# TECHNICAL IMPLEMENTATION AND OPERATION OF THE LOW PRESSURE AERATION OF LANDFILLS

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SUMMARY: The in situ stabilization of the old landfill in Kuhstedt, Lower Saxony, and of other comparable disposal sites and old deposits aims at a lasting reduction of pollutant emissions from deposited waste. Likewise, duration and expenditure of post-closure measures shall be diminished. After extensive laboratory investigations, preliminary tests and first experiences concerning large-scale application, aeration of the landfill body for an accelerated stabilization of biologically available organic components turns out to be a reasonable and effective method to reach this objective.

## 1 LARGE-SALE APPLICATION OF IN SITU AERATION AT THE OLD KUHSTEDT LANDFILL, LOWER SAXONY

In October 2000, the innovative stabilization procedure started running at the old landfill of Kuhstedt in the district of Rotenburg (Wümme). The main feature is the technical installation for the newly developed low pressure aeration, a technically up-market but cost-saving procedure requiring little energy. It is to limit gaseous and water-bonded pollutant emissions of old landfills and other waste deposits in a controlled way, so that long-term after-care measures for landfills and securing of old deposits are significantly reduced.

The aerobic in situ stabilization accelerates biological degradation processes in the landfill body so that with the treatment time of approx. 2 years the emissions - normally produced over many years or decades - can be released in a controlled way, collected and specifically treated. Due to the improved environmental compatibility the following options are obtained concerning subsequent landfill closure-, post-closure measures and securing measures for old deposits:

- Replacement of a cost-intensive surface sealing by durable alternative surface covering systems adjusted to the landfill body poor in emissions, lowering costs - such as maintenance costs
- Lower expenditure for old deposits with regard to groundwater decontamination and technical securing measure

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- Lower running costs for sanitary landfills with regard to leachate purification, shorter leachate purification period
- Avoidance of long-lasting diffuse gas emissions, likely to cause the risk of explosions and atmospheric pollution
- Reduction of the after-care period by several decades
- Earlier recultivation and high-grade after-use of increasing importance especially in densely populated urban areas

This means that compared with the costs resulting from aeration measures, there are significant cost-saving potentials so that cost reductions can therefore be expected in the medium- respectively in the long-term.

The stages of the aeration procedure for a landfill body are presented in the following. Furthermore, both the planning for the technical implementation and first experiences concerning the aeration of the old Kuhstedt landfill are explained.

## 2 THE BASIC PRINCIPLE OF IN SITU AERATION

The basic principle of aeration and waste gas collection is shown in Figure 1. For an air supply under low excess pressure, ambient air is pressed into the landfill body by means of aeration wells. Air resp. atmospheric oxygen is distributed by convection- and diffusion processes in the landfill body. Thus, an aerobization of the whole landfill body and an accelerated degradation of the organic waste components is achieved depending on rate and duration of aeration. Waste gas is collected and treated by means of a gas collection system (gas wells with identical design).

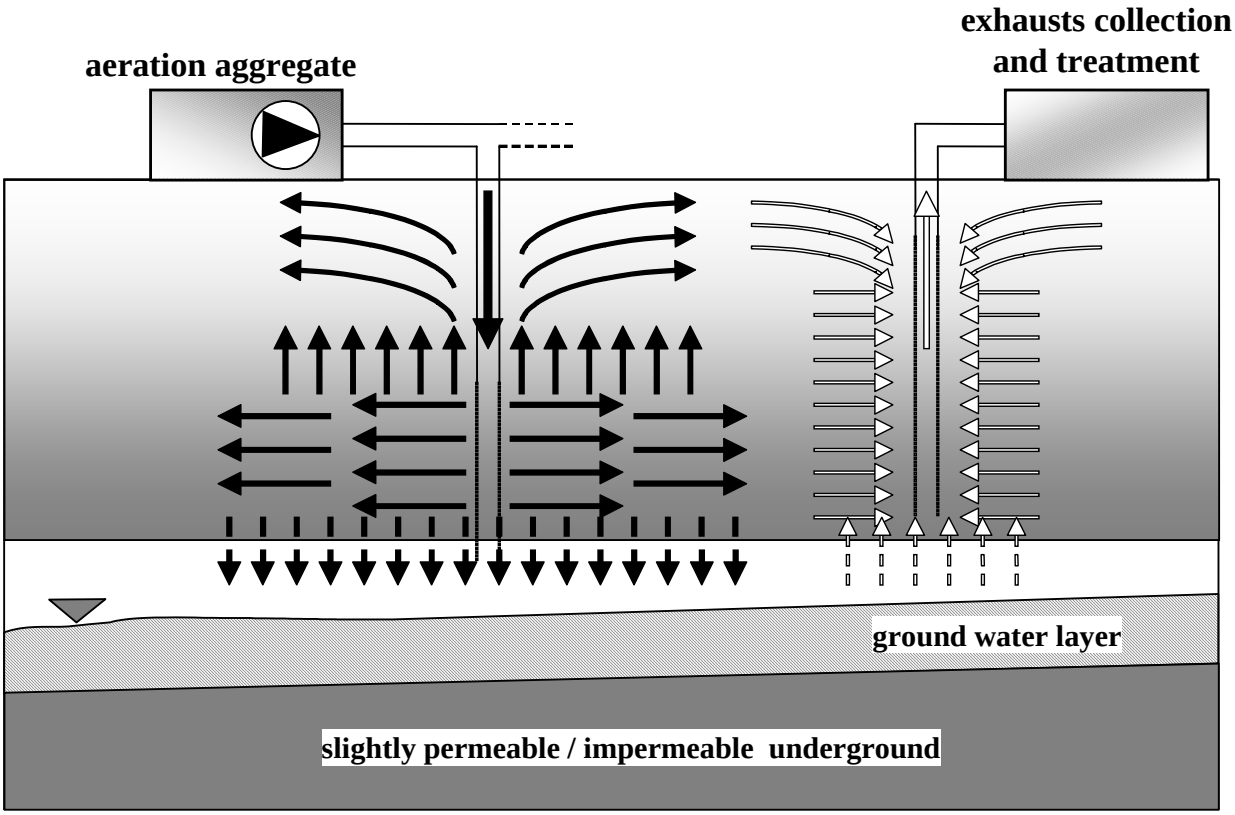


Figure 1. Fundamental concept of remediation by aeration processes

## 3 EFFECTS OF THE IN SITU AERATION OF WASTE IN THE LANDFILL BODY ON THE EMISSION BEHAVIOR

Extensive laboratory investigations and field tests have already been carried out to assess the fundamental effects of aeration on the emission behavior of deposited waste (Heyer et al., 1999). Apart from investigations into the long-term behavior of landfills with waste from human settlements under mainly anaerobic conditions, the German joint research project "Landfill bodies" of the Federal Ministry for Education and Research has already undertaken a large number of laboratory tests with regard to accelerated aerobic in situ stabilization, aiming to reduce the landfill after-care phase and post-closure expenditure (Heyer et al., 1997).

Several examinations of the leachate pathway have shown that biodegradable organic compounds are rapidly converted due to aeration which is proven in particular by a fast decrease of the parameters COD, $BOD_5$ and nitrogen. At the end of stabilization, organic compounds only consist of the barely degradable or nondegradable organic compounds (Heyer et al., 1999).

Compared with strictly anaerobic conditions, the after-care periods for the leachate emission path are reduced by at least several decades for in situ aeration. After the end of aeration, the after-care period cannot be regarded as finished but post-closure expenditure is significantly reduced as cost-intensive leachate purification measures are not necessary. If leachate percolated directly into the underground - which could happen in old landfills without sealing and drainage systems for the collection of leachate - the polluting effects would be significantly lower after the aerobic stabilization.

Apart from the positive effects on leachate contamination, the rate of carbon conversion is considerably increased during in situ aeration. Thus, a faster stabilization of the organic substance can be achieved.

In solid waste samples in a "landfill simulation reactor", the carbon discharge during aeration resp. the degradation of organic substance was 1.5 to 5 times higher during the aeration period of one year than during the same period of time under anaerobic conditions (Heyer et al., 1997).

## 4 TECHNICAL REALIZATION OF THE LOW-PRESSURE IN SITU AERATION AT THE OLD KUHSTEDT LANDFILL

### 4.1 Details about the old landfill, risk potential

The old Kuhstedt landfill in the district of Rotenburg (Wümme), Lower Saxony, was originally used as a sand pit. Table 1 gives a perspective on the old deposit, considered to be typical in many respects of most old deposits.

Table 1. General details concerning the old Kuhstedt landfill

| Operation: | From the middle of the sixties to October 1987 |
|---|---|
| Deposited kinds of waste: | Household waste, bulky refuse, industrial waste similar to household waste, rubble |
| Total area: | About 3.2 ha |
| Height: | About 8 - 10 m |
| Volume: | About 220.000 $m^3$ |
| Excavation: | About 2 - 3 m |
| Base sealing: | none |
| Degasification equipment: | None before in situ stabilization |
| Surface sealing / covering: | Provisional before in situ stabilization |

Because of leachate outflows in 1987, a risk assessment has been carried out in 1988. A high hazardous potential due to the deposited waste was stated, mainly resulting from (IHP, 1990):

- the contamination of groundwater, backwater and soil,
- missing barrier layers and sealing,
- the pollutant potential above the groundwater conductor and
- the pollutant discharge via ground water conductor, i.a. into surface water.

## 4.2 Basic technical conception

The **basic technical conception** of the aeration of a whole landfill body consists of a system of gas wells, through which atmospheric oxygen is led into the landfill body via active aeration in such a way that an accelerated aerobic stabilization of deposited waste is realized. At the same time, the low-contaminated waste gas is collected and treated in a controlled way by means of further gas wells. Aeration is effected with low pressures and is continuously adjusted to oxygen demand so that energy consumption is low and constantly optimized.

Figure 2 shows the arrangement of the technical installations for aeration and waste gas collection at the old Kuhstedt landfill.

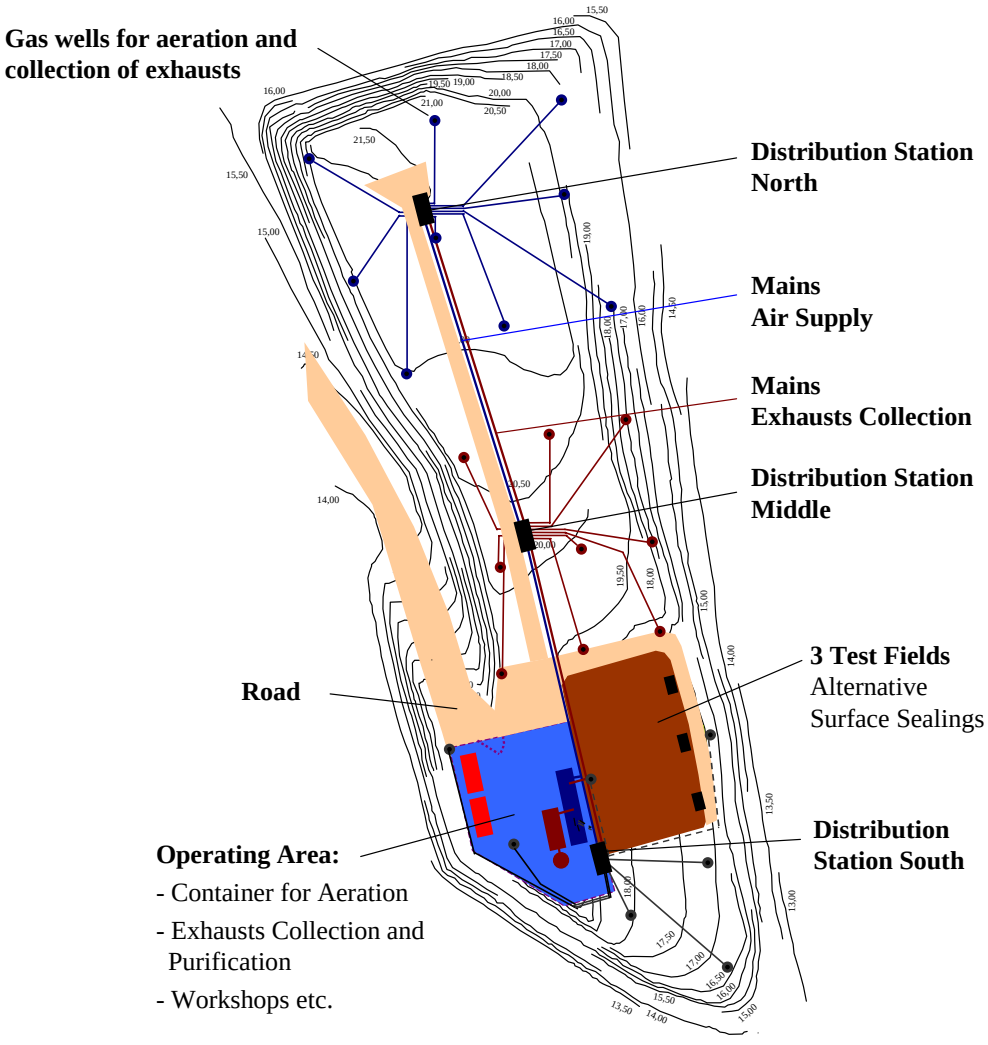


Figure 2. Master plan of the installations for an in situ stabilization of the old landfill in Kuhstedt (Heyer et al., 2000)

Each of the 25 **gas wells** is connected to a distribution station by means of separate mains. There, the mains can be connected to the distribution system for aeration or to the system for the collection of waste gas.

**Aeration via the gas wells:** aerobization of the area of influence of each gas well is guaranteed by the adjusted excess pressure respectively by the added air volume.

**Waste gas collection via the gas wells:** By means of adjusted negative pressure, waste gas is continuously sucked within the area of influence of the gas well so that uncontrolled waste gas emissions via landfill surface respectively gas migration via soil vapor path into the neighboring subsoil are kept at a low and acceptable level.

**Separate mains** connect the gas wells to the distribution station for the distribution of added air respectively for gas collection. The installation of the separate mains took place on the existing provisional surface covering. Uneven spots were adjusted when required and a planum was produced to serve as location route. They were installed with a continuous slope and covered with 30 cm of soil material.

Three **distribution stations** allow the connection of the separate mains to the main aeration ducts (air supply) and with the main gas extraction line (waste gas collection for a waste gas treatment). Furthermore, they include armatures (valves, ball stop-cocks etc.) for each separate main and for the trunk mains for supervision and control.

Figure 3 shows the layout of a gas distribution station.

The **distribution network for aeration** is connected with the compressing unit for aeration by the main supply duct. The **gas collection system for the collection of waste gas** is provided with a condensate separator and connected to the compacting unit for the collection of waste gas by the main suction duct.

**Compressing unit for aeration and collection of waste gas:** Design and operation of the aeration- and waste gas collection devices are chosen in such a way that, under normal automated operation,

- no explosive atmospheres are to be expected on the waste gas side
- a high level of utilization of the added oxygen is achieved - meaning that oxygen concentration is low in the waste gas.

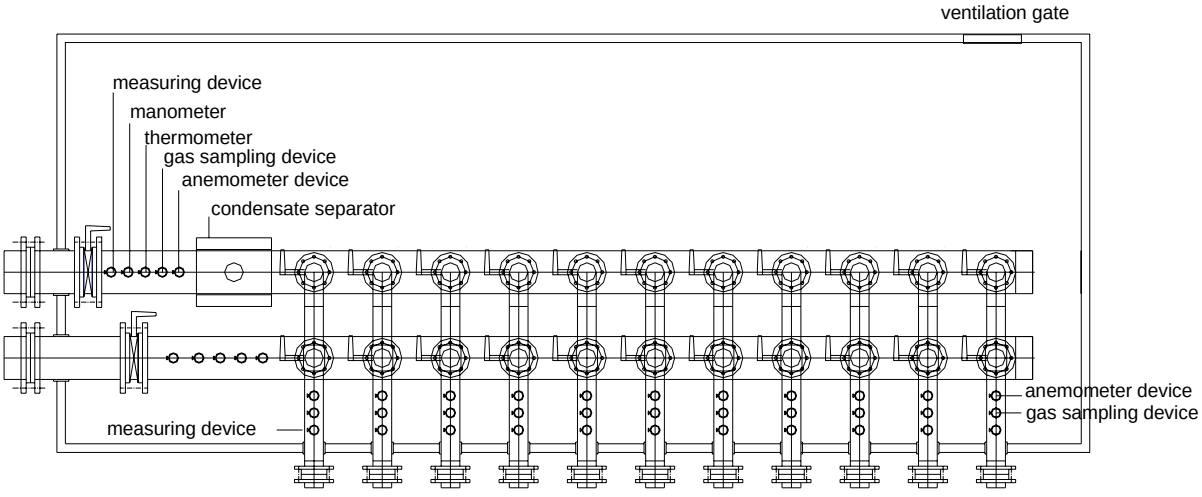


Figure 3. Layout of the aeration- and gas collection system in a distribution station

All compressing units for aeration and waste gas collection - including switchboxes and control devices - were installed in a mobile container (Figure 4).

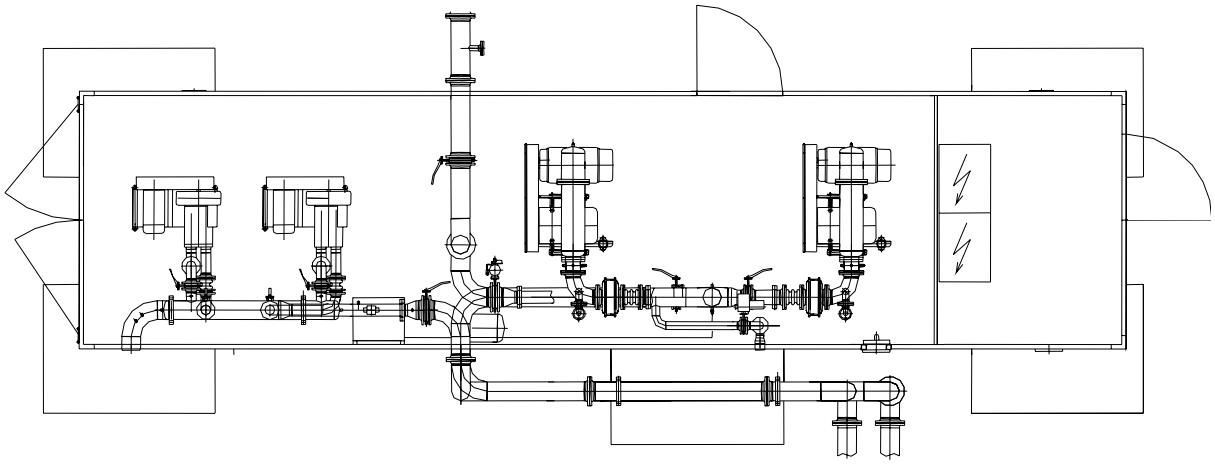

Figure 4. Layout of the compressing unit for aeration and collection of waste gas (as described by Company Haase Energietechnik GmbH, Neumünster)

**Waste gas cleaning:** As a matter of principle, the contaminated waste gas can be purified by means of biowashers and biofilters or by adsorption on activated carbon and by noncatalytic, autothermic methods.

The results of the preliminary tests at the old Kuhstedt landfill underlined that the waste gas will only be slightly contaminated by pollutants (trace contaminants such as CFC, semivolatile chlorinated hydrocarbons, BTEX), odorous substances or methane. Nevertheless, an autothermic procedure is applied for the waste gas treatment at first due to reasons regarding emission control.

The applied flameless, noncatalytic oxidation device offers a thermal treatment for the harmless removal of substances from process- and landfill waste gas. With it, poor gas can be treated in an environmentally-oriented way during in situ stabilization - nearly without additional energy expenditure. This method is especially suitable for the treatment of methane emissions during the first phase of in situ stabilization, when higher methane flows (up to 1 vol.-%) occur in the waste gas.

When - as a result of complete aerobization of the landfill body - the mentioned waste gas contamination is reduced in such a way that no methane and hardly any trace contaminants can be found in the collected waste gas, a bio- or an activated carbon filter can be applied.

In addition to the technical installations for aeration and waste gas collection, **3 test fields** for the examination of **alternative surface sealing systems** have been prepared at the old landfill in Kuhstedt.

The results of a study are taken into consideration when designing the test fields, in which different alternative surface sealing systems were developed and examined by means of the simulation program HELP. Guidelines and experiences gained from comparable investigations and Research & Development projects are considered as well. The investigation focuses on the design of the recultivation layer, which is to serve as both a water balance layer and a methane oxidation layer. The surface sealing systems are designed in such a way that they are nearly maintenance-free and guarantee a long-term function reliability (Hupe et al., 2001).

The building operations for the aerobic in situ stabilization started in summer 2000 and were finished in spring 2001.

## 5 START UP OF IN SITU AERATION, FIRST RESULTS

In the first stabilization phase, the landfill gas was sucked off solely via the 25 newly installed gas wells over a period of 3 months at the old landfill in Kuhstedt. The collected landfill gas with an increased methane content was incinerated without harmful effects by means of a high-temperature flare. Over this period of time, the methane content was reduced in such a way that, afterwards, the real biological in situ stabilization measure, the aeration for an optimal oxygen supply to the landfill body, could be started. In the second phase of the stabilization process, several gas wells were aerated with low excess pressures, the remaining gas wells were sucked off by means of negative pressure. Suction and aeration volumes are manually adjusted during the first operation phase - later on they are automatically adjusted to the oxygen demand of the landfill body.

Figure 5 shows the development of the waste gas composition by means of a gas well under initial conditions, during the first phase of operation I (suction with mobile flare), during a short inoperative phase and during the first phase of operation, part II (start of an intensive aeration in sections of the old Kuhstedt landfill). The initially high methane contents in the stable methane phase resp. long-term phase (starting point) can be discerned. During the discontinuous landfill gas suction, they decrease due to a slight over-suction but re-increase during an inoperative phase (realized due to scientific reasons). With the beginning of aeration, the methane contents are significantly reduced and are around the desired methane content of < 1.5 vol.-%, while the carbon dioxide contents range between 6 and 12 vol.-%.

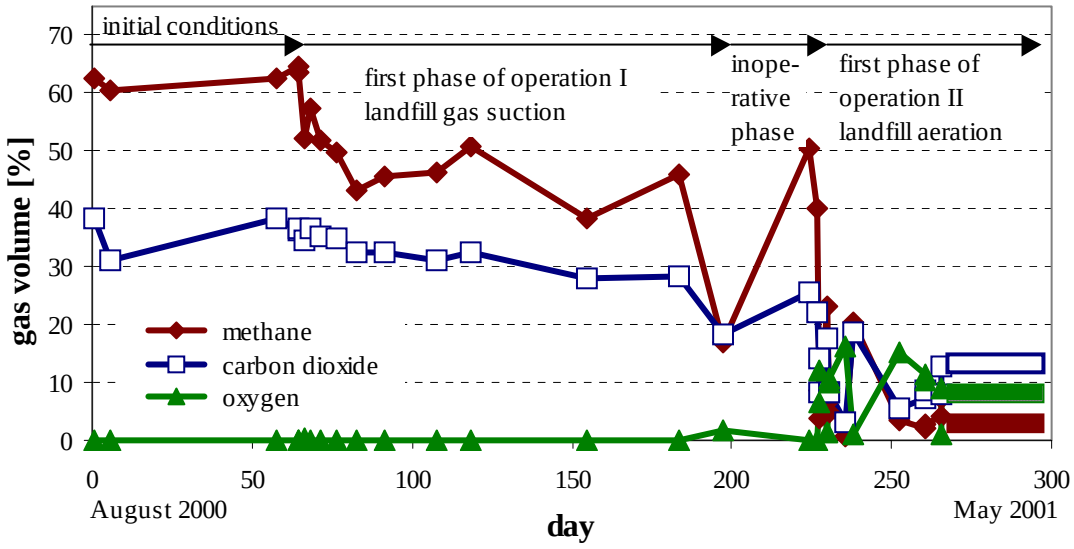


Figure 5. Development of the landfill gas- / waste gas composition shown by means of a gas well at the old Kuhstedt landfill during the first phase of operation

The explosive area with methane contents between 4.4 and 15 vol.-% and oxygen contents > 12 vol.-% was not reached within the gas wells. In particular at the compressors for the collection of waste gas, no explosive waste gas atmosphere could be ascertained.

Figure 6 shows the waste gas composition at the gas compressing device for aeration and waste gas collection during the first operation phase (phase II) over an operation time of 40 days in May and June 2001.

It can be observed that the methane content drops to under 1 vol.-% from the 266$^{th}$ day onwards (some days after the beginning of aeration) due to continuous aeration and waste gas

collection. The methane / carbon dioxide ratio is then at 1:5 to 1:11, proving that aerobic processes take place in the landfill body. During normal operation, aeration will be adjusted in a way that the level of utilization of the added oxygen is still increased, while the methane content remains low. On the whole, the development of the waste gas composition shows that the aerobization of the landfill body and the accelerated stabilization of biodegradation processes is achieved.

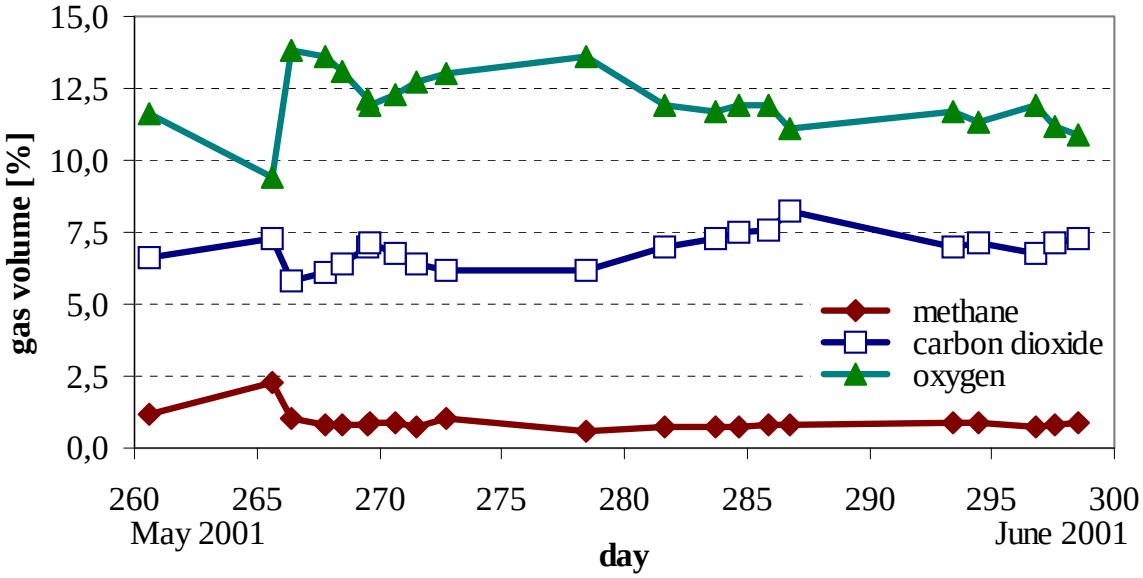


Figure 6. Development of the waste gas composition in the gas compressing device during the first operation phase (partial view)

## 6 COSTS OF LOW PRESSURE AERATION FOR THE IN SITU STABILIZATION

Depending on the site-specific technical expenditure of the aeration equipment to be ascertained, the calculated duration and intensity of stabilization and on further general conditions, the costs for landfill stabilization may vary considerably.

The projects currently started and realized such as landfill aeration and accelerated stabilization at the old Kuhstedt landfill, in Brandenburg and in Bavaria lead to costs of about 2 - 4 EURO/$m^3$ assuming an aeration period of approx. 1.5 to 2 years. Roughly estimated, 70% are purchase and 30% are running costs.

However, there are considerable cost saving potentials when existing installations and the existing infrastructure on old landfills are used as well:

- Existing gas wells and supply networks can be used for aeration and exhaust air collection, possibly even compressing units of the active gas collection. This results in significantly lower purchase costs.
- Existing electricity supply, roads, enclosures, buildings etc.

Furthermore, the installations for aeration are optimized with regard to economic and technical aspects by means of the experience gained concerning low pressure aeration.

Provisional estimations come to costs of about 1 - 2 EURO/$m^3$ landfill content for favorable general site conditions and for an optimized stabilization operation. With unfavorable general

conditions (very small old deposits without existing infrastructure, for example) the costs might amount to 2 - 4 EURO/$m^3$ landfill content.

There are further possibilities to reduce costs: namely to hire technical equipment – such as compressing units for aeration and waste gas collection and waste gas purification aggregates for the duration of the stabilization measures.

## 7 CONCLUSIONS

With the in situ stabilization of the old Kuhstedt landfill and of comparable landfills and old deposits the aim is to achieve a significant decrease in the pollutant emissions of deposited waste and to reduce landfill after-care measures with regard to expenditure and duration.

After first successful experiences, this method is applied at the old Kuhstedt landfill in the district of Rotenburg (Wümme), with the new technical concept and the low-energy low pressure aeration.. The effects are examined and continuously optimized.

The installations, measuring technique, control systems and the whole stabilization operation are designed in such a way that high process stability and far-reaching automation can be realized with low personnel costs. In addition, emission control and safety engineering (especially explosion protection) were taken into consideration concerning planning and operation of the plant.

The innovative stabilization procedure is an important step as far as the closure of many comparable landfills, timing and technical and financial aspects of landfill after-care and redevelopment of old deposits are concerned.

Both the innovative low pressure aeration for the biological stabilization of waste deposits and further development of surface sealing systems are significantly influenced by the premise not to cut back on environmental protection. New ecological approaches to better environmental compatibility of landfills and old deposits shall be prepared, leading to cost reduction – compared with existing redevelopment- and securing techniques. Taking into consideration the first operating results, it can be expected that this aim can be reached by means of the chosen procedures, the in situ aeration and the following adjusted security measures.

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