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DEVELOPMENT OF A WATER TREATMENT PLANT
OPERATION MANUAL USING AN ALGORITHMIC APPROACH

By

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The growing use of automatically controlled and monitored processes and the increasing complexity of the water treatment required to consistently produce high quality public water supplies demand highly qualified and knowledgeable water utility operators. This situation can be expected to grow more acute in the future as need for clean water increases.

Effective management of a modern water treatment plant requires an operator who is thoroughly familiar with the processes and equipment in use. Such knowledge is most easily effectively acquired through some planned form of operator training, but unfortunately very little attention has traditionally been given to this need.

In most plants at present training is accomplished by putting a new trainee on the job with an experienced operator, who familiarizes the trainee with the equipment and processes. The success of this method depends upon many factors, including (but not limited to) the following:

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1) the experienced operator's understanding of the equipment and processes; 2) his ability to explain his knowledge clearly and effectively; 3) his willingness to do a thorough training job; 4) the trainee's understanding of his instructor's explanations; 5) the willingness and ability of the participants to enter into the educational process by asking questions, making sure explanations are understood, etc; and 6) the ability of the trainee to remember accurately the many details involved. This method may or may not accomplish its purpose--to produce a fully qualified operator. It is certainly one of the least efficient and least economical methods that could be devised, both because of the time the experienced operator must devote to the process, the time wasted through inefficient presentation of the material to be learned, and the inability of most trainees to accurately assimilate a barrage of frequently confusing verbal instructions.

While a number of manufacturer's equipment manuals, conventional textbooks, and correspondence courses do exist, most of them are too general and too theoretical to be of help to the average operator. Nor does every actual or potential operator have access to a training course offered by a technical institution. What is needed, and has not

been available, is an operationally oriented training tool for those specific plant processes and equipment which the trainee will be required to operate. This material should be usable by an individual where few or no qualified instructors are available, when little time can be spent on training, and where a high degree of operational competency is demanded.

A technique for writing operation guides which fulfill the needs outlined above has been developed. These guides utilized flow prescriptions (or algorithms) to describe an orderly procedure or exact method for solving a problem (i.e., operating a piece of equipment or a process). In a flow prescription the user is led from a collection of input data to the desired result through a succession of small, directed steps. He responds to simple questions which require no prior knowledge of the task, working only through those questions which are relevant. He does not need to remember input data, rules, or decisions to complete the process, these factors being supplied by the prescription. When the appropriate path through the prescription is followed, however, a specification of the proper action to be taken is completed. Figure 1 is an example of a simple flow prescription.

S* - Stimulus

R* - Response

Figure 1. Flow Prescription Written for the Routine Inspection of a Caustic Soda Feed System

Figure 1 (continued)

Figure 1 (continued)

R

go to the CAUSTIC
SODA FEED INDICATOR
dial on the control
panel and reduce
the caustic soda
concentration in the
flash mixer by 1 ppm.
the concentration is
reduced by turning
the dial counter-clockwise

S

caustic soda
concentration
in the flash
mixer reduced
by 1 ppm

R

wait 2 hours
and take
another 25 ml
sample from
the SETTLED
WATER tap

END

R

go to the CAUSTIC
SODA FEED INDICATOR
dial on the control
panel and increase
the caustic soda
concentration in the
flash mixer by 1 ppm.
the concentration is
increased by turning
the dial clockwise

S

caustic soda
concentration
in the flash
mixer increased
by 1 ppm

1

Figure 1 (continued)

An advantage of the flow prescription, or description of the tasks being performed written in a flow chart format, is that extraneous, "nice to know" but inessential information is omitted. This is not to say that the operator will never learn the principles and reasons for the actions he takes. Such knowledge will undoubtedly come as experience increases. However, the flow prescription approach enables the inexperienced operator to perform immediately and with accuracy the operation of the equipment and processes in question, and it does so without expensive and time consuming training techniques.

For plant use, reduction of the flow prescriptions to simplified prose versions (plant guides) is recommended because the flow prescriptions tend to be long and cumbersome due to the multitude of input data required for some processes. The simplified prose form condenses the flow prescription greatly and presents the steps in a more familiar and easily readable form. When using a guide, the operator starts with step one in each process and follows the flow prescription according to the factors in his particular task, making sure that he proceeds to the next step specified at the end of the action just completed. See Figure 2 for an example of a plant guide.

Figure 2. Plant Guide for Routine Inspection of a Caustic Soda Feed System

NORMAL OPERATING PROCEDURE FOR: Routine inspection of the caustic soda feed system.

ACTION:

1. Look at the illuminated lights on the control panel to determine whether the CAUSTIC SODA FEED PUMP is operating. (The pump is operating if its green ON button is illuminated. It is not operating if the red OFF button is illuminated):
 - a. If the pump is not operating, go to STEP 2.
 - b. If the pump is operating, skip to STEP 3.
2. Start the pump by pressing its green ON button on the control panel. Go to STEP 3.
3. Read the caustic soda concentration being maintained in the flash mixer from the CAUSTIC SODA FEED INDICATOR dial on the control panel. Note the caustic soda concentration on the inspection report. (This concentration can be read directly in parts per million [ppm] from the scale opposite the dial). Go to STEP 4.
4. Go to the laboratory workbench, turn the faucet handle on the SETTLED WATER sampling tap, and take a 25 milliliter (ml) sample of settled water. Go to STEP 5.
5. Using the HACH DIRECT READING COLORIMETER WATER TESTING KIT located on the laboratory workbench, determine the pH of the water according to the procedure described in the testing kit instruction manual. Go to STEP 6.
6. Note the pH of the water on the inspection report. Go to STEP 7.
7. Determine whether the pH of the water is within the optimum pH range of 7.7 to 7.9:
 - a. If the pH of the water is less than 7.7, go to STEP 8.
 - b. If the pH of the water is greater than 7.9, go to STEP 10.
 - c. If the pH of the water is within the 7.7 - 7.9 range, skip to STEP 11.
8. Go to the CAUSTIC SODA FEED INDICATOR dial on the control panel and turn the dial clockwise to increase the caustic soda concentration by 1 ppm. Go to STEP 9.
9. Wait two hours and take another 25 ml sample from the SETTLED WATER sampling tap, then return to STEP 5.
10. Go to the CAUSTIC SODA FEED INDICATOR dial on the control panel and turn the dial counterclockwise to reduce the caustic soda concentration by 1 ppm. Return to STEP 9.
11. Inspection of the caustic soda feed system completed.

Development of flow-prescription type operation manuals can begin in either of two places: a collection of guides for all equipment and processes in a particular treatment plant could be developed at the plant; alternately, equipment manufacturers might develop guides for the equipment they produce, and supply the guides to the plants which use their products. In either case, use of such guides would greatly improve the quality of operation produced by a trainee or new operator as well as reduce the need for training by an experienced operator. While a certain amount of orientation by a veteran operator may add to the trainee's security and self confidence, the bulk of the guidance needed can come from the easily followed training guides written specifically for the plant being operated. In addition, the guides can serve as reference materials in day-to-day plant operation.

A detailed description of the technique used to develop flow prescriptions and plant guides for the operational processes of a water treatment plant are contained in "Development of a Water Treatment Plant Operation Manual Using an Algorithmic Approach", by Cary A. Counts, published at Clemson University, Clemson, South Carolina, in 1972.