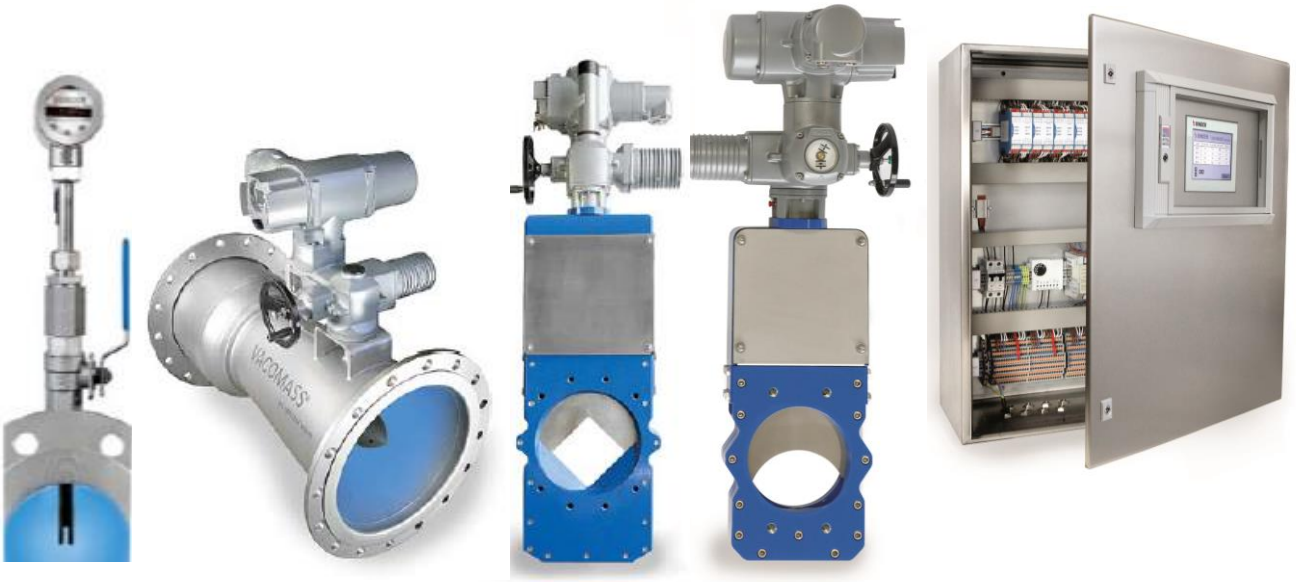
VACOMASS®

Technical Data VACOMASS®
Measurement and Control System



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 at lowest possible costs.

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 deni-

trification 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.

QUALITY OF CONTROL – THE AERATION CONTROLLER WITH AI:

Best control performance and flexibility can be achieved when mashed control loops are used. The blowers need to feed always a sufficient air flow rate respectively a sufficient header pressure (with a superimposed automatically adjustment). The actual DO-concentration shall be monitored and controlled at the DO-SET level. If the DO-concentration deviates from setpoint, the **VACOMASS® flexalgorithm** uses air flow rate as the dynamic control variable in the control loop. From the current situation, for actual and required DO-concentration as well as actual air flow and stroke of the control valve (including further damping and amplification factors) the necessary air flow rate is computed and adjusted directly by the control valve. Permanent off-set of last control steps is used to adjust the control parameter in the next step, the controller is of self-learning and self-adjusting type.

An immediate response to load changes is possible, so there is no need to wait until response of the control valve in the current oxygen concentration become apparent. Overshoots and undershoots of DO-concentration are reduced and DO set-point can be lowered in many cases.

PIPE SECTION FOR MEASUREMENT AND CONTROL OF AIR FLOW:

The design of the pipe section for measurement and control depends on type of the control valve (diaphragm or jet control valve) and available space. There are two general versions available. Using a diaphragm control valve, pipe size is usually reduced in front of the valve and expanded after. The **VACOMASS® jet control valve** is usually mounted directly into the original pipe with reduction/ expansion.

Standard version: If straight pipe section is sufficiently long, then the air flow meter is placed far away in front of the control valve, so that the changing stroke of the valve does not influence the flow signal.

Compact/ integrated version: The air flow meter is placed 500 m in front of the **VACOMASS® diaphragm control valve** or 0.5*D in front of the **jet control valve** respectively. If a diaphragm control valve is used, the changing stroke of the valve is used for simultaneous flow profile correction. Depending on piping section in front of the flow meter and/or on the requirements on accuracy of flow measurement, simultaneous flow profile correction is often not used for the **jet control valve**.

SAVINGS IN ENERGY:

In case of operating a plant under partial load conditions, the flow dependent counter pressures will decrease. At constant blower pressure, this is compensated by closing the control valve which results in an increased differential pressure. Instead of throttling the air supply via the valve, however, it makes more sense to provide a variable adjustment of the blower pressure according to the actual demand. For this, **VACOMASS® econtrol-p** monitors the stroke of all VACOMASS® valves (MOV – “most open valve” and MIV – “most important valve”) in order to determine the pressure necessary just to maintain sufficient air supply for the whole installation. A lower pressure level results in less energy consumption of typically 8-10% for the air supply. Thus an economical plant operation is ensured. As an option required air flow rate can be determined and transferred to the main PLC with **econtrol-Q**.

MAIN ADVANTAGES

- modular system for optimization of nitrogen removal with lower energy consumption – independent of the size of the sewage treatment plant, high-quality components for single use or use in a system - made in Germany
- precise air flow measurement in the different aeration tanks becomes possible
- unique, highly efficient control valves, especially developed and optimized for the use with aeration air, with demonstrably much lower pressure drop in control operation compared to all other available valves
- specially developed controller units in the flexcontrol enclosure, containing all control strategies for nitrogen removal, which are described in the standard paper of German Water and Wastewater Association DWA-A 268 as well as strategies for maintenance and operation of FBDA-systems described in DWA-A 229 and sensor monitoring function
- the flexalgorithm with a self-learning controller, improves process stability and reduces operation costs of the aeration system, reduces operational disturbances, secures effluent quality and makes an efficient operation of the purification plant possible
- control strategy with many international user references of plants in different sizes

TECHNICAL INFORMATION ABOUT COMPONENTS

VACOMASS® flow meter

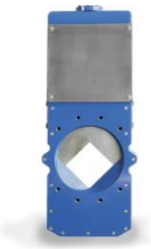
Air flow meter

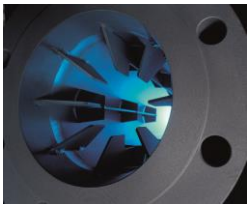
- based on thermal dispersion technology, including automatic pressure and temperature compensation
- using several single sensors, precise results can be achieved even if there are flow profile distortions or big pipe sizes
- robust stainless steel/ ceramic sensors made from one single bar stock. Enclosure is made of corrosion proof aluminum or stainless steel, protection class IP68, mounted with a hot tapping unit (option only)
- available types: SS, AL, AL DIN, AL100, SS100
- Reference for calibration: custody-transfer sensors or pipe sections in the **CAMASS® Calibration Lab** or in a DAkkS-certified Lab

VACOMASS® hot tapping unit

Hot tapping unit for the air flow meter in different versions:

- Standard version OEIN-S with flexible insertion depth
- Version OEIN-F for repeatable mounting position

VACOMASS® square diaphragm control valve	Gas-tight closing sliding gate control valve with actuator for precise control of air flow, with a falling flow axis implemented with a square shaped diaphragm orifice (construction, design and manufacturing according to VDI/VDE 2173, EN 60534 und VDMA 24422), supplied with the pre-mounted electrical **VACOMASS® actuator**	
VACOMASS® elliptic diaphragm control valve	Gas-tight closing air control valve with actuator for precise control of air flow, with a falling flow axis implemented and a lenticular (elliptical) diaphragm orifice (construction, design and manufacturing according to VDI/VDE 2173, EN 60534 und VDMA 24422), supplied with the pre-mounted electrical **VACOMASS® actuator** Specially developed for control of aeration air, complies to all requirements described in the German Standard Paper DWA-M 229, optimized for high air flow rates for diffuser flexing at comparable low pressure drop	
VACOMASS® jet control valve	World-wide unique gas-tight shut-off, aerodynamically optimized control valve, mainly made in stainless steel, with a linear operational characteristic in more or less full operation range, for precise control of air at very low pressure drop ▪ with a central control axis and actuator for sensitive control of air supply ▪ developed for control of aeration air, complies to all requirements described in the German Standard Paper DWA-M 229 ▪ changes in stroke are made in/ against flow direction (flow is routed to the outside wall in order to avoid vortices, supports rapid and high pressure recovery and so leads to a very low pressure drop of the whole valve) ▪ moving body has a very low drag coefficient (only a small driving torque is required, so a smaller size actuator with low torques can be used) ▪ all materials are of high-grade stainless steel type A4 (316), ambient and gas temperatures can range from – 40°C up to +150°C (corrosion-resistant & minimum maintenance) ▪ closes gas-tight, can be used in flexible zones. For further process improvements, the costs for an additional butterfly valve can be saved ▪ excellent repeatability (better than 0.2%) ▪ a nearly linear operational curve is best means for good resolution and stable control in combination with an ideal amplification factor of nearly 1	

VACOMASS® actuator	Sensitive electrical/ pneumatic actuator for control purpose, directly connected with the valve using flanges ▪ With a comparable low torque for the jet control valve, due to its aerodynamically design ▪ Standard: AUMA SAR with high corrosion protection ▪ Standardized options: AUMA SDM, AUMA SIPOS 7, Rotork ▪ Option: all other actuators can be used too, if they fit from a technical point of view	  
VACOMASS® tune valve	Hand-operated membrane valve for fine adjustment of air distribution (for small pipe diameters)	
VACOMASS® blow-off valve	Safety blow-off valve to prevent blower trip-out	
VACOMASS® flow conditio-ner	Flow-conditioner of different types are available. It reduces straight inlet pipe run to a few D only if piping has insufficient straight length. The baffles in the inlet pipe section equalize flow and pressure distortions. So flow metering becomes more precise.	
VACOMASS® silencer	Used in systems where tanks have permanent different water levels or to reduce noise of flow	

VACOMASS® flexcontrol

Modular PLC-based universal electronic modules in a stainless steel field housing, contains various modules to realize typical control strategies for nitrogen removal specified in the German Advisory Leaflet DWA-A 268 and modules for maintenance and operation of FBDA-systems according to DWA-M 229 (latest version) and sensor monitoring, which can be activated and configurated customized

- Standard: RITTAL cabinet, indoor/ outdoor installation
- Visualization via 7" graphic display (customized menus, error message screen, diagnosis, etc.) – **all** control parameter, damping and amplification factors are on the screen and can be changed by the experienced operator (no black box!)
- with 3 integrated safety levels, password protected (view only – view & edit for operator – view & edit for service/ specialists)
- Data transmission: digital and analog signals to the main PLC as well as all common bus systems
- With external access for fine-tuning of the control parameter and service work
- High level of process safety: monitoring of used on-line sensors for signal quality & maintenance reminder, plausibility checks, failure monitoring of hardware components, redundant PLC and other hardware components, substitute parameter & action management system

Overview Basic Functions for control of Air Supply, Header Pressure & Blower

- **VACOMASS® aeration controller-DO: follow DO**

  for the automatic calculation of the actual air flow SET and the stroke SET or time to open/ close the valve, based on process parameter DO SET and DO ACT for local control of the air flow, which is precisely controlled in one step; switching frequencies and thus wear is reduced, automatic adjustment high-load / low-load, summer/ winter

  Base: Flexalgorithmus as an advanced PID-controller with an adaptive self-learning P-portion for improved compensation of the control offset, multi-stage I-portion for improved evaluation and application of time tendencies, consideration of further influence factors e.g. water temperature, salinity, stroke-, flow rate- and pressure damping

- **VACOMASS® aeration controller-Q: follow air flow**
  for the local control of air supply by adjusting the control valve based on actual air flow SET, which is calculated by and transferred from another VACOMASS® master or the main PLC (SCADA)

In both cases the actuators can be adjusted directly using time control or stroke control (direct mode) or a recommendation is sent to the SCADA and SCADA adjusts the valves (external mode, we recommend to use stroke control only).

- **VACOMASS® econtrol:** higher-level systems electronics for the calculation and transmission of the header pressure SET (econtrol-p) or air flow rate SET (econtrol-Q) as a function of the current air requirement based on the most open valve (MOV) and most important valve (MIV) for energy saving in partial load situations (prerequisite for the implementation of a dynamic pressure control system, which is realized in the MCP, one cabinet can handle max. 3 blower groups)
- **VACOMASS® blower support unit:** automatic control of blower units for improved process safety (high precision of pressure control) and with energy efficient supply of required air flow rate, determines which blower safely can be used using the real-time blower curve; different types, makes and sizes of available machines can be controlled, future expansion possible
  smart algorithm with AI ensures that never full or absolute minimum capacity of the machines is used (less strain), considers minimum cooldown period whenever a machine is deactivated, duty hours can be spread out over time
  fallback scenario contains 2 substitute algorithms for advanced safety

Overview Modules for improved removal of nitrogen

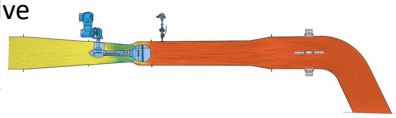
- **VACOMASS® DO-SET NH4-N:** calculation of the actually required DO-SET concentration for sufficient air supply based on actual NH_4-N concentration, prevents over-aeration and carryover of dissolved oxygen to denitrification zones in low-load phases, reduces total nitrogen in the effluent of the plant, lowers energy costs
- **VACOMASS® DO-SET KASK:** automatic adjustment of DO-SET concentration in plants with several sequential aerated tanks, improves distribution of load to all aerated zones, prevents over-aeration and carryover of dissolved oxygen to denitrification zones in low-load phases, reduces total nitrogen in the effluent of the plant, lowers energy costs
- **VACOMASS® VAer-SET:** for the control and adjustment of aerated volume, based on NH_4-N ACT and NO_3-N ACT in summer/ winter times or in high/ low load phases, aeration in additional flexible zones can be started and controlled based on a DO SET (VAer-SET DO) or air flow SET (VAer-SET Q), improves process and effluent quality
- **VACOMASS® biocontrol:** organizes time cycles aeration ON/ OFF in intermittendly aerated tanks based on NH_4-N and NO_3-N (or Redox) or switches to intermittend aeration in low-load phases (biocontrol-L)
- **VACOMASS® DIFF-MIX:** organizes short flushes of air (pulse aeration), to prevent sedimentation of activated sludge in non-aerated process phases if there are no mixers, using a project-specific air flow rate (requires a special type of actuator or further measures)
- **VACOMASS® IntRezi-SET:** is used for the control of the internal recirculation rate of nitrate loaded water, based on water flow and NO_3-N ACT concentration, reduces dilution of raw water in the first zone, improves denitrification and so lowers total-N in the effluent, reduces energy consumption
- **VACOMASS® CDos-SET:** organizes the dosing of external carbon sources to reduce nitrate concentration

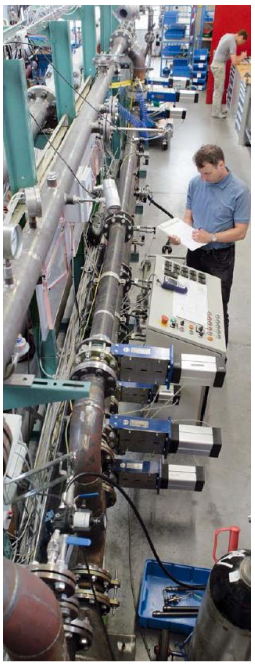
Overview Modules for sensor monitoring and diffuser maintenance

- **VACOMASS® SENS-CHCK:** monitors all kinds of on-line sensors e.g. flow meter, DO-meter etc. for availability and plausibility of signals, recognizes and alerts frozen or jumping values, displays and reminds for required manual cleaning cycles and replacement of spare parts
- **VACOMASS® DIFF-FLEX:** organizes the diffuser cleaning process with a specific air flow rate ("Flexing"), for a certain amount of time, in fixed time cycles, one zone after the other, keeping header pressure at lowest possible level, typically for EPDM rubber membranes and ceramic diffuser
- **VACOMASS® PRESS-REL:** organizes the diffuser cleaning process for over-pressure release from diffuser grids using a magnetic valve, typically for polyurethane membrane and silicone diffuser
- **VACOMASS® DIFF-CLEAN:** organizes the diffuser cleaning process with an acid, a specific air flow rate for a certain amount of time for constant mixture of acid and air, manual start, keeping header pressure at lowest possible level
- **VACOMASS® DIFF-CHCK:** long-term monitoring of pressure loss of the FBDA system based on air flow rate & stroke, to prepare a decision about regular diffuser replacement

Overview further Modules

- **VACOMASS® basic-SC:** for the automatic flow profile correction of the currently measured air flow rate on the basis of the current stroke of the valve and/ or correction due to unfavourable piping
- **VACOMASS® multi:** sensor system consisting of multiple flow sensors and electronics for the automatic flow profile correction, when used in large diameters and too small straight inlet and outlet pipe sections

VACOMASS® simulation	CFD-simulation of flow in the piping section with control valve and flowmeter, considering detailed installation situation, piping geometry, further installations in the inlet and outlet pipe run	

VACOMASS® calibration	The VACOMASS® calibration module is the integration of all individual components under simulation of the real plant conditions in the **CAMASS® Calibration Lab** for system integration. The air flow meter is calibrated by simulating the operating conditions (blower pressures, operating temperatures, load conditions, etc.) to achieve best measuring accuracy not only at the Calibration Lab but also under site conditions.  Level 1: If sufficient straight inlet and outlet pipe sections are available, the **VACOMASS® flow meter** receives the system-specific standard calibration as a single meter. The process conditions such as installation situation, pipe orientation, flow range, pressure and temperature are taken into consideration. This ensures a high accuracy of measurement.  Level 2: If there is not sufficient straight inlet and outlet pipe run, the air flow meter is placed together with the **VACOMASS® control valve** as a compact unit into the calibration loop. If a simultaneous flow profile correction depending on the actual stroke of the **VACOMASS® control valve** is required, this compensation can be processed in the **VACOMASS® flexcontrol** or directly in the electronics of the flow meter AL 100/ SS100. Level 3: If pulsations are to be expected or if the inlet section is far too small, a **VACOMASS® flow conditioner** can be used upstream. The calibration is carried out as a compact unit of flow meter, flow conditioner and possibly the control valve. Level 4: If the installation conditions are very tight and if there is not sufficient straight inlet and outlet pipe run, the calibration of the **VACOMASS® flow meter** is done completely with the control valve and a piece of original pipe run.  Level 5: The calibration of the **VACOMASS® flow meter** is carried out according to criteria to be determined beforehand on an external DAkkS-accredited test stand with measuring equipment regularly in a DAkkS-accredited calibration station or be recalibrated by PTB. Level 6: If straight pipe run is very short and/or if pipe diameter is big and/or if requirements on accuracy are high, a multiple sensor calibration is used to improve accuracy of flow reading. Calibration is customized and considers all conditions at site.
VACOMASS® start-up/ fine tuning	Technical support during start-up phase, fine-tuning of control parameters in the control system based on local conditions by Binder specialists at site or via remote

INVESTIGATION OF POTENTIAL IMPROVEMENT

We develop together with the customer, special control strategies based on local situation related to the number of aeration tanks and their geometry, scope of supply (integration of existing equipment if possible, from technical point of view) and process requirements on the **VACOMASS® system**.

IMPRINT

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