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Ask Tom! Column

In Control - Considerations for Control Systems
Part One: Process Parameters

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Instrumentation is a vital component of any water treatment plant. The measurement and control of the various processes is paramount to the proper performance of the plant. Several key parameters are regularly monitored and controlled:

- **Flow:** The rate of flow of a fluid or material past a certain point is measured to control the amount of a fluid or material to be added to a process. This fluid may be wastewater, raw drinking water, chemicals, slurries, and/or sludge. Each material presents different and unique characteristics that must be dealt with to accurately measure the amount of material passing through a flowmeter. Flow can be measured in many different ways, each method having advantages and disadvantages over another. The proper choice and application of flowmeters allows for maximum accuracy and efficiency.

- **Level:** The amount of material in tanks and other vessels is important for many reasons. Chemical storage tank level must be constantly monitored to avoid spillage from over-filling or for maintaining a required supply of the chemical. Also, many processes, such as sequential batch reactors (SBR), rely on accurate measurement of level to perform the proper process sequences. Protection of pumping equipment is also an important application for level measurement. Level measurement instruments are available using a variety of measurement techniques. Material characteristics and cost are the major determining factors in the specification and application of level measurement instruments.

- **Pressure:** Pumps and plumbing are rated to the maximum pressure sustainable. When the pressure of a material within some vessel falls outside of a specified range of pressures, equipment is prone to inefficient operation, improper operation and failure. Excessively high or low pressure is known to cause catastrophic equipment failure, and in some cases, injury to personnel. Pressure is also used to determine level, especially in large storage tanks.

- T**emperature:** Process temperature is among the most common and important parameters controlled by instrumentation. Many processes require heat for proper operation and must be precisely controlled in many cases. Many options are available for temperature measurement and control. Each method presents good and bad points. Some processes involving extremely high temperatures can only use specialized non-contact types of measurement, such as infra-red, to measure and control temperature.

- **Dissolved Oxygen:** DO is a crucial parameter used to control the common treatment process known as “activated sludge”. In this process, “bugs” are grown in order to digest organic material and make it more “settle-able”. The predominant method of this parameter is done using a membrane-type sensor, which is either floating or immersed in the process fluid. The proper application and maintenance of these sensors allows significant cost reductions in their use.

- **Oxidation-Reduction Potential (ORP):** ORP is an indicator of the state of a process involving oxidation-reduction. A familiar example is the application of chlorine to water and wastewater for disinfection. While it is possible to accurately control the application of chlorine using this parameter, Newer and specialized chlorine sensors perform the task more efficiently. Processes where several chemical components are

being mixed and are reacting dynamically, such as in the sump of a packed column, require the continuous response of an ORP instrument to allow precise control of the process.

- **pH:** This is another process parameter which is commonly monitored. Many processes will operate in a very narrow range of pH while others rely on the ability of the operator or control system to dynamically manipulate process pH. An example of such a process is the removal of metals by precipitation. Understanding pH and it's effects is crucial to effective process control

These parameters are the most common among many different types that may characterize a process. Other familiar process parameters are: alkalinity, turbidity, density, viscosity, mass flow, weight, relative humidity, the concentration of specific chemicals or reagents; there are countless others. Our preliminary discussions will involve the theory behind the various parameters and the methods for measuring and controlling them.

The second part of the equation is the methods by which a parameter is controlled. The point of measurement can be considered the start of the measurement and control process, control action the end. In between, many operations can take place, depending on the process and the desired results. Many processes rely on dynamic controllers to allow superior and precise control, resulting in high quality end products. Other processes are much more simple, being of the mostly repetitive type which would otherwise require human intervention, leaving the end-product subject to the vagaries and unpredictability of human error. In both cases, control systems can be as simple or sophisticated as desired.

Simple Control Systems

The simplest systems consist of a single monitoring device, which directly drives a controlling device. A good example would be a flow-control system consisting of a magnetic flowmeter and a single loop controller, and a control valve. A flow set-point is entered into the loop controller, which obtains actual flow data from a magmeter.

The controller will compare the actual flow rate to the desired flow rate and generate an error signal, assuming the flow is not at the desired rate. This error signal is processed and applied to the control valve, which either opens or closes, proportionately, as the situation dictates. This is basic closed loop control, so called because of the use of an active measurement point providing "feedback" to the system.

Another type of system is a chemical feed system that adds a chemical to a process based upon another parameter without relying on the use of feedback. The chemical is added according to a pre-determined formula, or proportionately. A good example would be the addition of chlorine to plant effluent. If the strength of the effluent is well known, a pump may be set to "pace" the injection of chlorine based on flow rate. This method does not allow for any variation in the strength of the wastewater, so these systems will consistently over- and under-dose the effluent. These systems are known as "feed-forward", or "open-loop" systems.

Fine Tuning Control Systems

Within each system, several control settings are used to fine-tune the response of the control system. The most common tuning parameters are Proportional Band, Integral, and Derivative, collectively known as "PID". Some controllers provide expanded capabilities such as logic operations, ramping and profiling. Briefly:

Proportional Band is the most commonly used tuning parameter. Proportional Band is simply the range around a set point which will cause a 0-100% output from the controller. It is a "proportional response" to the variation of a process parameter around the set-point and controls the rate of the "corrective response".

Integral or Rate: This is the amount of time, usually in seconds, that a controller performs corrective action. This means that if a controller has a setting of 0.01seconds, a corrective change will occur, if required, every 0.01 seconds. This feature is useful for very fast processes. Derivative is not commonly used, but is useful for improving control response in fast processes. Derivative acts as an anticipatory response to a rapidly changing process.

Next month: Methods of Flow Measurement for the Liquid Phase.

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Welcome to Ask Tom!, a monthly column by our resident water treatment guru, Tom Keenan of National Environmental Services Agency (NESA). Tom addresses the issues that bug you the most. And Tom knows!! With 35 years experience in providing environmental support services to public and private sector clients on a wide range of environmental issues.

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