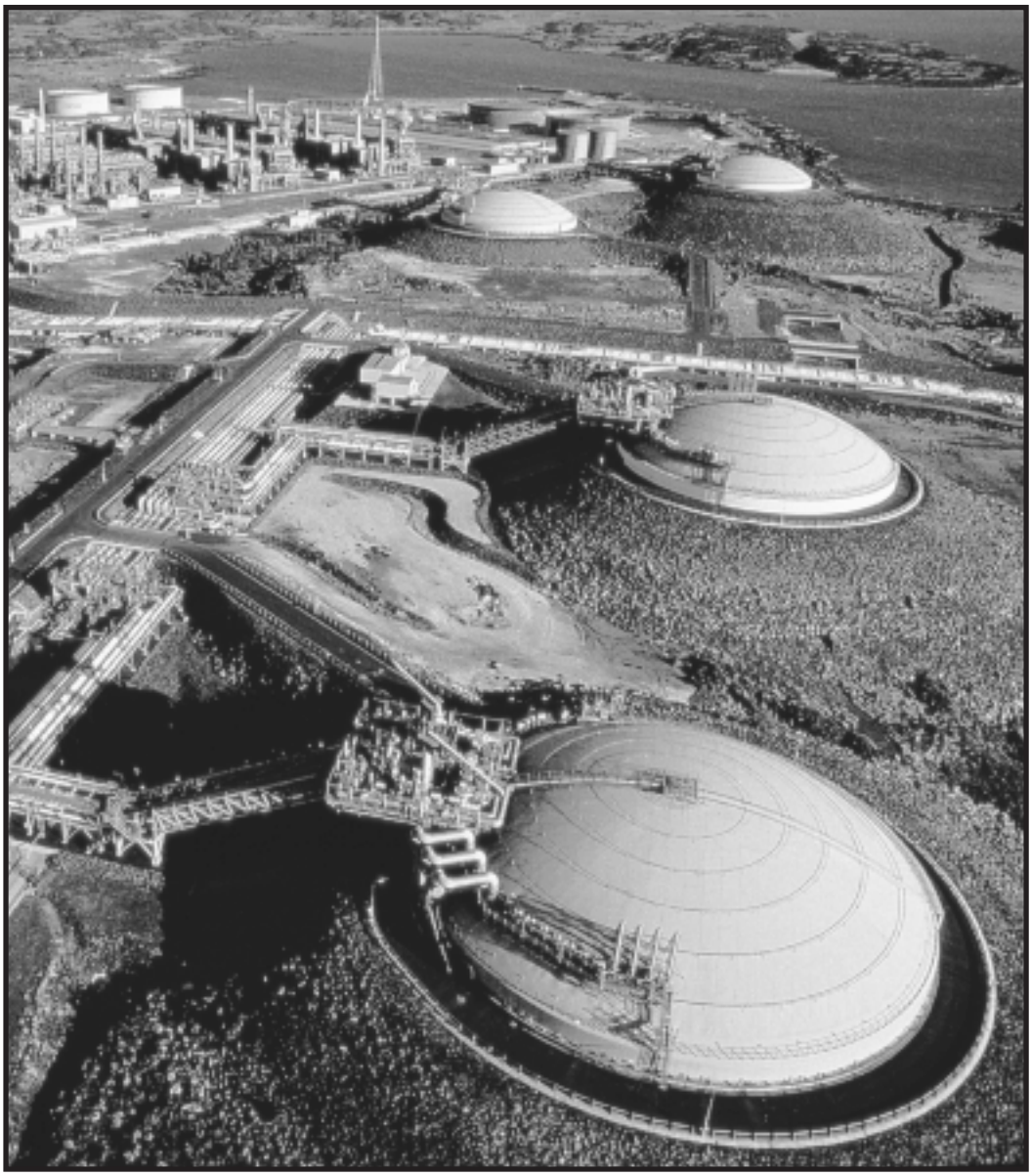
Honeywell

Measurement and Control of Dissolved Oxygen in Wastewater Treatment

Application Note



Total Plant

The Background

The purpose of a wastewater treatment plant is to remove impurities from water so that the water leaving the plant, the plant effluent, is as pure as possible. While suspended solids are generally removed by physical means, such as screens or simple settling, dissolved solids must be treated chemically or biochemically. Dissolved organic materials pose the greatest threat to the waters (streams, rivers, oceans) receiving the plant effluent. Unless the effluent is very low in dissolved organics, odors will be discharged into effluent-accepting waters, and, far more importantly, these discharged organics will provide food for bacteria. As the bacteria consume these organic compounds, they also consume the oxygen dissolved in a stream or river. This, in turn, can lead to the death of fish and other marine animals—which can provide more food for bacteria and further oxygen depletion.

The Process

The most effective way to remove dissolved organics from wastewater is to allow bacteria to consume them before the water leaves the wastewater treatment plant. Required for this process are food (the dissolved organics), bacteria, and dissolved oxygen. This process is most frequently carried out in a large "aeration" basin, where the wastewater is mechanically aerated to provide the bacteria with enough oxygen to support a high rate of consumption of the dissolved organics. The bacteria are later removed from the water as suspended solids. The simplified reaction can be represented as:

$$\text{Dissolved Organics} + O_2 \xrightarrow{\text{bacteria}} \text{Insoluble Organics} + CO_2$$

The Problem

Water is aerated mechanically, either by churning it in air with large impellers or by bubbling compressed air through it from a level near the bottom of the basin. Controlling the amount of aeration is important. If too little dissolved oxygen is available to the bacteria, the process will slow; in an extreme case, the bacteria will die from lack of oxygen, leading to "losing the basin." Recovery of a lost basin is expensive and time-consuming. If the aeration provides more oxygen than the bacteria can use, the excess usually does not upset the process but represents a significant unnecessary cost in the electrical energy required to run the compressors or aerators. (In some wastewater treatment plants, energy required for aeration is the largest line item expense after salaries.)

Required is first an accurate measurement of the dissolved oxygen concentration and then efficient control of the dissolved oxygen concentration. The dissolved oxygen concentration that provides the most efficient treatment depends on the specific process being used and on the nature of the organics being consumed. Typical values are in the range of 2 to 4 ppm—that is between one-fourth and one-half of the air-saturation value.

Honeywell's Dissolved Oxygen Solution

Long-term accuracy depends on both the inherent stability of the probe and analyzer and independence from variables that can interfere with measurement. For instance, non-Honeywell dissolved oxygen probes produce signals that depend on diffusion rate of oxygen through the membrane. Variations in flow rate or cleanliness produce variations in signal, which are erroneously interpreted as variations in dissolved oxygen concentration. Furthermore, results can be compromised as a probe ages because parts of the probe are consumed during the measurement. Probes must be maintained by changing internal electrolytes and etching internal electrodes. Or the whole active portion of the probe must be replaced with some regularity.

The patented Honeywell probe is unique in that the oxygen consumed to make the measurement is balanced by oxygen produced within the probe. The oxygen within the probe is in equilibrium with that in the sample, so results are independent of flow rate and inert fouling. Since no internal parts of the probe are consumed, the probe is permanent. Eliminated is maintenance to replace electrodes, electrolyte, or entire probes. The fact that no probe materials are being consumed leads to great probe stability.

Honeywell's 7020 Series Dissolved Oxygen System

Automatic Cleaning and Calibration

Although the Honeywell probe accuracy is unaffected by inert fouling, there are two conditions where probe cleaning may be required. (These conditions affect all conventional dissolved oxygen probes as well.) The first is where the fouling is so thick that the response time of the probe becomes unacceptably long. The second is where organic fouling is consuming oxygen before it reaches the surface of the probe. A feature allowing automatic cleaning at preconfigured times is included in the 7020 Series analyzer. Cleaning may be initiated with a frequency of every few minutes to monthly. Functionally, relays within the analyzer are tripped, allowing withdrawal of the probe from the sample, turning on a cleaning spray, turning off the spray, and reinserting the probe into the sample. Execution of automatic cleaning and calibration requires the user to install a drive unit, a solenoid valve, and mounting hardware.

Similarly, all probes drift with time. Although the Honeywell probe is very stable, included in the analyzer is a feature that allows withdrawal of the probe into air for automatic air calibration at user-configured times. The sequence of calibrations and cleanings are user-configurable.

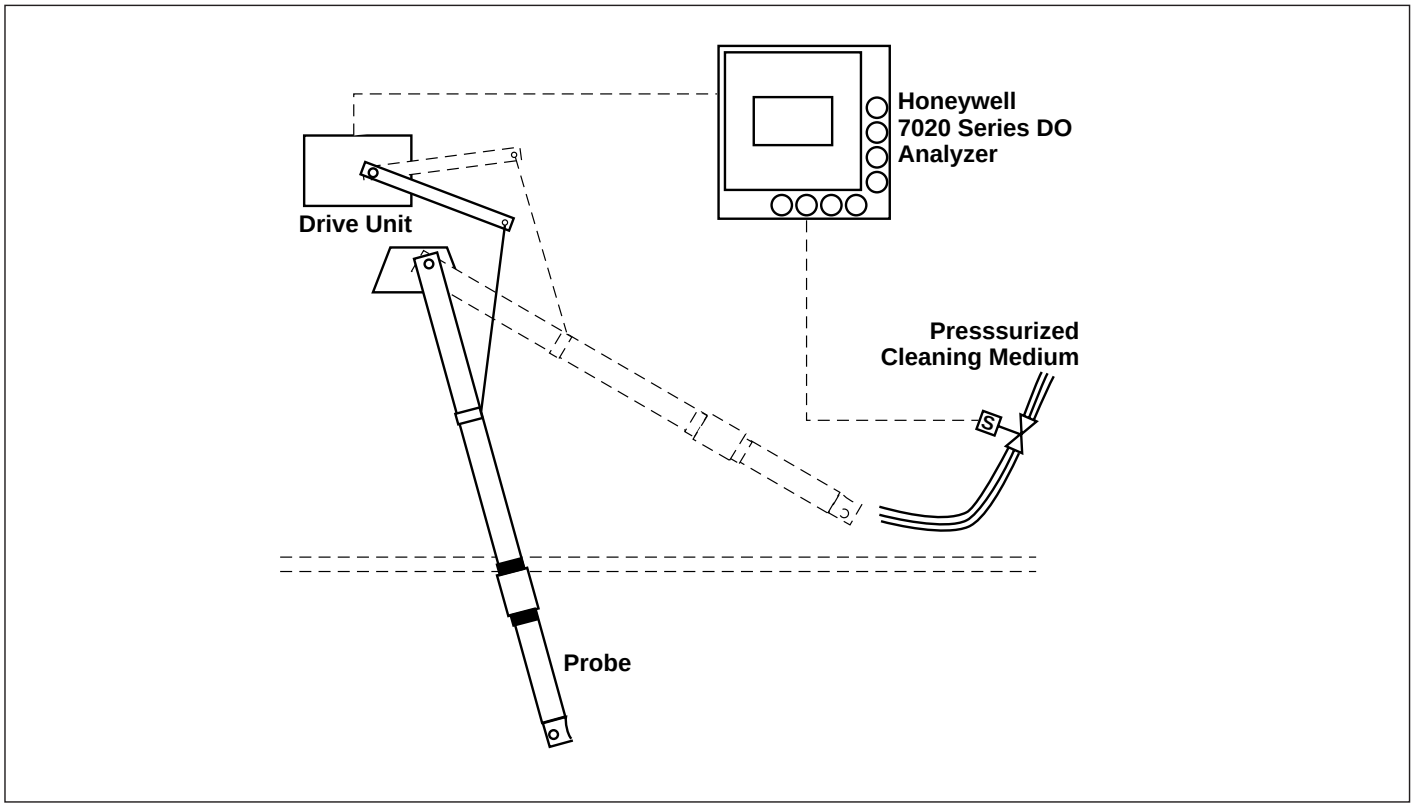
One symptom of the need for cleaning is a low dissolved oxygen reading. The 7020 Series dissolved oxygen analyzer can be configured to execute a cleaning cycle if the measured dissolved oxygen falls below a user-selected value. An alarm can be configured to alert the user if the cleaning fails to restore the dissolved oxygen to a higher level. The alarm will indicate either a true decrease in dissolved oxygen concentration or unsuccessful cleaning.

A dedicated calibration key may be configured to execute calibration, cleaning, or both whenever it is pushed.

Variations in salinity affect the relationship between probe output and dissolved oxygen concentration. The readings can be corrected automatically by either entering a constant value or providing for continuous variation in salinity using the signal from a conductivity meter. While this condition is rarely observed within the wastewater treatment plant itself, it can be present in downstream monitoring of dissolved oxygen where the stream receiving the effluent is brackish or tidal.

Control of Dissolved Oxygen

The 7020 Series analyzer can function as a controller with choices of control, including On/Off or PID (proportional, integral, derivative) control with CAT (current adjusting type) or DAT (duration adjusting type or time-proportioned) outputs. For instance, in simple On/Off control, one or more of the relays can be dedicated to turn additional blowers or impellers on and off based on dissolved oxygen concentration. If a continuously variable aerator is being used, its output can be controlled with full PID function based on dissolved oxygen concentration.



Automatic cleaning and/or calibration in wastewater applications.

A secondary input from a flowmeter allows the control action to provide rapid response to variations in process flow. Control based on remote setpoint is also user-configurable. To facilitate control tuning, an active display of a graph of the dissolved oxygen vs. time may be displayed.

Cascade Control

With a second analyzer, cascade control is available. In cascade control, the output of a downstream controller is used to adjust the setpoint of an upstream controller. To control the dissolved oxygen of either the plant effluent or the receiving body of water, cascade control may be useful. If the dissolved oxygen concentration in the aeration basin is within the desired range, but the readings at either the discharge point or farther downstream are approaching some low limit, a cascade control action can automatically raise the setpoint in the aeration basin to keep the downstream dissolved oxygen concentration within compliance.

Probe Diagnostics

In addition to the low-dissolved-oxygen diagnostic associated with cleaning, described above, additional tests identify such conditions as AC noise on the probe signal and out-of-range dissolved oxygen and temperature signals.

There is also a sophisticated diagnostic that allows operation under unusual sample conditions. Under most conditions observed within a wastewater treatment plant, the probe exhibits a current-voltage characteristic compatible with factory settings. However, in some industrial applications, particularly those in petroleum refineries, active gases dissolved in the wastewater can cause probe characteristics to change. The 7020 Series analyzer includes a diagnostic feature that automatically varies the probe operating voltage while displaying the probe output. At completion of the test, an opportunity to change the operating voltage is provided. Thus, even where significant gaseous contamination might otherwise interfere with the response of the probe to dissolved oxygen, this advanced feature allows the probe to operate successfully.

Analyzer Diagnostics

Extensive alarm summaries, alarm histories, and diagnostic summaries are included within the software, greatly facilitating documentation for operation and proving permit compliances.

Security

A fear of wastewater treatment plant supervisors is that operators will change programmed operations. The 7020 Series analyzers' security codes may be owner-configured to lock out many operations, leaving the operator with the ability to execute routing operations but not to interfere with configured control parameters.

Additional Applications

Dissolved oxygen is frequently monitored in at least two additional locations in the plant, and each may benefit from 7020 Series features. The effluent from the plant is monitored to prove compliance with regulatory agency requirements. While this water should be very clean, its flow can vary, and the flow-independence of the Honeywell probe proves particularly useful. Additional checks may be required at one or more points downstream from the treatment plant discharge.

Applications to Avoid

Not all wastewater treatment plants use energy-intensive aeration such as impellers or blowers. Where biological treatment of dissolved organics is by trickling filters or biological contactors (bio discs), the control of aeration is not an important requirement. However, the effluent and downstream monitoring requirements should still be addressed.

There are rare applications where water can contain dissolved sulfides. Continuous exposure to sulfides can interfere with the Honeywell probe (as well as most other probes), and these applications should be avoided.

To learn more about control and measurement of dissolved oxygen in wastewater treatment, or to arrange for a demonstration, contact your Honeywell representative, 800-343-0228, or visit our World Wide Web Site at www.iac.honeywell.com.

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