

Technical Instructions on the Recycling, Treatment and Other Management of Municipal Waste¹

(TI Municipal Waste)

of 14 May 1993²

In accordance with Article 84, paragraph 2 of the Basic Law (GG) and in accordance with Article 4, para 5 of the Act on the Prevention and Disposal of Waste – Waste Management Act (WMA) dated 27 August 1986 (Federal Law Gazette I, p. 1410, 1501), last amended by Article 2 of the Act of 26 June 1992 (Federal Law Gazette I, p. 1161); and after hearing those parties involved, the Federal Government does hereby promulgate the following General Administrative Regulation:

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¹ No rights or obligations may be derived therefrom other than those set out in the lawfully enacted and published legal texts which alone are authoritative.

² Technical Instructions on the Recycling, Treatment and Other Management of Municipal Waste, (Joint Ministerial Gazette, 29 May 1993, p. 4967, **repealed as of 16 July 2009 by administrative regulation of 27 April 2009**)

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1. Objectives and scope of application

1.1 Objectives

The objectives of these Technical Instructions are to

- recycle as far as possible non-avoided wastes,
- keep the pollutant content of wastes as low as possible,
- secure an environmentally sound treatment and dumping of non-recyclable wastes.

In doing so, the security of disposal must be ensured.

Wastes are to be deposited in such a manner that the waste management problems encountered today are not shifted onto future generations.

1.2 Scope of application

These Technical Instructions contain requirements relating to the recycling, treatment and other management of municipal wastes in accordance with the state of the art as well as associated regulations that are necessary to ensure that the wellbeing of the public is not impaired.

This Technical Instruction shall apply accordingly to production wastes as well as the recovery and disposal of waste requiring particular supervision in accordance (Article 2, para 2 of the Act on the Prevention and Disposal of Waste - WMA) which can be managed together with municipal waste or managed in the same way as them.

These Technical Instructions shall provide the competent authorities with a basis for examination and decision-making, and shall in particular be applicable to the

- a) drawing up of waste management plans (Article 6, WMA),
- b) decisions regarding applications for the official approval of plans or authorisation for the construction and operation of stationary waste management facilities as well as on fundamental modifications to such a facility or the operation thereof (Article 7, 8 WMA)
- c) authorisation of the premature commencement of constructing waste management facilities (Article 7a, WMA),
- d) inclusion of, amendment to and supplementation of conditions relating to requirements placed on waste management facilities or on their operation subsequent to official planning approval or after the granting of authorisation (Article 8, para 1, sentence 3 of the WMA),
- e) setting of time limits, conditions and instructions for fixed waste management facilities which were in operation or whose construction was commenced prior to 11 June 1972, and to the prohibition of their operation (Article 9 WMA),
- f) setting of time limits, conditions and instructions for fixed waste management facilities which, in the territory specified in Article 3 of the Unification Treaty, were in operation or whose construction was commenced prior to 1 July 1990, and to the prohibition of their operation (Article 9a of the WMA),
- g) the setting of post-operational measures when a waste management installation is closed down after these Technical Instructions come into force (Article 10, para 2 of the WMA),
- h) the setting of post-operational measures when a waste management installation is closed down in the territory specified in Article 3 of the Unification Treaty (Article 10a of the WMA),
- i) the supervision of waste management and disposal (Article 11 of the WMA).

The scope of application of these Technical Instructions shall not apply to facilities that exclusively or predominantly serve the development and testing of new procedures (test facilities).

2. General regulations

2.1 State of the art

Within the meaning of these Technical Instructions, state of the art shall be understood to mean that level of development of progressive processes, facilities and modes of operation, which reliably suggest the practical suitability of a measure for the management of waste in an environmentally sound manner. In determining the state of the art, it shall, in particular, be necessary to draw on comparable suitable processes, facilities or modes of operation that have been tested successfully in practice.

2.2 Definition of terms and units of measure

2.2.1 Definition Of terms

Within the meaning of these Technical Instructions, the following definition of terms shall be applicable³

Landfill areas

Areas of a landfill site in which wastes are deposited for an unlimited period;

Existing facilities

Waste management facilities that have not been closed down, the installation and operation of which were approved at the time these Technical Instructions came into force or whose plans have been made public within the scope of an official planning approval procedure;

Waste medicaments

Unconsumed medicaments in quantities normally accruing in households;

Anaerobic treatment

Controlled biodegradation or conversion of native organic wastes in closed systems separated from contact with the air; this process is also referred to as digestion;

Facilities for the production of compost

Waste management facilities in which native organic wastes are transformed into usable composts;

Work areas

Areas on the operating site of a waste management facility in which wastes are handled openly; work areas may also be located within the entrance, storage or treatment area of a waste management facility;

Building wastes

Building rubble, construction waste, excavated soil and waste from road construction;

Building rubble (314 09)

Mineral materials from building activities, also including a small share of extraneous materials;

Construction wastes (912 06)

Non-mineral materials from building activities, also including a small share of extraneous materials;

Treatment plant

Waste management facility in which wastes are treated by means of chemo-physical, biological, thermal or mechanical processes, or combinations of these processes;

Treatment area

Area of the operating site of a waste management facility accommodating the equipment necessary for treating wastes;

³ The relevant waste codes contained in the waste type catalogue of the Federal States Working Party on Waste (LAGA) are indicated in parentheses.

Bio-waste

Degradable native or derivative-organic waste elements, (e.g. organic kitchen waste, garden waste) contained in municipal waste;

Biological treatment

Controlled degradation and conversion of biologically degradable organic wastes employing aerobic (rotting) or anaerobic (digestion) methods;

Excavated soil (314 11)

Non-contaminated, naturally generated or used soil or rock material;

Landfill site

Waste disposal facility in which wastes are stored above ground for an indefinite period;

Landfill class I

Landfill sites in which waste can be deposited that exhibit a slight organic content and which release a very low level of pollution in the leaching test;

Landfill class II

Landfill sites in which waste can be deposited which contain a higher share of organic material than those wastes deposited on landfills of class I and which release a higher level of pollution in the leaching test than wastes allowed to be deposited on landfills of class I; to compensate for this, higher requirements are placed on the landfill site and on the landfill seal;

Internal composting

Composting of biodegradable native-organic materials at the point of generation or in the immediate vicinity thereof (e. g. composting by farmers; garden owners and allotment gardeners; composting by municipal parks and gardens departments);

Entrance area

Area of the site of a waste management facility, within which wastes are delivered, weighed or measured and checked;

Security of disposal (recovery and disposal)

Adequate availability of facilities and capacity for guaranteeing the environmentally sound management of wastes;

Faecal matter (951 01)

Excrements of human origin accumulating in blind collecting pits or basins and not discharged into sewerage systems;

Faecal sludge (943 03)

Sludge accumulating from the treatment of waste water in small-scale treatment plants (domestic treatment plants);

Garden and park wastes (917 01)

Wastes of a predominantly vegetable origin and accumulating a hydro culturally used sites in public parks and cemeteries as well as green areas adjacent to roads and motorways;

Separate keeping

The keeping of wastes, recyclable material, recyclable material mixtures and contaminated products are their sorting in accordance with prescribed criteria, as well as their separate transport;

Household waste (911 01)

Wastes deriving primarily from private households and which in standardised containers prescribed in a waste collection district are at regular intervals collected, transported away and channelled into a system of further management by those corporations responsible for waste management or by third parties commissioned by them;

Commercial wastes similar to household waste (-)

Wastes accumulating in commercial undertakings, including businesses, service enterprises, public institutions and industry insofar as they can, in terms of type and quantity, be managed together with or in a similar way to household waste;

Sewage sludge (943 01, 943 02, 945 01, 945 02, 946 01, 946 02, 946 03, and, if applicable, also 948 01)

Sludge accruing from the treatment of waste water in municipal and similar industrial waste-water treatment facilities, including sludge that has been de-watered or dried or treated in any other form;

Composting

Biological degradation or conversion of biologically degradable organic wastes under aerobic conditions;

Storage area

Area within the site of a waste management facility in which wastes, operating resources or residues are stored for a limited period;

Market wastes (916 01)

Wastes, such as fruit, vegetable wastes, and non-recyclable packaging materials, accumulating on the sites of markets;

Mono landfill

A landfill or landfill area for the temporally unlimited storage of wastes which, in terms of type, pollutant content and reaction behaviour, are similar and mutually compatible;

Production-specific wastes

Wastes occurring in industry, commerce or other establishments and which are not wastes arising from human settlements but which, in terms of type, pollutant content and reaction behaviour, can be managed in the same way as such wastes;

Residue from sewage treatment plants (947 01, 947 02, 947 04)

Screenings, grit-separator and grease-separator residue from sewage treatment plants as well as residue from drainage sluice, sewer and gully cleaning;

Pollutants

Organic and inorganic materials in a concentration presenting a risk to health or the environment;

Polluted (contaminated) products

Contaminated products contained in wastes, which may lead to management problems;

Pollutant removal

Purposeful removal of pollutants and contaminated products from wastes;

Municipal Waste

Wastes, such as household waste, bulky waste, commercial wastes similar to household waste, garden and park wastes, market wastes, road sweepings, construction wastes, sewage sludge, faecal matter, faecal sludge, residue from waste-water treatment plants and water purification sludges;

Sorting plant

Waste management facility in which collected, mixed wastes are separated into fractions, in particular for the recovery of recyclable raw materials;

Bulky waste (914 01)

Solid wastes, which because of their bulkiness, are unable to fit into the containers prescribed in the refuse-collection district and which are collected and transported separately from household waste;

Road construction waste (314 10)

Mineral materials that, hydraulically bound with bitumen or tar or in an unbound state, have been used in road construction;

Road sweepings (915 01)

Wastes from road cleaning, e.g. road and tyre abrasion, leaves and winter grit;

Thermal treatment

Process for the thermal drying, incineration, pyrolysis or gasification of wastes as well as a combination of these processes;

Water purification sludge (941 01, 941 02 941 03, 941 04, 941 05)

Sludges accumulating from the treatment of water in water treatment plants, including sludges that have been de-watered or treated in any other form;

Resources

Waste components or waste fractions, which are suitable for re-use or for the manufacture of recyclable intermediate or final products;

Interim store

Waste management facility in which wastes are received, and if necessary subjected to preparatory treatment, collated for further processes of waste management or stored, but not for the collection and provision for wastes for disposal.

2.2.2 Units of measure and abbreviations

mg/kg - milligram per kilogram (measure of concentration)

mg/l - milligram per litre (measure of concentration)

µS/cm - micro Siemens per centimetre (conductance)

kN/m² - kilonewton per square metre (compressive strength)

kJ/kg - kilojoule per kilogram (energy content)

TOC - total organic carbon

AOX - absorbable organic halogens

2.3 Methods of sampling, measurement and analysis

The sampling and analysis for determining allocation of wastes to landfill class as well as assessment of measurement results must be carried out in accordance with the procedures and regulations described in Appendix A.

2.4 Exemption provision

The competent authority shall be able to permit deviations from the requirements laid down in these Technical Instructions if in specific instances it can be proved that other suitable measures will not adversely affect the wellbeing of the public - gauged against the requirements of these Technical Instructions.

3. Licensing of waste management facilities

The pertinent regulations set out in these Technical Instructions must be observed when licensing waste management facilities (Article 7 of the WMA) or when licensing the premature commencement of operation (Article 7a of the WMA).

The information that must generally be furnished upon submitting an application for the licensing of a waste management facility or of any significant modification is stipulated analogously in Appendix A of the Technical Instructions on the Storage, Chemical, Physical and Biological Treatment, Incineration and Landfilling of Waste requiring Special Supervision - TI Waste) of 12 March 1991 (Joint Ministerial Gazette, p. 139, 469).

4. Selection of the method of waste management

4.1 Selection criteria for recycling

4.1.1 General

Wastes must be recycled if

- a) such is technical feasible,
- b) the resultant additional costs are not unreasonable in comparison with other methods of waste management,
- c) a market is available or can be created for the recovered products, in particularly by commissioning third parties, and
- d) recycling has an altogether more advantageous effect on the environment than other methods of waste management.

4.1.2 Technical feasibility

Recycling is technically feasible if a practical and suitable method is available. Within the precept of recycling, the characteristic of technical feasibility means exhausting all the recycling techniques that are actually feasible. In order to achieve this objective, it may be necessary not to mix differing residue materials. The recycling of residues must also be regarded as technically feasible if only methods are available that demand prior treatment of the residues. In cases such as this, the recycling precept encompasses the implementation of measures of processing.

4.1.3 Reasonableness

In ascertaining the existence of reasonableness, examination must, amongst other things, take into account whether

- recycling has an altogether more positive effect on the environment than other methods of waste management,
- recycling of a similar nature is already being performed successfully elsewhere,
- the joint use of facilities by several waste collection corporations supports the objectives of waste management laid down in this Administrative Regulation.

4.1.4 Existence and creation of a market

A market exists for the recovered products if their sale appears to be secured now and for a reasonable period to come. In this context, it is, in particular, necessary to examine whether the joint recycling of wastes by several refuse collection corporations can create a market.

4.1.5 Ecological effects

Although priority is given to the recycling of wastes for the recovery of resources, it may in some cases necessary to examine the ecological effects of recycling if there are reasons to suggest that recycling has an altogether higher impact on the environment than that of system of well-ordered disposal.

4.2 Allocation criteria for landfilling

4.2.1 General

Wastes may only be deposited if they cannot be recycled and the allocation criteria laid down in Appendix B are observed.

In the event of inadequate stability, it shall be permissible to implement measures of stabilisation in order to adhere to the applicable allocation values.

Wastes giving rise to any possible adverse impact on the wellbeing of the public on the grounds of their origin or properties attributable to their content of long-lived or bio-accumulating toxic substances must under no circumstances be deposited above ground.

Wastes containing asbestos must be deposited separately. The requirements laid down in the LAGA⁴ Leaflet ("Management of Wastes containing Asbestos") as amended must be observed.

4.2.2 Landfill class I

Wastes may be allocated to landfill class I if they adhere to the relevant allocation values contained in Appendix B.

4.2.3 Landfill class II

Wastes may be allocated to landfill class II if they adhere to the relevant allocation values contained in Appendix B.

4.2.4 Mono landfill

The requirements laid down in nos. 4.2.1 to 4.2.3 shall be applicable to mono landfills.

Depositing on mono landfills is to be selected if, because of the pollutant contents of waste or the bonded form of pollutants in the wastes, a mobilisation of pollutants and adverse reactions with other wastes are to be avoided. In this context, the responsible authority shall be able, on a case-to-case basis, to permit the depositing of wastes on mono landfills even if the individual allocation values set out in Appendix B (with the exception of no. 1 and no. 2) are not met.

It shall be permissible to deposit verifiably non-recyclable excavated soil even if the allocation values contained in no. 2 of Appendix B are not met.

When depositing wastes containing asbestos, it shall be necessary to observe the requirements contained in the LAGA Leaflet "Management of wastes containing asbestos".

5 General requirements on resource recovery and pollutant removal

5.1 Principles

Municipal wastes and the production-specific wastes intended for joint management must be held, at the point of accumulation, sorted into recyclable components and non-recyclable residual waste. Of this, pollutant products must be collected separately and channelled in further-reaching measures of waste management.

The corporation responsible for waste management is to employ suitable systems to collect the recyclable materials accruing in its area of responsibility and ensure that such materials are channelled into the recycling process. For this purpose, it is to provide adequate sorting and composting capacities.

The waste-managing corporation is furthermore to support the collection systems outside the sphere of municipal waste management and encourage their use by the public at large.

5.2 Separate keeping and separate collection

5.2.1 Household waste

5.2.1.1 Recyclable materials

Unless a comprehensive private system of collection is in operation, the corporations responsible for waste management shall be required to install their own collection systems and sorting systems for recyclable materials contained in household waste, the separate collection of which is not covered by measures laid down in Article 14, para 2 of the WMA. In this context, cooperation between the corporations responsible for waste management and the operators of private sector waste-management systems must rule out the existence of concurrent collection systems.

5.2.1.2 Bio wastes

Collection systems for bio wastes must be organised and operated in such a way that any nuisance, caused in particular by odours, insects and rodents, is avoided, bio wastes are as far as possible free

⁴ LAGA = Federal States Working Party on Waste

from extraneous materials and collection covers bio wastes that are, as far as possible, free from pollutants.

The biological treatment of separately collected bio wastes must be ensured.

5.2.1.3 Bulky waste

Bulky waste must be collected, transported and treated in such a way that it is possible to employ the options of re-use and recycling, e.g. by separately storing recyclable bulky waste fractions.

5.2.1.4 Polluted products

The corporations responsible for waste management are to set up suitable collection and pick-up systems for contaminated products accumulating as waste in private households as well as small quantities of hazardous waste (< 500 kg/a per generator) from commerce, the trades and industry, and channel the collected products into a proper system of recycling or waste management.

This shall remain unaffected by measures implemented based on Ordinances specified under Article 14, para 1 of the WMA.

5.2.1.5 Waste medicines

Insofar as waste medicines are managed together with household waste, it must be ensured that such activities prevent any improper access to wastes of this type.

5.2.2 Commercial wastes similar to household waste

Suitable collection systems must be set up for recyclable materials accruing in commercial undertakings, including shops, small-scale businesses, service undertakings and public institutions, such materials not being subject to any regulations set out in Article 14, para 2 of the WMA, in particular recyclable or compostable constituents. All possibilities of in-house recycling must be utilised.

5.2.3 Garden and park wastes

Wastes from public parks, gardens and cemeteries are, as far as possible, to be recycled (i.e. used for mulching or composting) on an internal basis. Wastes that cannot be recycled internally must be collected separately and, as far as possible, channelled into a measure of external recycling.

Wastes of vegetable origin from gardens and parks adjoining busy roads or relevant industrial locations must only be composted if the compost generated (unmixed) conforms to the quality requirements laid down in no. 5.4.1.2.

5.2.4 Market wastes

The materials not covered in Article 14, para 2 of the WMA as well as compostable substances must be collected separately by means of suitable systems and fed into a resource recovery or composting system.

5.2.5 Road sweepings

The grit spread on roads in winter is as far as possible to be separated from other road sweepings and channelled into a system of recycling.

5.2.6 Building wastes

Insofar as not covered by Ordinances specified in Article 14 of the WMA, the recyclable components of road construction waste, building rubble and construction wastes as well as excavated soil are to be separately collected at the point of accumulation and channelled into a recycling system. Of this, any polluted building wastes are to be collected separately and channelled into a system of further reaching waste management.

After processing in an appropriate manner, road construction waste is to be re-used in road construction.

Building rubble is to be channelled into a building-rubble processing system and reconditioned, e.g. for use in road and path construction or as aggregate.

Excavated soil is to be re-used, e.g. in landscape construction, for measures of re-cultivation, for the routing of traffic routes or in agriculture and forestry. To facilitate re-utilisation, it may be necessary to process the excavated soil by separating it into different fractions (e.g. fine fractions, sand and gravel).

The recycling of excavated soil may be assisted by the creation of soil exchanges.

5.2.7 Sewage sludges

The Sewage Sludge Ordinance (*AbfklärV*) of 15 April 1992 (Federal Law Gazette I, p. 912) governs the use of sewage sludges for agricultural purposes.

Insofar as the competent authority permits the use of sewage sludge in areas that do not fall under the Sewage Sludge Ordinance (e.g. for the purpose of re-cultivation or landscape forming) the requirements placed on sewage sludges in the sewage Sludge Ordinance should be observed in order to safeguard the aspects of soil and groundwater protection in particular. After use, the soil values set out in the Sewage Sludge Ordinance should not be exceeded at the point of application.

5.2.8 Faecal matter and faecal sludges

Faecal matter and faecal sludges are to be managed in central, adequately equipped wastewater treatment facilities that afford sufficient capacity. In the event of management, not being possible through sewage treatment facilities, faecal matter and faecal sludges must be recycled by means of biological treatment or managed in some other manner.

The sewage sludge Ordinance stipulates that any utilisation on agriculturally and horticulturally used land shall only be permissible for faecal sludges.

5.2.9 Residue from wastewater treatment facilities

An effort must be made to process and recycle the residues (grit separator and grease separator residues, screenings, residues from drainage sluice, sewer and gully cleaning). If this is not possible, such products must be channelled into further measures of waste management.

5.3 Facilities for processing and sorting

5.3.1 Commercial wastes similar to household waste

Insofar as separation at the points of generation does not lead to recyclable or marketable products, the corporations responsible for waste management shall be required to install suitable sorting facilities. These must employ preferably automated sorting processes.

Attention is drawn to the requirements laid down in no. 7.

5.3.2 Building wastes

Facilities, preferably of an automated type, must be installed for the processing of building wastes.

Construction wastes must be sorted insofar as the separate collection of recyclable components is not possible. Construction wastes may be sorted together with commercial wastes.

Attention is drawn to the requirements laid down in no. 7.

5.4 Processing facilities for biologically degradable organic wastes

5.4.1 Composting

The composting of biologically degradable organic wastes (bio-waste, plant wastes, sewage sludge, and other biologically degradable organic wastes) has the purpose of transforming such wastes into usable compost.

5.4.1.1 Requirements on waste delivery and pre-treatment

Preliminary organisational and technical measures of composting must ensure that unsuitable wastes or waste fractions are extracted or minimised since based on technical measures employed within the compost-making facility, it is virtually impossible to influence the quality of composts (e.g. heavy-metal content).

Gear selecting the starting materials for composting must as far as possible towards the requirements placed on the later application area for the compost.

5.4.1.2 Requirements on generated composts

The composts generated must satisfy the requirements laid down in LAGA Leaflet M10 (as amended).

The requirements of the LAGA Leaflet must also be observed in respect of application quantity (repeated application, non-recurring application for land amelioration).

The provisions contained fertiliser law must also be taken into account with regard to the application of composts.

5.4.1.3 Requirements on the installation and operation of a compost plant

5.4.1.3.1 Plant-related requirement

The composting system must be equipped with pre-treatment, rotting compost processing facilities.

The capacity of the composting plant should be rated in such a way that the seasonally fluctuating volumes of wastes can be reliably processed.

Sufficient storage capacity must be secured for the compost volumes generated in order to compensate for seasonal fluctuations in sales.

Attention is drawn to the requirements specified in no.7

5.4.1.3.2 Requirements on residues and wastewater

In addition to generating gaseous emissions, the composting of wastes may also produce:

- Residues:
 - selection residue
 - screening residue
 - settlement residue from the compost leachate
- Waste water:
 - rain water run-off
 - compost leachate

Prime attention must be given to recycling the residues. These must be collected and kept separately unless they are subsequently recycled, treated or stored together.

Settlement residues from leachate collection must be channelled into the composting process.

Wastewater must be reliably collected and, as far as possible, used for wetting the composting material.

Attention is drawn to no. 7.1.4 and 7.1.5.

5.4.1.3.3 Requirements on the rotting process

In order to enhance the composting process, preliminary rotting is to take place in closed systems that permit monitoring and control.

It shall be possible to dispense with the closed mode of operation in small-scale facilities if there is no likelihood of nuisance being caused to the neighbourhood or adverse effect on the generated product.

The odorous emission gas accruing from compost-making facilities must be collected and treated in such a manner that any neighbouring residential population is not exposed to nuisance.

For reason of hygiene, operation in closed buildings is to be carried out in such a way that the operating personnel is not exposed to fungal spores, odour and noxious gases.

5.4.1.4 Requirements on the secured utilisation of generated composts

In order to ensure the continual utilisation of generated composts, licensing of a composting plant shall be subject to presentation of the following verification documents:

- estimate of potential sales (including internal utilisation),
- sales concept,
- concept on the intended marketing structure

5.4.1.5 Exemptions

It shall be possible to diverge from the requirements set out in no. 5.4.1 in the case of plant composting facilities (freshly cut vegetation).

5.4.2 Fermentation (anaerobic treatment)

The anaerobic treatment of biodegradable organic wastes is intended to achieve the fast and extensive degradation of hydrocarbon compounds as well as their transformation into usable gas.

Resultant sludge is to be primarily recycled.

5.4.2.1 Requirements on waste delivery and pre-treatment

Upon delivery, the properties of wastes must be such that

- the quality requirements on the final sludge product are satisfied in relation to any agricultural application or composting,
- the quality requirements on the final gas product are satisfied in relation to such being used for the generation of energy.

It must furthermore be ensured that preliminary organisational and technical measures are implemented to segregate out or minimise those wastes or waste components that are, from a technical aspect unsuitable for anaerobic treatment (extraneous materials, pollutants and polluted products).

5.4.2.2 Requirements on the installation and operation of an anaerobic treatment plant

5.4.2.2.1 Plant-related requirements

Anaerobic waste treatment plants must be equipped with waste treatment and fermentation as well as gas treatment facilities. Provisions must, in addition, be made for treating the sludge-like residues.

Anaerobic waste treatment facilities must be operated on a strictly anaerobic basis (i.e. without air oxygen).

In composting the accruing sludges, those criteria demanded in no. 5.4.1 for the rotting process must be observed.

Attention is drawn to the requirements laid in down no. 7.

5.4.2.2.2 Requirements on the generated gas

When used internally for the production of energy in firing plants, combustion engine plants and gas turbine systems, the generated gas must satisfy the requirements of the Ordinance on small-scale combustion plants (1st Federal Immission Control Ordinance - *BImSchV*) in the wording published on 15 July 1988 (Federal Law Gazette I, p. 1059) or the Technical Instructions on Air Quality Control (*TA Luft*) of 27 February 1986 (Joint Ministerial Gazette, p. 95, 202); other provisions shall remain unaffected.

5.4.2.2.3 Requirements on explosion safety

In order to ensure explosion safety, no. 5.1 in Appendix C must be observed accordingly.

This shall not effect any requirements contained in other statutory provisions-

5.4.2.2.4 Requirements on wastewater

The anaerobic treatment of wastes may produce:

- process effluent
- leachate from post-treatment processes (composting of sludges),
- waste water from the de-watering of accruing sludge

Wastewater must be collected in a reliable manner and is to be utilised in process.

Attention is drawn to no. 7.1.4 and 7.1. 5.

5.4.2.2.5 Requirements on residues

Anaerobic waste treatment may produce the following residues:

- separated materials (selection residue, screening residue) from pre-sorting activities and operation,
- sludge (in liquid or de-watered form) after waste fermentation.

The residues must primarily be recycled. They must be collected and kept separately unless they are to be subsequently recycled, treated or stored together.

Settlement residues from leachate collection must be channelled back into the process.

5.5 Recycling report

The operators of waste recycling plants shall undertake to provide the following information each year:

- information on volume and composition of input material,
- information on quantity, composition and quality of resource materials recovered,
- information on the whereabouts of the resources recovered,
- estimation of sales certainty for the resources recovered,
- information on volume and whereabouts of remaining wastes.

6 Requirements on the organisation and personnel of waste management facilities as well as on information and documentation

Insignificant facilities are excluded from the following requirements. Insignificant facilities shall be understood to mean such waste management facilities which

- a) are licensed for less than ten different waste types (waste code) and annually store or treat less than 5,000 t of these wastes and employ less than six persons or
- b) are located near a production facility and closely related to it operationally.

6.1 Structural organisation

Separated also in terms of personnel from other organisational units, waste management facilities should operate at least one organisational unit that is responsible for "control".

This "control" unit shall, in particular, be responsible for checking incoming delivery in accordance with no. 6.2.2 and 6.2.3 as well as for performing all of the inspections demanded in nos. 5, 6, 7, 8, 9, 10, 11 and 12.

The structural organisation of the waste management facility must be presented in an organisation chart indicating the tasks of the various organisational units. The persons responsible and their representatives must be named. The organisation chart shall form part of the operating manual specified in no. 6.4.2. It shall be presented to the responsible authority upon request.

6.2 Operational organization

6.2.1 General

The Management of wastes shall require fulfilment of the operational tasks described in nos. 6.2.2 and 6.2.3.

It shall be possible to diverge from the requirements set down in no. 6.2.2 and 6.2.3 if the waste management facility exhibits a physical and operational connection with other facilities approved under the WMA or licensed under the Federal Immission Control Act (*BImSchG*) as amended on 14, May 1990 (Federal Law Gazette I, p, 880) last amended by Article 1 of the Act of 26 June 1992 (Federal Law Gazette I, p. 1161) which guarantee equal fulfilment of the tasks specified.

6.2.2 Acceptance control and safeguard

An Acceptance control must be performed when waste is delivered to a waste management facility. Acceptance control is to involve:

- a) determining the quantity in units of weight; also in units of volume insofar as this is appropriate,
- b) ascertaining the type of waste, including waste code,
- c) performing visual checks; the procedure laid down in no. 6.2.3 must be adopted where wastes are deposited on landfills.

If the waste management facility is not licensed for managing the waste, the authority responsible for the waste management facility must, after hearing the operator of the facility, decide on further measures. The waste must be kept in a specially approved area of the waste management facility until a decision is reached by the authority.

The data specified in letters. a) to c), and the quantity, nature and mode of management of the rejected wastes must be recorded in the operating journal (no. 6.4.3.1).

6.2.3 Control analysis for landfills

In addition to visual inspection, it shall also be possible to conduct a control analysis.

Visual inspection shall involve checking the delivered wastes in a suitable manner. The landfill personnel must check for appearance, consistency, colour and odour. In substantiated cases, visual inspection may also take place when the wastes are deposited on the landfill.

If visual inspection unveils reasons to suggest that the requirements placed on deposition are not being met or that discrepancies exist between accompanying papers and delivered waste, a control analysis must be performed, the parameter of which shall be geared to the nature of waste and its distinguishing character. Reserve samples must be taken. The period applicable to the safeguard of reserve samples shall, in particular, be governed by the frequency of official monitoring but must amount to at least one month.

The results of control analyses must be recorded in the operating journal (no. 6.4.3.1).

Control analysis and sample reserve may, in particular, be waived if the delivering party submits a description of waste indicating without doubt that the landfilling allocation values are observed.

6.3 Personnel

6.3.1 General

The operator of the waste management facility must at all times dispose of adequate and appropriately qualified personnel. The task related basic and further training of personnel must be guaranteed.

6.3.2 Management personnel

The management personnel must avail itself of reliability, expertise and practical experience.

6.3.3 Other personnel

The other personnel must avail itself of reliability and proficiency.

The management personnel shall be responsible for providing the other personnel with instruction and regular information.

6.4 Information and documentation

6.4.1 Working regulations

The operator of a waste management facility shall be required to draw up a set of working regulations before putting any such facility into operation. These must be updated.

The working regulations shall contain those provisions of significance to operational safety and proper order. They must be submitted to the responsible authority.

The working regulations govern the procedure and operation of the waste management facility and shall also apply to its users. They must therefore be displayed at a prominent position in at least the entrance

area. The working regulations must also, if applicable, contain rules for the handling, of specific waste types.

6.4.2 Operating manual

The operator of a waste management facility shall be required to draw up an operating manual prior to putting any such facility into operation. It must be updated.

In respect of normal operation, maintenance and malfunctions, the operating manual must define those measures that are necessary for the proper management of wastes and for the operational reliability of the facility. The necessary measures must be coordinated with alert schedules and action plans.

The operating manual must define the tasks and areas of responsibilities of personnel under no. 6.3, the work instructions, inspection and maintenance measures as well as information, documentation and preservation duties under no. 6.4.3 and 6.4.4.

6.4.3 Operating journal

6.4.3.1 Content of the operating journal

The operator of a waste management facility must keep an operating journal as verification of proper operation.

The operating journal must be set up before putting the facility into operation.

The operating journal must contain all data of significance to the operation of the waste management facility, in particular:

- a) data on waste accepted under no. 6.2.2 letters a) – c):
- b) acceptance declarations, management confirmation and verification records in accordance with the Ordinance on the Monitoring of Wastes and Residual Materials (AbfRestÜverwV) of 3 April 1990 (Federal Law Gazette I, p. 648),
- c) data on surrounding material (resources, residual wastes) and their whereabouts,
- d) results of material-related monitoring inspections (internal and/external inspections),
- e) particular occurrences, in particular malfunctions, including the possible causes and remedial action taken,
- f) operating times and downtimes of the facility,
- g) nature and scope of structural and maintenance measures,
- h) results of plant-related inspections and measurements, including function checks (internal and external monitoring).

Any other verifications demanded by the responsible authority as well as their results must also be recorded in the operating journal.

6.4.3.2 Keeping the operating journal

The operating journal must be examined at regular intervals by the head of the control organisation unit. It shall be possible for the operating journal to be kept by means of electronic data processing. It must be set up in such a way that it is indelible and protected against unauthorised access. It must be possible at any time to inspect the operating journal and present it in plain text.

6.4.3.3 Preservation periods

The operating journal must be preserved for a period of at least five years calculated from the date of the last entry or, in the case of landfills, at least until the time of release from the duty of aftercare, and presented to the responsible authority on request.

In the case of landfills, the annual overviews specified in no. 6.4.4.2 and inventory plans under no. 10.6.3 must at least be preserved until termination of the aftercare phase under no. 10.7.2.

6.4.4 Obligations to give information to the authorities

6.4.4.1 Reporting of particular occurrences

Malfunctions leading to a significant divergence from proper operation, in particular to a standstill of the facility, must be reported immediately to the responsible authority.

This shall not affect reporting duties laid down in other statutory provisions of Federal and Federal States Government.

6.4.4.2 Annual overview

The operator of a waste management facility must draw up an annual overview of the data specified in no. 6.4.3.1, letters a), c), e) and f). In the case of landfills the operator shall furthermore be required to evaluate and assess the data from letters d) and h), and in the case of other management facilities, from letters e), f) and h).

The annual overview must be presented to the responsible authority within a period of three months after the end of every calendar year.

6.5 Exemptions

On a case-to-case basis, it shall be possible to diverge from the requirements laid down in no. 6 if such do not appear appropriate in the light of particular circumstances.

7 General requirements on interim stores, treatment facilities and landfills

7.1 General

7.1.1 Facility areas

Interim stores of the type specified in no. 8, treatment facilities of the type specified in no. 9, landfills of the type specified in no. 10, processing and sorting facilities of the type specified in no. 5.3 and processing facilities for biologically degradable organic wastes of the type specified in no. 5.4, must at least comprise an entrance area, storage area and working area.

Treatment facilities must furthermore exhibit a treatment area, landfills a landfill area, each of which must be set up separately from the other areas.

The areas of the facility must be provided with at least the following:

- a) Materials and equipment for the combatting of fires and facilities for collecting extinguishing media,
- b) Equipment for cleaning as well as facilities for rinsing pipework, receptacles and containers,
- c) adequate quantities of sorbents for taking up spilled wastes or waste leakages.

These materials and equipment may also be kept at a central position if the various locations or areas directly adjoin each other.

7.1.2 Water supply

DIN 1988 must be observed.

7.1.3 Pipework

Outside sealed landfilling areas of landfills, pipelines conveying water-hazardous substances or wastes must be installed and operated in accordance with the regulations contained in water and building law.

7.1.4 Sealing

All facility areas capable of accumulating contaminated water must be sealed in accordance with water and building law provisions in such a way, that the underlying stratum and adjoining areas are prevented from becoming contaminated.

7.1.5 Wastewater collection and management

Insofar as it is not possible to avoid wastewater, the requirements laid down in the Act on the Organisation of Water Management (Federal Water Act – *WHG*), as amended, must be observed in relation to discharges into water bodies.

The regulation laid down in Federal States water legislation must be additionally observed in respect of discharges of wastewater into a public sewer.

7.2 Delivery of waste

Specific delivery conditions must be defined for the delivery of wastes to a facility.

7.3 Facility areas

7.3.1 Entrance area

The entrance area must at least comprise:

- a) parking space for delivery vehicles
- b) weigh-bridge with reception office
- c) sampling bay with separate waste-water collection facility (island de-watering),
- d) storage facility for reserve samples,

unless it is proved that these facilities are closely related in terms of physical location and operation or that it is possible to dispense with them in the case of insignificant facilities (e.g. facilities for making compost, interim stores primarily accepting small quantities from private households).

7.3.2 Storage area

Wastes must be stored separately from operating resources

Separate storage must be guaranteed based on at least an adequate distance unless the nature and properties of wastes necessitate other additional technical measures.

8 Particular requirements on interim stores

It must be guaranteed that the properties of stored wastes do not undergo adverse change to such an extent that they become unsuitable for recycling or management in any other way. It shall only be permissible to admit wastes to an interim store if their further management is guaranteed within a specified period.

9 Particular requirements on treatment facilities

9.1 Thermal treatment

Thermal treatment must perform the following functions:

- destroy, transform, separate, concentrate or immobilise harmful or hazardous substances contained in wastes,
- reduce the volume and quantity of the wastes to the furthest possible extent,
- transform remaining residues into usable substance or convert them into a deposable form

The resultant thermal energy must be utilised to the furthest possible extent.

9.1.1 Requirements on the delivery and pre-treatment of wastes

9.1.1.1 Pre-treatment of solid waste

It must be ensured based on preliminary organisational and technical measures that problematic substances, inert substances and special bulky wastes contained in the waste intended for thermal treatment are minimised or extracted.

Depending on the method of thermal treatment selected, the residual waste must, if necessary, first be crushed and/or homogenised. The appropriate facilities must be provided for this purpose.

The residual waste entering the process of thermal treatment should exhibit a calorific value that produces sufficient energy to carry out the treatment process. Otherwise, it must be mixed with other non-recyclable wastes with a high calorific value.

9.1.2 Requirements on the installation and Operation of a thermal treatment plant

9.1.2.1 Plant related requirements

The waste-management requirements to be placed on the installation and operation of the plant, e. g. provision of additional treatment capacity or establishment of a plant network in the light of interrupted operation or temporary drop in sales of materials from processing facilities, must be defined on a case-to-case basis.

The thermal treatment system must be equipped with charging facilities, a main reaction chamber and, in the case of waste incineration plants, with an interconnected or downstream after-reaction chamber. Within this system, suitable measures must ensure that the wastes and emission gases burn to the fullest extent possible.

For processes in which wastes are gasified or pyrolysed under anaerobic conditions and the resultant gaseous and dust-like materials are not subsequently burned, a system of process gas purification must be envisaged that is appropriate for the application purpose of these materials.

The solid constituents must be treated in the main reaction chamber for a period that is sufficient to achieve the treatment objective. It must be possible to vary the treatment duration.

The trouble-free evacuation of solid residue from the main reaction chamber must be guaranteed. In this context, measures must be taken to prevent the inlet of air.

Particular attention is drawn to the requirements laid down in the Ordinance on Incineration Plants for Wastes and Similar Combustible Materials (17th Federal Immission Control Ordinance - *BImSchV*) of 23 November 1990 (Federal Law Gazette I, p. 2545, 2832) and the Technical Instructions on Air Pollution Control (*TA Luft*).

9.1.1.2 Requirements on residues and wastewater

The thermal treatment of residual waste may, based on gaseous and dust-like emissions, in particular produce the following:

- Residues
 - slags and ashes,
 - grate riddlings,
 - dusts from waste-gas purification,
 - reaction products and unspent chemicals from waste-gas purification;
- Wastewater
 - wastewater from the slag bath,
 - wastewater from waste-gas purification,
 - stack condensate,
 - sealing, rinsing, cleansing and spray water,
 - elutriation water.

Primarily, the residues must be recycled. They must be collected and kept separately unless they are to be subsequently recycled, treated or deposited together.

Insofar as inadequately burned residues accumulate with an ignition loss of more than 5%, they must be collected separately and, if necessary after prior conditioning, channelled back into the thermal treatment process.

The nature and design of waste-gas purification facilities must ensure that the accruing volumes of residues and wastewater are minimised and that their flows are controlled in such a way that they yield recyclable residual materials or wastes capable of being deposited above or below ground.

Processed combustion slag is currently the main product for recycling. In this context, it is in particular necessary to observe the LAGA Leaflets.

In respect of depositing non-recyclable ashes and slags, an effort must be made to achieve the allocation values set out in Appendix B for landfill class I, however at least those for landfill class II.

Attention is drawn to no. 7.1.5 (wastewater).

9.2 Requirements on the installation and operation of a facility for the biological treatment of waste

9.2.1 Aerobic treatment

The facility must be installed and operated in such a way that it ensures the most intensive possible biological transformation of wastes and prevents any adverse effect on operating personnel and/or neighbourhood by fungal spores, odour or noxious gases.

This shall not affect the requirements laid down in any other provisions, particularly those contained in Immission control law or industrial safety law.

9.2.2 Anaerobic treatment

The requirements laid down in no. 5.4.2 shall apply to the anaerobic treatment of wastes.

10 Particular requirements on landfills

10.1 Principle

Landfills must be planned, installed and operated in such a way that by

- a) selecting geologically and hydro-geologically suitable locations,
- b) selecting suitable landfill sealing systems,
- c) selecting suitable waste depositing techniques,
- d) observing the allocation values laid down in Appendix B,

several extensively independent barriers are created and the release and dissemination of pollutants are prevented by the best available technological means.

Compliance with the allocation values according to Annex B is intended in particular to ensure that practically no landfill gas develops, that the organic leachate load is very low and that only minor settlements occur because of biological degradation of organic components in the deposited waste.

Planning, installation and operation must be aimed at minimising the effort arising from aftercare measures and the monitoring thereof.

Landfills must be operated in such a way that by compressing wastes to the maximum possible extent full utilisation is made of the available landfill volume.

The following requirements shall in all cases apply to landfill class I as well as to landfill class II unless diverging requirements are expressly specified.

10.2 Interim storage areas

In landfills of class II, a separate area must be installed outside the landfilling area. It must be kept clear for wastes necessitating a decision on the ultimate mode of disposal. The area must be in such a way that it is capable of accommodating a volume of waste of at least 300 m³.

10.3 Location

10.3.1 General

Landfills must not be installed:

- a) in karst regions and areas with heavily faulted substrata particularly permeable to water exemptions shall be possible for landfill class I if case assessment shows the location to be suitable,
- b) within defined, provisionally secured or officially planned drinking-water or mineral-spring protection areas as well as water priority areas (areas designated in regional planning in the interest of securing the future supply of water); in water priority areas, water protection areas belonging to zone III B, mineral-spring protection areas belonging to zone IV or an area corresponding to these protection zones, the installation of landfills shall be possible if the location is shown to be suitable on the basis of case assessment,
- c) within a defined, provisionally secured or officially planned flood zone,
- d) in pits from which it is not possible by free flow to discharge leachate into drainage shafts located outside the landfilling area,
- e) in the area of designated or secured nature reserves or in corresponding priority areas for forest and nature protection, as well as in areas which must be assessed as specially protected biotope areas under section 20 c of the Federal Nature Conservation Act (*BNatSchG*) in the version published on 12 March 1987 (Federal Law Gazette I, p. 889), amended by Article 6 of the Act of 12 February 1990 (Federal Law Gazette I, p. 205).

In examining the suitability of a proposed site, attention must be paid to, the following:

- f) geological, hydrogeological, pedological and geotechnical conditions at the landfill site and in the downstream groundwater collection area,
- g) position in relation to an existing or designated settlement area; an endeavour should be made to provide a protective distance of at least 300 m separating such areas from the landfill body; individual buildings must be subject to separate consideration,
- h) location in areas subject to the risk of earthquake and tectonically active fault zones,
- i) location in areas in which landslides and sinkholes have not come to rest or in which subsidence and mining damage may still take place or which must be expected as a result of discontinued mining work,
- k) the settlement behaviour of filled-in open cast mines and other plugged residual holes.

The scope of geological, pedological and hydrogeological investigations depends on the site-specific conditions. In each case, it must be defined in such a way that a sufficiently accurate description of the substratum is possible down to significant depths.

The substratum must be of such rigidity that it is capable of adsorbing strain from the landfill in such a way that no damage is caused to the landfill base sealing system and the stability of the landfill body is not jeopardised. Allowance must be made for the different landfilling phases in making up the landfill body.

10.3.2 Geological barriers

The geological barrier is understood to be the natural substratum extending as far as the landfill formation level beneath and surrounding a landfill which, based on its property and dimensions, extensively prevents the spread of pollution.

The geological barrier in all cases comprises naturally arranged, slightly permeable, unconsolidated or consolidated rock (DIN 18130) of several metres in thickness and exhibiting a high pollution retention capacity extending beyond the area of the dumping site. The geological barrier must be as homogeneous as possible beneath the dumping site.

Insofar as the above-mentioned requirements are not fully satisfied in the dumping area and proximity of the landfill, although a geological barrier affording the greatest possible effect played a major part in selecting the site, the requirements must be met by implementing additional technical measures.

Should the requirement set out in paragraph 2, sentence 2 not be met down to a depth of three metres below the landfill formation level, such must be guaranteed in this region by installing a homogeneous equalising layer of $k_f \leq 1 \times 10^{-7}$ m/s.

No particular requirements are placed on the geological barrier for landfills belonging to class I.

In the case of landfills belonging to classes I and II and depending on soil type, a degree of compaction must be achieved at the surface of the landfill formation level in accordance with Table 4 of the Provisions and Guidelines for Earthworks in Road Construction (ZTEV).

10.3.3 Location in relation to groundwater

The landfill formation level must be arranged in such a way that after the substratum has finished settling under the load of the landfill, it comes to rest at least one metre above the highest expected groundwater surface or groundwater pressure area in the case of free or confined groundwater to DIN 4049, Part 1 (issued in September 1979).

Higher levels of hydraulic pressure head are permissible if it is proved that the groundwater actively participating in the groundwater cycle is not adversely affected.

Any adverse effect of this type is, in particular, not to be expected if the substratum comprises very slightly permeable soils or rock strata of adequate thickness and significant horizontal expanse beyond limits of the actual landfill area.

10.4 Installation

The landfill must be provided with landfill sealing systems in the dumping area.

Leachate must be monitored and, if necessary, treated in accordance with the provisions laid down in water legislation.

10.4.1 Landfill sealing systems

10.4.1.1 General

Landfill sealing systems are to be planned and constructed in accordance with nos. 10.4.1.3 and 10.4.1.4 or with equivalent systems.

Load-induced deformations of the seal-supporting surface must not impair the proper function of the landfill sealing systems. Settlements and deformations in the seal-bearing surface and sealing systems must be calculated and monitored during the operational phase, (e.g. by measuring deformation around the drainage pipes).

Pipes passing through the sealing system in the sloping area must, as far as technically possible, be constructed in such a way that they can be monitored and repaired.

The requirements laid down in Appendix E of the Technical Instructions on Waste Management (TI Waste) shall be applicable. It shall also be possible for the Federal Agency for Materials Research and Testing to approve materials for the sealing of landfills, e.g. sealing webs, geo-textiles etc.

It shall only be permissible to use plastic sealing webs approved for landfill sealing systems. Their suitability must be ascertained for each specific application case. This shall not affect any examination duties laid down in other statutory provisions, e.g. in the building code in the form of general approval by the construction supervision authorities or in water law.

A single responsible contractor must be appointed for constructing the sealing system of a landfill or of a construction phase.

Weather protection must be provided and if necessary employed for the proper construction of landfill sealing systems. In particular, the requirements set out in nos. 3.1.1, letter b) and 3.1.2, letter d) of Appendix E in the Technical Instructions on Waste Management (TI Waste) shall be applicable.

10.4.1.2 Quality plan (to DIN 55350)

A quality plan must be set up before constructing landfill sealing systems. This plan is to define the specific elements of quality assurance as well as the responsibility, material means and activities in such a way as to ensure adherence to the quality characteristics of landfill sealing systems listed below and in no. 10.4.1.3 and no. 10.4.1.4.

The quality plan must at least contain the following:

- a) responsibility for the setting up, implementing and monitoring of quality assurance
- b) the results of suitability tests performed on the materials to be used,

- c) the measures of quality control, e. g. by specifying the construction process,
- d) the measures of quality surveillance and inspection during and after construction of landfill sealing systems,
- e) the nature of construction documentation (inventory plans and explanatory reports).

In defining measures of quality surveillance and inspection described in letter d), a distinction must be drawn between the following independent functions:

- f) inspection on the part of the constructor (of the client or commissioned third party),
- g) external inspection by third parties in agreement with the responsible authority, e.g. by an external engineering office or institute,
- h) monitoring by the responsible authority.

Quality inspection shall be carried out in accordance with no. 3.2 of Appendix E of the Technical Instructions on Waste Management (TI Waste).

Performance of external inspection shall not bring about any unreasonable delays in constructing the sealing systems. If necessary, additional laboratory facilities must be provided on site for this purpose.

Commencement of the main individual work phases involved in constructing the landfill sealing system shall be brought to the attention-of the responsible authority in good time.

10.4.1.3 Landfill base sealing systems

A landfill sealing, system must be arranged on the landfill formation level under no. 10.3.2 and on the sloping areas. The type of landfill sealing system for the sloping area must be defined in accordance, with angle of inclination.

Vertical penetrations through the sealing system shall not be permitted.

10.4.1.3.1 Landfill base sealing system for landfill class I

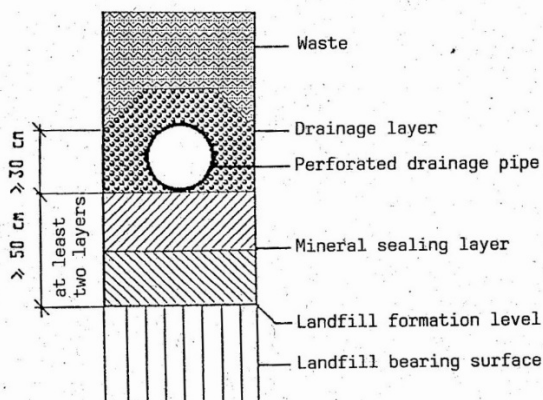
The landfill base sealing system is to comprise the system components, presented in Figure 1 a) or an equivalent sealing system.

The thickness of the mineral sealing layer must not be less than 0.5 m.

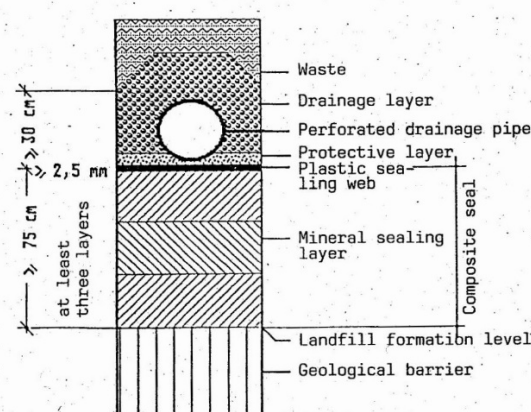
The requirements laid down in no. 10.4.1.3.2 shall apply accordingly in all other respects.

Figure 1: Landfill base sealing system

a) Landfill class I



b) Landfill class II



10.4.1.3.2 Landfill base sealing system for landfill class II

The landfill base sealing system is to be constructed in accordance with Figure 1 b) or comprise an equivalent system, the material and inspection requirements of which are specified in Appendix E of the Technical Instructions on Waste Management (TI Waste):

- a) The mineral seal in the sealing system must exhibit a thickness of least 0.75 m. A permeability coefficient of $k \leq 5 \times 10^{-10}$ m/s at $i = 30$ (laboratory value of undisturbed sample taken from the seal) must be observed. Plastic sealing webs in sealing systems must have a thickness of $d \geq 2.5$ mm. They must be protected by suitable measures against load-induced damage. The surface of the seal is to be formed in the manner of a roof profile. Once the sealing bearing surface has finished settling, the surface of the sealing layer must exhibit a transverse gradient of ≥ 3 % and a longitudinal gradient of ≥ 1 %.
- b) The drainage layer must be constructed in a thickness of $d \geq 0.3$ m. The drainage material must be placed in blanket form and exhibit a permeability coefficient of no less than $k = 1 \times 10^{-3}$ m/s. Perforated pipes (collectors), additionally capable of being rinsed and monitored, must be provided for the collection and discharge of leachate. The leachate must be channelled by means of free flow into drainage shafts that are to be installed outside the landfilling area. DIN 19667 "Draining of Landfills" must be observed.

10.4.1.4 Landfill surface sealing systems

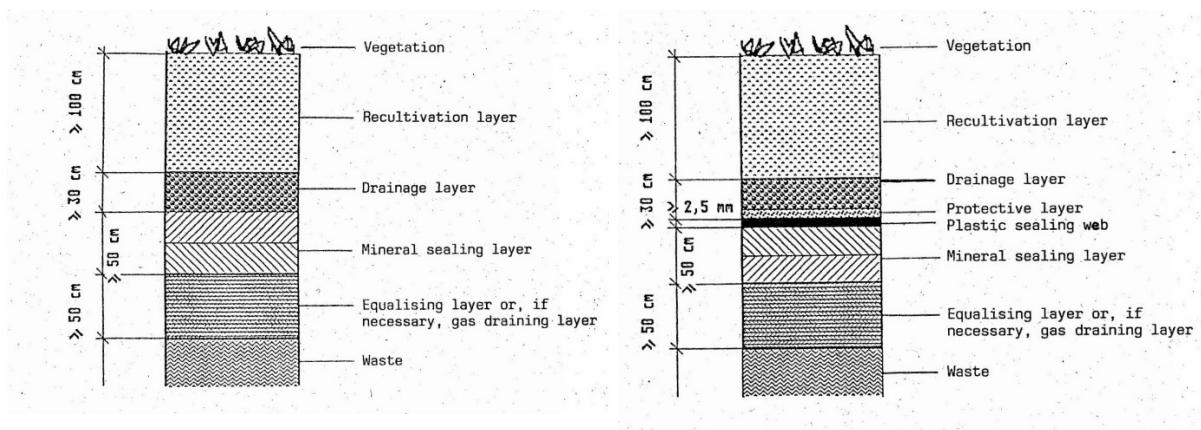
A surface sealing system must be applied to the landfill body after a landfill section has been filled.

If required by the intended and permissible mode of subsequent utilisation, the re-cultivation layer may be substituted by a cover layer tailored to the relevant usage and having an equivalent protective effect on the sealing system.

Figure 2: Landfill surface sealing system

a) Landfill class I

b) Landfill class II



The individual elements shall be subject to the following requirements:

- a) The sealing-bearing surface must comprise a compressed equalising layer of homogeneous, non-cohesive material. Thickness must not be less than 0.5 m. Insofar as gas formation is established and the gas cannot be collected and channelled away in the equalising layer, a gas drainage layer with a minimum thickness of $d \geq 0.3$ m must be additionally provided above the equalising layer. The calcium carbonate component of the material forming the degassing layer must not exceed 10 % by weight.
- b) In the case of landfills belonging to class I, the seal must be constructed in the form of a mineral seal in accordance with Figure 2 a) or with an equivalent seal. In respect of landfills of class II, the seal is to be constructed as a composite seal of the type illustrated in Figure 2 b) or with an equivalent sealing system. The thickness of the mineral sealing layer must be no less than 0.5 m. The permeability coefficient of $k \leq 5 \times 10^{-9}$ m/s at $i = 30$ (laboratory value) must be observed.

Plastic sealing webs in sealing systems must have a minimum thickness of $d \geq 2.5$ mm. Preference should be given to the use of sealing webs made from recycled material that satisfies suitability testing. Final Settlement in the seal bearing surface must leave a gradient of ≥ 5 % No. 3.1.1, letter k) of Appendix E of the Technical Instructions on Waste Management (TI Waste) shall not be applicable.

- c) The drainage layer shall be subject to the requirements laid down in 10.4.1.3.2, letter b), sentences 1 and 2.
- d) The re-cultivation layer must comprise a layer of tillable soil of at least a 1 m in thickness and be planted with suitable vegetation. It must be placed in such a way that the seal is protected against the effects of roots growth and frost. The vegetation must provide adequate protection against wind or water erosion.

In observing the meteorological data series to be collected under no. 10.6.6.2 in conjunction with Table 1 of Appendix G of the Technical Instructions on Waste Management (TI Waste), and in applying good water management practice, the vegetation must furthermore be selected in such a way that it minimises infiltration of precipitation water into the drainage system.

10.4.2 Leachate treatment facility

The leachate treatment facility must be installed and operated in the form of a wastewater treatment plant in observance of the conditions of use and obligations applicable to the discharge and indirect discharge of wastewater in accordance with the relevant code of practice.

Attention is drawn to no. 7.1.5.

Collected landfill leachate and residues from leachate purification must not be channelled back into landfill body.

10.5 Stability of the landfill body

The landfill body must be constructed in such a way that it is mechanically stable in itself and in relation to its surroundings.

In planning the landfill, stability of the landfill body must be forecast based on assumptions for soil-mechanical characteristic values and the firmness of wastes. These assumptions must be examined in accordance with the operating plan under no. 10.6.1 based on independent expert recommendations. The results must be attached to the annual evaluations of internal monitoring activities specified in no.10.6.6. If necessary, new stability calculations must be performed and appropriate amendments made to the operating plan applicable to the structure of the landfill body.

10.6 Operation

10.6.1 Operating Plan

It shall be necessary to draw up an operating plan; this shall form part of the operating manual specified in no. 6.4.2.1. The operating plan must lay down all the main regulations of landfill operation, in particular regarding the structure of landfill body under no. 10.6.4, collection and discharge of gas, leachate and other wastewater under no. 10.6.5 and in relation to the nature and scope of monitoring activities under no. 10.6.6.

The landfilling area must be divided up into landfill sections. In particular, the following information on waste to be landfilled must be specified for each landfill section and taken into consideration at the planning stage:

- a) nature of waste,
- b) site of landfilling,
- c) landfilling method.

10.6.2 Landfilling plan

If landfill sections are to be differently structured and filled with different waste types exhibiting varying high pollutant contents a dumping plan must be set up for the structure of each landfill section. The

landfill section is to be divided up into grid squares with a maximum base area of 2,500 m² and a maximum height of 2 m. The following information is to be documented in the dumping plan for those wastes deposited in each grid square:

- a) waste type, including waste code and waste quantity,
- b) site of landfilling (indication of grid numbers),
- c) method of landfilling,
 - layer thicknesses,
 - compaction equipment,
- d) time of landfilling,
- e) deviations from operating plan.

10.6.3 Inventory plan

An inventory plan must be drawn up by the latest six months after a landfill section has been filled. The entire landfill section, including landfill base sealing systems, must be recorded and documented in the inventory plan.

The dumping plan must be included in the inventory plan.

10.6.4 Structure of the landfill body

10.6.4.1 Placement of wastes

- a) The landfill body must be structured in such a way that no adverse reactions take place among the wastes themselves or with the leachate. If necessary, separately drained areas must be provided for different waste types.
- b) An attempt must always be made to structure the landfill body in such a way that individual sections are filled as quickly as possible enabling the landfill surface sealing system to be installed.
- c) The machines kept on the landfill site are, in general, to permit the immediate dumping and compacted placement of wastes delivered to the site. Placement must be carried out in such a way that only slight settlements are to be expected in the landfill body over the long term.
- d) The landfill body must be structured in such a way that its stability under no. 10.5 is ensured.
- e) The wastes must be placed as far as possible without voids and in a compacted manner.
- f) Wastes must be placed in such a way that they are unable to release any significant emissions.
- g) Wastes capable of reacting exothermically by themselves, in conjunction with water or with other wastes must be placed in such a way that the function of the landfill base is not impaired.

10.6.4.2 Leachate reduction

The formation of leachate is to be minimised upon building the landfill body to restrict the mobilisation of pollutants in the deposited wastes and reduce the effort and expenditure required for any necessary leachate treatment.

10.6.5 Leachate, other wastewater and gas

10.6.5.1 Leachate and other wastewater

The following wastewater types may occur in surface dumps:

- a) leachate from the landfill base sealing system as well as leachate collected in peripheral ditches,
- b) surface water from landfill sections or areas on which no wastes are deposited,
- c) surface water from other paved areas,
- d) wastewater from the sampling points, laboratories, transfer sites and storage areas,
- e) run-off from landfill sections with surface seal,
- f) external water inflows to the landfill site, for example surface or foreign water,

g) waste water from the sanitary sector.

Attention is drawn to no. 7.1.5 (wastewater).

The discharge of wastewater beneath the dumping area (dolination) is impermissible.

10.6.5.2 Gas

Insofar as significant gas concentrations are measured in the course of monitoring under no. 10.6.6.1 or the generation of landfill gas is to be expected on the grounds of exemption from allocation under no. 12.1, suitable facilities must be employed to catch and utilise the volumes of gas accruing. no. 11.2.1, letter f) must be observed in such instances.

10.6.6 Checks

The following requirements shall apply to landfill class II. The requirements on checks to be performed in relation to landfill class I shall be governed by the conditions underlying each individual case.

10.6.6.1 General

Checks performed by the landfill operator or a body commissioned by the landfill Operator shall verify that the requirements applicable to landfill behaviour are satisfied, that the landfill is operated in a proper manner, that the landfill sealing systems function correctly and that the groundwater control wells are secured.

10.6.6.2 Monitoring facilities

The following monitoring facilities must in general be provided and checked at regular intervals for proper operation:

- Groundwater monitoring system with at least one measuring station in the inflowing current of groundwater and a sufficient number of measuring stations in the current of groundwater flowing out of the landfill area; it must at all events be ensured that the entire downstream flow of groundwater can be subject to accurate monitoring,
- measuring facilities for monitoring settlements and deformations in the landfill body,
- measuring facilities for monitoring settlements and deformations in the landfill sealing systems,
- measuring facilities for recording meteorological data:
 - precipitation measuring facility,
 - temperature measuring facility,
 - wind measuring facility,
 - evaporation measuring facility,it shall be possible to use the data recorded by meteorological measurement stations at a comparable location in the immediate vicinity,
- measuring facilities for collecting the water quantities that are necessary for analysing the water balance,
- measuring facilities for recording the quality of leachate and other waters,
- measuring facilities for monitoring the temperature at the landfill base.

If landfill gas is to be expected, it shall be necessary to provide facilities for measuring landfill gas and install gas level indicators for the purpose of emission control.

Internal checks must be performed and evaluated during the landfill operational and aftercare phase. The requirements laid down in Appendix G of the Technical Instructions on Waste Management (TI Waste) shall be applicable.

The data shall be recorded by means of electronic data processing.

10.6.6.3 Declaration on landfill behaviour

Landfill behaviour must be documented based on the time history of the volume and properties of leachate and, if applicable, gas emissions, temperature development in the landfill body as well as based on settlement and deformation behaviour of the landfill body.

Based on the annual evaluation of measurement results under Appendix G of the Technical Instructions on Waste Management (TI Waste), a declaration on landfill behaviour must be drawn up and presented together with the annual survey specified in no. 6.4.4.2 to the responsible authority.

The time history of landfill behaviour must be portrayed from beginning of the operating phase and compared with the computed assumptions for the landfill body under no. 10.5 and, if applicable, the assumptions on leachate and gas emissions (quantity and composition) contained in the licence granted under waste management law.

10.7 Landfill closure and aftercare

10.7.1 Landfill closure

After closing down the landfill or landfill section, it shall be necessary to seal off the surface in accordance with no. 10.4.1.4 and install the monitoring facilities still to be provided for the recording of data specified under no. 10.6.6.2.

At the end of the operational phase, the responsible authority shall be required to perform a final inspection and thereby allow for the following,

- a) the annual declarations on landfill behaviour,
- b) annual evaluations of checks,
- c) the functional reliability of the landfill sealing systems and monitoring facilities,
- d) the operating plans under no. 10.6.1 and inventory plans under no. 10.6.3.

10.7.2 Aftercare

Landfills shall require aftercare. The aftercare phase shall commence upon completion of final inspection.

During the aftercare phase, it shall, in particular, be necessary to implement and document long-term protection measures and checks in relation to landfill behaviour under no. 10.6.6 as well as in accordance with Appendix G of the Technical Instructions on Waste Management (TI Waste).

The checks and measures performed in the aftercare phase shall be conducted by the landfill operator within the scope of checks carried out under no. 10.6.6 as well as in accordance with Appendix G of the Technical Instructions on Waste Management (TI Waste) until such time as the responsible authority releases the operator from the duties incumbent upon him during the aftercare phase.

11. Requirements on existing sites

11.1 General

The responsible authority shall, in respect of existing waste sites, be required to issue subsequent orders under Article 8, para 1, sentence 3, Article 9 or Article 9a of the Act on the Prevention and Disposal of Waste (WMA) at the latest by 1 June 1996 to ensure that the following requirements are met:

- a) no. 6 at the latest by 1 June 1999,
- b) no. 5.4, 7 and 8 at the latest by 1 June 2002,
- c) no. 9 at the latest by 1 June 2002. In the case of facilities in operation at the time these Technical Instructions enter into force, it shall be necessary to strive for the allocation values of Appendix B for landfill class I in respect of dumping non-recyclable slags and ashes, however at least those applicable to landfill class II.

11.2 Existing landfills

11.2.1 Household refuse landfills

In respect of existing landfills, the responsible authority is to

- a) issue subsequent orders under Article 8, para 1, sentence 3, Article 9 or Article 9a of the WMA that a retrofit programme be set up and that complete and verifiable plans be presented within two years of issuing the order; the requirements laid down in letters e) to h) must be observed,
- b) reach a decision on licensing under Article 7, subsection 2 or order under Article 8, para 1, sentence 3, Article 9 or Article 9a of the WMA at the latest two years after submitting the plans specified in letter a),
- c) practise, until expiry of the period for objection, the procedure for licensing under Article 7, para 1 of the WMA at the latest two years after submitting the plans specified in letter a),
- d) issue a licence or order stipulating that the requirements set out in letters e) to h) be satisfied at the latest six years after receiving the final notice of approval or final order.

The following minimum requirements shall apply to existing landfills:

- e) The landfill must satisfy the requirements placed on stability under no. 10.5 and on operation under no. 10.6.
- f) The landfill gas from operational and closed landfill sections shall, as far as possible, be collected and utilised. The state of the art is, for example, combustion with energy utilisation, if necessary after prior purification, in furnaces or combustion engine systems. Combustion without energy utilisation shall only be permissible in substantiated cases of exception.
The quantity and quality of collected landfill gas shall be examined at regular intervals; the efficiency of degassing shall be verified based on regular checks. The requirements laid down in Appendix C shall be applicable to the nature and operation of landfill gas collection, landfill gas analysis as well as to monitoring the efficiency of degassing.
The requirements of other provisions, particularly those contained in Immission control legislation, shall remain unaffected in the event of landfill gas being used for the generation of energy.
- g) Any leachate must as far as possible be collected, monitored and, if necessary, treated. The requirements set out in no. 10.4.2 must be observed.
- h) A surface sealing system must be installed after filling a landfill section.
Landfill surface sealing systems must conform to the requirements for landfills of class II in accordance with nos. 10.4.1.1, paragraph 2ff, 10.4.1.2 and 10.4.1.4.
If major settlement is expected, a cover may be installed until the main settlement activity has abated. Covers of this type must minimise the formation of leachate and prevent landfill gas migration.
In respect of landfill sections already re-cultivated at the time these Technical Instructions come into force, exemptions shall be permissible if it can be proven that, the quantity and quality of any leachate accruing will not lead to an impairment of the aquatic environment.

In the case of existing facilities (landfills or landfill sections) closed down after these Technical Instructions come into force, the responsible authority shall be required to perform a final inspection in accordance with no. 10.7.1.

10.2.2 Other landfills

No. 11.2.1 shall apply accordingly.

The responsible authority shall, in each individual case, decide on the requirements set out in letters e), f), g) and h).

A surface sealing system conforming to the requirements applicable to landfills of class I shall be provided for landfills for excavated soil and building rubble insofar as such is necessary on the basis of the nature and composition of the deposited wastes.

12. Transitional provisions

12.1 Exemptions from landfill allocation

The responsible authority shall be able to permit allocation exemptions in the case of household waste, commercial wastes similar to household waste, sewage sludge and other organic wastes for the period up to 1 June 2005 and, in the case of excavated soil, building rubble and other mineral wastes, by 1 June 2001, if it is foreseeable that for reasons of lacking treatment capacity, the waste is unable to satisfy the allocation criteria.

Such permission must be subject to the following conditions:

- a) The dumping of wastes not satisfying the allocation values specified in Appendix B is to be permitted on existing landfills or separate sectors of landfills belonging to class I or II.
- b) In the case of existing landfills and landfills belonging to class II, additional measures are to be employed as from 1 June 1999 at the latest in order to increase placement density and reduce the content of native organic components in the wastes.
- c) Declarations on landfill behaviour under no. 10.6.6.3 must be drawn up every year.

12.2 Existing facilities (existing landfills)

The responsible authority shall, by 1 June 1995 at the latest, issue subsequent orders under Article 8, para 1, sentence 3, Article 9 and Article 9a of the WMA to satisfy the requirements laid down in no. 4.2 and the periods set in no. 12.1.

13. Entry into force

These Technical Instructions shall enter into force on the first day of the calendar month following that of publication.

It shall be examined in 1995 in relation to establishing whether it can be implemented within the period set.

The Federal Council has given its consent

Appendix A

Methods of sampling and analysis

1. Sampling

The samples necessary for conducting the tests specified in Appendix B and for determining the calorific value under no. 9.1.1.1 of these Technical Instructions shall be taken in accordance with Guidelines PN 2/78 and PN 2/78 K "Guidelines on the taking and preparation of samples from solid, sludgy and liquid wastes" (state: 12/83) or "Fundamental rules on the taking of samples from wastes and deposited materials" (state 12/83) of the Federal States Working Party on Waste (LAGA). These guidelines shall be applied with the following supplements and modes of simplification:

1.1 Homogeneity/heterogeneity

The following allocation shall apply:

Homogeneous is an attribute that shall normally be applied to

- a) all liquid arid pumpable waste,
- b) other wastes the homogeneity of which is verifiable through visible inspection, e.g. dust; filter dust from combustion plants, reaction products from flue-gas purification systems.

All other wastes shall be heterogeneous.

1.2 Number of samples and sample quantity of wastes not supplied in containers (e.g. tanker vehicles, heavy goods vehicles, rail tankers)

Number of individual samples, per waste generated and per waste code:

- a) for homogeneous waste - 1 sample per consignment
- b) for heterogeneous waste - 1 sample per started 5 t or 5 m³

Minimum sample quantity per individual sample:

- a) for homogeneous waste - 1,000 g or ml,
- b) for heterogeneous waste - 1,000 g or ml,

unless the lumpiness of waste demands a larger sample quantity.

1.3 In the case of household waste and wastes similar in structure, appropriate samples must only be gained by sorting analysis.

2. Determination of parameters specified in Appendix B and of the calorific value

The parameters and calorific value listed in Appendix B of these Technical Instructions must be determined in accordance with the following methods:

2.1 Strength (B1)

- | | | |
|-------|--|-------------------------------|
| 2.1.1 | Vane shearing strength (B1.1) | DIN 4096 (issued May 1980) |
| 2.1.2 | Axial deformation (B 1.02) | DIN 18136 (issued March 1987) |
| 2.1.3 | Uniaxial compressive strength (B 1.03) | DIN 18136 (issued March 1987) |

2.2	Organic component of dry residues in original substance	
2.2.1	Ignition loss of dry residue in original substance (B 2.01)	DIN 38414-S3 (issued November 1985)
2.2.2	TOC of dry residue in original substance (B 2.02)	Analytical-grade sample (< 0.2 mm). By determining the difference between total carbon content (reaction of sample in stream of oxygen at 900-1300°C) and inorganic carbon (expulsion by acidification and heating in stream of oxygen) or direct determination of total organic carbon after prior expulsion of inorganic carbon by means of acid treatment, detection of CO ₂ formation in accordance with DIN 38409-H3 (issued June 1983)
2.3	Extractable lipophile substances (B3)	Extraction in accordance with LAGA Guideline KW 85 (effective February 1990) gravimetric analysis in accordance with DIN 38409-H 17 (issued May 1981)
2.4	Eluate preparation for parameter determination (B 4.01 – B 4.17).	DIN 38414-S4 (issued October 1984) The following supplements/deviations must be observed: <ul style="list-style-type: none"> - The original structure of the sample to be used should be extensively retained. Lumpy pieces must be crushed. - A wide-neck glass bottle (10 cm diameter) is to be used. - Turn full circle through vertical axis once a minute. - Centrifuge. - Then filter once through membrane filter (pore size 0.45 µm), compression filtration if necessary.
2.4.1	pH value of eluate (B4.01)	DIN 38404-C5 (issued January 1984)
2.4.2	Conductivity of eluate (B4.02)	DIN 38404-C8 (issued September 1985)
2.4.3	TOC in eluate (B4.03)	DIN 38409-H3-1 (issued June 1983)
2.4.4	Phenols in eluate (B4.04)	DIN 38409-H16-3 (issued June 1984)
2.4.5	Arsenic in eluate (B4.05)	DIN 38405-D18 (issued September 1985)
2.4.6	Lead in eluate (B4.06)	PIN 38406-E6-1 (issued May 1981)
2.4.7	Cadmium in eluate (B4.07)	DIN 38406-E9-1 (issued July 1980)
2.4.8	Chromium-VI in eluate (B4.08)	DIN 38405-D24 (issued May 1987)

2.4.9	Copper in eluate (B4.09)	DIN 38406-E7 (issued September 1991); alternatively DIN 38406-E22 (issued March 1988)
2.4.10	Nickel in eluate (B4.10)	DIN 38406-E11 (issued September 1991); alternatively DIN 38406-E22 (issued March 1988)
2.4.11	Mercury in eluate (B4.11)	DIN 38406-E12-3 (issued July 1980)
2.4.12	Zinc in eluate (B4.12)	DIN 38406-E8-1 (issued October 1980)
2.4.13	Fluoride in eluate (B4.13)	DIN 38405-D4-1 (issued July 1985)
2.4.14	Ammonia nitrogen in eluate (B4.14)	DIN 38406-E5-1 (issued October 1983)
2.4.15	Cyanide, easily liberatable, in eluate (B4.15)	DIN 38405-D14-2 (issued December 1988)
		Where wastes contain sulphide, analysis shall be carried out in accordance with DIN 38405-D13-2 (issued February 1981)
2.4.16	AOX in eluate (B4.16)	DIN 38409-H1-4 (issued March 1985)
2.4.17	Water-soluble component of dry residue in original substance determined through filtrate dry residue in eluate (B4.17)	DIN 38409-H1-2 (issued January 1987)
2.5	Calorific value	DIN 51900, Part 1 (issued November 1989) DIN 51900, Parts 2 and 3 (issued August 1977)

3. Evaluation of measurement results from control analyses

Adherence to the allocation values listed in Appendix B shall still be deemed as given if the values ascertained from the control analyses do not exceed the following deviations from the allocation values:

No. of parameter	Deviation
2.01	50 %
2.02	50 %
3	25 %
4.01	0.5 pH units
4.02	10 %
4.03 to 4.17	50 % each

Appendix B

Allocation criteria for landfills

In allocating wastes to landfills, it shall be necessary to observe the following allocation values; these are based either on the analysis methods specified in Appendix A or on equivalent methods:

No.	Parameter	Allocation values	
		Landfill class I	Landfill class II
1	Strength¹⁾		
1.01	Vane shear strength	≥ 25 kN/m ²	≥ 25 kN/m ²
1.02	Axial deformation	≤ 20 %	≤ 20 %
1.03	Uniaxial compressive strength	≥ 50 kN/m ²	≥ 50 kN/m ²
2	Organic component of dry residue in original substance²⁾		
2.01	Determined as ignition loss	≤ 3 % by weight	≤ 5 % by weight ³⁾
2.02	Determined as TOC	≤ 1 % by weight	≤ 3 % by weight
3	Extractable lipophile substances in original substance	≤ 0.4% by weight	≤ 0.8 % by weight
4	Eluate criteria		
4.01	PH value	5.5 - 13.0	5.5 - 13.0
4.02	Conductance	≤ 10,000 µS/cm	≤ 50,000 µS/cm
4.03	TOC	≤ 20 mg/l	≤ 100 mg/l
4.04	Phenols	≤ 0.2 mg/l	≤ 50 mg/l
4.05	Arsenic	≤ 0.2 mg/l	≤ 0.5 mg/l
4.06	Lead	≤ 0.2 mg/l	≤ 1 mg/l
4.07	Cadmium	≤ 0.05 mg/l	≤ 0.1 mg/l
4.08	Chromium-VI	≤ 0.05 mg/l	≤ 0.1 mg/l
4.09	Copper	≤ 1 mg/l	≤ 5 mg/l
4.10	Nickel	≤ 0.2 mg/l	≤ 1 mg/l
4.11	Mercury	≤ 0.005 mg/l	≤ 0.02 mg/l
4.12	Zinc	≤ 2 mg/l	≤ 5 mg/l
4.13	Fluoride	≤ 5 mg/l	≤ 25 mg/l
4.14	Ammonium-N	≤ 4 mg/l	≤ 200 mg/l
4.15	Cyanide, easily liberatable	≤ 0.1 mg/l	≤ 0.5 mg/l
4.16	AOX	≤ 0.3 mg/l	≤ 1.5 mg/l
4.17	Water soluble component (dry matter)	≤ 3 % by weight	≤ 6 % by weight

1) 1.02 may, together with 1.03, be applied in equivalence to 1.01. Strength must in each case be defined separately in accordance with the static requirements on landfill stability.

Particularly in the case of cohesive, finely grained wastes, it shall not be permissible to fall short of the values indicated for 1.02 in conjunction with 1.03.

2) 2.01 may be applied in equivalence to 2.02; requirement shall not apply to contaminated excavated soil deposited on a mono landfill.

3) Shall not apply to ashes and dusts from coal firing plants not subject to licensing under the Federal Immission Control Act (*BImSchG*).

Appendix C

Collection, treatment and analysis of gas from existing landfills

1. Preliminary remark

The requirements set out in this Appendix shall apply to the nature and mode of landfill gas collection, gas analysis as well as to monitoring degassing efficiency.

Landfill gas collection and landfill gas treatment are necessary in order to reduce as far as possible the discharge of gaseous emissions from the landfill into the atmosphere. Gas collection and gas treatment are also necessary in order to prevent the hazard of fire and explosion as well as impairment on vegetation growth on and in the vicinity of the landfill.

2. Definition of terms

Landfill gas

Landfill gas is a mixture which, under favourable conditions, comprises up to 55 % by volume of methane, up to 45 % by volume of carbon dioxide and a host of trace substances. The percentage of trace substances in most cases falls clearly below 1 % by volume. In practice, however, the methane contents are frequently lower since, for example, the landfill gas is diluted with air because of gas collection and gas conveyance. Under normal operating conditions methane contents of about 35 to 55 % by volume must be expected; the calorific value consequently amounts to about 3.5 to 5.5 kWh/m³. According to laboratory investigations, most municipal waste has a potential landfill gas generating capacity of between 150 and 250 m³ gas per tonne of municipal waste.

Landfill gas collector

Facility for the collection and conveying of landfill gas.

Landfill gas collection

In contrast to landfill gas collectors, this term refers to the concept of collecting and conveying landfill gas.

Collection elements (collectors)

Components, which take up the landfill, gas from the landfill body and channel it away under a specific vacuum.

Degree of collection

Ratio between the level of landfill gas being collected and volume being generated at any given time. The volume of gas calculated based on forecast models is only seldom identical with the quantity of gas actually generated. It is therefore not suitable for determining the degree of collection.

FID

Portable instrument for leak detection, space and landfill monitoring, based on the flame ionisation detector in gas chromatography. The instrument is highly sensitive to combustible carbon compounds.

Collector head

Point of connection between the collection element and pipe system. It is possible to equip the collector head with measuring and control facilities.

Trenching

Packed beds with void-forming material exhibiting a higher degree of gas or water conductivity than the surrounding area.

Receiving system

Pipe system forming the connection between collector and central or substation.

3. Landfill gas collection

Gas can only be collected satisfactorily with the aid of active degassing. Passive degassing, in which landfill gas escapes through natural pressure, can only be contemplated in existing landfills with an extremely low level of gas formation.

Degassing must be commenced while the landfill is in operation. The degassing plant must be ready for operation at the latest six months after landfilling begins.

Optimum gas collection will only be guaranteed by a combination of active degassing (base/surface sealing) well as system monitoring and maintenance.

The time history of landfill gas development must be sufficiently known before it is possible to rate the gas collection system and gas treatment facility. The gas quantities are generally computed based on forecast models; in the case of existing landfills, the results must be verified by field trials. Forecast models are not suitable for determining the degree of collection.

4. Collection systems

Collection systems comprise a number of collection elements (collectors) - also differing in type - which are used jointly for landfill degassing.

4.1 General requirements

- The prime objective of degassing is to prevent pollutant emissions as well as to avert dangers and nuisance from landfill gas.
- In order to optimise utilisation of landfill gas, it may be worthwhile separating the collection system into a protective degassing system - which higher air component - and useful degassing system. It must always be possible to reliably drain collection elements of water. Water in the collection elements will render them partially or fully ineffective. Since water must also be expected in all areas of the landfill body in which gas flows, it must be possible to discharge the water in respect of the collection elements.
- Collection systems must be operationally reliable and require little maintenance. Consequently, freely draining collection elements and drainage elements exhibit greater operational reliability than such in which water must be removed by means of pumping.
- Collection systems must not impair the sealing systems. Particularly in the case of collection systems with vertical collection elements, there is a danger that in the event of settlements taking place in the landfill body, the base and surface sealing systems could be subject to strain from the rigid collection elements. Appropriate measures must be taken in this respect to prevent any harmful strain (refer to 4.2).
- Collection systems must be reliably sealed against the inlet of air. The inlet of air may lead to the generation of explosive mixtures. Collection elements still in the process of construction must, in the same way as completed elements, be protected against the admission of air.
- The material from which the collection systems are made must be capable of permanently withstanding any anticipated physical, chemical and biological strain. Physical strain is mainly the result of load in conjunction with high temperatures (up to approx. 70° C). Exposure to chemicals must be expected from gas and leachate constituents, biological strain possibly from waste-decomposing micro-organisms.
- The formation and arrangement of collection elements must also permit the active degassing of the operating area. For this purpose, the pipes must be routed in such a way that they permit unimpeded landfilling operations and reliably prevent the penetration of air.
- The leachate draining systems must not be used for the purpose of active degassing. Active degassing measures bring about a change in temperature and pressure gradients in the drainage layers, leachate flow and the lime-carbon dioxide balance of leachate, possibly resulting in increased incrustation and blockages.

4.2 Collection elements, types and arrangement

As far as collection elements are concerned, a distinction is drawn between

- single-point
- vertical, blanket-type and linear-shaped
- horizontal, blanket-type and linear-shaped

as well as

- combinations of horizontal and vertical collection elements.

Single-point collection elements

Degassing chambers in general filled with coarse material, which, after closing the landfill, is drilled and degassed via probes. Such chambers are difficult to drain. . Therefore, they should only be provided in exceptional cases.

Vertical, blanket-type collection elements

Drainage walls of coarse material (also suitable waste) in the landfill body which are constructed as the landfill is filled. If these are envisaged for reasons of drainage planning, they may also be used for degassing. While they are being constructed, the relevant surface must be sealed with plastic sealing webs in order to permit active degassing without penetration of air.

Vertical, linear-shaped collection elements

Degassing shafts

Owing to the low level of gas permeability and rigidity of shafts, these should only be used in specific instances.

When rating the foundations, sufficient allowance must be made for the load of the landfill body, which, in the event of settlement, will be transferred to the shaft by negative skin friction; edge pressure must also be taken into consideration in the event of shafts deviating from the perpendicular. Sufficient spacing from the surface seal must be maintained.

A drainage pipe of nominal diameter ≥ 200 mm must be built up as the shaft is being constructed. Larger diameters may be necessary where particularly corrosion-resistant leachate pumps (e.g. membrane pumps) are used. In order to enhance the stability of the pipe, it may be expedient to use adequately adjustable pipe joints. The shaft filling material is subject to the same requirements as those applicable to gravel and crushed-stone columns.

During the construction phase, the shaft section projecting beyond the dumping surface must be sealed off with a tight-fitting cap of steel or plastic. Covers of plastic web or tarpaulins have not produced the desired effect.

Gravel or crushed-stone columns

Gravel or crushed-stone columns must be founded on a cushion of fine-grade waste or other equalising material. The cushion thickness shall correspond to 10 - 15 % of the final height, however at least 2 m. Drainage may take place by means of trenchings running at an angle to the landfill base or via permeable foundation material. At least one drainage pipe of up to 200 mm nominal diameter must be built up as the column is constructed. Larger diameters may be necessary where particularly corrosion-resistant leachate pumps (e.g. membrane pumps) are used. In order to enhance the stability of the pipes, it may be expedient to use adequately adjustable pipe joints. The following requirements are placed on the column material: Grain size $\geq 16/32$, carbonate content ≤ 10 % by weight. A minimum space of 2 m from the surface seal is to be maintained.

Gas wells

Gas wells may only be drilled to such a depth that they, maintain a sufficient settlement cushion on the base seal (see above). Enhanced requirements must be placed on the drainage pipes to be installed. Minimum diameter must be 200 mm; it is recommended to install two pipe lines.

Larger diameters may be necessary where particularly corrosion-resistant leachate pumps (e.g. membrane pumps) are used. In order to enhance the stability of the pipes, it may be expedient to use adequately adjustable pipe joints. The shaft filling material is subject to the same requirements as those applicable to gravel and crushed-stone columns.

Horizontal, blanket-type collection elements

Gas drainage layers in the landfill body may be constructed of suitable waste material. Attention must be paid to ensuring an adequate angle of inclination (< 5 %). The bearing layer beneath the surface seal must always be constructed as a gas drainage layer. It should be supplemented by a drainage pipe system to optimise gas collection.

Horizontal, linear-shaped collection elements

The efficacy of gravel sheeted drainage lines in the landfill body is particularly jeopardised by leachate blockages after varying degrees of settlement (subsidence).

Adequate initial gradients (> 7 %), vertical drainage facilities in the landfill body and controllable lines affording the possibility of cleaning are necessary precautions to ensure long-term operational reliability.

The drainage lines must be constructed of heat-resistant plastic materials with a nominal diameter > 250 mm. The requirements on drain material shall correspond to those applicable to gravel and crushed-stone columns. If only horizontal linear-shaped collection elements are employed in the construction of a collection system, such elements must be arranged with a horizontal spacing of approx. 30 m and vertical spacing of approx. 5 - 10 m.

Combination of horizontal and vertical collection elements

Adding horizontal collection elements represents one possibility of enlarging the catchment area of vertical collection elements. These may, for instance, be employed for degassing horizontal drainage lines converging onto a gravel column.

5. Gas collection and control

5.1 General requirements

The prime task of gas collection and control facilities is to enable the gas collectors to catch the accruing landfill gas in such a way as to prevent any major migration from the landfill. The air component of landfill gas must however, be minimised. For this purpose, a finely adjustable suction extraction line must be provided at each collector. It must be possible to attain a vacuum of $p = 3 \text{ kPa}$ (30 mbar) at each collector head in any operating status. The velocity of gas in the receiver lines is to be less than 10 m/s. In rating the collection system, allowance must be made for the fact that the theoretically determined gas formation capacities include major uncertainties and, in addition, air is able to penetrate the system.

Landfill gas is corrosive and produces deposition, particularly on the control facilities. Allowance must be made for this in respect of design, material selection and maintenance.

Landfill gas is explosive when mixed at specific concentrations with air. When planning the facility, therefore, it shall be necessary to heed the relevant specification sheets and guidelines.

The facility must be examined for safety by an expert and recognised body. Inspection of this type must be repeated at regular intervals and, in particular after any modification activities.

5.2 Collection and control systems

General

The line network is subject to physical, chemical and biological strain. Allowance must be made for these factors when rating the facility, constructing the pipe system as well as in selecting the materials. Tension and deformations in the pipe network will be caused by settlement of the landfill body and exposure to temperature.

- In order to avoid the formation of troughs, all gas and condensate pipes in areas subject to settlement must be installed below ground at a gradient of least 5 % or above ground at gradient of at least 2.5 %.

- The horizontal and vertical movements of collectors must be absorbed at all times by flexible connections.
- Central stations must and substations should be erected on ground exhibiting an adequate load-bearing capacity.
- The aspects of safety, particularly in the area of central stations, may require the use of materials affording particular properties (compressive strength, electrical conductance, heat resistance etc.).

The collection system must not be located below the surface seal.

In order to enhance operational reliability and minimise pressure loss, pipe inside diameters should be ≥ 100 mm.

Preference must be given to the use of recycled material for embedding and burying the pipes.

Suitable measures must be taken to prevent the degassing system from freezing.

Receiving systems

Gas collectors may be linked to the central stations directly or via intermediate receivers. When connected individually, the gas collectors are linked directly to the central station. Although the requisite pipe system is complicated to construct, it is easy to monitor and adjust.

When connected in groups, individual gas collectors are collated into substations and linked with the central stations via a single or two-line system. The additional time requirement for the monitoring and adjustment of group connections at substation level contrasts with a shorter overall length of piping, in particular where large landfills are concerned;

Direct connection to a ring main or pipe network should only be selected in conjunction with a small number of collectors owing to the time-consuming process of mutual coordination.

Control systems

Control must take place by monitoring the quantity and quality of gas and comparison with a specific range of values. Manually monitored control variables must be determined at least once a week.

5.3 Condensate separation

The water-vapour saturated landfill gas precipitates condensate in the pipe system. It must undergo regular examination. The volume of water occurring when the gas cools down from 55° C to 20° C (approx. 100 g/m³ of landfill gas) must be regarded as the basis for rating the condensate volume.

Suitable measures must be employed to ensure that no air can be sucked into the pipe network via the condensate separator.

The condensate must be managed in accordance with means available in the state of the art. In many cases, it may be managed together with the leachate.

6. Monitoring the efficiency of degassing

The discharge of gas from the landfill surface must be prevented and landfill gas must be prevented from migrating into the area surrounding the landfill, or at least be - minimised to such an extent that no detrimental effects need be feared.

Open landfills or landfill sections

In addition to the weekly degassing efficiency check performed by the landfill operator, an external check must be carried out every three months by an expert body.

Finally covered and sealed landfills or landfill sections

The efficiency of active degassing must be monitored every six months by means of FID at the landfill surface and peripheral landfill area as part of the external control activity.

Freedom from landfill gas in the vegetation layer of the landfill cover and in the area surrounding the landfill shall be checked by means of gas level indicators. The efficiency of degassing in landfills not sealed at the base and/or edges must be established by means of regular measurements at the level indicators located on the landfill perimeter (fence). The level indicators covering the gas-conductive layer must be spaced apart by no more than 50 m.

In order to examine the migration of gas from sealed landfills, level indicators may be spaced further apart.

7. Landfill gas analyses

Landfill gas analyses have the purpose of gaining information on the quality and quantity of the gas collected. An initial landfill gas analysis must be conducted three months after the active degassing facility is put into operation.

Scope of analysis

Using existing or appropriately positioned gas collectors, the collectability and gas formation potential must be ascertained by conducting a suction extraction test lasting for a period of at least one month. The subsequent landfill gas measurements must determine the contents of at least the following gas components:

Methane, carbon dioxide, nitrogen, oxygen, total chloride, total fluorine, total sulphur, benzene and chloroethene (vinyl chloride).

The scope of analysis must be extended in specific instances. In this context, allowance must also be made for the condensate.

Irrespective of necessary emission measurements at combustion and other treatment plants, and landfill gas measurements necessary in this context as well as measurements to optimise the facility, the landfill gas collected must be analysed at least once a year for the above-mentioned "minimum scope". In cases where landfill gas is collected and treated separately, each flow portion must be analysed in the way described above.