</math></p> <p><math>30 \times 8.34 \times 135 = 33777 \text{ lbs}</math></p> <p><math>15 \times \frac{33777}{(157 \times 3)} = 71.7</math></p>	<p><b>B</b> 53.8 lbs BOD/1000 cu ft (0.86 kg/m<sup>3</sup>)</p>
	<p><b>C</b> 71.7 lbs BOD/1000 cu ft (1.15 kg/m<sup>3</sup>)</p>
	<p><b>D</b> 127.5 lbs BOD/1000 cu ft (2.04 kg/m<sup>3</sup>)</p>
<p>1</p> <p><math>\left(\frac{30.5}{2}\right)^2 \times \frac{1}{11} \times 6.1 = 4456.76 \text{ m}^3 \text{ each}</math></p> <p><math>\frac{113,560 \times 135}{1000} = 15330.6 \text{ kg}</math>      <math>\frac{15330.6}{3 \times 4456.76} = 1.1466</math></p>	<p><b>E</b> 382.5 lbs BOD/1000 cu ft (6.13 kg/m<sup>3</sup>)</p>

<p>For grader's use only</p>
<p>Proper answer <u>C</u></p>
<p>Points earned <u>90</u></p>

# Scenario #1: Trickling Filters

Use the scenario information for all questions and circle the correct answer for each.

You must show your work to receive full credit even if the answer is correct.

<p>Maximum point value for this question: <b>90</b></p> <p>Under plant operating conditions and assuming an equal flow split from the primary clarifiers, what is the wetting rate on the high rate TFs as defined by the cross sectional area?</p> <p style="color: red;"> <math>30 \text{ MGD} + 0.5 \times 30 = 45 \text{ MGD}</math>  <math>\left(\frac{100}{2}\right)^2 \frac{\pi}{11} = 7854 \text{ ft}^2 \text{ each}</math>  <math display="block">\frac{45,000,000 \text{ gpd}}{7854 \times 3} = 1909.85</math> </p> <hr style="border: 1px solid gray;"/> <p style="color: red;"> <math>113560 \times 1.5 = 170340 \text{ m}^3/\text{d}</math>  <math>\left(\frac{30.5}{2}\right)^2 \frac{\pi}{11} = 730.617 \text{ m}^2 \text{ each}</math>  <math display="block">\frac{170340}{730.6 \times 3} = 77.715</math> </p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; width: 5%;"><b>A</b></td> <td>1273 gpd/sq ft (15.9 m<sup>3</sup>/m<sup>2</sup>/d)</td> </tr> <tr> <td style="text-align: center;"><b>B</b></td> <td>1911 gpd/sq ft (77.9 m<sup>3</sup>/m<sup>2</sup>/d)</td> </tr> <tr> <td style="text-align: center;"><b>C</b></td> <td>4770 gpd/sq ft (194.3 m<sup>3</sup>/m<sup>2</sup>/d)</td> </tr> <tr> <td style="text-align: center;"><b>D</b></td> <td>5732 gpd/sq ft (233.5 m<sup>3</sup>/m<sup>2</sup>/d)</td> </tr> </table>	<b>A</b>	1273 gpd/sq ft (15.9 m <sup>3</sup> /m <sup>2</sup> /d)	<b>B</b>	1911 gpd/sq ft (77.9 m <sup>3</sup> /m <sup>2</sup> /d)	<b>C</b>	4770 gpd/sq ft (194.3 m <sup>3</sup> /m <sup>2</sup> /d)	<b>D</b>	5732 gpd/sq ft (233.5 m <sup>3</sup> /m <sup>2</sup> /d)
<b>A</b>	1273 gpd/sq ft (15.9 m <sup>3</sup> /m <sup>2</sup> /d)								
<b>B</b>	1911 gpd/sq ft (77.9 m <sup>3</sup> /m <sup>2</sup> /d)								
<b>C</b>	4770 gpd/sq ft (194.3 m <sup>3</sup> /m <sup>2</sup> /d)								
<b>D</b>	5732 gpd/sq ft (233.5 m <sup>3</sup> /m <sup>2</sup> /d)								

For grader's use only
<p>Proper answer</p> <p style="font-size: 2em; color: red; text-decoration: underline;">B</p>
<p>Points earned</p> <p style="font-size: 2em; color: red; text-decoration: underline;">90</p>

2