INTRODUCTION Nanoreactor Photocatalytic odour control site trials and installations.

Document prepared by iPURtech Ltd. UK supplier of photocatalyst odour control systems

www.ipurtech.com 0161 745 7005

Introduction

The process of photocatalysis as a gas treatment process is based on the combination of UV-light and a catalytic converter. The process is applicable for all parts of waste water treatment plants which release oxidizable odorants such as hydrogen sulphide, ammonia, mercaptans, dimethyl sulphide, hydrocarbons, VOC's or other.

Typical applications are headworks, dewatering buildings, sludge holding tanks, sludge aeration and drying facilities and anaerobic digestion sites. The process is especially effective on "difficult to oxidize" contaminants and high and varying odour loads. The process is characterized by very low maintenance, energy and control demand.

In the ionisation chamber UV-C LIGHT activates a large area of catalytic membranes. The UV tubes emit wavelengths specially designed for odour treatment and in conjunction with the catalyst, oxy' radicals, hydroxyl radicals and radicals of the contaminants are generated. These radicals are significantly more reactive than untreated molecules and start oxidation in the presence of available oxidants immediately.

Complete oxidation of the contaminants contained in the raw gas requires sufficient contact of the reacting parts. The catalytic converter designed with its large surface can perform complete degradation of contaminants and provides at the same time a buffer for peak loads.

PHOTO-CATALYTICAL OXIDATION – CASE STUDIES

Case Study No. 1: Faecal sludge reception

The treatment process is especially effective on high odour loads and varying odour concentrations. Faecal sludge reception facilities pump stations but also headworks buildings may be the source of extreme hydrogen sulphide concentrations especially in case the connected sewer lines are extremely long or the detention time in the faecal sludge reception facility is extended.

For plants that experience high odour emissions from preliminary treatment processes, source monitoring typically shows that H2S dominates the reduced sulphur compounds (WEF, 2004). Hydrogen sulphide concentrations may go up to several hundreds of ppm as also the following example shows.

A pilot testing has been carried out for a faecal sludge reception facility in the Middle East. The capacity of the pilot unit was 300 m^3/h. In this case the process had to cope with extremely high and varying odour concentrations based on hydrogen sulphide (H2S) as the major contaminant.

Because of the varying H2S loading the testing has been carried out over a period of 24 hrs. Figure 1 shows the H2S concentration and temperature of the raw off-gas drawn from the faecal sludge reception to the treatment unit. ItisobviousthattheH2S concentration highly fluctuates. The lowest readings start from below 100 ppm. Frequently appearing peak loads reach several hundreds of ppm, even up to 1,000 ppm. The averageH2S concentration during 24 hrs testing period was 355 ppm. It has to be pointed out that with the H2Smonitoring equipment readings were limited to 1,000 ppm in maximum. The true H2S peak emissions were probably higher.

The temperature of the raw off-gas was between 40 and 45°C at about noon and dropped down to 25 to 30°Cduring night.

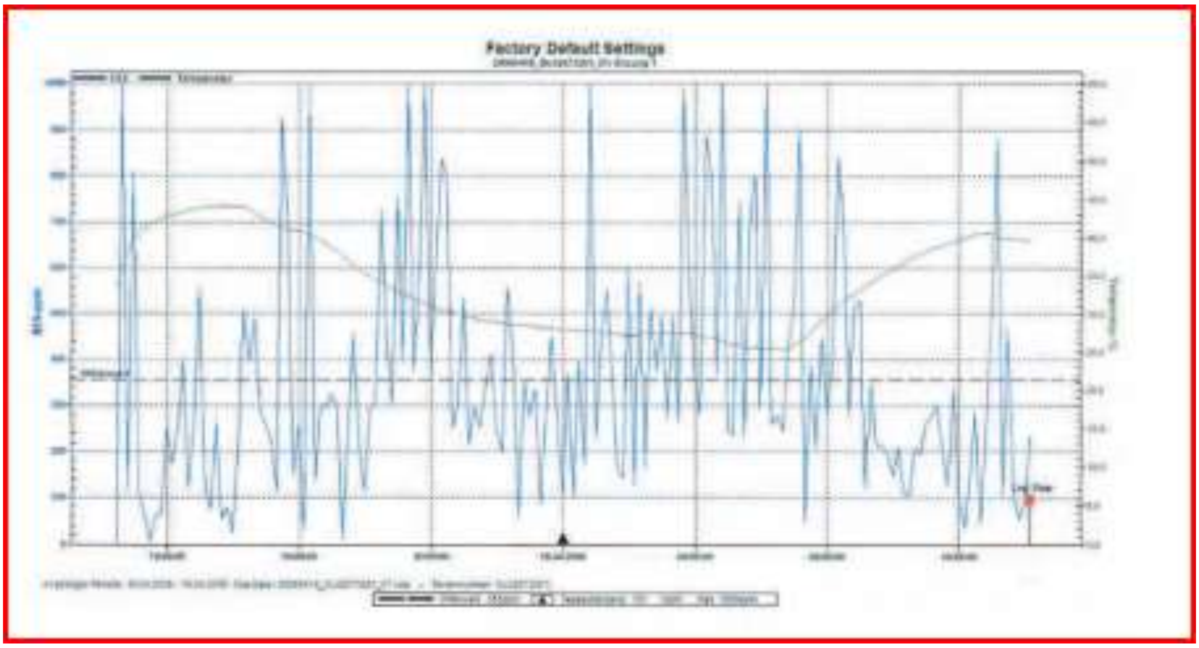

Figure 1: H2S and temperature readings, raw off-gas

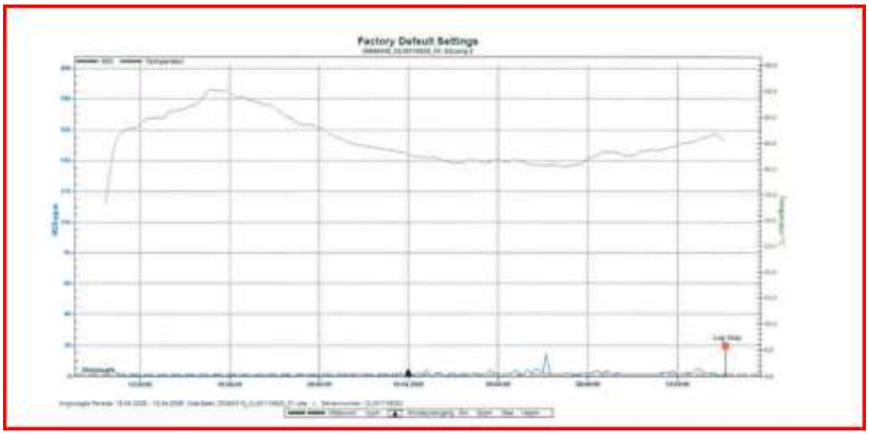

Figure 2 shows the readings for hydrogen sulphide and temperature at the same time in the cleaned airstream.

The temperature curve of the cleaned air is approx' 10 Kelvin higher than the respective raw gas curve. This is mainly due to the heat released by the UV-tubes and catalyst activity. However, the hydrogen sulphide curve of the cleaned air is constantly below 5 ppm (average 1 ppm) with only one exceptional peak of 14 ppm.

Case Study No. 2: ATAD sludge treatment in Florida, USA

The ATAD-process (Auto heated Thermophilic Aerobic Digestion) is a sludge digestion process to effectively stabilise and disinfect sewage sludge or other organic sludge. By the ATAD-process sludge is converted into so called “Class A Biosolids” which can be used in agriculture as a valuable fertiliser.

The process is aerobic and the required air is drawn by aspirating aerators into the sludge treatment reactors.
The heat released through the biochemical oxidation is kept inside the insulated reactors. In this way the process auto-thermally heats up to the higher thermophilic temperature range of 55 - 65°C. In order to meet the disinfection criteria the process is batch fed once per day (Schwinning, 1993).

Nitrification is inhibited at thermophilic temperatures and therefore the off-gas of ATAD-plants may contain several hundreds of ppm of ammonia (NH_3).Furthermore, dimethyl sulphide ($(CH_3)_2S$) and mercaptans(CH_3-SH, CH_3-CH_2-SH) are typical constituents of ATAD off-gas.

In the past mainly biofilters and chemical scrubbers were used for ATAD off-gas treatment. The semi-batch feeding of the ATAD-process causes peak odour loads just after feeding of the reactors is completed. Biofilters do not cope very well with peak loads; the biofilter biology rather requires constant load conditions. Chemical scrubbers as well have difficulties to cope with changing odour loads and do usually not provide satisfying treatment results when treating ATAD off-gas. Furthermore, the handling of the required chemicals may be a headache for the plant personnel regarding health and safety issues.

The odour of ATAD-plants is difficult to treat and conventionally designed bio-filters and chemical scrubbers often fail to provide adequate odour reduction.

On a waste water treatment plant (wwtp) in Florida, USA, the off-gas from an ATAD plant is treated insufficiently with a chemical scrubber. Odour released from the ATAD has been the source of many complaints from the neighbourhood in the past.

A piloting of the process for the off-gas released from the ATAD has been carried out on this wwtp in July 2006.

The pilot unit consists of a small off-gas scrubber (operated with plant effluent) followed by the photocatalysis pilot unit.


Pilot unit

The pilot unit is designed to operate at an airflow rate of approx. 200m³/h to maintain adequate contact time for complete oxidation of odorants. The small water scrubber was used in front of the photocatalysis unit to cool the off-gas stream and to remove any particulates, but also contributed especially to ammonia reduction prior to photocatalysis treatment.
During the piloting samples were taken at the site with gas-detector-tubes and by an independent odour laboratory to carry-out olfactory analysis. Samples were collected prior to treatment (Raw Off-Gas) after the scrubber (inlet) and from the outlet of the photocatalysis (discharge). In an effort to overload the pilot unit and ascertain the systems ability to accommodate peak loads, data was also collected at an air-flow rate of 390m³/h (195%of design load). Results are shown in the following table.
At the site the readings of the gas-detector tubes already demonstrated high odour loads. With the scrubber, operated with plant effluent, the odour constituents were already efficiently reduced (>50% reduction), but the photocatalysis inlet concentrations were still considerably high. The main task for the scrubber was the reduction of the off-gas temperature (from 52.5°C to 33°C). With the pilot unit all measurable odour constituents were reduced down to non detectable limits.

The lab which did the olfactory analysis was able to measure a max. of 60,000 OU due to technical limitations. While the raw off-gas and the off-gas which was already partly treated with the scrubber had higher readings than 60,000 OU, the clean air at the outlet of the pilot unit showed readings of 130 to 640 OU.
This corresponds with a treatment efficiency of>99%.

Table 1: piloting results ATAD Florida

Odour Compound	Raw Off-gas	Inlet	discharge	Time
Air-flow rate: 200 m³/h				
Mercaptans	80 ppm	40 ppm	n.d.	12:50 pm
Dimethyl Sulfide	150 ppm	80 ppm	n.d.	1:00 pm
Hydrogen Sulfide	32 ppm	8 ppm	n.d.	1:15 pm
Ammonia	200 ppm	n.d.	n.d.	1:25 pm
Temperature	52.5°C	33°C	46°C	1:30 pm
Detection Treshold			270 OU	2:45 pm
Recognition Treshold			130 OU	2:45 pm
Detection Treshold	> 60.000 OU	> 60.000 OU	640 OU	3:05 pm
Recognition Treshold	> 60.000 OU	> 60.000 OU	420 OU	3:15 pm
Air-flow rate: 390 m³/h				
Mercaptans	80 ppm	30 ppm	n.d.	3:30 pm
Dimethyl Sulfide	200 ppm	125 ppm	n.d.	3:40 pm
Hydrogen Sulfide	30 ppm	12 ppm	n.d.	3:55 pm
Ammonia	200 ppm	2 ppm	n.d.	4:05 pm

Table 1: piloting results ATAD Florida

The results show that the photocatalysis plant was able to reach odour removal efficiencies of>99%when loaded with the design air-flow rate but also when overloading the pilot unit with a higher air-flow rate(390m³/h or 195% of design load). This confirms that the photocatalysis is able to effectively treat the off-gas under normal conditions as well as during peak load times.

Case Study No. 3: Headworks building in Poland

A full scale photocatalysis plant has been started-up on a wastewater treatment plant in Poland in November 2005. The off-gas originates from a headworks building wherein two step screen are installed. Depending on the characteristics of the wastewater when entering the treatment plant, especially the H2S concentration in the off-gas from headworks may be quite high. However in the present case, the H2S concentration at the inlet channel was only 14 ppm and in the off-gas drawn into the unit only 1-2 ppm. The process treated this relatively low inlet concentration down to 0 ppm.

Apart from the treatment efficiency the photocatalysis process provides further important advantages. The ambient temperature in Poland may go down to-30°C(about 0°F) at wintertime. While the treatment efficiency is not affected by the old temperatures, in addition the process does not require any water, chemicals, effluent piping, freezing protection etc. compared too their odour treatment processes. Therefore, the process ensures effective treatment and ease of maintenance the whole year round.

Figure 4: Full scale photo ionisation plant for headworks building in Poland

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Case Study No. 4: Poultry building in UK

Poultry houses generate odours, ammonia and fungal spores. These are vented to atmosphere at a rate determined by the ambient temperature. Higher ambient requires more cooling of the shed interiors and this is accomplished by air replacement.

To reduce the effect on the local inhabitants a photocatalytic reactor removes the odours, ammonia and the health hazard of fungal spores. Test rigs have been trialled with results giving 80% odour and ammonia reductions whilst filtering out spores.

Case study No.5 : Odour reduction tests at anaerobic site in the UK.

An empirical study was carried out on the odours released from distillate storage vessels at an anaerobic site. A tank and loose cover did not keep odours from percolating out and be carried to nearby receptors. A small photocatalytic reactor was fitted to pull air from the storage vessel and filter it. The results were that the production of a slight negative pressure kept odours from leaking into the atmosphere and the odours and air which were withdrawn were free of odour after passing through the reactor.

CONCLUSIONS

Characters of odours released from processes of wastewater and sludge treatment are very different. Odours are based on different odorants like hydrogen sulphide, dimethyl sulphide, mercaptans, ammonia, VOC's and other. Combinations of these contaminants do of course also occur. Furthermore, the loading of contaminants in the off-gas may also vary widely and may fluctuate in wide ranges throughout the day.

The readings from a faecal sludge reception facility show that the process is especially effective on high and well fluctuating odour loads(H2S in this case). The combination of UV-light and a catalyst ensures that the cleaned air has constantly low H2S readings which averaged below 5 ppm while the raw gas varied between below 100 to up to 1,000 ppmH2S.

Results from ATAD sludge treatment plants show that this off-gas which was historically known to be difficult to treat because of strong and fluctuating odour loads can be effectively treated with the process. Odour is reduced below acceptable limits, strong odorants like H2S, dimethyl sulphide or mercaptans are reduced down to non-detectable limits.

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Apart from the high treatment efficiency, the photocatalysis also provides further advantages. The process does not require any water or effluent piping, no chemicals. The process is not affected by very low ambient temperatures. Therefore the process is very suitable for cold weather conditions. The low maintenance demand plays an additional important role.

The photocatalysis process represents an effective odour and off-gas treatment process applicable for all processes found on wastewater and sludge treatment facilities.

The combination of the two differently acting treatment stages has proven to treat difficultly degradable and varying loads effectively as the presented examples show.

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