

LANDFILL FOR HAZARDOUS WASTE

APPLICATION OBJECTIVE:

- Environmentally safe depositing and permanent secure storage of hazardous waste materials

OUTLINE ON APPLICATION FRAMEWORK

PARTICULARLY APPLICABLE FOR WASTE TYPES

Glass		Light-weight packages	X ¹	Biowaste	X ²
Paper / paperboard		Mixed household waste		Bulky waste	X
Lamps		Textiles		Electrical and electronic waste	
Scrap metal		Waste wood		C&D waste	
Waste oil		Old paint & lacquer	X ³	Waste tires	
Hazardous waste	X				
Branch specific waste	X	Industrial effluents and sludge, contaminated materials			
Other waste material	X	dangerous matter, contaminated ashes, slags and residues from other treatment processes			

SPECIAL CHARACTERISTICS AND REQUIREMENTS OF THE APPLICATION:

Pre-treatment of the input material:

Loose waste can be solidified or filled into big bags (see fact sheet on “**Big Bag**”), barrels or other suitable containers if transportation, stability or other features require that for subterrestrial deposits; in case that over-ground hazardous waste landfills are being used, moisturization of dusty waste if necessary for dust-free emplacement or its transfer in big bags.

Aftercare requirements:

First of all, aftercare comprises safeguarding of the area, regular inspections and monitoring of the wells and other control facilities. These measures must principally be undertaken as long as a potential danger still exists.

Protective needs:

Protection against the leak of hazardous substances into water, soil or air, measures to prevent unauthorized access and use of the facility.

Financing options:

Financing can be supported by a landfill tax, fees and charges.

RESTRICTIONS OR INFLUENCE OF EXTERNALITIES ON THE APPLICATION:

Infrastructural conditions:

Facilities for hazardous waste deposition and/or storage

- do have high spatial needs with specific geological and hydrogeological requirements
- must be erected/located in sufficient distance to dwelling areas
- need to be accessible via roads or railway

Climatic conditions:

- no limitations regarding the erection and operations of facilities for hazardous waste deposition due to climatic influences

¹ not properly emptied or yet filled

² potentially infectious or contaminated

³ encapsulated

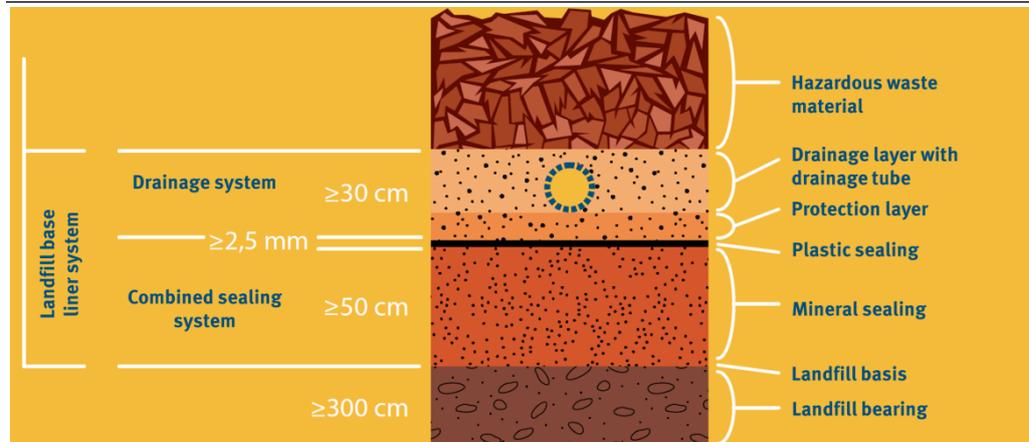
TECHNICAL DETAILS	
GENERAL OVERVIEW	
ABSTRACT	A landfill for hazardous waste is a specially engineered and protected site for the safe storage of hazardous and potentially hazardous material that cannot be treated in order to lose its danger potential or possible risk for the environment. Landfills for hazardous waste are characterized by the dangerousness of the deposited material and a constructional design which includes particular structural and/or material components to minimize the chance of release of hazardous substances into the environment. They can be set up as temporary storage places or permanent deposits.
BASIC REQUIREMENTS	<p>Requirements of location:</p> <ul style="list-style-type: none"> - suitable geological and hydrological conditions, and especially - not in Karst areas or areas with a cleft basis - not within water protection areas and catchments for potable water production - not in flood-prone zones - not in geologically faulted areas, areas with tectonic activities or areas containing mine workings - The underground should have a low permeability (permeability index $k_f \leq 1 \cdot 10^{-9}$ m/s) and a thickness of ≥ 5 meters. <p>Additionally ensured are:</p> <ul style="list-style-type: none"> Base liner system (combined sealing and ground drainage) Safety distance to dwelling areas
EXPECTED RESULTS	Eliminating public health and environmental hazards and minimizing nuisances that go out from hazardous or potentially hazardous material thru a long lasting, controlled deposition without contaminating surface or groundwater resources
SPECIFIC ADVANTAGES	<ul style="list-style-type: none"> - safe deposition of hazardous and potentially hazardous material - prevention of harmful emissions by the way of special protection measures such as base liner, surface sealing and collection systems for effluents and gases - long lasting safety through aftercare and special safety measures - economically advantageous as opposed to other, more expensive treatment options
SPECIFIC DISADVANTAGES	- requires intensive and long lasting control and aftercare
APPLICATION DETAILS	
TECHNICAL SCHEME	<p><u>General technical design and components of a landfill for hazardous waste (aboveground)</u></p> <p>Facilities for the overground deposition and/or storage of hazardous waste are of following (general) design:</p> <p>Figure 1: General design of a landfill for hazardous waste (aboveground)</p>

TECHNICAL
SCHEME
– CONTINUATION

Construction of the combined base sealing

Figure 2 shows the basic elements of a combined landfill base liner system that is used as a barrier to prevent a discharge of leachate into groundwater and soil during the filling process and the after-closure phase.

Figure 2: Cross section of a base sealing (according to German Landfill Ordinance)



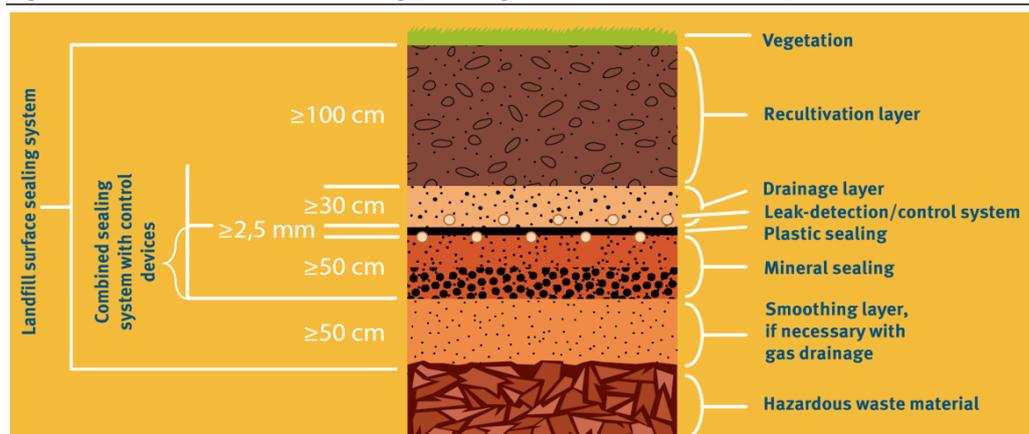
The compaction ratio on top of the landfill bearing should have a density of Proctor of > 95 %, the base liner sealing is erected on the top of the landfill basis and should comprise the following components:

- 50 cm mineral sealing (k_f -value $\leq 5 \cdot 10^{-10}$ m/s)
- ≥ 2.5 mm thick plastic sealing
- 30 cm drainage layer (including a protecting layer from sand or similar material) that consists of gravel or other crushed stone material with a permeability index not lower than k_f -value $\leq 1 \cdot 10^{-3}$ m/s
- Drainage tubes that can be controlled and flushed have to be installed within the drainage layer (see fact sheet “Landfill for non-hazardous waste“)

Construction of the surface sealing

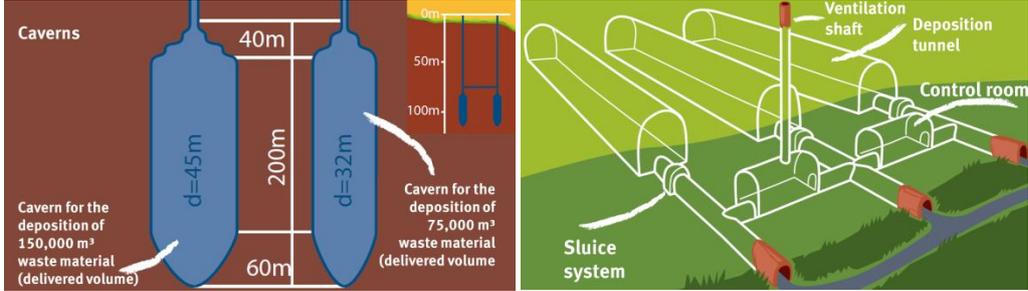
Figure 3 shows the possible construction of a surface sealing that is used to protect the landfill body towards infiltration and weather effects (e.g. wind and water erosion) and to prevent an uncontrolled discharge of emissions out of the landfill body.

Figure 3: Cross section of a surface sealing (according to German Landfill Ordinance)



Once the deposition of waste material is completed in a certain section of the landfill or in the overall, a surface sealing need to be erected in the following way:

- 0.5 m thick smoothing layer, if necessary integrating a gas drainage (made from gravel)
- 0.5 m thick mineral layer (or similar sealing) with a permeability index $k \leq 5 \cdot 10^{-10}$ m/s
- ≥ 2.5 mm thick plastic sealing and leak – detection and control system
- 0.3m thick drainage layer with a permeability index not below $k \geq 1 \cdot 10^{-3}$ m/s
- 1 m thick recultivating layer from arable soil

<p>TECHNICAL SCHEME – CONTINUATION</p>	<p><u>Constructional design – caverns, tunnels (subterrestrial deposition)</u></p> <p>Figure 4 illustrates possibilities for the subterrestrial deposition of hazardous wastes in caverns and tunnels. Caverns (mostly salt caverns) are technically made cavities (e.g. old salt mines), that can be used to store solid waste materials.</p> <p>Subterrestrial deposits are especially suited to store waste materials which contain still a potential risk for the environment (especially water and air) even if they are deposited under controlled conditions overground and whose treatment would otherwise be too costly.</p> <p>Figure 4: left: cavern / right: tunnel</p>  <p>Deposit sites on the overground are divided into three principal sections:</p> <ul style="list-style-type: none"> - Gate area with space for incoming trucks, weighing platform, registration office and lab facilities for sample taking and storage of control samples - Working area with installations to open, transfer the content, empty and clean the transport containers - Storage area with space for the intermediate storing of waste to be deposited, treated or incinerated in separate ways
<p>SCALE OF APPLICATION</p>	<p>The location of the deposit/landfill should be chosen to allow active operations for at least 10 years, better 15–20 years, in order to ensure the amortization of the investment for the erection and closure of the site (Access roads, drainage system, fencing, weighing platform, security and aftercare measures). Size of the area and of the installations must be determined depending on the local circumstances, size of the collection area resp. the collected quantity of wastes and manner of their deposition (over-/underground).</p>
<p>INTEROPERABILITY</p>	<p>A hazardous waste landfill is intended for the safe and long lasting deposition of waste materials that could be hazardous or potentially hazardous to the environment. Such facility can be combined with any suitable installation for the pre-treatment of the materials to be deposited.</p>
<p>OPERATIONAL BENCHMARKS: RESOURCE CONSUMPTION</p>	
<p>ENERGY BALANCE</p>	<p>Input:</p> <ul style="list-style-type: none"> - energy, e.g. fuel for landfill equipment, electricity <p>Output:</p> <ul style="list-style-type: none"> - possibly electric energy by the utilization of collected landfill gas and also thermal energy in the case of a cogeneration system
<p>CO₂-RELEVANCE</p>	<p>Expectable emissions of landfill gases (methane, CO₂, H₂S) result in a negative balance. Landfilling of untreated municipal solid waste is being considered as large contributor to the greenhouse effect, especially if effective gas collection systems are not in place.</p>
<p>HUMAN RESOURCES NEEDED</p>	<p>The personnel requirements depend on the facility design which in this field is very specific for each case. The estimated personnel requirement for an exemplary size of 110,000m³ annual receipt is about 5–6 specialized staff</p>

AIDS AND ADDITIVES NEEDED	- Cover and sealing materials as specified above																		
SPATIAL NEEDS	The spatial needs depend on the planned capacity of the facility. A deposit area of approx. 200,000 m ² is needed to deposit an annual volume of 110,000 m ³ of waste materials over a filling period of 20 years. Further space is required for: <ul style="list-style-type: none"> - Fresh water supply - Power supply - Connection to road, optional also railroad or waterway network 																		
AFTERCARE REQUIREMENTS	Aftercare measures must principally be undertaken as long as a potential danger still exists. Aftercare comprises first of all safeguarding of the area, regular inspections and monitoring of the wells and other control facilities. Under normal circumstances, the expenses for aftercare should reach a steady state at relatively low level after about 80–100 years after closure, depending on the deposited material.																		
OPERATIONAL BENCHMARKS: COST DIMENSIONS																			
INVESTMENT COSTS	Investment costs of a landfill are highly dependent on the volume, the planned duration of the filling process and current market conditions. As an orientation for investment costs can be cited the values for the following components and examples: <ul style="list-style-type: none"> - Base sealing system: to over EUR 35 million (e.g. landfill “Flotzgrün”) - Complete sealing incl. surface: to over EUR 48 million (e.g. landfill “Nord“, “Weißer Weg”) 																		
OPERATIONAL COSTS	The total annual operating costs for an average example are estimated with (status 2008): <ul style="list-style-type: none"> - Running costs: approx. EUR 400,000 - Repair and maintenance: approx. EUR 1.2 million - Personnel + administration: approx. EUR 250,000 																		
POSSIBLE PROCEEDS	- from tipping fees, possible landfill taxes and generated energy from landfill emissions that is feed to electricity grid																		
MASS SPECIFIC OVERALL COSTS	The following overall estimates can be used as indicative figures of the total costs (status 2008): <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr style="background-color: #333; color: white;"> <th style="text-align: left;">Annual receipt of material for deposition [m³/a]</th> <th style="text-align: center;">50,000</th> <th style="text-align: center;">250,000</th> </tr> </thead> <tbody> <tr style="background-color: #eee;"> <td colspan="3">Estimated investment [in million EUR]:</td> </tr> <tr> <td>Landfill allocation survey, underground expertise, permitting</td> <td style="text-align: center;">2.6</td> <td style="text-align: center;">8</td> </tr> <tr> <td>Construction planning, supervision and quality assurance</td> <td style="text-align: center;">77</td> <td style="text-align: center;">133</td> </tr> <tr> <td>Operating equipment, closure and recultivation</td> <td style="text-align: center;">61</td> <td style="text-align: center;">110</td> </tr> <tr> <td>Monitoring equipment, leachate/gas collection and treatment</td> <td style="text-align: center;">74</td> <td style="text-align: center;">123</td> </tr> </tbody> </table>	Annual receipt of material for deposition [m ³ /a]	50,000	250,000	Estimated investment [in million EUR]:			Landfill allocation survey, underground expertise, permitting	2.6	8	Construction planning, supervision and quality assurance	77	133	Operating equipment, closure and recultivation	61	110	Monitoring equipment, leachate/gas collection and treatment	74	123
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MISCELLANEOUS																			
MARKET INFORMATION																			
REFERENCE FACILITIES <i>(important note: the list of firms does not constitute a complete compilation of companies active in the specified fields)</i>	Most countries in Europe do run facilities for the storage and safe deposition of hazardous waste. In Germany, some examples are: <p>Overground deposits:</p> <ul style="list-style-type: none"> - HIM GmbH www.him.de - GSB - Sonderabfall-Entsorgung Bayern GmbH www.gsb-mbh.de - GBS Gesellschaft zur Beseitigung von Sonderabfällen mbH www.sad-rondeshagen.de <p>Subterrestrial deposits:</p> <ul style="list-style-type: none"> - K+S Entsorgung GmbH www.ks-entsorgung.com - GSES GmbH www.gses.de - Grube Teutschenthal Sicherungs GmbH & Co. KG www.grube-teutschenthal.de 																		

<p>RECOGNIZED PRODUCER AND PROVIDER FIRMS</p> <p><i>(important note: the list of firms does not constitute a complete compilation of companies active in the specified fields)</i></p>	<p>Numerous firms in Germany do produce and/or offer specialized technical components, construction and other services for the erection and safe operation of facilities for the storage and safe deposition of hazardous waste. Some examples are:</p> <p><u>Producers of plastic sealing:</u></p> <ul style="list-style-type: none"> - GSE Lining Technology GmbH www.gseworld.com - Naue Fasertechnik GmbH & Co. KG www.naue.com <p><u>Producers of leak-detection and control systems</u></p> <ul style="list-style-type: none"> - PROGEO Monitoring GmbH www.progeo.com - SENSOR Dichtungs - Kontroll - Systeme GmbH www.sensor-dks.com <p><u>Laying of plastic sealing:</u></p> <ul style="list-style-type: none"> - G² G-quadrat Geokunststoffgesellschaft GmbH www.gquadrat.de - NAUE Sealing GmbH & Co. KG www.nauesealing.com - von Witzke GmbH & Co www.vonwitzke.de - SIEBERT + KNIPSCHILD GmbH www.ibsiebert.de <p><u>Laying of mineral sealing:</u></p> <ul style="list-style-type: none"> - TD Umwelttechnik GmbH & Co. KG www.trisoplast.de - Bickhardt Bau AG www.bickhardt-bau.de - Kügler & Belouschek www.kuegler-textoris.de <p><u>Collection and utilization of landfill gas:</u></p> <ul style="list-style-type: none"> - Haase Energietechnik AG www.bmf-haase.de - LAMBDA Gesellschaft für Gastechnik mbH www.lambda.de - Green Gas Germany GmbH www.greengas.net
REMARKS AND REFERENCE DOCUMENTS	
<p>A list of companies dealing with the construction of facilities for the storage and safe deposition of hazardous waste and further information on the subject can be obtained from:</p> <ul style="list-style-type: none"> - AK GWS Arbeitskreis Grundwasserschutz e.V. www.akgws.de - Überwachungsgemeinschaft Bauen für den Umweltschutz BU www.bu-umwelt.de 	