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Biological equipment for treating air and other gases — General requirements

Équipements biologiques pour le traitement de l'air et autres gaz — Exigences générales

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Foreword

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This document was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The biological exhaust air purification has experienced a very rapid spread in recent years with very positive effects in various applications.

The most important advantage is the fact that the cleaning process is natural and carried out by microorganisms. It is currently by far the most environmentally friendly exhaust air purification technology.

The main advantages of this technology are as follows:

— it is a natural process at ambient pressure and ambient temperature;

— the principle is comparable with the wastewater treatment technology which is also well-established for years;

— there is no need of additional energy in the form of natural gas or oil;

— it is a nearly CO_2 neutral air cleaning technology;

— it has low operation costs;

— it has low investment costs.

Long lasting experiences have shown that biological systems especially can be useful for the treatment of:

— odorous air from waste water treatment plants (e.g. H_2S, sulfides);

— odorous air from waste treatment plants as composting plants, anaerobic digestion plants (e.g. H_2S, NH_3, organic compounds);

— odorous air from industrial processes;

— waste air from paint houses and other industrial processes containing volatile organic compounds (VOC)[9].

Some parts of this document are based on the German Standards VDI 3477[1] (Biofilter, first published in 1984), VDI 3478-1[2] (Bioscrubber, first published in 1985) and VDI 3478-2[3] (Biotrickling filter, first published in 1985). (With permission of the Association of German Engineers VDI).

Biological equipment for treating air and other gases — General requirements

1 Scope

This document specifies the technology of biological exhaust air purification. The relevant requirements for a possible application are specified. The different variants of this technique are also presented.

NOTE The process principles of this method are described in Clause 4.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
biofilter
bioreactor treating waste gas with the aid of biofilm attached to the packing media which moisture is maintained by a prepositive humidifier or intermittent water feeding to the filter bed

Note 1 to entry: Organic materials are usually used as carrier materials. However, inorganic materials with a large inner surface area and corresponding microorganism population are also used. The materials used are usually arranged as bulk layers through which the exhaust gases flow.

[SOURCE: ISO 29464:2024, 3.5.10, modified — Note to entry has been added.]

3.2
biotrickling filter
bioreactor treating waste gas with free moving liquid layers on the surface of inert packing media to supply nutrients, take away metabolites or control pH for the biofilm attached to the packing media

3.3
bioscrubber
absorber transferring contaminants from waste gas to liquid absorbent, and removing the dissolved contaminants by suspended-growth microorganisms in a supplementary space

3.4
waste gas
odorant and pollutant-laden gas streams from industrial and agricultural processes and exhaust ventilation streams from tanks and rooms unsuited for being permanently occupied by humans

3.5
acclimation
adaptation of microorganisms to the substrate volume and composition as well as other environmental factors

3.6
absorbent
liquid suitable for collecting gas components

3.7
absorber
device in which specific substances are absorbed into an absorption liquid

3.8
absorption
selective separation of one or more components from gas mixtures by scrubbing with a scrubbing medium (typically water)

Note 1 to entry: A distinction is made between physical absorption, for the assessment of which the physical equilibrium curve is used as a basis, and chemical or biochemical absorption, during which the absorptive and absorbent enter a chemical reaction with each other and substances are converted.

3.9
absorptive
substance destined for absorption

3.10
microbial activity
biological conversion/elimination of waste gas components per unit time

3.11
support media
slatted floor or grating with sufficiently small openings to support a bed of solid particles (e.g. filter media)

3.12
C:N:P ratio
carbon :nitrogen :phosphorus ratio
ratio of biologically available carbon in the exhaust air to nitrogen and phosphorus in the filter media

3.13
pressure drop
Δp
difference between the static pressures at the inlet and outlet of a bounded flow system which is used as a measure for the energy loss caused by the flow within the system

Note 1 to entry: The pressure drop across a biofilter system is the total of the flow resistances offered by the piping, dampers, bed of media, etc[4].

Note 2 to entry: Endotoxins are released on lysis or death of the bacterial cells and can be, due to its low vapour pressure, inhaled after aerosol formation only.

3.14
moisture content
mass fraction of water related to the moist mass of the filter media

Note 1 to entry: This definition is different from that of the European odour unit, in that only the latter is traceable to a known odorant mass, defined as the EROM[5].

3.15
nutrient salt
nitrogen- and phosphorus-containing salt of inorganic ions such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} which is required in major amounts to maintain the cell function

3.16
relative humidity
U
ratio of the partial water vapour pressure to the saturation water vapour pressure at a given temperature:

$$U = \left.\frac{p_{\mathrm{D}}}{p_{\mathrm{DS}}}\right|_{T}$$

3.17
pollutant concentration
ratio of pollutant mass to the waste gas volume at standard temperature and pressure conditions (0 °C, 1 013 hPa), dry basis

Note 1 to entry: The unit ppm (parts per million) (volume fraction or mass fraction) denotes the volume or mass fraction.

3.18
sorption
process by which a substance is selectively sorbed on or attached to another substance with which it is contacted

3.19
service life
duration over which the filter media retains its function at a sufficient efficiency

3.20
substrate
substances on which the microorganisms both feed and colonise, and which are suitable for synthesising cell mass or supplying energy for metabolic action

3.21
residence time
empty bed residence time
ratio of the filter volume to the volumetric flow of the fluid

3.22
water retention capacity
water storage capacity
maximum mass concentration of water that can be retained by the filter media for prolonged periods, expressed as per cent moist filter media mass

3.23
efficiency
removal efficiency, η
difference between the biofilter inlet and outlet concentrations of one or several defined waste gas constituents related to their concentrations in the raw gas:

$$\eta = \frac{\rho_{crude}^{G} - \rho_{clean}^{G}}{\rho_{crude}^{G}}$$

3.24
elimination capacity
Ev
microbially converted VOC freight per m^3 of packing or aeration tank volume in g C m^{-3} h^{-1}.

$$Ev = \frac{\rho_{crude}^{G} - \rho_{clean}^{G}}{V_{\mathrm{filter}}} \cdot \dot{V}^{G} = \frac{\eta \cdot \rho_{crude}^{G}}{V_{\mathrm{filter}}} \cdot \dot{V}^{G}$$

4 Process principles

4.1 General fundamentals

Biological air treatment systems are particularly suited to all waste gas cleaning applications involving air pollutants that are readily biodegradable[10],[11]. Biodegradation of the air pollutants is accomplished under aerobic conditions by microorganisms colonizing on solid support media or existing as activated sludge in washing liquid.

The requirements for a possible application of biological air treatment techniques are:

— Good biodegradability of the pollutants so that the biochemical conversion will take in a few seconds. Otherwise, the residence time in the filter chamber or in the scrubber would be too long and this would lead to very large filter volumes. If the degradation rate of the substances is not known pilot tests are recommended.

— Good water solubility of the pollutants, as nearly all biochemical reactions take place in an aqueous environment.

— A temperature in the mesophilic range (under special conditions also in thermophilic range possible).

— Absence of toxic compounds.

4.2 Steps involved in pollutant elimination

4.2.1 General

Biological waste gas purification is based on two steps.

A physical absorption followed by biochemical conversion of pollutants by microorganisms (enzyme catalysed reactions).

The bacteria are mainly suspended in water (bioscrubbers) or fixed on supporting elements (biotricklingfilters, biofilters).

4.2.2 Mass transfer

Mass transfer from the gas phase to the liquid phase (absorption and diffusion) is described by the simplified two-film theory[13].

In detail, the following steps take place:

— mass transfer to the gas/liquid interface;

— absorption into the liquid phase;

— mass transfer through the liquid phase to the bacterial cell;

— sorption and degradation by the cell.

The driving force is the concentration gradient between the pollutant concentration in the gas phase and the concentration in the liquid phase.

4.2.3 Biochemical conversion by microorganisms (enzyme catalysed reaction)

As in all biological purification processes (waste water/waste air cleaning, soil remediation), the substance being cleaned is biochemically processed by the microorganisms after absorption in the microorganism cell and gradually converted to yield energy for the cell and biomass. Waste air purification so far has always been an aerobic process, i.e. the substances are broken down by oxidation – ideally to yield the end products of complete oxidation, CO_2 and H_2O as well as sulphate and nitrate in the case of sulphur and nitrogen components in the raw gas.