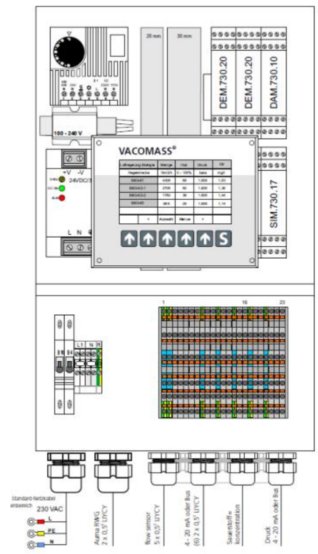
VACOMASS®

Technical Information

Control loops based on air flow with VACOMASS® master



BINDER

BINDERGROUP

THE SYSTEM VACOMASS®

COMPONENTS:

The modular design of the VACOMASS® measuring and control system operates on the building block principle. It can be used as a single component or a complete system in sewage treatment plants. In the simplest case, there is only an air flow meter or a control valve being used. The system can be one single local control loop for oxygen control only or alternatively a complex system of several control loops including control of blower pressure set-point of the air header pipe. The **VACOMASS® system integration** and the precise calibration of the air control and distribution system in our **CAMASS® Calibration Lab** ensure always an optimum interaction of the system components and thus the highest precision for the control of the air supply.

USE IN THE BIOLOGICAL STAGE:

The undersupply of oxygen in the biological process leads to process problems and the consequences that the legal limits of the effluent quality of the purification plant will be exceeded. However, if too much compressed air is fed into the wastewater, this can lead to process disadvantages and an uneconomical operation of the purification plant with a distinct waste of energy. Only an intelligent and load-dependent distribution and control of aeration air guarantees an equally economical operation of the purification plant.

Moving towards the aeration basins, air must overcome several static and dynamic counter-pressures against each other to balance in equilibrium. These pressures vary with the flow rate or vary in dependence of the external interference factors, which can be controlled only with much difficulty. Examples of these are changes of the loading, the wastewater level in the basins or the differential pressure drops across aerators (due to ageing). With minimum changes to these pressure ratios, it can have a significant influence on the air distribution.

CONTROL CONCEPTS:

The **VACOMASS® concept** - utilizing local air distribution and control - can solve this problem. Every VACOMASS® air distribution system supervises continuously the air supply and distribution and recognizes immediately the smallest shifts in the pressure ratios. The local controller intervenes immediately and eliminates the influence of external disturbances on the air distribution. VACOMASS® provides - depending upon actual load and oxygen demand - for this air supply meeting its demand in the various basins, zones and/or cascades of the purification plant. Furthermore the required and optimum aeration time can be determined based on further process information for intermittently aerated basins.

Conventional monitoring systems are usually based on the measurement and control of the dissolved oxygen concentration only. In larger purification plants, it is usually overlapped from further process parameters like the ammonium and/or nitrate concentration. Using only an oxygen control strategy, due to basin size, system inertia and in addition, unfavorable sizing of blowers and control valves as well as the use of butterfly valves as a control valve can lead to deviations in the actual concentration compared to the desired setpoint from up to 1.5 mg/l and more.

In the negative case, this deviation can lead to the undersupply of oxygen to the activated sludge with negative effects to the sludge characteristics, and the expiration values regarding ammonium can emerge.

In the positive case, this leads to over-aeration in the biological tanks, increasing energy consumption unnecessarily. Subsequently, this can also lead to substantial negative process effects such as increased oxygen concentration in the denitrification zones (reduction of the denitrification capacity, increase of the nitrate concentration in the effluent) or mineralizing effects of the activated sludge. These negative effects arise particularly fast in under-loaded purification plants.

Furthermore, in unfavorable cases in large size plants with several automatic control loops, it can lead to swinging in the automatic control loops and thus to an unstable air distribution.

HARDWARE BASIS VACOMASS® CONTROL LOOPS

VARIANT 1: VACOMASS® control cabinet – control cabinet with microprocessor-controlled electronics for fitting DIN rail modules basic, slave, master and econtrol with 4–20 mA standard data transmission

VARIANT 2: VACOMASS® flexcontrol – PLC-based control cabinet with hardware & software modules basic, slave, master and econtrol with data transmission through analogue signals/bus systems, remote dial-in for parameter monitoring/adaptation and further functions (F)

CONTROL MODULES (ON DIN RAIL OR IN FLEXCONTROL)

VACOMASS® basic

F1 Air flow signal correction, through pipe characteristics and/or opening/closing control valves

VACOMASS® slave

F1 Air flow signal correction, through pipe characteristics and/or opening/closing control valves

F2 The customer/the PLC specifies a setpoint for the air flow and the control valve opens/closes until the setpoint is reached

F3 Optional: Programmable diffuser cleaning cycle with air flow limitation

VACOMASS® master

F1 Air flow signal correction, through pipe characteristics and/or opening/closing control valves

F2 Based on empirical calculation as well as setpoint and actual O_2-concentration, 1. the setpoint of air flow is calculated and 2. the control valve opens/closes until the setpoint has been reached, irrespective of any static and dynamic pressure changes in the system

F3 Plausibility check: Only signals from correctly functioning sensors are processed

F4 Alarm management: If severe faults occur, the valve automatically approaches a safety position. Automatic reset into normal operation when the process value returns to within the alarm thresholds

F5 Optional: Redundant monitoring of further process parameters possible

F6 Optional: Based on the NH_4-N concentration (superimposed NO_3-N if present) a new O_2 setpoint value is calculated

F7 Optional: Programmable diffuser cleaning cycle with air flow limitation

VACOMASS® econtrol F1 The degree of opening of all valves in the air distribution system is continually monitored. The valve with the highest stroke be operated at an opening degree of …% (value depends on plant situation). If the valve falls below this opening degree, econtrol issues a signal to reduce the header pressure. If the air flow and therefore the O_2-concentration is too low, econtrol issues a signal to increase the header pressure.

FUNCTION OF VACOMASS® MASTER AIR CONTROL LOOPS

WHAT PARAMETERS AFFECT OPERATION?

In addition to a PID controller, the air control loop software contains a set of further parameters or variables to meet the following plant-specific requirements:

- Different water depths (deep tanks generally react more slowly than shallow tanks)
- Tank geometry – tank bottom coverage with aerators, such as completely covered or partially covered (partially covered tanks, such as circulation or ditch shaped tanks generally respond more slowly than fully covered rectangular tanks)
- Number of sensors in the control loop (e.g. averaging from several O_2 readings, also weighted)
- Whether the O_2 setpoint value is to be calculated from NH_4-N and possibly NO_3-N or is specified by the PLC
- Whether particular peak volumes are expected. Whether more biomass is already preventively introduced into the system in the event of strong rain showers (superimposed predictive controller). The availability of mixing and compensation tanks to reduce load fluctuations
- The likelihood of pressure fluctuations in the system (interactions of blower types; activation/ deactivation of individual control loops that could cause temporary pressure fluctuations; configuration settings in the blower control system/blower management MCP´s, i.e. the blower's rate of response to rising or falling air demand, …)

These parameters are, as far as possible, ascertained before commissioning and the starting variables for the control loop determined and saved. As part of the control parameter fine tuning, the control parameters are checked and, if necessary further adapted (the blower controller's programmed rate of response often becomes apparent only in the optimisation phase).

WHY NOT ONLY ONE PID CONTROLLER?

A PID controller with only one set of P, I and D variables cannot provide optimum process control since the system (the aeration tank or control loop) has a different response behaviour under heavy load than it does in low-load operation. An increased air flow of amount **xx** results in a lower increase in dissolved O_2-concentration during a heavy-duty phase (higher oxidation rate of C- and N-compounds) than it does during low-load phases. Over-aeration by amount **yy** is less critical. Over-aeration by the same amount **yy** in a low-load phase results in a significantly higher increase in O_2-concentration with much longer lasting effects and possibly undesirable oxygen entrainment in denitrification tanks.

Each second, the control loop polls every input as well as the alarms. The readings are then weighted with evaluation factors for O_2 ACTUAL, O_2 SETPOINT, NH_4 ACTUAL and pH. The corresponding main record is loaded in this loop and the required air volume calculated using a 4-quadrant formula. A variable attenuator is then applied to the sum of the evaluation factors.
The inclusion of attenuator and real-time loop in the calculation allows attenuation to be applied to every version between time-controlled 2-point controller and analogue controller.
The oxygen surplus has the highest weighting and is additionally limited through alarm values. The independently operating air flow control loop transmits the iteratively calculated setpoint for the air flow to the valve and adjusts it to the actual (measured) air flow.

WHY AN AIR CONTROL LOOP AND NOT AN OXYGEN CONTROL SYSTEM?

On its way to the aeration tank, the air must overcome several static and dynamic counterpressures, which are in equilibrium with each other. These counterpressures vary with the flow speed or fluctuate depending on external, difficult to control interference factors. Examples include changes in wastewater level in the tank or the state of the blowers. Minimal changes in these pressure conditions can therefore have a significant impact on air distribution.

Every VACOMASS® aeration system continually monitors the air supply, thereby allowing it to detect and compensate even minimal changes in pressure ratio. The local controller immediately responds to eliminate the influence of external influences on air distribution. Conventional control systems usually measure and control the oxygen concentration, in larger treatment plants usually superimposed by further process parameters such as ammonium and/or nitrate concentration.

Tank size, slow system response behaviour, inappropriate blower and control element sizes and the use of valves and sliders with insufficient or severely limited control function result in delayed control responses that can lie in the region of 1 to 5 minutes, resulting in deviations between setpoint and actual concentration of up to 1.5 mg/l.

PLAUSIBILITY CHECKS/SAFETY SETTINGS

If connections are not assigned or in the event of a line breakage, the software replaces the missing reading with a programmable contingency value.
If air flow sensor/O_2 setpoint information from the PLC/ NH_4-N actual fails or if no reading is available due to a line breakage, the software calculates a contingency value from the slider position.
The empirically determined time steps for new control loop setpoints are applied linearly to all parameter sets.
If any alarm value in the direction of oxygen undersaturation is reached, the software terminates normal processing of each priority and initiates a project-specific problem rectification procedure. Example: If the O_2 alarm threshold is reached, the software exits its time loop and actuates the valve in the position assigned to the fault.
If the setpoint values return to within the alarm thresholds, the software automatically resumes its normal control function.
In “External operation” mode, the software continues to run in the background. In this case, it transmits only the direct control commands to the control room (open/close valve by …).

AUTOMATED CLEANING CYCLES

At a programmable time, the valve fully opens/closes from its current position.
After cleaning, the valve returns to its original saved position. This is an option that can be enabled in the software.
For safety, the valve’s stroke in the cleaning cycle can be limited with a programmable maximum flow rate.

OPERATION FROM THE GRAPHIC DISPLAY

All necessary parameters for all application cases can be entered and changed through the graphic display (separate module for each control loop in VACOMASS® control cabinet or one single common touch display for all control loops in VACOMASS® flexcontrol).

PARAMETER TYPES (EXAMPLES)

Variables on-line IN	e.g. O_2-concentration, ACTUAL degree of valve opening (stroke), ACTUAL header pressure, etc.
Control parameters IN	e.g. cycle time between two setpoint value calculations, attenuation parameters, weighting factors, etc.
Control parameters OUT	e.g. setpoint air flow or setpoint stroke of the valve
Alarms OUT	customized, e.g. flow meter error

IMPRINT

BINDER GmbH
Buchbrunnenweg 18
89081 Ulm, Germany
Tel. +49 731 18998-0
Fax +49 731 18998-88

info@bindergroup.info
www.bindergroup.info

BIDE-M-D-VACOMASS-EN-R00 Data Sheet
VACOMASS control loops with master