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System of Air Noxious Compound Removal by Biological Processes

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Abstract

Due to the nature of its specific activities, oilfield industry stands for a huge pollutant of the environment. Whereas oil or oilfield product leakage sometimes affect irreparably the soil, subsoil and groundwater aquifers, deposits of products or residues in storage pits or leaking tanks represent a source of systematic pollution in the atmosphere. This work present a system allowing for destroying by bacterial activity some harmful compounds in the air can be used for deodorising some emissions of volatile organic carbon (VOC).

Key words: *bio filter***,** *humidifier, turf, bacteria*.

Foreword

It is acknowledged that oilfield industry stands for a huge environmental pollutant, as pollution results out of the very nature of activities of crude and oilfield product production, processing, transportation and storage.

Slimes are much debated that occur as residues in storage, treatment and refining of crude-oil and that join the category of difficult to treat pollutants as being typically deposited in on site excavated pits with hazard of contaminating subsoil and ground waters. Further to a long proven oilfield activity there are in Romania numerous such “provisional” deposits (that have grown as permanent) practically located in each division of production.

It is however to specify besides the subsoil contamination hazard that also atmosphere pollution occurs due to volatile fractions released in the air especially in the summer time.

Releases of hydrocarbon vapours also occur in fuel storage and run-over storage tank farms especially in the case of fixed roof tanks.

Within such context you have hereinafter presented one system for gas filtering throughout permeable environment populated with bacteria specialised in metabolizing hydrocarbons that was experimentally installed into some fuel tank farm with an aim at damaging by bacterial activity the emissions of volatile organic carbon (VOC).

Operating Principle for a Bio-filtering System

The air deodorizing procedure by bio-filtering assumes bio-damaging of molecules pertaining to bad smell substances present in the air by means of selected bacteria or yeast residues.

This type of procedure has got essential applications in effluent purge treatment and pumping stations, in numerous industrial branches generating emissions of volatile organic compounds (VOC) as well as waste composting and treating undertakings.

Air is caught and taken out of the badly smelling sources by mechanical venting after which it is injected into the treating unit where it is first humidified then biologically damaged.

Biodegradation occurs inside a bio-filter where the micro organisms sown in the wet material it has been filled in metabolize badly smelling molecules by oxidizing them due to their endo-enzymatic complex.

NOVABIO French society uses for the filling in of the bio-filter an incompressible material with low pressure losses composed of old brown turf thus allowing for construction of filters in height resulting in a significant gain of soil surface. Work is however possible with other materials such as coconut tree bark fibre that was used in the experiment referred hereto.

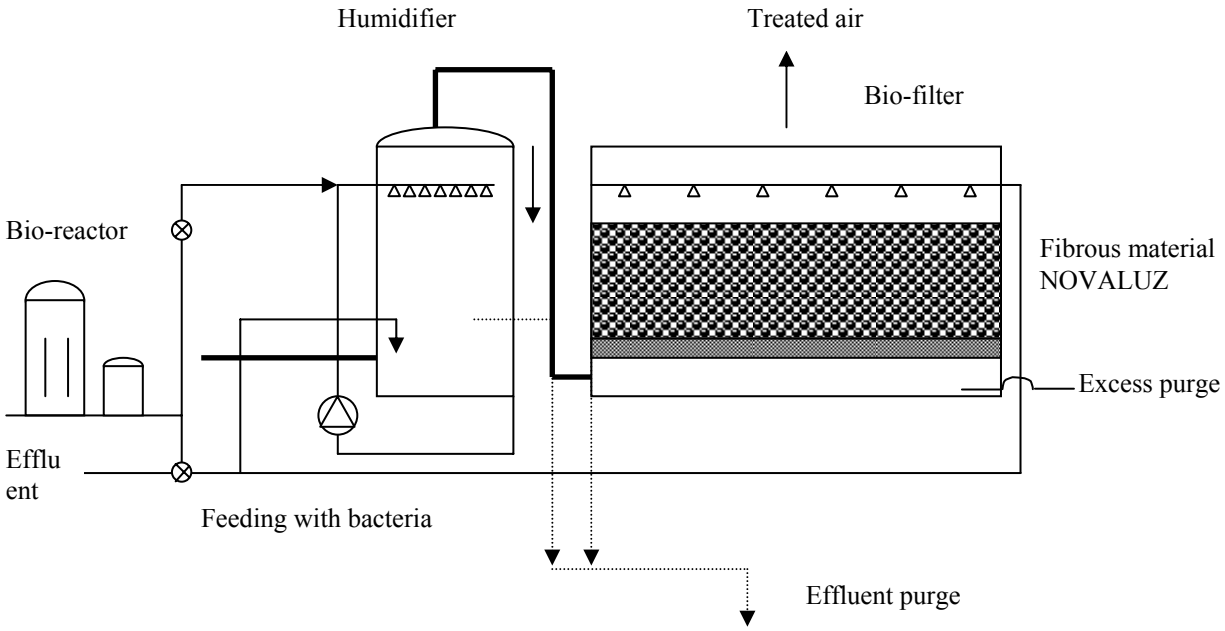


Fig.1. Master Diagram of a Bio-Filtering System

Main Parameters of Operation

This treating procedure is very advantageous from point of view of economy and safety in operation: it only requires very low electric power and consumption of chemical reagents is not necessary but in the case of high concentrations of pollutants. The most significant parameter that needs monitoring during operation is the turf wetness ensured by permanent wetting of the air upstream the bio-filter as well as by periodical spraying of the backfill material.

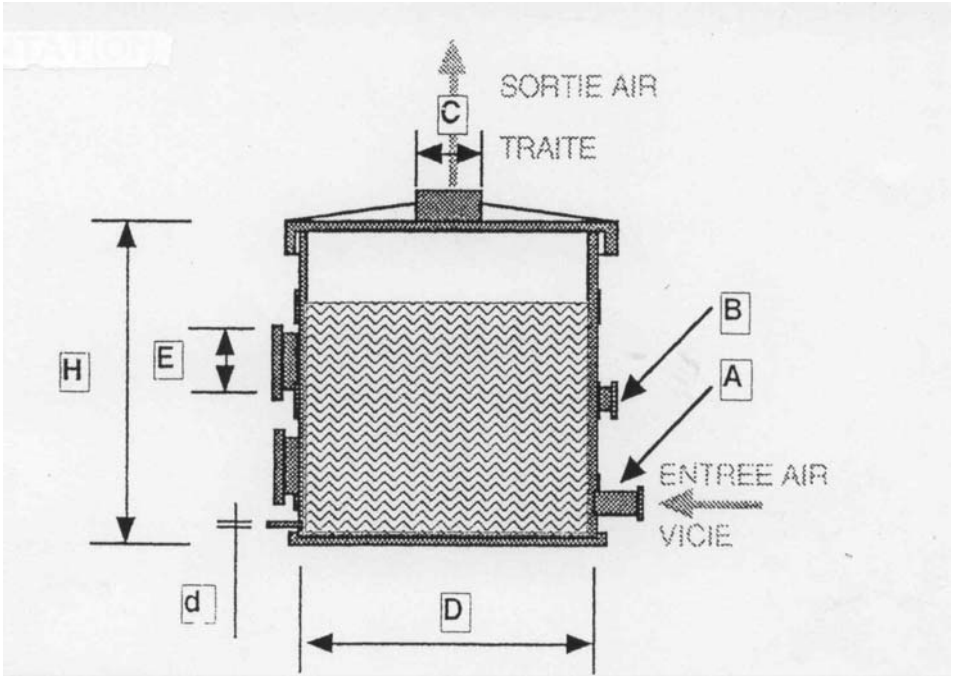


Fig.2. Diagram of Bio-Filter and the Main Design Features

Table 1. Description for selection of bio-filter depending on the flow rate to treat

Bio-Filter Type	**Treated Flow rate (m3/h)**		**500**	**1000**	**2000**	**3000**	**4000**
Pay volume (m^3)			7	12,56	28,26	38,5	50,24
Dimensions	Description	Nr.					
A (mm)	D inlet	1	150	200	250	315	350
B (mm)	R.W.* bond	1	200	200	200	200	200
C (mm)	D outlet	1	150	200	250	315	350
D (mm)	Diameter		1500	2000	3000	3500	4000
H (mm)	Height		4000	4000	4000	4000	4000
d (mm)	Filter	1	50	80	80	100	100
E (mm)	Portholes	2	300	300	400	400	500
Spraying flow rate (m3/h)			2	3	3	4	5
No. of hours for spraying			1	1	2	2	3
Water max. flow rate (m^3/h)			2	3	3	4	7
Gas passage rate m/h			282	318	285	312	320

* R.W. = relative wetness

Table 2. Dimensioning Features

Treated Flow rate (m3/h)	Diameter (mm)	Surface (m^2)	Elevation (m)	Δp (mmCE)	Evap. H_2O (l/h)
500	1500	1,77	4	27	6
1000	2000	3,14	4	37	12
2000	3000	7,07	4	27	24
3000	3500	9,62	4	35	36
4000	4000	12,57	4	37	48
Note : Evaporation is calculated for air at 30°C , with relative wetness RW = 60%					

Experimental Installation of a Bio-Filter to damage the VOC Emissions

Considering the operating principle and the design range destruction systems of noxious gases by bio-filtering process that are used at a large scale in residual water treating stations or in other industrial divisions generating noxious gases, implementation was proposed of this system also to destroy VOC emissions.

Among activities generating VOC emissions in the atmosphere there is also the hydrocarbon storing in oilfield product tank farms that remove significant amount of such. This is a reason why an oilfield product tank farm was sought (gasoline and gas oil) that should become the potential beneficiary for experimental application for the first time in Romania of the procedure of biological treatment of emissions.

Oilfield product tank farms have in their composition fixed roof tank units to store gasoline whose dispersion of vapours (VOC) in the atmosphere is regulated by Government Decision HG 568/2001 and related dispositions to 0.01% weight of the annual full amount of run over gasoline. According to provisions in Appendix 2 of the above-mentioned Decision the existing fixed roof tanks must meet one of the following requirements:

a) Be connected to a vapour recovery unit, or

b) Have a floating roof inside provided with primary seal device that shall be designed so that to provide for a degree of vapour retention of at least 90% compared to a fixed roof tank that is not endowed with vapour control system.

The technical solution of VOC destruction by biological way was presented and discussed in several commercial societies and decision was taken for experimental application on the platform of a fuel tank farm at a 5000 m^3 capacity gasoline tank.

To mention that this tank farm has already had available a vapour condensing recovery plant, John Zink (USA) type, which is in progress to be finalised. Under typical working conditions it shall meet the legal standards: average hourly concentration of vapours purged (non-condensed) at getting out of the plant shall not exceed the limit value of 35 g/Nm^3.

Within the said context the biological treating system was decided to be experimentally applied and be possibly complementary with the John Zink plant for the as stressed as possible purification of gaseous emissions resulted out of fuel storage tanks.

The supplier of the bio-filtering technology is NOVABIO Company of France, and works of installation and operation monitoring were provided for by Novabio Rom society.

Description of Gas Purifying with Bio-Filter

The system plays the role of purifying the mixture of gasoline vapours and air occurring in the tank vapour gap at getting out of the plant resulting in fresh air less hydrocarbons that are metabolized by bacteria. The plant manufactured by NOVABIO Company of France has not a role to recover gasoline vapours out of the air mixture but to destroy VOC. From point of view of noxious released in the atmosphere the method of biological treatment is more competing than the one based on vapour recovery if considering the fact at the plant outlet fresh air is released without volatile products.

The system has never been implemented in Romania so far, its application for this moment under the form of experiment may further on be multiplied in fuel storing and distributing stations.

The plant is highly dependable in operation, its start-up and shutdown may be done quickly and simply, it is flexible from point of view of the flow rate circulated and practically there is no need for supervision. The space needed at erection is reduced (platform 4 x 3.2m) which makes possible its location over the area in vicinity of the tank farm, over regular zone from point of view of explosion hazard.

In accordance with data we hold from supplier the pattern proposed for the system may take over a 250 Nm^3/h (min.150 Nm^3/h – max. 300 Nm^3/h) gas nominal flow rate. Vapours are gathered from the flange of the breathing valve of the tank through Dn 150 pipeline and sent to the biological treatment plant inlet. The system is composed of three main modules (figure 3).

1. *The Spraying Water Washing System (Humidifier)*, the first step of the plant where the gas mixture gets in plays the role to bring part of the fuel vapours to the state of saturation and remove them out of the plant. Within this module a fine and intense spraying takes place of an aqueous solution recirculated by means of a pump. Water resulted out of this operation is gathered into a buffer vat from where it is periodically emptied to industrial sewage. To prevent from frost in winter the humidifier is protected with an electric heater.

2. *The fan intakes* gases passed through humidifier and discharge them into the bio-filter at the bottom.

3. *Bio-filter is* the main part of the plant: within this device air crosses a filtering medium composed of turf enriched with cellulose mass fermented (bacterial environment). Treated air gets out directly in the atmosphere through an emptying stack. Biological material (strains of bacteria selected for hydrocarbon metabolizing) supplied by NOVABIO under powder form packed into polyethylene sacks is soluble in water, non-noxious, non-sour, biodegradable and does not involve bio-accumulation as according to data sheet and safety spec attached hereto.

Also the electric feed, automation and control switchboard takes part in the plant supply. Total installed power is 4.5 kW.

All component elements of the system are made of antistatic polyethylene (PEDH). For erection a concrete plated platform is necessary connected to industrial sewage by means of a hydraulic shut-off manhole. According to the supplier's recommendations such equipment need no foundation.

To cut off costs utilisation may be proposed of a regular design plant as such plant may be located in regular zoning area from point of view of explosion hazard; for this pilot-study experimentally applied all elements mounted on the plant platform have been provided with ATEX.

Given that within the process of purifying hydrocarbons are totally metabolized in biological filter the solution may be deemed ideal for fulfilment of requirements by the applicable environment legislation.

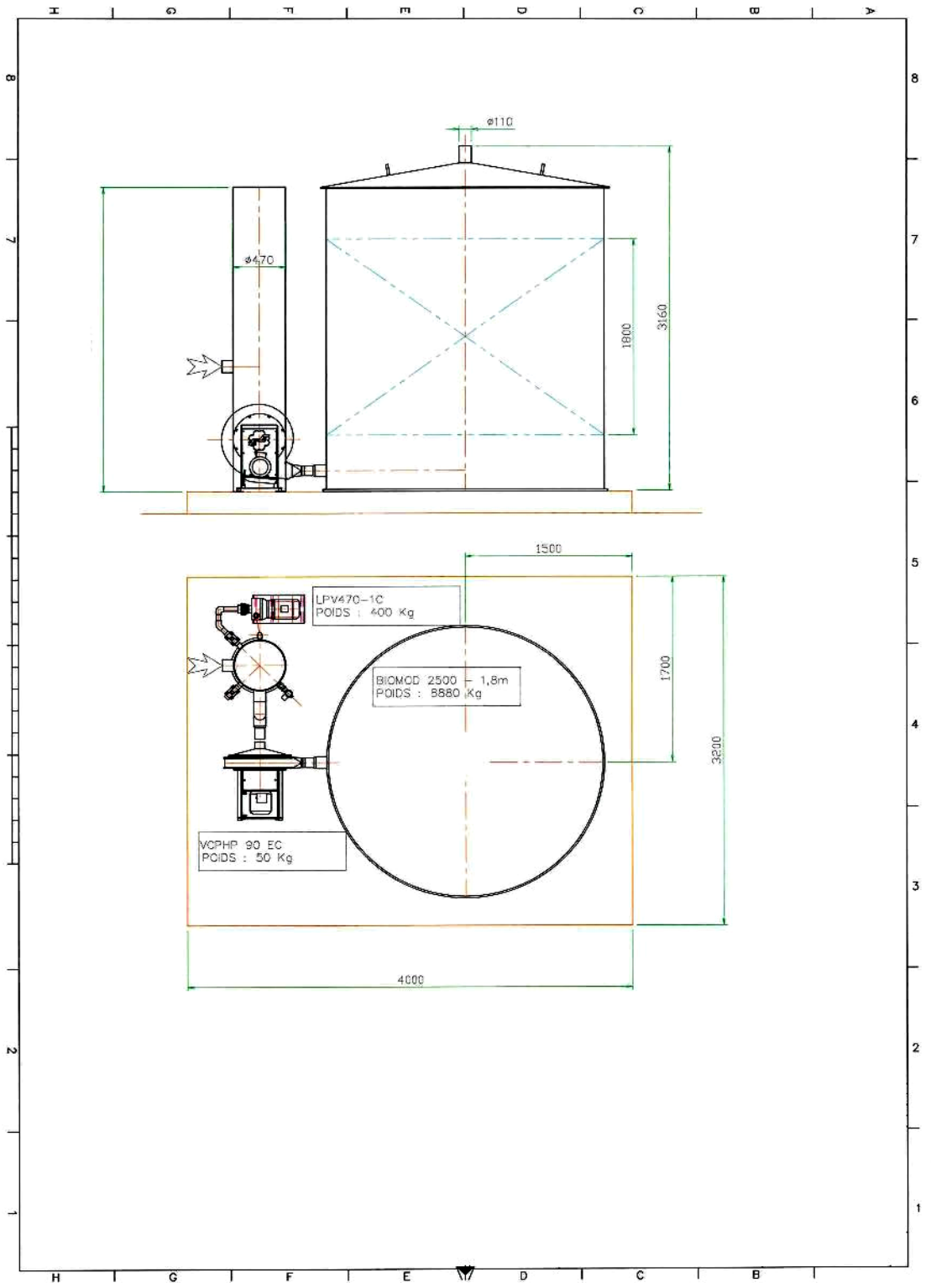


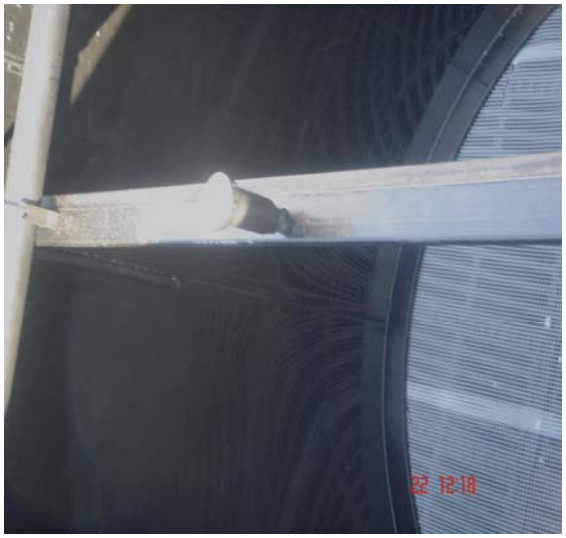
Fig. 3. Process Flow Diagram for BIOMOD Filter

The results guaranteed by producer shall be acknowledged by a strict schedule of analysis of the gases purged out of bio-filter.

Here you have further on presented also some suggestive pictures referring the manner of installation and start-up of the bio-filtering system.

Placing bio-filter in position

Entering backfill material (Coconut tree bark)



Inside View:
Notice metallic holder for filtering mass
and automated spraying device

Detail to show up humidifier, fan and
water recirculation pump

References

1. Contract 641/2005 CEEX-MENER – *Study on Detection, Prevention and Fighting of Increasing Pollution: Stage 1/2005 – Documentary Study; Stage 4/2007 –New technologies for ecological activities in drilling, as well as in hydrocarbon production, transportation and storage (Study applicable to Oil Production Fields).*

Instalaţie pentru eliminarea compuşilor nocivi din aer prin procese biologice

Rezumat

Prin natura activităţilor pe care le desfăşoară, industria petrolieră se constituie într-un mare poluator al mediului. Astfel, scurgerile de petrol sau produse petroliere afectează uneori iremediabil solul, subsolul şi acviferele freatice, în timp ce depozitarea unor produse sau reziduuri în bataluri sau rezervoare neetanşe constituie o sursă de poluare sistematică a atmosferei.
Lucrarea prezintă o instalaţie care permite distrugerea prin activitate bacteriană a unor compuşi nocivi din aer. Aceasta poate fi utilizată pentru dezodorizare în cazul substanţelor rău mirositoare, dar a fost testată experimental şi pentru degradarea unor emisii de carbon organic volatil (COV).