Rules: Process Control Event – 2021

The process control event for the 2021 Operations Challenge will be very similar to the 2019 event with one notable change. As in the past, the event consisted of both a handwritten and computer portions of the event. The change this year from 2019 will be to transition the handwritten multiple choice into a computer-based format. The computer-based portions of the event will be similar to the 2020 Virtual Event and as provided with the practice versions that have been made available.

Overview

Teams will perform three portions of the Process Control Event:

1. A written test consisting of short math and process scenario questions
2. Electronic multiple-choice questions completed on a computer
3. Process simulation questions completed on a computer

All three portions of the event will occur simultaneously. Each team will have two laptops provided at their table; one (1) for multiple choice questions and one (1) with the simulator software. Teams have the option to divide the workload between team members at their discretion, but all team members need to participate in the event. It is expected that due to the need for two computers per team when completing the event, the overall event may be completed with two groups of teams completing the event, with somewhere between 15 and 25 teams in the first group and the remaining teams in one followed by the second.

Written Test

The test content and layout of the short math and process scenarios will be essentially unchanged from previous years. Test questions containing math or process data will have both English and metric units listed allowing teams to work a problem in whatever units they desire.

The written event portion consists of answering short math questions with multiple choice answers, and up to four operational type scenarios that have three to six questions each that may require considerable calculations and judgement. The event is timed, with a total of 23 minutes (3 minutes of review, 20 minutes for the event competition). The team can split up the test any way it chooses during the test. The team that scores the most points for correct answers will win the event. The event should be viewed as an opportunity for a team to demonstrate their accumulated knowledge of wastewater treatment and skills in plant process
control. There are no penalties for incorrect answers, but there will be no points awarded for short math and operational scenarios without substantial work shown.

Time is an important factor in taking the test. The total time available for each team for all portions of the test event is 23 minutes. The first portion of the test is a three minute test preview period. No work on the test paperwork may be done during the preview period. The second portion of the event consists of 20 minutes for answering the questions (both written and on the computers).

**Written Test Questions and Procedures**

Only pencils, paperclips or binder-clips and non-programmable calculators are allowed. Phones, notes and any other materials are not allowed at the table. Cellphones may not be used as calculators and team members are not allowed to have any headphones or earbuds at the table.

Once the teams are in place, the tests are passed out. When instructed the test envelope is opened and the test cover sheet is verified for team name and number, and the team captain’s name is filled out. In addition, the team captain shall fill in the number labeled on the outside of each of the two computers that the team will use for the event on the test cover sheet.

During the 3-minute review period, the teams can open the test and examine all the written questions and their point values. The teams may talk among themselves. **Except for filling out the written event cover sheet, no marks of any kind may be made on any test page during this period or the team will receive an event score of zero.** By the end of the 3-minute review period the team must return all the pages to the envelope in whatever order they desire. Teams may fold pages together or clip them together (within reason).

The second portion of the event follows quickly. At the signal by the event coordinator teams open the envelope and have 20- minutes to complete the test. All pages must be in the envelope at the end of twenty minutes.

**Computer-based Multiple-Choice Questions and Procedures**

**New for 2020 will be a computer-based electronic M**ultiple-choice questions for the event will be completed on one of the two computers at each table. There will no longer be any multiple-choice questions on the paper portion of the event. The multiple-choice questions will be of a similar nature as the simple multiple-choice questions included in previous events but there will be no extended, matching multiple-choice questions. A practice multiple-choice test is included with the simulator download available from the Rocky Mountain WEA Operations Challenge website.

The multiple-choice portion of the event must be completed by the team members with a 10-
minute period at their own pace but must be completed and submitted within the overall 20-minute event period. Similar to the simulator portion of the event that has been included previously, the team member completing the multiple-choice questions must enter the team’s name and number before starting the event. Please be sure to enter your team’s name accurately as provided with your team registration or you may not receive points for this portion of the event. After completing all the questions and pressing the “Submit” button, a popup box will display the team score for this portion of the event. Do not close this box until your event proctor has recorded the score on the event cover sheet and the team captain has acknowledged.

Note that the multiple-choice questions can be completed in any order and the team members involved can move back and forth across all the questions until either pressing the “Submit” button or the 10-minute timer expires. However, only 1 attempt is allowed to “Submit” the multiple-choice portion of the event. Once the answers are submitted, the questions will no longer be available to edit.
**Process Simulator**
The Process Simulator is a treatment plant software model created by Hydromantis (now part of the Hatch Group). The user interface is designed so that operators start with an overview of a plant layout and a series of process questions. Starting from the Main Menu, each question will have a description and the performance objectives needed to solve that problem. These performance objectives are typically related to effluent performance but may also include process operating conditions, as well as chemical and energy costs. Competitors can then open windows to change operational controls and view data for various unit processes. They can adjust aeration, pump settings, chemical feed rates and even the number of units in service. Note that in some problems, units may start the simulation as out of service or chemical addition may be on at the start of the problem that will need to be turned off. There may also be some unit processes that are out of service and cannot be used for a particular problem.

Essentially the simulator allows operators to see data and adjust plant operations just as they would in real life.

There are 710 steady state questions and 21 dynamic questions in the 2021 event. The computer run time for the steady state questions is typically only a few seconds each but the run time for the dynamic questions (#8, #911) is typically between 90 and 120 seconds and will be nearly identical in duration on every computer.

Each of the steady state questions will have from 2 to 5 objectives to meet and there will be 25 points awarded for each objective correctly answered (question point totals ranging from 50-125 points). The dynamic questions will have a simulated run time of 5 days and points are awarded only if the target performance for each parameter (i.e., TSS) is met for the entire 5-day simulation run time.

Each team will have up to 15 minutes to achieve as many process objectives as they can. The software will display points as objectives are met as well as the time remaining. At the end of the allotted time the simulator will stop and display the points earned. Note that points will be awarded for each problem objective met but only if the question answer has been submitted during the 15-minute time limit. **Remember, that if you do not press the submit button on a question, no points will be recorded for your score.**

**Process Simulator Procedures**
The team will be given paperwork briefly describing each of the questions. The paperwork describes the type of plant and the goals to be achieved. The point value for each problem will be listed.

During the 3-minute review period, each team will be able to review the list of simulator questions, then must return them to the envelope with the written test paperwork.
The computers may not be touched during the 3-minute preview period. Once the overall 20-minute event time begins, each team may proceed to log in to the simulator computer.

**Please be sure to enter your team’s name accurately as provided with your team registration or you may not receive points for this portion of the event.** The 15-minute timed simulator event will begin once the competitor presses the “START” button but must be completed within the overall 20-minute duration of the event.

After logging in to the simulator, a 15-minute timer starts, and a menu of the questions is presented. Teams can choose any question and begin studying the initial conditions and current outputs. Then they make as many adjustments as desired and update the simulation. An update to the steady state questions will take a few seconds and present new results. The team can repeat the adjustments and results as many times as desired. Goals will be highlighted as they are achieved. A team can move to a different question before all goals are achieved if they wish. They will earn points only for the goals achieved and SUBMITTED. The software doesn’t allow returning to the exact point where a scenario was left, so some of the prior changes made will need to be re-entered. In the time provided, the team should complete as many question objectives as possible. The time remaining will show continuously in the middle of the screen.

**Event Philosophy**

The purpose of the Process Control event is to distinguish the relative process control skills of the teams so that points can be awarded proportionately. In an ideal world this would consist of each team standing before a panel of judges and reciting all their wastewater knowledge and answering questions from the judges. In the context of the Operations Challenge this is not practical, so a timed written test is used.

Unlike most test situations, the expectation is not that all teams will complete all the questions. The goal is not to see who can answer all questions with the fewest mistakes. Instead, teams are given the opportunity to provide as many correct answers as they can in the allowed time. The test is designed to be long enough so that teams should not run out of questions to answer.

The types and difficulty levels for questions are roughly matched to the points awarded for getting the correct answer. Solving the process scenario questions are usually worth more than the quick multiple choice questions. It is up to each team to develop a strategy to figure out which questions to answer in the time allotted to achieve the highest final score.

Showing work is required and emphasized **for the short math and operational scenarios** because it allows distinction between knowing the right answer and guessing the right answer. Test graders can only see what is written by the team and cannot infer what was meant. Since the
goal of the test is to demonstrate knowledge, graders need to see the steps used to arrive at an answer to a math question.

**Process Scenario Categories**

The scenario problems will be chosen from the following processes:

- Activated Sludge
- Aerobic Digestion
- Thickening and Dewatering

It is always possible that categories could change due to changes in volunteer time available. There are no mandatory questions.

**Grading**

The tests will be graded as follows:

- Electronic multiple choice questions as: correct answer, incorrect answer, or no answer.
- Short math multiple choice questions as: correct, incorrect, or no answer as well as whether work is shown on test paper. No points awarded unless adequate work is shown but partial credit may be awarded if sufficient work is shown.
- Operational scenarios as: correct, incorrect, or no answer as well as whether work is shown on test paper. No points awarded unless adequate work is shown but partial credit may be awarded if sufficient work is shown.
- Simulator steady state questions with each objective as: correct answer or incorrect answer. Simulator dynamic question as: points awarded for each parameter within permit limits or process goals for the duration of the simulation for each parameter.

**Scoring**

The overall score for the Process Control event is the sum of the points earned in the electronic multiple choice, the simulator and the written test.

The electronic multiple-choice score will be presented based on the number of correct answers and the point value for each question after the questions are completed and answers submitted.

The process simulator software will add all the points earned for objectives achieved in all the problems. This will be the score for the simulator event. There are no penalties in this event.
Scoring for the written test consists of adding all the team’s points for correct answers and any partial credit given in math or process scenario problems. There is no time bonus or penalty for finishing before the 20 minute time limit.

There are no penalties for incorrect answers or not answering a question.

For the electronic multiple-choice questions, there are three possible results: no answer, incorrect answer, or correct answer. For no answer or incorrect answer, zero points are awarded. If the question is answered correctly the score is the point value of that question.

In general, multiple choice questions range from 10 to 30 points each.

Math and Operational Scenario questions are handled in a similar manner with one additional requirement and one exception. The requirement is that a certain amount of work must be shown to receive any credit. If a correct answer is circled on a math or scenario question, but no work is shown, zero points are awarded for the effort. The exception is that even if there is no answer or the answer is incorrect, the team may receive half credit for that question if work is shown as described below. Short math questions range from 25 to 50 points each. Operational scenario questions may range from 25 to 200 points.

<table>
<thead>
<tr>
<th>Grading of Written Test Questions (percent of question value awarded)</th>
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<tbody>
<tr>
<td>Test section</td>
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<tr>
<td>Short math multiple choice</td>
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<tr>
<td>Operational scenarios (except mandatory)</td>
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</tbody>
</table>

<sup>1</sup>Half credit possible for showing work as described below

If a Judge determines that a team member is not attempting to help with parts of the test, a 500 point penalty will be assessed for each non-participating team member.
**Rounding and Significant Digits**

As a general practice, values should not be rounded off or digits dropped until the final answer is achieved. The possible answers for a math question should differ enough that choosing an incorrect answer due to rounding errors is unlikely, but this is not guaranteed in long, complex questions. When showing the work, it is not necessary to write out all the digits that may be displayed on the calculator; generally three or four is enough for the grader to determine how you are working the problem.

When using conversion factors, such as 8.34 lbs per gallon, you must show the appropriate number of digits as used in wastewater textbooks. For example, 7.48 is the common conversion factor for gallons per cubic feet. Using 7.5 or even 7 is not acceptable. Part of demonstrating process knowledge is knowing appropriate conversion factors. While shortcuts and approximations might be acceptable in the field, test takers must show the grader that they know the proper conversion factor.
**Half Credit and Showing Work**

For any math question, the team must write out the numbers used and show them in an equation form.

**Example:**

\[ 16 \text{ mg/l} \times 8.34 \times 2.4 \text{ MGD} = 320 \text{ lbs} \]

Simply writing down numbers does not count. The equation (including the mathematical operation – add, subtract, multiply, etc) used must also be relevant to the question. For example there will not be credit for writing down the lbs formula when the question is about detention time. The work shown must be consistent with the operational theory described in the problem.

For the math and operational scenario questions, if the grader feels that the work shown is **conceptually correct and substantially complete**, but is either not complete or incorrect, progress towards the answer the work shown may receive the half credit listed in the Points Table. If the work shown uses a conceptually incorrect approach half credit will likely not be awarded.

Note that in the Operational Scenarios, sometimes answers that are text rather than numbers may still require work to be shown. For example, if the correct answer for a problem is “the hydraulic loading rate is too high” then the work shown **must** include a calculation of the hydraulic loading rate.

The test grader can only use what the test taker writes down to determine how the test taker is attempting to solve the problem. Therefore it is the responsibility of the test taker to clearly show how the answer has been derived. The grader cannot infer missing steps in solving the problem. While labeling of units is not required, it is highly encouraged so that graders can better determine if partial credit is warranted.

Because each math problem is unique, the requirements of “significantly complete and conceptually correct” will be based on the content of the question. “Significantly complete” generally means that all but one step is shown or that only one mistake is made. “Conceptually correct” depends on the question and what it is asking. Most questions are designed to focus on one or two key elements of wastewater knowledge. For example, an F/M question focuses on food and mass. So if an answer doesn’t show BOD, or uses MLSS instead of MLVSS, a key element is missing and no half credit would be given.

**Scope**

The questions will cover the following areas of wastewater treatment as well as general topics such as: collections, pumping, maintenance, laboratory, safety, flow measurement, and metering:
<table>
<thead>
<tr>
<th>Process Areas</th>
<th>Example Systems</th>
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<tbody>
<tr>
<td>Collections System</td>
<td>Odor Control</td>
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<td></td>
<td>Inspection and Testing</td>
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<td>Pipeline Cleaning and Maintenance</td>
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<td>Underground Repair and Construction</td>
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<td>Preliminary Treatment</td>
<td>Screening</td>
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<td>Grit Removal</td>
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<td>Flow Equalization</td>
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<tr>
<td>Odor Control</td>
<td>Wet Chemical Scrubbing</td>
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<td></td>
<td>Chemical Addition</td>
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<td>Biofilters</td>
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<td>Primary Treatment</td>
<td>Primary Sedimentation</td>
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<td>Flow Equalization</td>
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<td>Clarification</td>
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<td>Secondary Treatment</td>
<td>Activated Sludge</td>
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<td>Suspended Media</td>
<td>Biological Nutrient Removal</td>
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<td></td>
<td>Clarification</td>
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<td>Sequencing Batch Reactors</td>
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<td>Secondary Treatment</td>
<td>Trickling Filtration</td>
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<td>Fixed Media</td>
<td>Biological Nutrient Removal</td>
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<td>Advanced Treatment</td>
<td>Filtration</td>
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<td></td>
<td>Biological Nutrient Removal</td>
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<td>Thickenig</td>
<td>Gravity Belt Thickener</td>
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<td></td>
<td>Dissolved Air Flotation</td>
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<td></td>
<td>Gravity Thickening</td>
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<tr>
<td>Solids Stabilization Methods</td>
<td>Anaerobic Digestion</td>
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<td></td>
<td>Aerobic Digestion</td>
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<tr>
<td>Dewatering</td>
<td>Belt Filter Press</td>
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<td></td>
<td>Drying Beds</td>
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<tr>
<td></td>
<td>Centrifuge Dewatering</td>
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<tr>
<td>Disinfection</td>
<td>Chlorination \ Dechlorination</td>
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<td></td>
<td>Ultraviolet Disinfection</td>
</tr>
<tr>
<td>Management and Support</td>
<td>Process Instrumentation</td>
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<tr>
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<td>Treatment Plant Security</td>
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Resources
The following references will be used in creating and grading the test questions:

- Water Environment Federation: Manual of Practice 11 and Study Guide
- Water Environment Federation: Wastewater Collection System Operator Certification Studybook
- California State University Sacramento: Operations of WWTPs Volumes 1 & 2 and Advanced Waste Treatment
- California State University Sacramento: Operations and Maintenance of Wastewater Collections Systems.
- Manual on the Causes and Control of Activated Sludge Bulking and Foaming, Jenkins, Richards & Daigger
- Water Environment Federation: Wastewater Treatment Fundamentals I – Liquid Treatment
- Water Environment Federation: Wastewater Treatment Fundamentals II – Solids Handling and Support Systems

Additional general study material includes:

- EPA design manuals, which can be obtained at: http://nepis.epa.gov/EPA/html/pubindex.html. Select Browse to see the full list of available documents. Only some are applicable to wastewater.
- Wastewater Engineering Treatment Disposal, and Reuse, Metcalf and Eddy, McGraw-Hill
- Note that these sources will NOT be used in creating or grading tests. They are listed for those interested in additional sources of wastewater knowledge.

Test Details
The same test is used for all both Divisions 1 and Division 2.
The electronic multiple-choice test will consist of up to 60 questions with four possible answers each. The short-math portion of the event will consist of up to 15 multiple choice questions that include a small amount of math.

Up to four process scenarios with three to six questions each are in the test. Teams may answer as many parts of any scenario that they desire.

The Simulator portion of the event will consist of 740 steady state questions and 24 dynamic questions that will run for a longer duration.

Formula sheets, reference books or any other material are not permitted.
Team members may talk among themselves but may not be disruptive. Teamwork in solving problems is encouraged. Also consider that other teams may overhear your discussions.
**General Details**

What will be supplied at the event: Answer sheet forms.

Competitors must supply their own pencils and calculators (calculators cannot have programming or printout capability). We will also try to have a pencil sharpener available prior to the event but this is not guaranteed.

All four team members must be present before the start of the event. If a team is disqualified from the event, they will receive a score based on every question left blank and no work shown.

**Notes**

The exact number of questions may change slightly between now and the event. The points may also be adjusted to ensure test balance.

Scenario topics will be listed as soon as possible. However since all scenarios are written from scratch and created by volunteers, the final topics in the test may change slightly or a topic may be omitted.

Graders and event judges will not have reference books available at the event; plan on bringing your own copies as needed. (No reference material can be used during the test)

Process Control Event committee members will be available to discuss scoring of test questions the morning after the event.