Dulcometer®
Measurement and control systems

An Introduction to Process Measurement and Control

Process control in water treatment involves measurement of a variable related to water quality, combined with automation of chemical feed equipment or other physical/ chemical processes to keep the measured value as close as possible to the desired setpoint or between high and low control limits.

ProMinent's approach combines the functions of an analyzer and a controller into one instrument, dedicated to a specific water quality parameter to simplify calibration and operation.

Each ProMinent Dulcotest® sensor measures a specific water quality parameter and sends an electronic signal back to a Dulcometer® controller. The operator calibrates that sensor to a known standard. It then displays any changes that are measured in that parameter within the sensor's range.

Measured Value Outputs

Up to two outputs are available. Dulcometer controllers offer the ability to continuously record measured values to document water quality or to send to another control device. Analog 4-20 mA or 0-20 mA measured value outputs are proportional to the measuring range of the sensor or spannable to provide greater detail within a smaller range, for connection to a chart recorder, datalogger or distributed control system (D1C or D2C).

Control Outputs

Different control outputs are available to control virtually any type of actuating device.

Setpoint relays change state (open or close contact) when the measured value drops below or exceeds the setpoint to start a process control device or alarm, and shut it off when the setpoint is reached (D1C, D2C or WS).

Analog control outputs (4-20 or 0-20 mA) can drive a variable speed analog control device, such as a DC SCR drive or AC inverter, according to the control action used (D1C, D2C or WS).

Pulse outputs are brief contact closures to pace pulse-input metering pumps corresponding to the control action used (D1C or WS).

Modulating relay outputs cause a relay to open and close according to the control action used. These are used with solenoid valves or constant-speed motor-driven metering pumps. Minimum on-times may be set to prevent overheating of motors (D1C or D2C).

3P relays provide two relay outputs to control a bi-directional actuator (such as a stroke length controller on a metering pump) with provision for feedback potentiometer from the actuator to display the position according to the control action used (D1C or D2C).

Control Actions

A variety of control actions are available to suit the application and budget. Any variable control output listed above may be used with any of the control actions listed below.

Setpoint Control

Setpoint control uses a setpoint relay to start a constant output pump or open a solenoid valve when the measured value drops below (or exceeds) the setpoint. Once the measured value reaches setpoint again, the pump stops or the valve closes. This always results in overshooting the setpoint because of the lag time between the point of chemical addition and the point of measurement. This can waste chemicals and cause excessive variation on either side of the setpoint. It is suited only for closed systems or batch applications where tight control is not required (D1C, D2C or WS).

Proportional Control

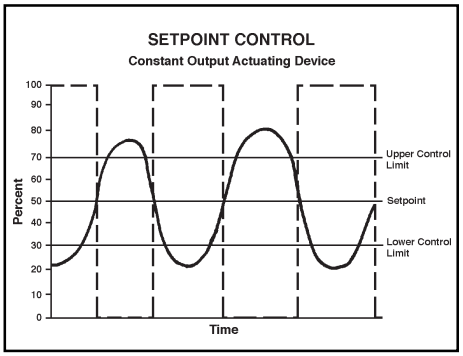
Proportional control gives an output that is directly proportional to the measured value's deviation from the setpoint. The farther from setpoint, the greater the output of the actuating device, and the closer to

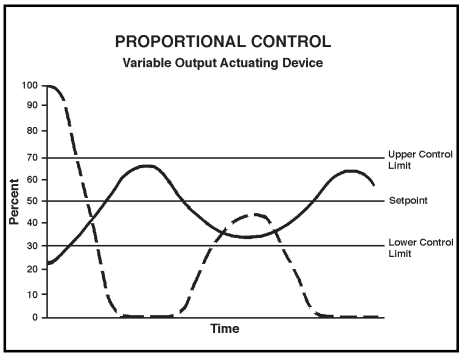
CONTROL ACTION RESPONSE IN ONCE-THROUGH SYSTEMS

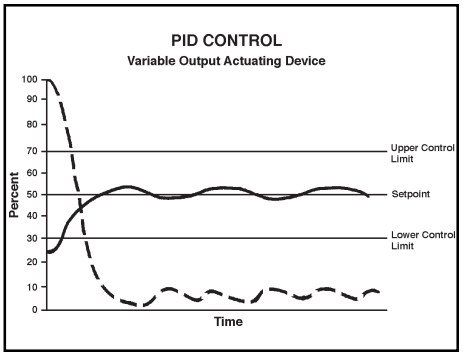
Note: Actuating device output increases measured value in example (e.g. chlorine feed)

—— **Measured value (as percent of measurement range)**

– – **Actuating device output (as percent)**







setpoint, the lesser the output. Proportional control is suitable for closed systems or batch applications where more precise control is required. The proportional bandwidth may be spanned to set the distance from setpoint at which the actuating device is operating at maximum output. A small bandwidth results in maximum output at a measured value close to setpoint, and may cause overshooting. A large bandwidth may result in long time periods required until the setpoint is reached (D1C or D2C).

Modified proportional control

The WS series controllers offer proportional control with a modification that causes the control output to decrease exponentially as the deviation from setpoint approaches zero to pevent over-shooting.

PID Control

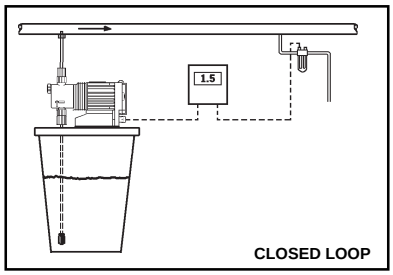
PID control combines proportional, integral and derivative control actions, or any combination thereof.

Integral control considers the time interval of deviation and increases output when the deviation exceeds a programmed time interval. Derivative control considers the rate of change of deviation and increases the output when the rate of deviation exceeds a programmed rate. PID control ensures the least deviation from setpoint possible. (D1C, D2C available in Spring '99)

Control Techniques

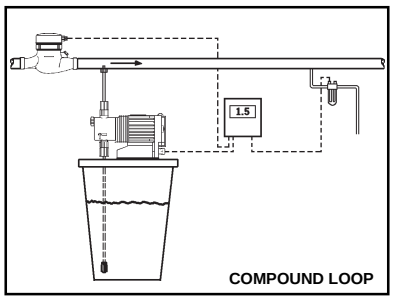
The control technique used depends on the location of the sensor in relation to the actuating device, the presence of other inputs which may effect the measured value, or the requirement for secondary actuating devices to handle large swings. Some common control techniques are described below.

Closed loop control is where the sensor is located downstream of the actuating device and measures changes caused by the device. The controller varies the device's output to maintain the desired setpoint. This is usually used in recirculating or batch applications, or once-through systems with constant flow rate. The sensor must be located far enough downstream to ensure that any physical/chemical changes are complete, whether measuring pH, oxidant residuals or other variables (D1C, D2C or WS).



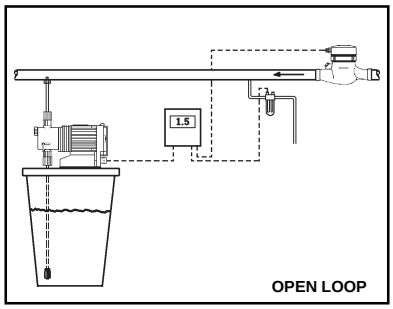
CLOSED LOOP

Compound loop control combines the closed loop signal from the sensor with a second (disturbance) input, normally water flow rate, and changes the actuating device's output in response to both variables. This is typically used in once-through applications with varying flow rates (D1C or D2C).



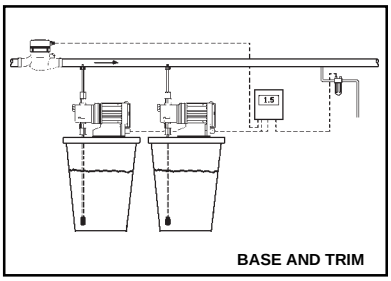
COMPOUND LOOP

With *open loop control*, the sensor is upstream of the actuating device and a control signal changes the actuating device's output. Usually, this is only used when the resulting measured value would be outside of the sensor's measuring range (D1C or D2C).



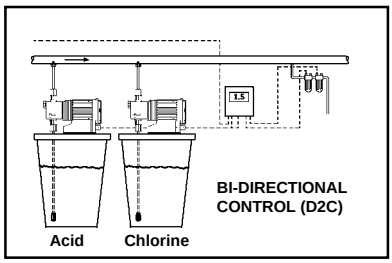
OPEN LOOP

Base and trim control uses two actuating devices to bring large fluctuations into control very quickly, yet provide tight control under normal operation. A variable output actuating device is normally used with proportional or PID control for the trim or fine tuning. A constant output device would be started by a setpoint relay for the base load to make fast changes in the event of large fluctuations that the trim device cannot handle (D1C, D2C or WS).



BASE AND TRIM

Bi-directional control of two opposing actuating devices, such as pumps for acid and base in a pH control application, is possible with one controller (D1C, D2C or WS). To prevent repeated corrections caused by overshooting on both sides, a deadband may be programmed (between two setpoints) in which both actuating devices are stopped (D1C or D2C).



PROPORTIONAL CONTROL ONLY (BATCH LINE)

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System Components

The ProMinent catalog lists a variety of components that must be combined to create a functional control system. *Please ensure that you select all required components, as follows:*

Minimum Requirements

- ✓ Controller
- ✓ Sensor(s)
- ✓ Sensor holder(s) (to mount sensor in process)
- ✓ Sensor cable(s) (to connect sensor to controller)
- ✓ Standardizing solution(s) (for pH or ORP, others use the sample water analyzed on site for calibration)
- ✓ Metering pump(s) with control input matched to controller's output

Optional Equipment

1. Impedance converter (millivolt) to minimize interference and maximize sensor life when distances between pH, ORP or temperature sensors and the controller are between 30 and 300 feet. Provides mV output.
2. 4-20 mA Signal Converters for pH, ORP or temperature sensors when distances between the sensor and controller is up to 300 feet, or where required by the controller (e.g. pH correction for chlorine). Provides 4-20 mA output.
3. Chart recorder
4. Spare membrane caps and electrolyte for membrane style sensors.
5. 2-wire shielded cable for transmission of 4-20 mA signals.

DGMa in-line sensor housings, Dulcotest instrumentation and Dulcometer D1C panel/wall mount controllers

Sample System for Single Variable: Free Chlorine

Application: to measure free chlorine in the range of 0-20 ppm. Controller to be wall mountable with 4-20 mA output for a chart recorder, PID control output to a sodium hypochlorite metering pump. Flow monitoring on the sensor holder and pause input on the controller.

Equipment	Part Number/Ident Code	Reference
chlorine controller	D1CAW1C10011G220E	Dulcometer-7
free chlorine sensor CLE 3	792920.1	Dulcotest-7
2-wire sensor cable/ft. - __ ft.	7740215.4	Dulcotest-22
sensor holder and flow module	DGMA301T000	Dulcotest-19
mounting set for CLE	791818.8	Dulcotest-19

Sample System for Dual Variables: pH and Chlorine

Application: to measure total chlorine in the range of 0-10 ppm or free chlorine in the range of 0-20 ppm along with pH in the range of pH 0-14. Controller to be wall mountable with 4-20 mA output for a chart recorder, PID control output to a sodium hypochlorite metering pump. Flow monitoring on the sensor holder and pause input on the controller.

Equipment	Part Number/Ident Code	Reference
pH/chlorine controller	D2CAW1PC1004G10E	Dulcometer-7
PHED sensor	741036.8	Dulcotest-5
free chlorine sensor CLE 3	792920.1	Dulcotest-7
(2) 2-wire sensor cables/ft. - __ ft.	7740215.4	Dulcotest-22
(2) sensor holders & flow module	DGMA301T000	Dulcotest-19
mounting set for CLE	791818.8	Dulcotest-19