

**VALORSABIO**



Parque Empresarial de Torres Vedras  
Ed. Serviços A1  
Paul  
2560-383 TORRES VEDRAS  
PORTUGAL

**CAS+<sup>®</sup>**

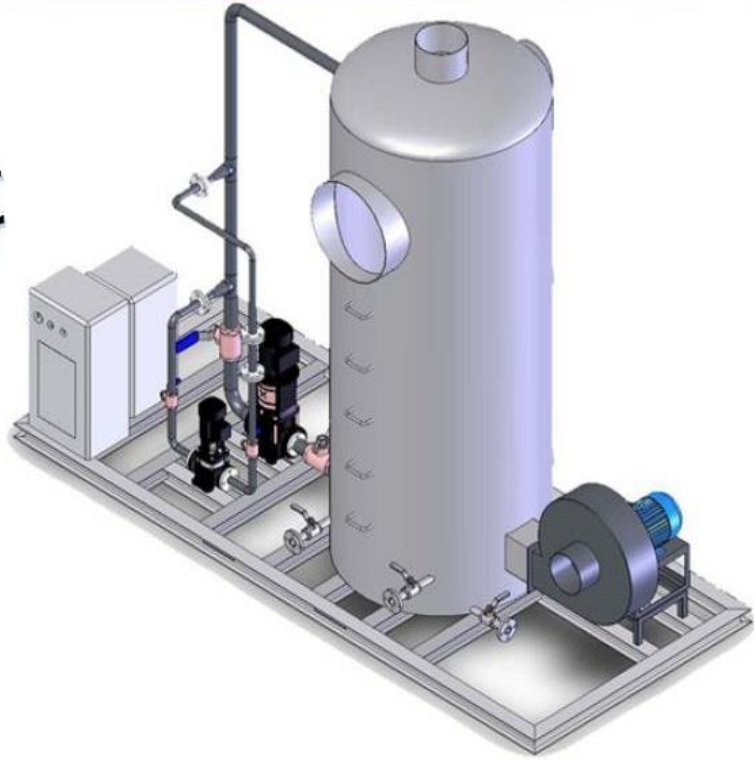
**Chemical Air Scrubber**



VALORSABIO

# CAS+

Chemical Air Scrubber



*The new Breath in Odor Control and Air Purification*

**CAS+** Chemical Air Scrubber



**VALORSABIO**

Product Technical Data

**Product Commercial Name: CAS+®**

· **Index**

**1 - The CAS+® Product**

**2 - CAS+® Product Competitive advantages**

**3 - CAS+® Product Application Fields**

**4 - CAS+® Product Specifications**

**5 - CAS+® Product Drawings**



### 1. The CAS+® Product

· Context:

Sewer gas, chemical name hydrogen sulfide – H<sub>2</sub>S – and ammonia – NH<sub>3</sub> –, are common sources of odor complaints around Waste Water Treatment Plants, and other odor producing related plants and industries. At low concentrations, range 10 ~ 50 ppm (vol), it is the source of 'rotten egg' odors associated with treatment plants. It has a very low odor threshold of 0.3 ppmv. Hydrogen sulfide is also dangerous, at 100 ppmv loss of eyesight will occur and at 300 ppmv the gas is at its lethal concentration.

Besides to being a nuisance at low concentrations and dangerous at higher concentration, exposure to H<sub>2</sub>S between 50 ~ 100 ppmv can't be detected by smell as at this concentration level it causes one's olfactory organs in the nose to fail. In addition to safety and nuisance odor concerns, H<sub>2</sub>S can lead to the formation of sulfuric acid, which is very corrosive to most exposed materials and can lead to reduced life of concrete structures and common plastic piping, steel materials, such as piping, valves, pumps , etc.

The main parameters that regulate the pollutants concentrations in the atmosphere are the following ones:

- Permissible level of concentration (NAC)<sup>1</sup>, concentration value below of it admits that the majority of the workers can successively be exposed, day after day, without adverse effect in the health; Maximum concentration (CM)<sup>1</sup>, concentration value that never should be exceeded even instantly; Threshold Limit Value (TLV), value with a similar meaning to NAC value; and Immediately Dangerous to Life or Health (IDLH), contaminant's surrounding concentration value that in an exposition time lower than 30 minutes doesn't occur any symptom or irreversible effect in the health.

1 - Portuguese Standard NP 1796 (1983).

Table nº 1.1 – Concentration range of the odors related with the several stages of Waste Water Treatment Plant. In: Degremont, 1989.

Location	Air concentration (mg/m <sup>3</sup> )		
	Ammonia (NH <sub>3</sub> )	Sulfide gas (H <sub>2</sub> S)	Mercaptans (CH <sub>3</sub> SH)
Primary Works	1 to 3	1 to 3	0,5 to 1
Primary Sedimentation	1 to 3	0,5 to 1	0,2 to 0,5
Primary Sludge Well	--	10 to 500	2 to 250
Aeration Tank	--	< 1	< 0,5
Secondary Sedimentation	--	< 1	< 0,5
Thickener	2 to 10	5 to 30	2 to 10
Dehydration	5 to 25	10 to 50	2 to 15



Table n° 1.2 - Characteristics of the main odor compounds related with wastewater.

Odor Compound	Chemical formula	Molecular weight (g/mol)	Volatility (at 25° C, ppmv)	Limit value (ppmv)		Odor description
				Detection	Recognition	
Ammonia NH <sub>3</sub>	NH <sub>3</sub>	17,04	Gas	17	37	Acre
Hydrogen sulfide	H <sub>2</sub> S	34,08	Gas	0,0005	0,0047	Rotten eggs
Methyl mercaptan	CH <sub>3</sub> SH	48,11	Gas	0,0005	0,001	Borecole in decomposition

In: WEF/ASCE, 1995.

Table n° 1.3 - Number of renewals per hour according to the confined space to ventilate.

Space to ventilate	N° of volume renew per hour
Areas where the workers operated regularly	8-10
Remaining areas	2-5

In: OSHA, 2003; ATSDR, 1992.

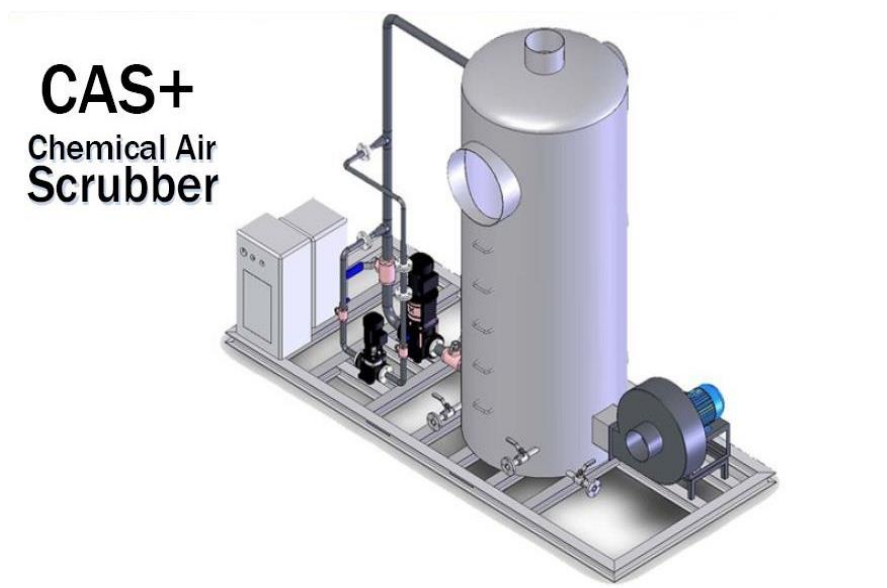


• **Introduction to CAS+®**

CAS+® product was developed by Antonio Ferreira, after 2004. On the original base of CAS+® was the solid background in environmental problems, combined with research for a solution that would solve the identified problems of odor and hazardous gases in wastewater plants, with advantages against conventional chemical wet scrubbers. Thus, CAS+ was developed to operate as a complete and independent deodorizing system using the wet scrubbing technology.

Due to its specific features, the CAS+® is a solution able to reduce high levels of sulfide, or any other acidic gas to the legal values, or others previously introduced by the user. It is equipped with an advanced monitoring technology and, being totally configurable and programmable, can easily satisfy specific needs or clients particular conditions of operation.

Figure nº 1.1 – CAS+® system 3-D image. Final application may result with different configuration and aspect, as a result of a specific design conditions and parameters.



CAS+ Is built with a vertical configuration wet scrubber tower.

The contaminated air and scrubbing solution flow in counter current. The CAS+ features an innovative oxidation process, where air is deodorized by pure oxygen reaction with the contaminants. The main advantage in CAS+ is the fact that the oxygen is produced by the unit, thus no need for oxygen external supply. This production is supported by an innovative PSA ozone generator, dimensioned for each required capacity.



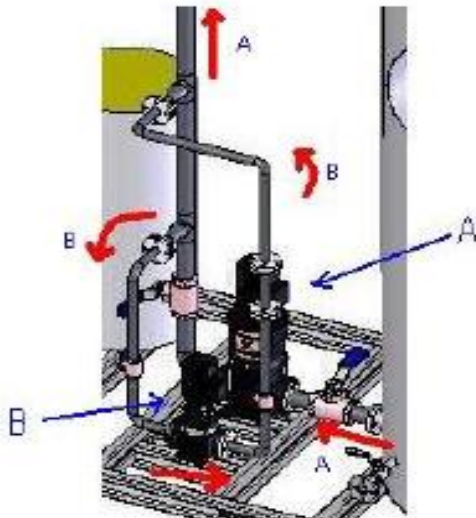
The CAS+<sup>®</sup> equipment can also be connected to any other existing deodorizing system, working, by this way, as an enhancement to the concentration reduction of acid gaseous compounds, either organic or inorganic.

The CAS+<sup>®</sup> product is available in three standard models: CAS+<sup>®</sup> 10, CAS+<sup>®</sup> 20, and CAS+<sup>®</sup> 30. The suffix number traduces the equipment's contaminated air treatment capacity, respectively up to 10.000,0 m<sup>3</sup>/h (5.885,8 ft<sup>3</sup>/min), 20.000,0 m<sup>3</sup>/h (11.771,6 ft<sup>3</sup>/min), and 30.000,0 m<sup>3</sup>/h (17.657,4 ft<sup>3</sup>/min).

### **Brief description of the CAS+<sup>®</sup> functioning and constitution**

The contaminated air is directed through the mass transference column, to the internals of the CAS+<sup>®</sup>, by an industrial fan. Inside the column the contaminated air is forced to cover a vertical and ascendant trajectory. Meanwhile the oxidant molecules of the scrubbing solution, in counter-current, reacts with the contaminants compounds, transferring them from the gaseous phase to the liquid phase. The scrubbing solution, constituted by water and sodium hydroxide (a. k. a. caustic soda, NaOH), is produced by the CAS+<sup>®</sup> through a dosing pump. To this scrubbing solution, by an adjacent piping system (circulation B), is also added a variable flow of gaseous ozone, also produced on site. This circulation B flow, variable through a centrifugal pump and specific controllers in the control panel, is drawn from the main piping system, and later is introduced again into this same piping system, after the gaseous ozone flow injection.

Figure nº 1.3 – CAS+ system centrifugal pumps flow tri-dimensional image.



The gaseous ozone flow is injected at high pressure into the circulation line B and is completely dissolved and mixed with the scrubbing solution throughout the static mixer. The ozone, transferred as micro bubbles, reacts with the water molecules forming several



compounds; two of these are of extreme importance since they have a high oxidation power, and one of them even higher than the ozone itself: the hydroxyl radicals, HO\*, and the hydroxide ions, OH-.

These short-lived free radicals go on to oxidize the more complex molecules, the contaminants, found in the inlet gas flow, while the radicals themselves are used up in the process, as both oxidizing molecules as forming H<sub>2</sub>O<sub>2</sub> (hydrogen peroxide), another strong oxidizing agent. The end result is a sequential and instantaneous gas breakdown with very little by-products, in the form of odor and elemental traces, but mostly simple, harmless carbon dioxide, water vapor, molecular oxygen, and weak mineral acids.

Alongside to this oxidizing process, some NaOH (sodium hydroxide) is added to the scrubbing solution, both as an OH- complement, also responsible for the oxidation power of the washing solution, as a buffer for maintaining the pH level in the appropriate range. CAS+ chemical deodorizing system section is constituted by a mass transference column, made of stainless steel.

Inside this section is included a demister fixed packing. This demister act as a retention surface for the micro drips produced in the scrubber, preventing thus the scrubbing drag off the system, by the air flow.

The demister included also a solution distribution piping, enhancing the exchange between air and scrubbing solution.

CAS+ scrubbing solution is also equipped with a dosing pump for pH control of scrubbing solution. The dosing pump injects a specific flow or alkaline solution into the circulation section B, where it mixes with the circulation liquid.

Figure nº 1.4 – CAS+® system's dosing pump photo. Figure nº 1.5 – CAS+® system's internal components



Figure nº 1.4 – CAS+® system's dosing pump photo.



Figure nº 1.5 – CAS+® system's internal components (distributor and demister) photo.

(distributor and demister) photo.



CAS+ is supplied with H<sub>2</sub>S sensors and ORP sensors as also pH probes. Ozone production is monitored.

### Ozone production in CAS+

Ozone production in site by CAS+® is accomplished within two units in sequence: the Oxygen Generator (O2G-201) and the Ozone Generator (O3G-201).

Figure nº 1.6 – Ozone Generator (model CAS+® 10) Figure nº 1.7 – Oxygen Generator (model CAS+® 10)



The oxygen generator installed in the deodorizing system CAS+® uses an innovative technology for the production of pure oxygen from atmospheric air; this technology is called PSA - Pressure Swing Adsorption. This technology is a non-cryogenic way of purify gas with high energy efficiency. Certain porous materials, such as activated coal or specially designed zeolites, have the capacity to adsorb on its surface preferably some molecules instead of others. In such way, the “impurities”, that is, the remaining molecules that constitute the atmospheric air for beyond the oxygen (nitrogen, carbon dioxide, water, etc.), are adsorbed on the surface of these porous materials, allowing only the passage off the oxygen molecules. These oxygen molecules, that form a continuous volume of pure oxygen, are then fed to the ozone generator. The oxygen production rate of the generator that constitute the CAS+® is between 90 to 95%, that is, in each 100,0 g of produced oxygen, between 90,0 to 95,0 g are effectively of pure oxygen; the remaining 5,0 to 10,0 g are constituted by such “impurities”.



Figure nº 1.8 – Pressure Swing Adsorption (oxygen generator in model CAS+® 10)



The ozone generator of the CAS+® system uses oxygen molecular flow produced in situ in an oxygen generator for the ozone production, also in situ. The ozone production in CAS+® is done through a physical-chemical process named *corona discharge*. A brief explanation of this process that produces ozone molecules by oxygen molecules:

An electric current is generated by of a high potential electrode in a neutral fluid that ionizes it as that creating plasma conditions around this electrode. In this in case the fluid is the oxygen flow produced in the oxygen generator, fed to the ozone generator. That electric current gives a high electric potential to the initial molecules of the fluid, such as they ionize, remaining the ions with sufficient energy. Due to high energy that each ion carries, the ions generated by the ionization of the fluid are recombined forming new ions, O<sub>2</sub>, but these have a higher energy than the previous ones. These ions of positive charge, cations, through electrostatic attractions pick up other ions, of negative charge – anions –, making relatively stable molecules of ozone O<sub>3</sub>. These molecules have a half-life time relatively short, about 15 to 20 minutes, according to temperature, so they are produced locally and then injected into the system – see Table nº 1.5.

Table nº 1.4 – Physical-chemical and organoleptic properties of the ozone.

Properties	Value
Molecular formula	O <sub>3</sub>
Color	Light blue
Smell	Odor after storms and lightning; Photocopier machines
Electrochemical potential	(V) 2,07
Water solubility	(0º C) 0,64
Density	(g/L) 2,144



Table nº 1.5 – Typical half-life time vs. ozone temperature.

Gaseous phase		Dissolved in water (pH 7)	
Temperature (° C)	Half-life <sup>2</sup>	Temperature (° C)	Half-life <sup>2</sup>
-50,0	0,3 months	15	0,30 minutes
-35,0	0,18 days	20	0,20 minutes
-25,0	0,8 days	25	0,15 minutes
20,0	0,3 days	30	0,12 minutes
120,0	1,5 hours	35	0,8 minutes
250,0	1,5 seconds	40	0,3 minutes

Table nº 1.6 – Ozone solubility<sup>3</sup> in water.

<i>O<sub>3</sub> gaseous</i>	<i>5° C</i>	<i>10° C</i>	<i>15° C</i>	<i>20° C</i>
<b>1,5 %</b>	11,09	9,75	8,40	6,43
<b>2,0 %</b>	14,79	13,00	11,19	8,57
<b>3,0 %</b>	22,18	19,50	16,79	12,86

1-Solubility units in mg/L or ppm.

2 - This values are based only in the molecules thermal decomposition. The related effects with relative humidity, organic charges, or any other catalytic Effects are not considered.

3 - The ozone solubility in water depends only of the liquid temperature and the ozone concentration in gaseous phase.

## **2. CAS+® Product Competitive advantages**

### Introduction

The similar products of the competition currently existing in the market, in complete and independent versions of systems, as well in versions of autonomous equipment that constitute the system, are, normally, commercialized for leader companies in the sector. In general, the deodorizing systems commercially available are similar technical models, with functional characteristics very close between them, independently of the exterior configuration and the extra components that each system can present. The majority of the existing deodorizing systems in the market, depending on some specific applications and some suppliers in particular, present geometry and a set of relatively similar



components: cylindrical form, vertical, with a circular air inlet into a height from the base between 1/4 and 1/3 of total column length, and with a air exit, normally centered and of an equal diameter, in the top of the column. They have a dosing system for the washing solution, and a centrifugal pump that makes the liquid recirculation inside, Sucking in the base and pumping laterally, close to the top. Moreover, the column is equipped with automatic electro valves for the liquid inlet and outlet from the inside, regulated by a controller connected with the liquid pH. The functioning of these systems is also very similar, being based in oxidation reactions and/or reduction reactions. There are very complete deodorizing systems, constituted by more than one column, normally two, capable of removing acid compounds (for example hydrogen sulfide – H<sub>2</sub>S) as well as alkaline compounds (for example ammonia – NH<sub>3</sub>). In the cases of deodorizing systems of double reaction, the contaminated air is introduced in the bottom of the first column, normally for the acid compounds removal, leaving by the top of the same one, and, through a pipe between the outlet of the first column and the inlet of the second one, is introduced in this last one for a second reaction, normally for the alkaline compounds removal. In this type of double reaction systems, the treatment order is generally the mentioned one – acid compounds removal followed by the alkaline compounds removal – for the simple fact that the washing solution pH, for the acid compounds removal, should be about 9,30 (2,3 units of pH above of the neutral one), and washing solution pH should be close to 2,0~2,5 (at least 4,5 units of pH below of the neutral one) for the alkaline compounds removal.

Therefore, the CAS+ treatment has an advantage when there is an eventual inverse order of treatment phases: the acid amount to supply to the washing solution of the second column is less since the washing solution acidity of the first column, for where during that treatment phase the acid compounds of the air are transferred, has a closer pH (2,0~2,5). That is, the alkaline amount needed is added to reach 9,3 pH units, from the common water pH, and then a lower acid amount (enough to decrease about 0,5~1,5 pH units), since the outlet solution of the first column has a pH close to 3,0~3,5. If the phases were in an inverse order, would have to add a great amount of acid to the washing solution of the first column (to decrease the pH from ~7,0 to 2,0~2,5), and then an huge alkaline amount to the washing solution of the second column, increasing the pH from 2,0~2,5 to 9,3.

Whichever are the deodorizing systems available in the market, without exception, they have a lack of raised amounts of ions capable to oxidize and reduce the contaminants to be removed. These ions from the acid solution – to be removed the alkaline compounds – or from an alkaline solution to remove the acid compounds, are supplied to the washing solution by the dosing pump(s) that exist in the system. Through the accomplishment of some stoichiometric calculations for a conventional system of acid compounds removal, realize that the necessary amount of alkaline solution is very high and therefore also the operation cost of the system. An example of this consume types is the need of 2,19 L/h of NaOH at 50% w/w, for oxidize 100,0 ppmv (about 141,69 mg/m<sup>3</sup> at a temperature of 20o C and a atmospheric pressure) in a flow of 10000,0 m<sup>3</sup>/h (considering, for example, 10 volumes renewal per hour in a infrastructure with an air volume of 1000 m<sup>3</sup>). If the mass



concentration of caustic soda was less comparing with the mass concentration of the solution, that is 25% w/w (common concentration of commercial containers), the need of this consumable for an hypothetical situation would be 4,38 L/h, increasing the a cost only for the caustic soda of 51,51€ for each 24 hours of operation. The CAS+R system, as previously referred, has two innovative features in this type of air contaminated treatment:

- I- **Automatic production *in situ* of a pure ozone flow**
- II- **Smaller dimensions of the mass transference column comparing with the market average. Immediately after the injection and instantaneous dispersion in the water of the gaseous ozone molecules through a static mixer, several free radicals are created with different times of half-life and with an oxidation power higher than the ozone itself. This way, existing a continuous variety of chemical species being reduced, the oxidation efficiency of the air contaminant molecules is higher than what the one reached only with the addition of an alkaline solution.**
  
- III- **The washing solution of the deodorizing system CAS+ include a feed of variable caustic soda flow: This allow for a stable pH alkaline solution.**

Table no 2.1 – Oxidation potential of some species and chemical compounds.

<i>Substances</i>	<i>Potential (V)</i>
Fluorine (F)	2,87
Hydroxyl radicals (OH*)	2,86
Oxygen element (O)	2,42
Ozone molecule (O3)	2,07
Hydrogen peroxide (H2O2)	1,78
Chlorine (Cl)	1,36
Chlorine dioxide (ClO2)	1,27
Oxygen molecule (O2)	1,23

**Features and improvements of the C AS+ system toward its competitors :**

→ *Lower CAPEX costs* – Lower commercial value per treatment capacity due to the dimensioning and detail project and also to high construction standards; all components are totally optimized for this type of operation;



→ *Lower OPEX costs* – Comparing with the majority of the deodorizing systems commercially available, the global operation costs per cubic meter of contaminated air is lower than in CAS+R system specially concerning the electric consumption (total installed power of 10,76 kW - 28,32 A) and water. This last consumption decreased by the automation of the inlet and outlet water of Mass Transference Column instead of being continuously in and out, as it happen in most of the cases. In CAS+ system the water is discharged through electro-valves and controls that actuate depending of the pH values, conductivity and oxidation-reduction potential of the washing solution instantaneously.

– Use of materials with a high mechanical and chemical resistance as stainless steel AISI 304 and AISI 316 and polymers - PP (H), and others, providing a greater durability to the components of CAS+ system (plates, pipes, connection material - such as collars, flanges, curves, reductions and thread points, - centrifugal pumps internal parts that that have a direct contact with the contaminants, static mixer, and several other components constructed in stainless steel 304L and 316L)

→ *Substitution of the oxidant substance* – Higher efficiency in the removal of air contaminants with a reduced addition of chemicals, due to the replacement of common chemicals used in other deodorizing systems by ozone;

→ *Capacity of integration* – It can be easily adapted to an existing plant or erect a deodorizing system in a future project;

→ *Monitoring and instantaneous information* – Equipped with advanced SCADA monitoring technology capable of giving the user any information in a continuous way through a color *touch panel*, for instance on electric and electromechanical components of the system;

→ *Easy configuration and/or programming* – The system is completely programmable and configuration through a touch panel, making possible also the download of singular data or data series for a personal computer;

→ *Easiness of assembling/disassembling and transporting* – Any tasks related with the maintenance or the transportation of CAS+R system are easier due to the system be constituted by several independent components being able to only disassemble some of them just releasing the necessary screws and nuts.

Also in an eventual need of moving the CAS+R system without proceeding to the dismount, the platform have specific holes, in longitudinal symmetry, allowing its rise and transport through, for example, a stacker. Beyond this, the system CAS+R is also equipped with suspension rings in its components with the bigger dimensions allowing the independent rise of these through a crane/telescope arm.

### 3. CAS+® Product Application Fields

- Odor removal and contaminated air treatment (the air contamination should be mainly with soluble and oxidizing compounds)<sup>1</sup>:



- Wastewater Treatment Plants – Sewage – WWTP / STP;
- Wastewater Lift Stations – WWLS;
- Pulp and Paper industries;
- Kraft and card industries;
- Pharmaceutical Industries;
- Paper grinding and recycling industries;
- Farming and animal exploitations;
- Tanneries industries;
- Meat and fish processing industries;
- Fish and seafood processing industries;
- MSW landfills;
- Composting unit plants;
- WWTP sludge drying processes;
- Soil remediation units;
- Bark and auxiliary boilers;
- Black liquor recovery boilers;
- Lime kilns, shakers and hydrators;
- Lime sludge kilns;
- Limestone plants;
- Soda ash plants;
- Fertilizer plants;
- Ore dryers;
- Chemical evaporation vents;
- Pelletizing operations;
- Sintering plants;
- Carbon black plants.

1- Notice that the mentioned application fields are mere indicative of places (industries and processes) where odor generation really occurs, without always implying the existence of soluble and oxidizing compounds in the contaminated air. Thus, it is imperative to do the analysis of such compounds in order to confirm the CAS+® product applicability.

#### 4. CAS+® Product Specifications

- Design data

To be possible to design a mass transference system of the gaseous phase to a liquid phase, which is the scientific base of the CAS+<sub>R</sub> system, it is necessary to observe several inherent technical aspects, mainly those related with mass balances and others related with the associated chemical reactions.

Admitting the deodorizing system is similar to CAS+, it is convenient to have in consideration the chemical and mass transference mechanisms intrinsic to the system, such as the solubility, vapor pressure (*Clausius-Clapeyron* and *Antoine* equations), superficial tension, viscosity, diffusion coefficients, several laws that rule this area of chemistry (*Henry, Dalton, Raoult, Boyle, Charles, and Gay-Lussac* laws), associated constants to the chemical balances and the equilibrium between phases, chemical electrophilic and nucleophilic reactions, direct and inverse (generation of intermediary





Nominal power (kW)	7,5	1,5	0,55	0,012	0,35	0,4	0,45
Nominal tension (V)	400 -690	-	-	-	220	220	220
): Nominal current (A)	14,2 ~ 8,2	5,9 ~ 3,4	2,5 ~ 1,44	-	-	-	1,44 ~ 0,8

Nominal frequency (Hz): 50 .

Table no 4.3 – Chemical equations (in general) associated to H2S removal of a gaseous flow in CAS+R system.

Eq.	Reagent (s)	Product (s)	Obs.
1	$H_2S (g) + NaOH (aq) \rightarrow NaHS (aq) + H_2O (l)$		
2	$H_2S (g) + 4H_2O_2 (aq) \rightarrow H_2SO_4 (aq) + H_2O (l)$		pH > 7, 1:4
3	$2NaOH (aq) + H_2SO_4 (aq) \rightarrow Na_2SO_4 (aq) + 2H_2O (l)$		
4	$3O_2 (aq) + E(h\nu) \rightarrow 2O_3 (g)$		O2G – 201
5	$O_3 (aq) + H_2O (l) + E(h\nu) \rightarrow 2HO^* (aq) + 2O_2 (aq)$		O3G – 201
6	$NaOH (aq) \rightarrow Na^+ (aq) + HO^- (aq)$		
7	$H_2S (g) + O_3 (aq) \rightarrow SO (aq) + H_2O (l) + O_2 (g)$		
8	$2Na_2S (aq) + 2O_2 (g) + H_2O (l) \rightarrow Na_2S_2O_3 (aq) + 2NaOH (aq)$		
9	$2Na_2S (aq) + 2O_2 (g) \rightarrow Na_2S_2O_3 (aq) + H_2O (l)$		
10	$2NaHS (aq) + 2O_2 (g) \rightarrow Na_2S_2O_3 (aq) + H_2O (l)$		
11	$O_3 (aq) + OH^- (aq) \rightarrow O_2^{*-} (aq) + HO_2^* (aq)$		pKa(HO2*) = 4,8
12	$HO_2^* (aq) \rightarrow O_2^{*-} (aq) + H^+ (aq)$		
13	$O_3 (aq) + O_2^{*-} (aq) \rightarrow O_3^{*-} (aq) + O_2 (g)$		
14	$O_3^{*-} (aq) + O_2^{*-} (aq) \rightarrow HO_3^* (aq)$		pH ≤ 8
15	$OH_3^* (aq) + H^+ (aq) \rightarrow HO_4^* (aq)$		
16	$HO_4^* (aq) \rightarrow O_2 (g) + HO_2^* (aq)$		
17	$H_2O_2 (aq) \rightarrow O_2 (aq) + 2H^+ (aq)$		
18	$2O_3 (aq) + H_2O_2 (aq) \rightarrow 2OH^* (aq) + 3O_2 (g)$		
19	$H_2O_2 (aq) + 2H^+(aq) \rightarrow 2H_2O (l)$		
20	$H_2 (g) + O_2 (g) \rightarrow H_2O_2 (aq)$		
21	$H_2O (l) \rightarrow H^+ (aq) + OH^- (aq)$		$\Delta f_o = -31,95 \text{ kcal/mol } 25oC$
22	$H_2S (aq) \rightarrow H^+ (aq) + HS^- (aq)$		
23	$HS^- (aq) \rightarrow H^+ (aq) + S^{2-} (aq)$		pH > 11
24	$S^{2-}(aq) + 4O_3 (g) \leftrightarrow SO_4^{2-} (aq) + 4O_2 (g)$		

• Equipment list 2 and characteristics

Table no 4.4. – Components list.



<b>Spec.</b>	<b>Designation</b>	<b>Component</b>
1	Mass Transference Column	MTC-101
2	Blower	B-101
3	Circulation Pump A	P-101
4	Circulation Pump B	P-102
5	Ozone Generator Cooling Pump	P-201
6	Dosing Pump	DP-101
7	Oxygen Generator	O2G-201
8	Ozone Generator	O3G-201
9	Ball Valves	BV-101, BV-102, BV-103
10	Ball Valves	BV-104, BV-105, BV-201
11	Ball Valves – Pneumatic actuator	EV-101, EV-102, EV-201
12	Non-return Valves	NV-101, NV-201
13	Static Mixer	ST-101
14	Liquid Distributor (internal component)	LD-101
15	Packing Support Grid (internal component)	SG-101
16	Demister (internal component)	ME-101
17	Packing Material (internal component)	
18	Sulfide Gas Sensors/Transmitters' Controllers	CS_H2S-101, CS-H2S_102
19	Ozone Sensor/Transmitter's Controller	CS_O3-101
20	Console	C-101
21	pH, Conductivity, Temperature, and ORP Potential Sensors/Transmitters	S_pH-101, S_CT-101, S_ORP-101
22	Sulfide Gas and Ozone Sensors/Transmitters	S_H2S-101, S_H2S-102, S_O3-101
23	Pressure and Level Sensors/Transmitters	S_Pr-101, S_Pr-102, S_L-101



5. CAS+ product drawings, views, general dimensions and diagrams.

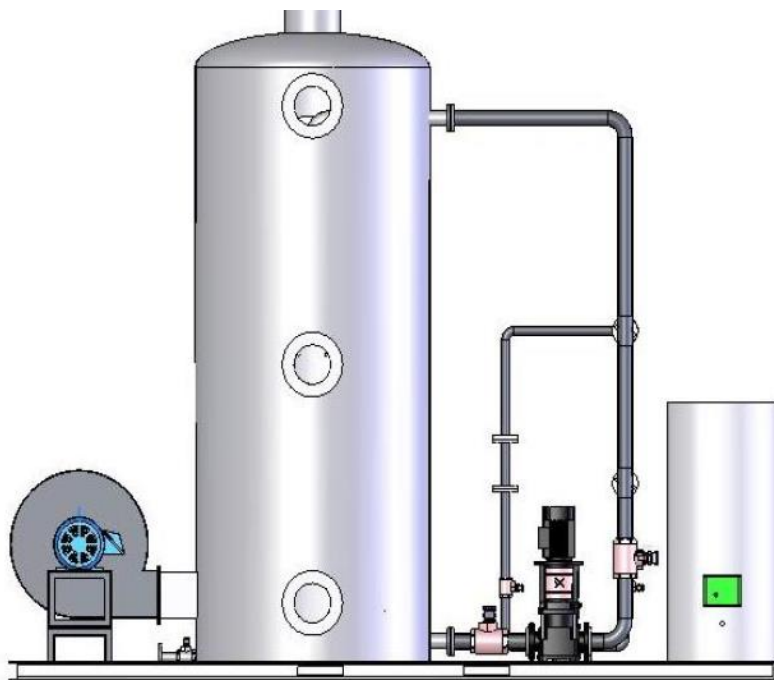
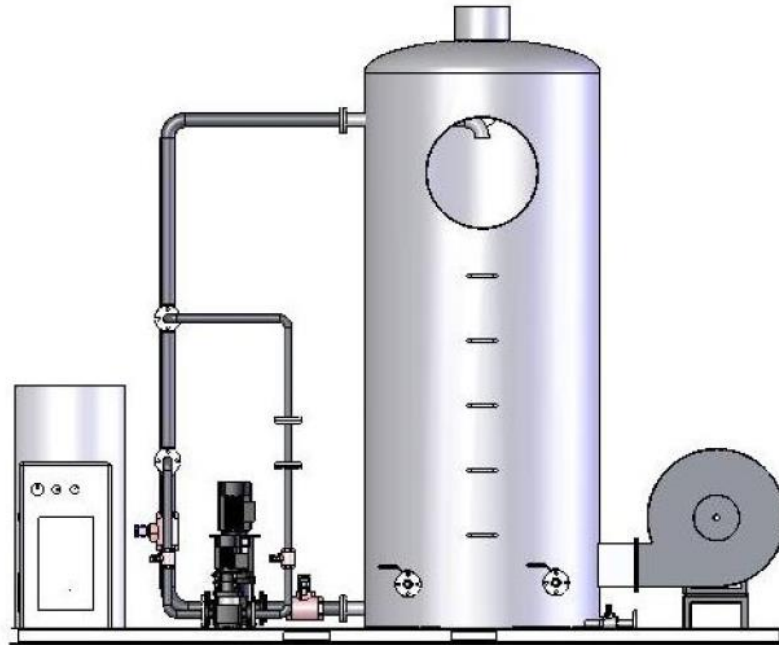


Fig. 5.2. Side views above.



Fig. 5.2.Plant view

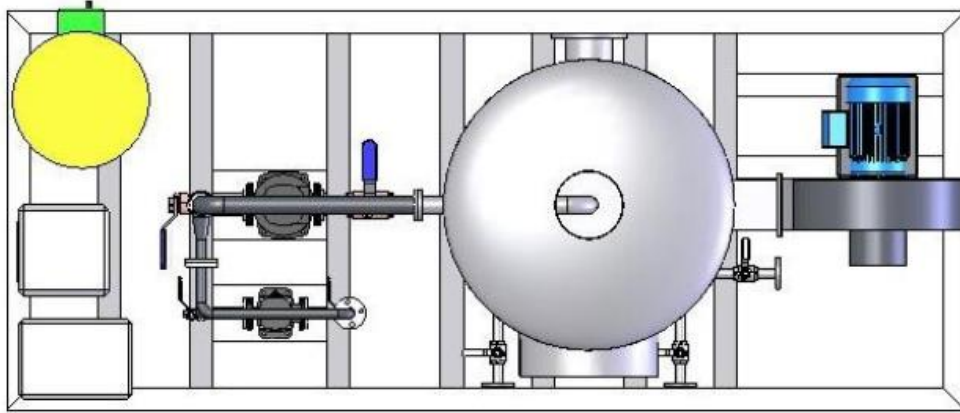
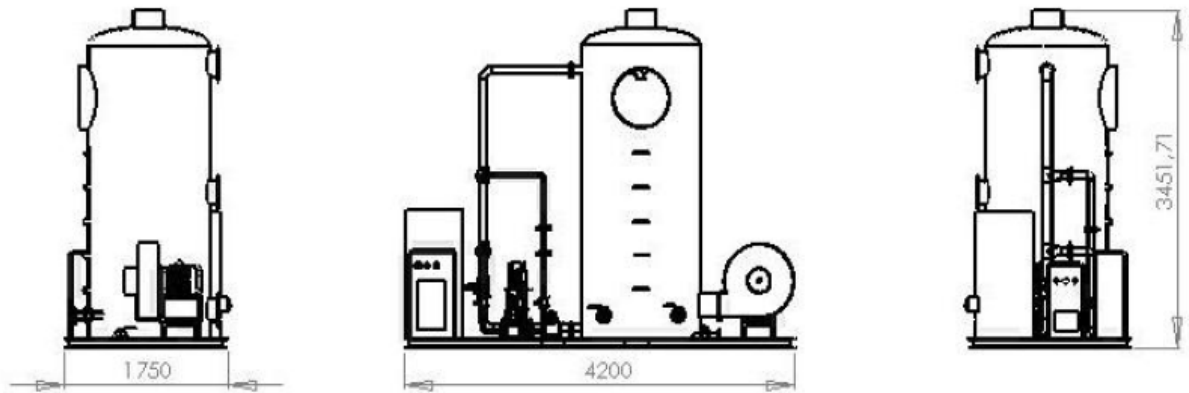


Fig. 5.3.CAS+ 10000 Main Dimensions



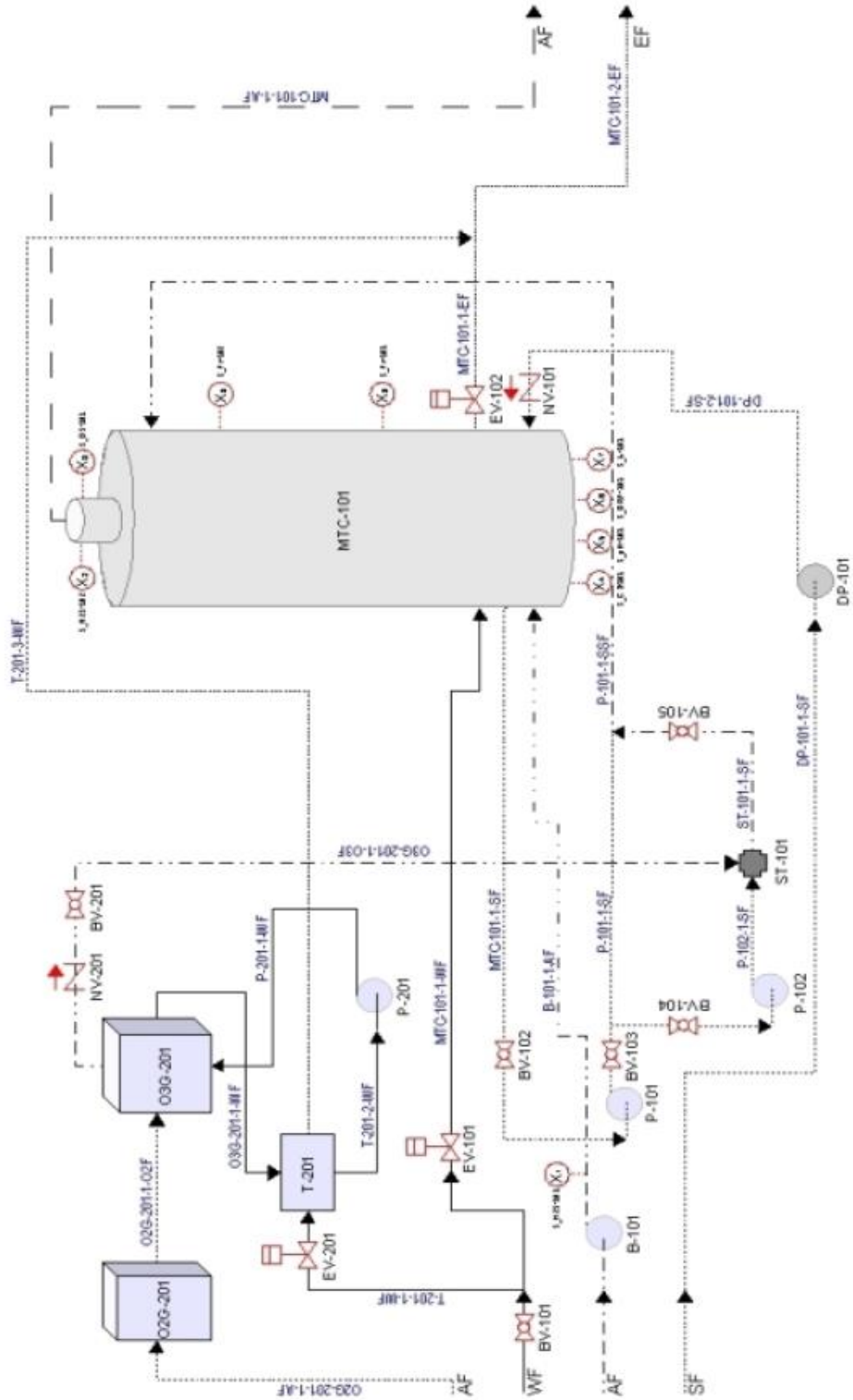


Fig. 5.4.P&ID diagram



**VALORSABIO**

Final Disclaimer:

All dimensions, sizes, installed power and related physical characteristics of the CAS+ items included in this document are subjected to changes and modifications as a result of our engineering revisions, suppliers materials changes, discontinuation and or upgrading of products and accessories included in the whole CAS+ solution.

CAS+ Is a proprietary solution owned by VALORSABIO and exclusively licensed for authorized representatives in each country where it may be applied.

CAS+ does not include any third party proprietary technology and doesn't infringe any third party technology.