IMPEL LANDFILL PROJECT
Inspection guidance book for Landfill inspection

A practical book with guidance on activities on landfills
(Revision 2016)

European Union Network for
the Implementation and Enforcement
of Environmental Law

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the EU Member States, acceding and candidate countries of the European Union and EEA countries. The association is registered in Belgium and its legal seat is in Bruxelles, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 6th Environment Action Programme and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

Information on the IMPEL Network is also available through its website at:

www.impel.eu

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Executive summary:

During the length of the project (2011-2016) we have been working on the project Reinforcement programme on inspections skills according to the landfill directive.

The Council Directive 1999/31/EC on the landfill of waste and the Council Decision of May 2002 establishing criteria and procedures for the acceptance of waste at landfills (2003/33/EC) set standards for the authorisation, design, operation, closure and aftercare of landfills.

Improving implementation of EU law is a high priority objective of both the European Commission and IMPEL. Recent reports on implementation of EU waste legislation have shown that "*implementation and enforcement of EU waste law remain poor particularly regarding the waste framework directive, the landfill directive and the waste shipment regulation*".

The project Landfill inspection started in 2011. The objectives of the project:

- identification of good inspection practices, developing guidance;
- improve cooperation between IMPEL member countries to work towards a consistent regulatory and enforcement regime;
- to give feedback to policy makers on (effectiveness) of the various approaches and practices in the field of permitting and inspection of landfill sites in the IMPEL member countries.

2011

In 2011 an information exchange forum was organized in Basecamp and the kick off meeting was held in Sardinia (Italy).

As an inspection at a landfill has to cover different subjects, the inspection team decided to choose certain subjects to focus on during the joint inspections. The results of the 2011 workshop and the information exchange forum showed that the activities, on which the project will focus, to begin with, were:

(1) Criteria and procedures for the acceptance of waste.

(2) Gas control.

(3) Protection of soil and water (underground water).

(4) Water control and leachate management.

2012

The aim of the project in 2012 has been to improve inspections skills for landfills by two joint inspections in Slovenia and Romania. Guidance and inspection tools that are available from the different EU member states have been used and checklists to be used during the inspections were developed. During a workshop in Utrecht in October 2012 the joint inspections were evaluated and the practicability of guidance's and tools used was discussed. A visit to the landfill Smink Hoogland (Amersfoort) has been performed.

2013

In 2013 three joint inspections have been performed in Czech Republic, Croatia and Poland. Each inspection group focused on different pre-defined topics

2014

A 3 days training session has been hosted by the Environment Agency of UK in Birmingham and a visit to a local landfill has been performed. Inspectors from England exchanged their knowledge and experience with the inspectors according to:

- procedures for the acceptance of waste,
- hazardous waste classification,
- sampling plans for waste,
- monitoring trigger level of groundwater,
- requirements on the conditions of top layers and bottom liners,
- biogas monitoring,
- water management (groundwater and leachate)

A further joint inspection was carried out in Lisbon. In 2014 we also worked on an inventory according to waste acceptance, sampling plan, groundwater trigger level, treatment of waste, stable non-reactive waste, leachate management, requirements on top and bottom layers, meteoric and surface water and monitoring report.

2015

Four working groups were identified to revise Guidance and checklists. Each of them dealing with a different topic. Two joint inspections were held in Wien and Santiago, focusing on practical experience on sampling of waste and groundwater by external laboratory.

2016

The biggest landfill in Malta was visited by the inspection group. The opportunity to draft a document to give feedback to the EU Commission on the main gaps of the Landfill Directive tackled during the performed site-visit was discussed.

Disclaimer:

This report is the result of a project within the IMPEL network. The views expressed in this document are solely of the individual participating within the project at the time and it does not in any way maybe applied, used or assumed, as the views and situation of the whole Country being represented within the project.

The content does not necessarily represent the view of national administrations or the European Commission.

CONTENT

ACRONYMS AND ABBREVIATIONS

AT	Austria
BAT	Best Available Technology
BC	Basic Characterization
CEN	European Committee For Standardization
CLP	Regulation (Ec) No 1272/2008 On The Classification, Labelling And Packaging Of Substances And Mixtures
CQA	Construction Quality Assurance
CQAP	Construction Quality Assurance Plan
DE	Germany
DK	Denmark
DOC	Dissolved Organic Carbon
EEA	European Economic Area
EEC	European Economic Community
EEC	European Economic Community
ELV	Emission Limit Value
EMAS	Community Eco-Management And Audit Scheme
EMP	Environmental Monitoring Plan
EMS	Environmental Management System
EU	European Union
EWC	European Waste Catalogue
FI	Finland
FID	Flame Ionization Detector
FR	France
HP	Hazardous Properties
IED	Industrial Emission Directive
IMPEL	European Union Network For The Implementation And Enforcement Of Environmental Law
LFG	Landfill Gas
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PRTR	Pollutant Release And Transfer Register
REACH	Registration, Evaluation, Authorization And Restriction Of Chemicals
SE	Sweden
TDS	Total Dissolved Solid
TOC	Total Organic Carbon
UK	United Kingdom
VOC	Volatile Organic Compounds
WAC	Waste Acceptance Criteria

1. Introduction

1.1. Purpose and context

Improving implementation of EU law is high a priority objective of both the European Commission and IMPEL. Recent reports on implementation of EU waste legislation have shown that "*implementation and enforcement of EU waste law remain poor particularly regarding the waste framework directive, the landfill directive and the waste shipment regulation*".

According to the waste management hierarchy, landfilling is the least preferable option and should be limited to the necessary minimum. Where waste needs to be landfilled, it must be sent to landfills which comply with the requirements of Directive 1999/31/EC on the landfill of waste.

The Council Directive 1999/31/EC on the landfill of waste set standards for the authorization, design, operation, closure and aftercare of landfills.

The acceptance criteria and the acceptance process are further specified in Council Decision 2003/33/EC. This includes a detailed description of waste characterisation procedures, limit values for waste composition and leaching behaviour as well as acceptance procedures to be executed at each landfill site.

Member States must ensure that existing landfill sites may not continue to operate unless they comply with the provisions of the Directive and Council Decision.

Within the last years, important efforts have been taken in order to meet the established legal requirements. However, infringement cases, complaints and petitions received by the European Commission show that there are deficits in implementation.

The project Landfill inspection started in 2011. The objectives of the project are:

- identification of good inspection practices, developing guidance and checklist;
- cooperation (and helping each other) between IMPEL member countries to work towards a consistent regulatory and enforcement regime;
- feedback to policy makers on the effectiveness of various approaches and practices in the field of permitting and inspection of landfill sites in the IMPEL member countries;
- Improvement of enforcement cooperation between authorities concerned at landfills.

A core team to achieve these main project objectives worked together during the length of the project. These objectives have been achieved by:

- carrying out joint inspections in landfill across Europe to exchange experiences and knowledge: 16 Member States participated to the joint inspections with their inspectors, dealing with the main environmental critical aspects of landfill management;
- organising a training session with the expert from the UK Environment Agency;
- developing Guidance and checklist to be used in the preparation of an inspection;
- extending the use of Basecamp under the IMPEL website for experts in all IMPEL member Countries as an exchange platform for information and specific questions, discussions etc.
- handing out a survey to highlight the gaps of the Landfill Directive across EU; 12 Member States filled in the survey.

The following picture shows where the joint inspections have been performed during the project:

Figure 1: Landfill visited along the project

The following project reports are available on the IMPEL website:

- Report Landfill project (2011-2012)
- Report Landfill project (2013)
- Report Landfill project (2014)

- Landfill project report 2014: Annex III Inventory Analysis (protected)

1.2. Structure of the Guidance book

The FIRST part of the Guidance (Chapter 2) is dedicated to the presentation of the relevant legislation about Landfill.

The SECOND part of the Guidance (Chapter 3) provides an overview of the main contents of the steps of the organisation of an environmental inspection (preparation, execution, reporting), according to Industrial Emission Directive (IED).

The THIRD part of the Guidance (Chapter 4-9) gives technical details for specific subjects to be covered during a landfill inspection; the topics focused in the Guidance are the following.

- Waste acceptance criteria for landfills classification of waste and sampling procedures
- Waste acceptance: pre-treatment of waste and stable non-reactive waste
- Biogas control
- Protection of soil and groundwater
- Water control and leachate management
- Top and bottom layers

Reference is given to existing guidance's and tools in EU member states.

The FOURTH part of the Guidance (Annex I-II) consists of a checklist to be used for the preparation of the landfill inspection and a checklist to be used on-site.

2. Landfills legislative references

2.1. Landfill directive

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste came into force on 16 July 1999. The deadline for implementation of the legislation in the Member States was 16 July 2001. All new and existing landfills had to fully comply with the requirements of Directive 1999/31/EC on the landfill of waste (Landfill Directive) at the latest by 16 July 2009 or as indicated in the accession treaties (for new member states). Detailed description on acceptance criteria and the acceptance process have been set by Council Decision 2003/33/EC. This decision entered into force on 16 July 2004 and the limit values had to be applied in the Member States at the latest by 16 July 2005.

The Directive 1999/31/EC on the landfill of waste and the Decision 2003/33/EC on acceptance criteria set standards for the authorisation, design, operation, closure and aftercare operations at landfills. The objective of the directive is to prevent or reduce as far as possible negative effects on the environment from the land filling of waste, by introducing stringent technical requirements for waste and landfills. The directive is intended to prevent or reduce the adverse effects of the landfill of waste on the environment, in particular on surface water, groundwater, soil, air and human health. It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills defined as waste disposal sites for the deposit of waste onto or into land.

Member States must ensure that existing landfill sites may not continue to operate unless they comply with the provisions of the Directive.

Landfills are distinguished into three classes:

- landfills for hazardous waste;
- landfills for non-hazardous waste (these landfills may be used for (i) municipal waste (ii) non-hazardous waste of any origin, which fulfil the criteria for the acceptance of waste at landfill for non-hazardous waste set out in accordance with annex II (and Council decision 2002/33/EC) iii) stable, non-reactive hazardous waste (e.g. solidified, vitrified) with leaching behavior equivalent to those of the non-hazardous waste referred to in point (ii) which fulfil the relevant acceptance criteria set out in accordance with Annex II (and Council decision 2002/33/EC). These hazardous waste shall not be deposited in cells destined for biodegradable non-hazardous waste);
- landfills for inert waste (waste that does not undergo any significant physical, chemical or biological transformations).

The Landfill Directives excludes the following activities:

- the spreading of sludge's, including sewage sludge's and sludge's resulting from dredging operations and similar matter on soil for the purposes of fertilisation or improvement;
- the use of inert waste which is suitable in redevelopment / restoration and filling-in work, or for construction purposes in landfills;
- the deposit of non-hazardous dredging sludge's alongside small waterways from where they have been dredged and of non-hazardous sludge's in surface water including the bed and it's sub soil;
- the deposit of unpolluted soil or non-hazardous inert waste resulting from prospecting and extraction, treatment and storage of mineral resources as well as from the operation of quarries.

The following types of wastes may not be accepted at a landfill:

- liquid waste;
- flammable waste;
- explosive or oxidising waste;
- hospital and other clinical waste which is infectious;
- used tyres, with certain exceptions;
- any other type of waste which does not meet the acceptance criteria laid down in Annex II of the directive.

The Directive sets up a system of operating permits for landfill sites. Applications for permits must contain the following information:

- the identity of the applicant and, in some cases, of the operator;
- a description of the types and total quantity of waste to be deposited;
- the capacity of the disposal site;
- a description of the site;
- the proposed methods for pollution prevention and abatement;
- the proposed operation, monitoring and control plan;
- the plan for closure and aftercare procedures;
- the applicant's financial security;
- an impact assessment study, where required under Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

Member States must ensure that existing landfill sites may not continue to operate unless they comply with the provisions of the Directive as soon as possible.

More information about the landfill directive is available on the website of the European commission: Waste - Environment - European Commission.

2.2. Council Decision of 19 December 2002 (2003/33/EC)

Council Decision 2003/33/EC contains criteria and procedures for the acceptance of waste at landfills. For more detailed information about the content see chapter 4.

2.3. Waste Framework Directive

Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours and without adversely affecting the countryside or places of special interest.

More information about this Directive and the Guidance on the Waste Framework directive are available on the following website: Directive 2008/98/EC on waste (Waste Framework Directive) - Environment - European Commission

2.4. Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste (COM/2015/0595 final – 2015/0275) and Directive 1999/31/EC on the Landfill of Waste (COM/2015/0594 final - 2015/0274)

The Union's economy currently loses a significant amount of potential secondary raw materials which are found in waste streams. In 2013, total waste generation in the EU amounted to approximately 2.5 billion tons of which 1.6 billion tons were not reused or recycled and therefore lost for the European economy. It is estimated that an additional 600 million tons could be recycled or reused. By way of example, only a limited share (43%) of the municipal waste generated in the Union was recycled, with the rest being landfilled (31%) or incinerated (26%). The Union thus misses out on significant opportunities to improve resource efficiency and create a more circular economy.

With respect to waste management, the Union also faces large differences amongst its Member States. In 2011, while six Member States landfilled less than 3% of their municipal waste, 18 landfilled over 50%, with some exceeding 90%. This uneven situation needs to be readdressed as a matter of urgency.

The proposals to amend Directive 2008/98/EC on waste 1 , Directive 94/62/EC on packaging and packaging waste 2, Directive 1999/31/EC on the landfill of waste 3 , Directive 2000/53/EC on end-of-life vehicles 4, Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators 5 and Directive 2012/19/EU on waste electrical and electronic equipment 6 form part of a Circular Economy Package which also includes a Commission Communication "Closing the loop – An EU action plan for the Circular Economy".

By virtue of Article 5(2) of the Landfill Directive, by 2014, the Commission was required to prepare a report based on the practical experience gained by Member States in the pursuance of the targets laid down in Articles 5(2)(a) and 5(2)(b) of that Directive, accompanied, if appropriate, by a proposal with a view to confirming or amending these targets in order to ensure a high level of environmental protection.

On 2 July 2014, the European Commission adopted a legislative proposal to review waste-related targets in the Landfill Directive as well as recycling and other waste-related targets in Directive 2008/98/EC on waste and Directive 94/62/EC on Packaging and Packaging Waste. The proposal aims at phasing out landfilling by 2025 for recyclable waste (including plastics, paper, metals, glass and bio-waste) in non-hazardous waste landfills, corresponding to a maximum landfilling rate of 25%.

Summary of the proposed action

The main elements of the proposals to amend EU waste legislation are:

- Alignment of definitions;
- Increase of the preparing for re-use and recycling target for municipal waste to 65% by 2030;
- Increase of the preparing for reuse and recycling targets for packaging waste and the simplification of the set of targets;
- Gradual limitation of the landfilling of municipal waste to 10% by 2030;
- Greater harmonisation and simplification of the legal framework on by-products and end-of-waste status;
- New measures to promote prevention, including for food waste, and re-use;
- Introduction of minimum operating conditions for Extended Producer Responsibility;

- Introduction of an Early Warning System for monitoring compliance with the recycling targets;
- Simplification and streamlining of reporting obligations;
- Alignment to Articles 290 and 291 TFEU on delegated and implementing acts. “

2.5. List of waste - Council Decision of 3 May 2000(Council Decision 2000/532/EC)

The Council decision contains rules about classifying different types of waste according to chapters in the list of waste and the content of one or more substances with hazardous properties. A waste is defined by a six digit code. The code is identified by using steps described in the Annex to the Council decision. The list of wastes are divided into 20 chapters. Waste are classified to be hazardous if it has a content of substances that have hazardous properties. The hazardous properties are listed in Annex III in the Waste Framework Directive (2008/98/EC). There are 15 properties (H1-H5). The content is calculated according to the legislation on chemicals and often contains limit values of concentration.

The Commission decided on changes on the 18 December 2014. (Council decision 2014/955/EC). The changes is adaption of the Decision to the new legislation on chemicals (CLP). The hazardous properties are now called HP1-HP15.

2.6. On-going work by the Commisson

Study to assess the impacts of different classification approaches for hazard property "H 14" on selected waste streams (2015)

The legislation governing waste classification was reviewed at the end of 2014 in order to adapt it to technical and scientific progress and to align, to the extent possible, to Regulation 1272/2008 on classification, labelling and packaging of substances and mixtures.

One issue left out of the review of the Legislation Governing Waste Classification was the hazardous property H 14 (ecotoxicity) of Annex III of Directive 2008/98/EC. The Commission considered that further information was needed in order to propose a well-grounded and justified definition of criteria for H 14 and, if appropriate, align the decision and the Directive with the CLP criteria.

Study to develop a guidance document on the definition and classification of waste (2015)

The legislation concerning waste classification has been recently reviewed. Those involved in the production, assessment, management and regulation of hazardous waste are in need of a comprehensive reference manual which provides technical guidance on the assessment and classification of hazardous waste.

The objective of this study was to assist the Commission in the development of such a guidance document, based on a thorough analysis of the legislative framework, the relevant literature and, if needed field research, and contributions from experts (from competent authorities, testing laboratories, industry and waste management practitioners).

2.7. Industrial Emissions Directive

Some landfills covered by Council Directive 1999/31/EC on the landfill of waste also fall within the scope of Council Directive 2010/75/EU concerning Industrial Emissions (integrated

pollution prevention and control) the successor of the IPPC directive. The Industrial Emission Directive (IED) entered into force on 6 January 2011 and had to be transposed into national legislation by member states by 7 January 2013.

Landfills that fall within the scope of Industrial Emission Directive are the following categories of activities in annex 1:

- 5.4 Landfills as defined in Article 2(g) of Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25 000 tonnes, excluding landfills of inert waste;
- 5.6 Underground storage of hazardous waste with a total capacity exceeding 50 tonnes.

For these landfills both the Landfill Directive and the Industrial Emissions Directive have to be taken into account. This means the following additional requirements for these landfills:

- **Updating of permit conditions**: Article 21 of the Industrial Emission Directive requires competent authorities to periodically reconsider permit conditions and where necessary to ensure compliance with the Directive to update those conditions. New is that within 4 years after publication of decisions on BAT conclusions the competent authority shall ensure that (a) all the permit conditions for the installation concerned are reconsidered and if necessary updated to ensure compliance with the Directive (in particular Article 15(3) and (4) where applicable) (b) the installation complies with those permit conditions. When an installation is not covered by any of the BAT conclusions the permit conditions shall be reconsidered and if necessary updated where developments in the best available techniques allow for significant reduction of emissions. For landfills no BAT conclusions have been developed. (BAT are the conditions of the Landfill directive).
- **Applications for permits**: Article 12 of the Industrial Emission Directive specifies information that must be included in the application for a permit. Much, but not all of this information is also required under the Landfill Directive (Art. 7). On the other hand some requirements are specific to the Landfill Directive (see Article 7(i)). It should be noted that the IED requires information on the sources of emissions from the installation as well as the nature and quantities of foreseeable emissions into each medium and identification of significant effects on the environment. An application for an landfill has to comply with both the provisions of Article 12 of the Industrial Emission Directive and Article 7 of the Landfill Directive.
- **Access to information and public participation in the permit procedure**: Article 24 of the Industrial Emissions Directive requires that permit applications for new or substantially changed installations are made available to the public. The public is given the right to comment on them before the competent authority reaches its decision. The decision, a copy of the permit, permit updates and the results of release monitoring must be made available to the public. No corresponding provision exists in the Landfill Directive. Any landfill also covered by the Industrial Emission Directive must be made subject to public participation and information as outlined above.
- **Environmental inspections**: Article 23 of the Industrial Emission Directive requires that member states shall ensure that all installations are covered by an environmental inspection plan at national, regional or local level and shall ensure that this plan is regularly reviewed and where appropriate updated. The period between two site visits shall be based on a systematic appraisal of the environmental risks of the installations concerned and shall not exceed 1 year for the installations posing the highest risk and 3 years for installations posing the lowest risks. Following each visit the competent authority shall prepare a report describing the relevant findings regarding compliance of the installation with the permit conditions and conclusions on whether any further action is necessary. The report shall be notified to the operator concerned within 2 months of the site visit taking place. The report shall be made publicly available by the competent authority in accordance with Directive

2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information within 4 months of the site visit taking place.

More information on the Industrial emission directive is available on the website: The Industrial Emissions Directive - Environment - European Commission

2.8. Monitoring requirements

Landfill Directive: Article 12 "Control and monitoring procedures in the operational phase".

Member States shall take measures in order that control and monitoring procedures in the operational phase meet at least the following requirements:

a) The operator of a landfill shall carry out during the operational phase a control and monitoring programme as specified in Annex III;

b) The operator shall notify the competent authority of any significant adverse environmental effects revealed by the control and monitoring procedures and follow the decision of the competent authority on the nature and timing of the corrective measures to be taken. These measures shall be undertaken at the expense of the operator.

   At a frequency to be determined by the competent authority, and in any event at least once a year, the operator shall report on the basis of aggregated data. All monitoring results are to be sent to the competent authorities for the purpose of demonstrating compliance with permit conditions and increasing the knowledge on waste behaviour in the landfill.

c) The quality of the analytical operations of the control and monitoring procedures and/or of the analysis referred to in Article 11(1)(b) are carried out by competent laboratories.

IED Directive

Article 14 "Permit conditions"

Member States shall ensure that the permit includes all measures necessary for compliance with the requirements of Articles 11 and 18. Those measures shall include:

c. suitable emission monitoring requirements specifying (i) measurement methodology, frequency and evaluation procedure;

d. an obligation to supply the competent authority regularly, and at least annually, with: (i) information on the basis of results of emission monitoring referred to in point (c) and other required data that enables the competent authority to verify compliance with the permit conditions.

Article 16 Monitoring requirements

1. The monitoring requirements referred to in Article 14(1)(c) shall, where applicable, be based on the conclusions on monitoring as described in the BAT conclusions.

2. The frequency of the periodic monitoring referred to in Article 14(1)(e) shall be determined by the competent authority in a permit for each individual installation or in general binding rules.

Without prejudice to the first subparagraph, periodic monitoring shall be carried out at least once every 5 years for groundwater and 10 years for soil, unless such monitoring is based on a systematic appraisal of the risk of contamination.

3. Inspection organization

3.1. Inspection preparation (See Annex I: Desk study check list)

There are different types of inspections to be performed at an installation. i.e.:

- regular, announced on-site inspection;
- regular, not announced inspection (according to an inspection plan)
- inspections in case of accidents, incidents and complaints.

The collection and evaluation of existing information about the installation is critical for the success of the inspection since it allows the easier formulation of targeted questions for the interview of the operator and the concrete investigation of those unit operations which show the highest potential for not complying with the conditions set in the permit.

Examples of information to be collected are listed below:

1. Environmental permit
2. Reports of previous inspections of the site
3. Environmental reports submitted by operator, including monitoring reports
4. Communications sent by the operator (incidents, modifications, requests, etc.);
5. PRTR and other registers such as register of polluting substances into air, register of waste producers and managers
6. Complaints received about the installation
7. Information on installation to be inspected received from other competent authorities
8. Application for the permit
9. Maps
10. Information available on the website of the operator.

The inspection team shall decide on the type of inspection and on the resources, including staff and equipment, which will be assigned to the task.

The analysis of the technical data acquired during the desk study allows to better prepare the checklist and Inspection Agenda that will be used during the site visit.

On the basis of the evaluation of the collected information the following has to be prepared:

- a comprehensive questionnaire which will be used for the operator's interview;
- a check list to facilitate the inspection;
- an outline of the "critical" ELV (i.e. those parameters which significantly contribute to the pollution load coming out of the installation);
- the list of BATs (according to the issued permit) which the operator should have installed and operated;
- the list of documentation to be provided by the operator (e.g. self-monitoring records, annual reports submitted to the authorities);

- the inspection notes and report templates (tailor-made for the installation) to be filled in at the end of the inspection;
- Agenda of the inspection.

The following parts of the Landfill Directive guarantee that information at the different stages being permit application, control/monitoring and not normal operation should be supplied to the competent authorities. This information should be used to prepare a landfill inspection on site.

Permit (application)

Article 7, Application for a permit according to the directive a application shall at least contain the following:

(a) the identity of the applicant and of the operator when they are different entities;
(b) the description of the types and total quantity of waste to be deposited
(c) the proposed capacity of the disposal site
(d) the description of the site, including its hydro geological and geological characteristics
(e) the proposed methods for pollution prevention and abatement
(f) the proposed operation, monitoring and control plan
(g) the proposed plan for the closure and after-care procedures
(h) impact assessment 85/337/EEC
(i) financial security by the applicant or any other equivalent provision

Control and Monitoring programme

Article 12, control and monitoring procedures in the operational phase

(a) the operator of a landfill shall carry out during the operational phase a control and monitoring programme as specified in Annex III;

Annex III contains conditions about:

2. meteorological data
3. emission data: water, leach ate and gas control
4. protection of groundwater
5. topography of the site: data on landfill body
6. specific requirements for metallic mercury

Notification of operator to competent authority of any adverse environmental effects

Article 12 under b

(b) The operator shall notify the competent authority of any significant adverse environmental effects revealed by the control and monitoring procedures

Report all monitoring results to the competent authorities

Article 12 under b
(b) At a frequency to be determined by the competent authority, and in any event at least once a year, the operator shall report, on the basis of aggregated data, all monitoring results to the competent authorities for the purpose of demonstrating compliance with permit conditions and increasing the knowledge on waste behaviour in the landfills.

3.2. On site inspection

The aim of the inspection will be to check compliance of the operator with the operating/environmental conditions set in the issued permit and the Landfill directive and Council Decision.

The first step of the inspection visit is the opening meeting, when the leader of the inspection team presents the members of the team and explains the purpose of the visit.

The organisation of the visit, according to the inspection Agenda, is presented by the leader of the inspection team, to agree on the stages of verification and define the staff to be made available by the company to follow one or more phases of the inspection. It is worth asking the operator to describe the status of the plant (to assess potential modifications) and to evaluate briefly the results of last monitoring assessments.

Should the need arise that an inspector has to check the administration during an inspection, it could be helpful to start the inspection with handing over a list with documents that the inspector needs to see. While executing the inspection outside (checking the technical installation) the company will have time to gather all the relevant documents. Returning from the technical inspection the inspector can assess the documentation.

During the administration checking, the following items should for example be verified:

- Waste input/output register;
- Maintenance operations register;
- Self monitoring register;
- Communications to Competent Authority (incidents etc);
- EMS Procedures.

On site technical inspections could include the following visual controls:

- steepness of slopes;
- content of top layer;
- condition of top layer;
- handling of waste;
- storage of waste;
- leachate and rainwater management.

Everything that can be found during inspections may be worth being collected and treated as evidence and must be attached to the report.

The inspection visit ends with a conclusive meeting when detected strengths and weaknesses are discussed and minutes of inspection are drafted and signed.

To sum up, the following steps can be followed:

- identify yourself. Clearly introduce yourself and show your identification card at the beginning of each inspection;
- explain purpose the of visit;
- the operating/environmental conditions set in the issued permit will be the guidance throughout the inspection. Use of the checklist to lead the inspection;
- if necessary take samples, and/or define the samples that should be taken by a certified laboratory;

- always record your inspection with photographs and/or videos. They are fundamental as a proof in Court.

It must be checked that all BATs that are prescribed in the permit are present and that the corresponding Emission Limit Values are met.

European Commission to support Member States enforcement actions and inspections concerning the application of EU waste legislation published a Practical Manual which include several questions about landfill inspection as follows. These questions can be used as part of the check list and focus on:

- Waste acceptance procedures
- Basic characterisation
- Compliance testing documents
- Documentation of the waste flow: traceable, complete and consistent (identification form, single weighing bridge documents, landfill internal monthly list, report of type and quantity of waste to the competent authority)
- Self monitoring results (leachate volume, leachate composition, volume and composition of surface water, potential gas emissions and atmospheric pressure in line with the permit, national legislation or the Landfill Directive)
- Waste Handling
- Biodegradable waste
- Asbestos waste
- Gypsum waste
- Fugitive Emissions

3.3. After inspection

After an inspection the following activities can be performed:

- record inspection in database;
- determine if changes in permit are necessary;
- determine environmental impact;
- written information (to operator).

In case of irregularities detected / identified the following general procedures are possible:

- administrative order;
- administrative ruling in terms of permit conditions, i.e. setting new additional conditions within a permit;
- sanctions, fines and penalties;
- withdrawal of a permit.

Member state legislation has to be consulted to check what kind of procedure is to be applied in case of irregularities and incompliance.

After the inspection, according to Article 23(6) of IED, the inspector has to draft a final inspection report describing the relevant findings regarding compliance of the installation with the permit conditions and conclusions on whether any further action is necessary.

The report shall be notified to the operator concerned within 2 months of the site visit taking place.

The report shall be made publicly available by the competent authority in accordance with Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information within 4 months of the site visit taking place.

The main contents of such a report are the following:

1. Baseline of the inspection

- Inspection basis (permit, legal regulations)
- Competent inspection authority, cooperating inspection authorities
- Class of landfill: Inert, Non hazard (B1, B2, B3), or hazardous wastes
- Phase: Before operating, open landfill, before closure, after closure))
- Operator (Name of the company)
- Address
- Date of inspection
- Length of inspection time
- Scope of the inspection (e. g. integrated inspection, media that were inspected, parts of the installation that were inspected)
- Kind of inspection (regular, extraordinary, control)

2. Inspection's results

- No or only minor non-compliances
- Significant or relevant non-compliances
- Serious or important non-compliances

3. Recommended corrective measures

- Minor corrective measures
- Significant or major corrective measures
- Serious or important corrective measures

The inspection report and any other additional material used for the preparation of the inspection should be stored and made accessible to any relevant authorities for their information.

4. Waste acceptance criteria for landfills and sampling procedures

To lower the impact of disposal of waste on the environment, landfills must be build with higher technical standards according to the Landfill Directive. The next step is to ensure that the different types of wastes are going to a landfill that provides a minimum of leakage of (any kind of) substances to the environment. The waste and its content of substances, leaking behaviour and other properties gives the type (class) of landfill. Thus the waste acceptance procedure is as important as landfill construction on a high technical level, i.e. with appropriate bottom sealing, leakage treatment, gas treatment and top cover etc..

The *waste acceptance procedure* at a landfill has to be split into 2 parts: the *pre-acceptance* and the *acceptance procedure*. Waste treatment sites require information and/or samples to be provided prior to the transport of waste to the site, to be sure that the waste is within the requirements of the site licence (thresholds / limitations). *Pre-acceptance* includes (in most cases) taking a sample (or various samples), completing an identification form, carrying out the chemical analysis and then assessing whether the waste can be accepted at the landfill or not.

Pre-acceptance is split into a *basic characterisation* (mostly performed by the waste producer) and the more simplified *compliance testing* (usually performed by the waste producer) aiming to determine if the waste complies with the results of the basic characterisation and the relevant acceptance criteria. The basic characterisation and analysis of a sample is required for each batch of incoming waste, in case these wastes are not regularly generated in the same process, in the same installation and are not part of a well-characterised waste stream.

Particular attention has to be paid to mirror-code waste, as the analysis also has to determine whether the waste is hazardous or not and the relevant hazard properties as well.

When the waste is accepted at the landfill, in most countries an unique code is assigned to the waste stream. Each delivery has an unique code. Upon delivery the waste is depending on the kind of waste tested. When waste is accepted the facility signs a declaration and sends a copy of this to the waste producer.

The last activity performed by the operator is the *on-site verification*: each load of waste delivered to a landfill is visually inspected before and after unloading and the required documentation is checked. Sometimes sampling and analysis are being performed by the operator.

4.1. Legal requirements in Landfill Directive & Council Decision

Acceptance criteria for landfills

In the Council decision of 19 December 2002 - establishing criteria and procedures for the acceptance of waste at landfills - most of the specified legislation on the subject of acceptance of waste at landfills are given.. It defines fundamental requirements for basic characterization of the waste and for testing. In paragraph 2 of the annex "*waste acceptance criteria*" criteria for the acceptance of waste at each landfill class (including underground storage) are given.

There are limit values for the following six types of landfills:

- landfill for inert waste (leaching values and total content)
- landfill for non-hazardous waste without testing (municipal waste)
- landfill for non-hazardous waste in same cell as stable non-reactive hazardous
- waste (leaching values and total content)

- landfill for non-hazardous gypsum waste without testing (in special cells without biodegradable waste)
- landfill for non-hazardous that accepts hazardous waste (leaching values and other criteria)
- landfill for hazardous waste (leaching values and other criteria).

Figure 2: An example of contaminated inert waste

Waste classification

Waste classification is based on the European List of Waste and if the waste has any hazardous properties. Member states have implemented this European legislation in national law, mostly as ordinances and regulations. More information on the European list of waste: Commission Decision on the European List of Waste (COM 2000/532/EC), Waste Framework Directive: Annex III to Directive 2008/98/EC

Sampling of waste

Sampling and testing of waste is covered by Article 4 of the Council Decision 2003/33/EC. Section 3 of the Annex comprises the issues of sampling and testing methods.

When Directive 2003/33/EC came into force the European Standard EN 14899 (*Characterisation of waste – sampling of waste materials – Framework for the preparation and application of a sampling plan*) was not yet published by CEN. Therefore sampling of waste was dealt with the wording “a sampling plan shall be developed according to part 1 of the sampling standard currently developed by CEN”. EN 14889 finally was approved by CEN on 28 October 2005.

Section 3 of the Council Decision Annex defined that “sampling and testing for basic characterisation and compliance testing has to be carried out by independent and qualified persons and institutions” (and securing the results through an efficient quality assurance system).

A list of testing methods(to determine *general waste properties* and regarding the *digestion of raw waste*) is to be amended in due time when more CEN standards are available.

4.2. Description

Acceptance criteria for landfills

According to European legislation there are limit values for the following six types of landfills:

Table 1: Types of Landfills

Type of landfill	Limit values
Landfill for **inert waste**	*(leaching values and total content)* The definition in the directive for **inert waste is: waste that does not undergo any significant physical, chemical or biological transformations**. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leach ability and pollutant content of the waste and the ecotoxicity of the leach ate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater. This kind of waste may be admitted without testing at a landfill for inert waste. In case of suspicion of contamination testing should be applied. If there is doubt that waste fulfils the definition of inert waste testing must be applied. In that case the methods listed under section 3 of the directive shall be applied. Examples of inert waste are: glass, soil and stones and concrete.
Landfill for **non-hazardous waste without testing**	*(municipal waste)* The definition for **municipal waste** in the directive is: waste from households, as well as other waste which, because of its nature or composition, is similar to waste from household (non-hazardous wastes in chapter 20 of the European waste list). The wastes may only be admitted it they have been subjected to prior treatment or if they are contaminated to an extent which increases the risk associated with the waste sufficiently to justify their disposal in other facilities then a landfill.
Landfill for **non-hazardous waste in same cell as stable non-reactive hazardous waste** (leaching values and total content)	The definitions that are in the current directive will be updated. In the proposal for the new Landfill directive is written that the definitions of hazardous and non-hazardous of the directive 2008/98/EC will apply .The definition of hazardous waste in that directive is: 'hazardous waste' means waste which displays one or more of the hazardous properties listed in Annex III of that directive. (more explanation under subject waste classification)
Landfill for **non-hazardous gypsum waste without testing**	*(in special cells without biodegradable waste)* In the decision is written that non-hazardous gypsum-based materials should be disposed of only in landfills for non-hazardous waste in cells where no biodegradable waste is accepted. The limit values in paragraph 2.3.2 and 2.3.1 should apply to waste land filled together with gypsum-based material. The reason for these limit values for TOC and DOC is that they are parameters that give an indication of the matter of biodegradable of the waste.
Landfill for **non-hazardous that accepts hazardous waste** (leaching values and other criteria)	Hazardous waste that may be accepted at landfills of non-hazardous waste must be stable, non-reactive which means that the leaching behaviour of the waste will not

	change adversely on the long-term, under landfill design conditions or foreseeable accidents. In decision limit values are given for granular hazardous waste and asbestos waste. (2.3.1, 2.3.2 and 2.3.3)
Landfill for **hazardous waste** (leaching values and other criteria)	In paragraph 2.4.1 and 2.4.2 limit values are given for granular waste at landfills for hazardous waste. (finally in 2.5 for underground storage)

The testing methods to be applied when testing the different kind of wastes are:

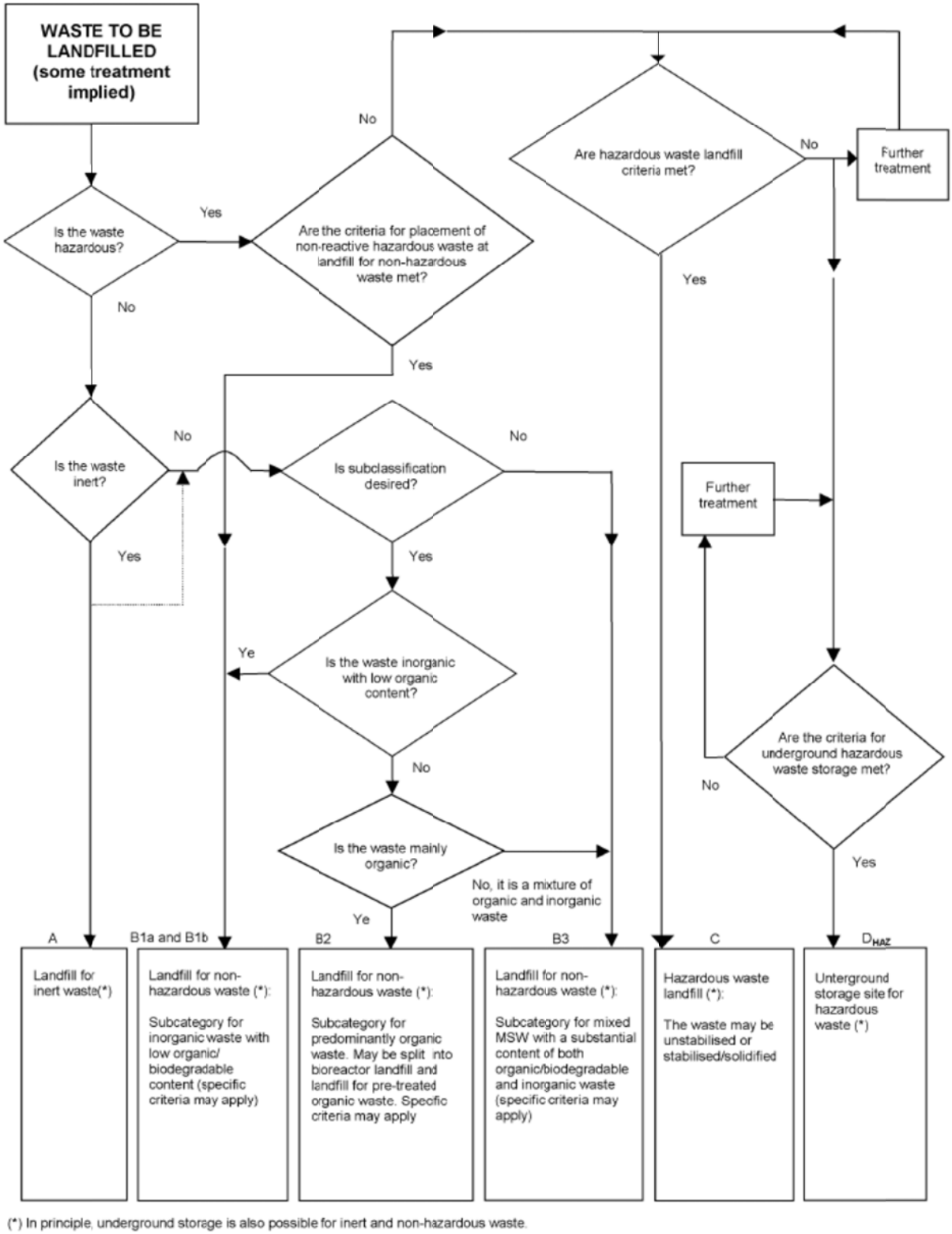
- Leaching limit values for parameters which are given in the decision depending on the kind of waste and kind of landfill;
- Leaching limit values for total content of organic parameters.

The website of the European commission contains a report about how 15 member states have implemented the decision of the commission in 2009:

http://ec.europa.eu/environment/waste/landfill/pdf/report_wac15.pdf

The report's findings are that the relevant testing methods as mentioned in the WAC decision have been implemented by the member states covered in that report. Some member states in addition to CEN standards have their own national standards. Many of these additional standards cover sampling, sampling plan, PAH, PCB, TDS, leaching tests with different pH levels and water analyses (testing).

In the following figure included in the WAC decision the steps to follow when land filling a waste are shown:



(*) In principle, underground storage is also possible for inert and non-hazardous waste.

Figure 3: Landfilling options

According to the Council decision (and directive) a procedure must be followed, before the waste can be considered to be landfilled or not. This procedure demands that the waste has to be described and in many cases also sampled and analysed.

The procedure involves three steps (see below):

- Basic characterisation (1.1)
- Compliance testing (1.2)
- On-site verification (1.3)

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Figure 4: Waste acceptance at weighbridge at landfills in Slovenia and Romania

1.1 Basic characterisation.	Basic characterisation is the first step in the acceptance procedure and constitutes of a full characterisation of the waste by gathering all the necessary information for a safe disposal of the waste in the long term. Basic characterisation is **required for each type of waste.** Depending of the kind of waste (and if this needs to be tested) this constitutes a thorough determination, according to standardised analysis and behaviour-testing methods, of the short and long-term leaching behaviour and/or characteristic properties of the waste.
1.2. Compliance testing.	This constitutes periodical testing by simpler standardised analysis and behaviour-testing methods to determine whether a waste complies with permit conditions and/or specific reference criteria. The tests focus on key variables and behaviour identified by basic characterisation. When waste has been deemed acceptable for a landfill type on the basis of a basic characterisation pursuant to section 1 in the Council decision**, the waste shall subsequently be subject to compliance testing to determine if it complies with the results of the basic characterisation and the relevant acceptance criteria** as laid down in section 2 in the Council decision The function of compliance testing is periodically to check regularly arising waste streams. The relevant parameters to be tested are determined in the basic characterisation. Parameters should be related to basic characterisation information; only a check on critical parameters (key variables), as determined in the basic characterisation, is necessary. The check has to show that the waste meets the limit values for the critical parameters. The tests used for compliance testing shall be one or more of those used in the basic characterisation. The testing shall consist at least of a batch leaching test (depending on the kind of waste). For this purpose the methods listed under section 3 shall be used. Wastes that are exempted from the testing requirements for basic

	characterisation in section 1.1.4(a) and section 1.1.4(c) in the Council decision are also exempt from compliance testing. They will however, need checking for compliance with basic characterisation information other than testing. Compliance testing shall be carried out at least once a year and the operator must in any event, ensure that compliance testing is carried out in the scope and frequency determined by the basic characterisation.
1.3. On-site verification	This constitutes rapid check methods to confirm that a waste is the same as that which has been subjected to compliance testing and that which is described in the accompanying documents. It may merely consist of a visual inspection of a load of waste before and after unloading at the landfill site. **Each load of waste delivered to a landfill shall be visually inspected before and after unloading. The required documentation shall be checked.** For waste deposited by the waste producer at a landfill in his control, this verification may be made at the point of dispatch. The waste may be accepted at the landfill, if it is the same as that which has been subjected to basic characterisation and compliance testing and which is described in the accompanying documents. If this is not the case, the waste must not be accepted. Member States shall determine the testing requirements for on-site verification, including where appropriate rapid test methods. Upon delivery, samples shall be taken periodically. The samples taken shall be kept after acceptance of the waste for a period that will be determined by the Member State (not less than one month; see Article 11(b) of the Landfill Directive.

Waste classification

The classification of waste (by using the correct EWC-code) defines whether a waste has to be treated before going to a landfill or if can be directly land filled at a specific landfill class (type).

If the classification is incorrect, it could mean that waste with hazardous properties ends up in a landfill with a lower level of protection. This could especially be the case when the waste is considered non-hazardous without appropriate sampling and analyses being done. For example waste: with a ”mirror-code’, which ends with a EWC-code of 99, which is irregularly generated, or if the waste is a mix of wastes such as EWC-code 17.05.XX.

It is the waste producer that is responsible for the correct classification of the waste according to the rules in the Waste Framework Directive and the European List of Waste. It means that when necessary the waste has to be sampled, analysed and classified according to the result of the analysis.

To classify a waste is difficult. It is done according to the Waste Framework directive and the Commission decision 2000/532/EC. To determine if the waste has hazardous properties(called H or HP in the directive), analyses have to be done and a calculation of the sum of the content of pollutants. Often it is the sum of several pollutants that will give a waste hazardous properties, not the concentration of one single pollutant. The properties are calculated according to REACH standards; the legislation for chemicals.

Sampling of waste

The more heterogeneous a certain kind of waste is, the more samples have to be taken to ensure that the sample(s) is (are) fully representing this waste. The size of the waste particles and the size of the waste population also affects the number of samples to be taken.
Many other factors also play an important role in the way a waste should be sampled to give an correct answer to how high the content of (potential) pollutants are.

Analytical results that are not based on a sampling plan must not be considered reliable representing this waste. A European Standard EN 14899:2005 has been developed for the purpose of waste characterization (approved by CEN 28 October 2005). This European Standard specifies the procedural steps to be taken in the preparation and application of a sampling plan.

The sampling plan describes the method of collecting the laboratory sample necessary to meet the objectives of the testing programme. The principles or basic rules outlined in this European Standard provide a framework that can be used to:

- produce standardised sampling plans for use in regular or routine circumstances (elaboration of derived standards dedicated to well defined sampling scenarios);
- incorporate the specific sampling requirements of European and national legislation;
- design and develop a sampling plan for use on a case by case basis.

There may be a need to take more than one sample to meet all requirements of the testing programme. Ultimately the sampling plan provides the sampler with detailed instructions how sampling should be carried out. By developing a sampling plan the responsible person has to reconsider and analyse the case specific sampling problem, which leads to better results and to reduce the probability of incorrect sampling.

The sampling plan determines how waste samples should be taken, to get a representative sample and also to determine the testing methodology (or total content leaching test) that should be performed. With repeated testing a sampling plan ensures that the sampling will be performed the same way every time. The sampling plan is a valuable system for quality control. If you have not taken a representative sample, the analysis itself has limited or no value. At worst the result is directly misleading.

To develop a sampling plan is a multi-step process with repeated contacts between stakeholders until a desired level of detail is achieved. A draft of the sampling plan is reviewed by stakeholders so that unrealistic objectives, inaccuracies, etc. can be corrected. A basic principle is that a sampling plan is made specifically for a particular sampling problem, not generally for a particular type of waste.

Important tasks to be defined in a sampling plan can for instance be as follows:

- the purpose of the test (basic characterisation or other).
- the defined population and sub-populations to be sampled to achieve the testing purpose.
- the scope of characterization.
- the degree of accuracy for the selected sampling strategy (statistical accuracy & precision).

4.3. Best practice

Acceptance criteria for landfills

In this paragraph best practice examples are given that were seen during the IMPEL project and in other studies that have been performed for the European Commission. In the following table for each country is given which percentage of the total waste in the country is being land filled.

Table 2: Deposit onto or into land in percentage of total waste management operations in a member state

Country	2012
Austria	9
Belgium	6
Bulgaria	85
Cyprus	51
Czech Republic	24
Germany (until 1990 former territory of the FRG)	10
Denmark	6
Estonia	71
Greece	79
Spain	46
European Union (28 countries)	27
Finland	11
France	25
Croatia	59
Hungary	55
Ireland	41
Italy	25
Lithuania	45
Luxembourg	4
Latvia	59
Malta	69
Netherlands	3
Poland	29
Portugal	43
Romania	47
Sweden	9
Slovenia	13
Slovakia	51
United Kingdom	31

During this project it seems that in most of the Member States (with the exception of Italy and Czech Republic) that have been visited, basic characterisation and compliance testing are both performed by the landfill operator. An exception is Austria where this is done by an external qualified and certified experts on behalf of the waste owner or the landfill operator.

When compliance testing is performed by the operator, the analysis is an equivalent of the basic characterisation and intended to be a further check in the waste characterisation procedure.

In the report “Assessing legal compliance with and implementation of the waste acceptance criteria and procedures by the EU-15” in which the following Member States were examined: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and UK, the following best practices are given from the Member States:

Best practices for on-site verification of the waste:

- Routine on-site sampling of each batch of hazardous waste delivered at a landfill including a quick test for all substances before land filling (e.g. FR)
- Mandatory automated check for radioactivity of all waste loads delivered (e.g. FR);
- Monthly on-site testing of mixed non-hazardous waste (e.g. DK).

Best practice for limit values: Specific limit values for parameters (heavy metals) to be tested BE (Flanders);

- The same criteria and test methods as for the same type of granular waste after the monolithic waste was crushed (e.g. UK Northern Ireland, SE, FI, DE, DK);
- Limit values have to be met before the stabilizing process (AT, DE);
- Specific provisions for sampling, maturation and leaching test (64 days) as well as specific national leaching limit values are set in the legislation for stabilised hazardous inorganic waste (NL);
- Definition of maturation time (e.g. FR, DE);
- Definition of pH (4 and 11) and size of particle (<10 mm) before the leaching test (DE);
- Additional limit values such as electrical conductivity and certain pH level to be met by monolithic waste (UK England/Wales, UK Scotland).

Best practice for asbestos waste

- Additional limit values for the disposal of asbestos waste are set (e.g. content of asbestos waste, storage density, relative density, liberation rate, thickness of the top cover)(IT);
- The legislation in England and Wales gives the notion “suitable asbestos waste” a broader meaning in terms of “suitable materials”;
- National legislation defines specific requirements to accept asbestos waste at class C landfills (e.g. sealed double big bags, only in cells were it is entombed into stabilised/solidified waste).

Waste classification

Having performed several on-site inspections, the project group eventually found that there is a significant need for a more detailed description of waste classification. Correct waste classification is needed to verify that a certain kind of waste is correctly land filled, so waste classification can be seen as the most crucial part of the waste acceptance process.

In the Commission Decision on the European List of Waste (COM 2000/532/EC) there are rules on how to select a waste code (EWC). It follows a chapter wise structure. A code is chosen according to the following procedural steps (see figure below):

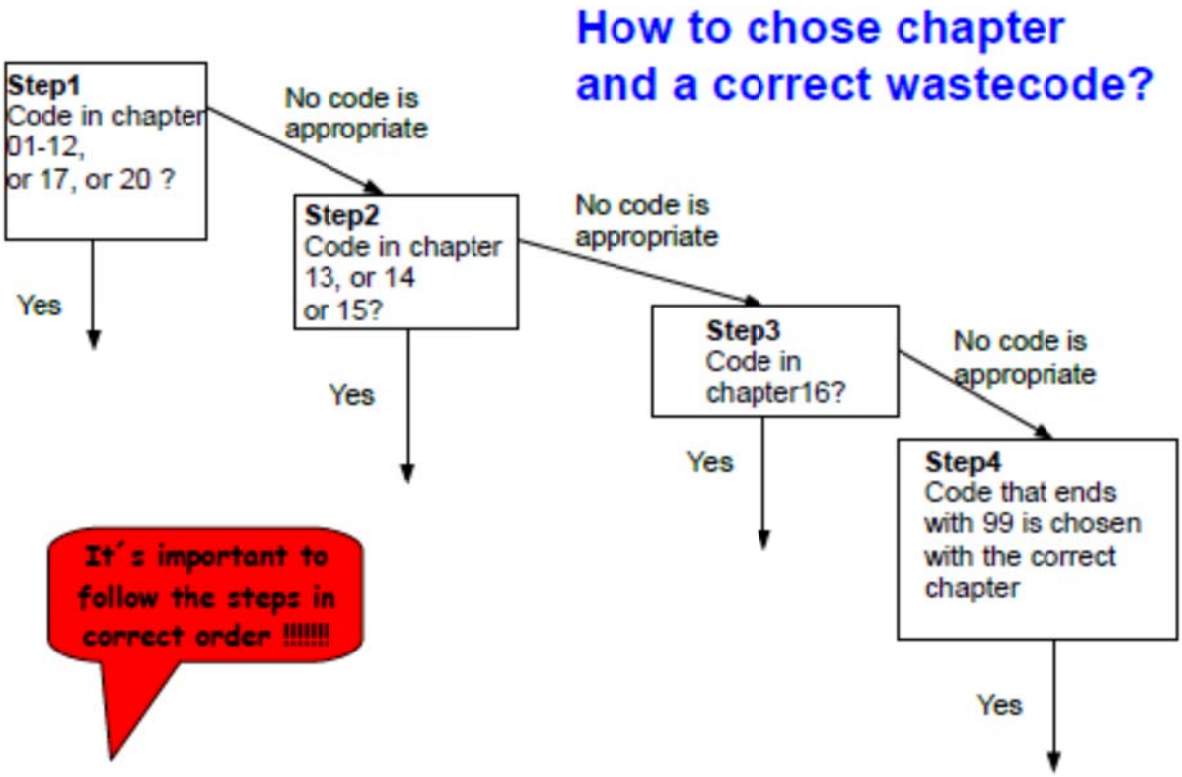


Figure 5: Choose a correct waste code

European legislation on waste classification is best understood when studied in existing up-to-date guidance's, preferably in languages that most inspectors can read and understand, (like EN in this project).

The environmental authorities of England, Northern Ireland, Scotland and Wales, in May 2015 published a new version of the Guidance on the classification and assessment of waste (Technical Guidance WM3, 1st edition 2015). It is available on the following website:

http://ec.europa.eu/environment/waste/pdf/consult/Draft%20guidance%20document_09062015.pdf

The Commission is preparing guidance on classification of hazardous waste. Several studies have been published in 2015. These documents can be found on the European Commissions website.

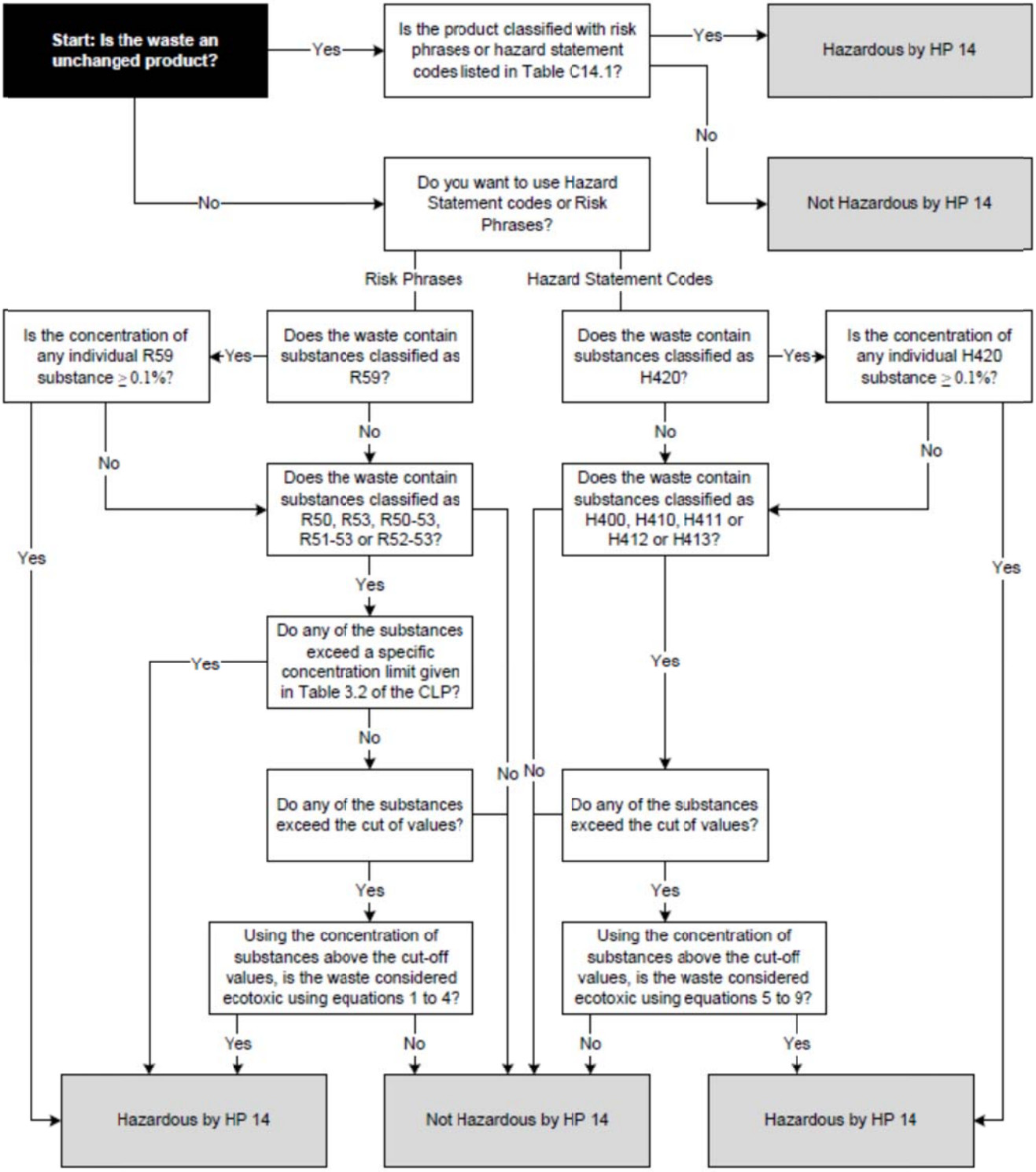


Figure 6: Classification of waste according to properties HP14 (economic)

Page C52 in Appendix C: Waste classification: Guidance on the classification and assessment of waste (1st edition 2015) Technical Guidance WM3, May 2015, Environment Agency.

Sampling of waste

After several on-site inspections, the project group eventually found that there is a significant need for a more detailed look into the way sampling is done with sampling being the most crucial part of the waste acceptance process. Being identified at a rather late stage, a first practical sampling demonstration was performed at an inspection in Austria (AT) in October 2015.

According to Austrian national legislation, sampling is an obligation for the waste owner and has to be performed prior to the waste transport to a landfill. Only in special cases the sampling part of the waste acceptance procedure is performed on-site at the landfill (at an intermediate storage facility).

Figure 7: Waste sampling demonstration at Lower Austrian landfill

To demonstrate waste sampling according to Austrian legislation a approx. 90ton heap of diesel fuel contaminated and already excavated soil was examined. Basic characterization of this kind of waste heaps has to be performed according to Austrian Standard (OeNORM) S2127 which also covers sampling from solid waste from containers and transport vehicles.

The preface of Austrian Standard S2127 constitutes that “by using this standard the requirements of EN 14899 are fulfilled”. S2127 gives reference to various other national technical standards (based on EN standards, like EN 903, EN 12457-4, EN 12506, EN 12879 and many more) as well as some ISO & DIN regulation.

Based on the waste owner’s basic information (“Waste information for the external certified expert /laboratory”; a form included in Annex A.2 for excavated soil material) a sampling plan was developed by an independent expert /laboratory (on behalf of the landfill operator).

Core data included total waste mass, population size, number of populations, number of qualified samples, number of increments, expected waste code and expected landfill (quality) class.

Sampling was performed under supervision of the visiting IMPEL inspectors. An excavator (grab dredger) was used to split the waste heap into 2 parts (populations) and the material prepared for taking the sampling of the calculated amount of increments.

Sampling was performed by an external qualified & certified expert (accredited laboratory) and a sampling record completed. Date and time of sampling, weather conditions, actual number of qualified samples, mass of qualified samples, number of increments per qualified sample, colour and odour of the waste, estimated particle size, material consistency and grade of homogeneity and the likelihood of any potential hazardous properties according to Directive 2008/98/EC on waste (Waste Framework Directive), Annex III were documented. A detailed description and characterisation of the qualified samples (mapping, location, depth) was also added. Further information regarding the collection of replicate samples, packaging and transport of the samples taken, GPS data and a photographic documentation was provided.

Figure 8: Waste samples taken and prepared for transport to laboratory

Preparations for sampling activities comprise the following activities:

- **Qualification for sampling:** waste sampling should be done only by certified /accredited persons /institutions (to be seen as best practice).
- **Compiling all necessary information** on the waste to be sampled ("waste information"):
  - Waste owner (name, address, e-mail, phone contact; contact person), project name and waste identification code
  - Origin of waste (production process, waste collection, treatment procedures or other)
  - Short description of the process the waste is originating from

- Relevant input materials (especially when waste already was processed/treated)
- Waste code - according to EWC or national standard
- Amount of waste – total mass (m³), density (tons/m³), total waste mass (tons); type and form of material
- Describe waste storage (address) still in-situ ? roof protected, open air storage, encased ? waste heap storage ? container storage ? any other ? waste stored since when ?
- Description of waste quality – material not contaminated / obviously contaminated / contaminations to be expected / contamination very likely? Describe contamination (known/obvious/likely)
- Background information e.g. previous investigations or analysis. Other information on contaminations of waste in question or, of input materials
- Document signed / approved by waste owner

- **Preparing a sampling plan:**

  Depending on the structure/quality (homogenous/heterogeneous) and location of the waste (in-situ sampling of soil material, sampling from waste heaps or containers /transport vehicles etc.) a sampling plan has to be made or depending on national legislation sampling plans for certain sampling scenarios have to be applied.

  Compile all relevant data, such as:

  - Waste information to be provided by waste owner (see above)
  - Sampling plan author (name, address, phone, e-mail)
  - Involved parties (waste owner / independent expert/laboratory)
  - Objectives/purpose of assessment (waste going to landfill/recovery/other destination/purpose)
  - Determine level of testing required
  - Constituents to be tested
  - Health & safety precautions
  - Technical goals (define populations /subpopulations
  - Variability (spatial /temporal); Scale of sampling
  - Practical Instructions (statistical approach, sampling approach & pattern, sampling place & points; equipment needed;
  - Sample details (individual /composite; number of samples / increments; composite sample size; primary samples combined into composite samples)
  - Requirements for sample reduction & on-site determination
  - Packaging, preservation, storage & transport requirements (sample labelling, preservation methods
  - Analytical laboratory (company details, contact name)

- **Preparing a sampling protocol:**

  - Sampling plan number / Identification /reference number /code
  - Waste owner / contact person;
  - Laboratory / qualified expert on sampling: contact person (name, address, phone, e-mail)
  - Involved parties /other persons attending (name, address)

- Sampling location (address, GPS data if available, site details)
- Data of sampling (data, hour, period)
- Weather conditions (sunny /dry /rainfall /snow /temperature /wind)
- Waste mass (tons);
- Qualified samples (number of); number of increments per qualified sample
- Mass of qualified sample (kg)
- Alternate / replicate samples taken (y/n; if yes who did it?)
- Way of sampling (conveyor belt moving/not moving; falling stream; from waste heap/ stockpile; soil: borehole, trench or other; machinery used)
- Description & characteristics of qualified samples (location)
- Transport of samples (open /closed container; cooled /not cooled)
- Contaminations apparent (odour / visible contaminations / gas/ other irregularities)
- Waste colour
- Odour
- Particle size (mm) & consistency (solid/dry/wet/sludge/dusty/powdery etc.)
- Homogeneity of waste (colour /odour/particle size)
- Hazardous properties to be expected (y/n) ? If yes, which ?
- Deviations from Sampling Plan (waste mass; number of populations; number of qualified samples; other ?)
- Additional relevant information
- Mapping (GPS or other geodatical data) and photographic documentation of location & waste (particle size /colour/ homogeneity)
- Date & signature of sampling expert (prepared by / prepared for)

- **Preparing all necessary technical equipment:** check availability of sampling instruments & machinery (excavator, grab dredger, soil anger, trier, thief, sampling scoop or other).

4.4. Preparing an Inspection (desk study)

Acceptance criteria for landfills

Before going on inspection it should be very clear what the subject of the inspection will be. Information needed for a inspection on the subject of waste acceptance at a landfill is:

- The permit which is issued to the landfill;
- Which legislation is relevant for the inspection besides the permit (are there general binding rules which have to be taken into account ?);
- The monitoring and other reports the landfill operator had to provide to the authority. Are these relevant for this subject;
- What kind of landfill is it ? Which waste stream are most critical for contamination ?
- If possible (some member states have this is) look at the waste streams the landfill has received the last 6 months previous to your inspection;
- Select four different kind of waste stream and with the help of the checklist perform your inspection (see checklist example).

Waste classification

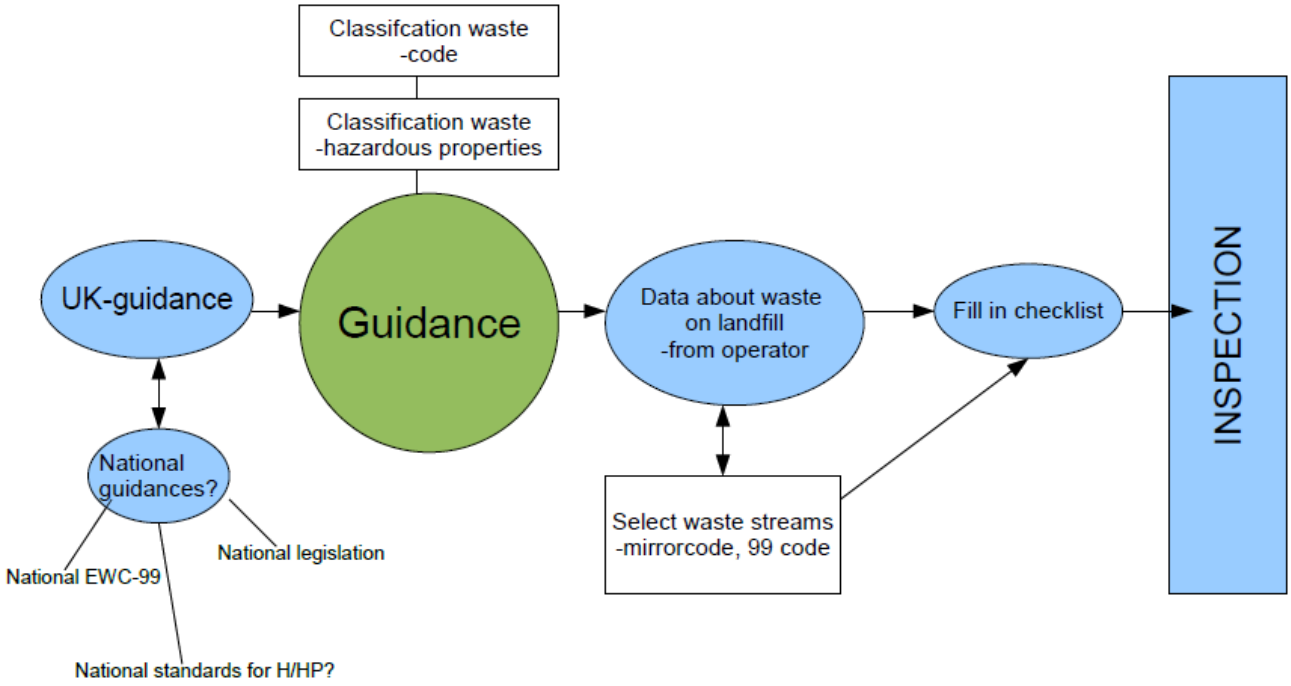


Figure 9: How to prepare inspection to check the correct "classification of waste".

The desk study activities includes:

- reading the UK-guidance and if available national guidance. There can be more specified national legislation, national waste codes and standards for assessment of hazardous properties, so check if so is the case in your country.
- Ask the landfill operator to send you a list of all the wastes that are land filled. Ask for a list from the last 12 months. Ask for: name of the waste, waste code, waste producer and amount of waste.
- Select 4 different waste streams that will be supervised. For example: a mixed waste, a waste with a mirror-code, a waste that ends with 99 and the most common waste that are land filled.
- Fill in the checklist until "risk of hazardous properties", see below.

1. CLASSIFICATION OF WASTE									
Chosen wastes									
Waste code	Name of waste	Absolute Hazardous or non-hazardous?		Mirror-code?	Code that ends with -99?	Risk of hazardous properties? Properties is:			In compliance?
		Yes Hazardous	Yes non-hazardous	Yes	Yes	not documented	not known	documented	no risk of hazardous properties	If waste is absolute hazardous or non-hazardous go to part for WASTE ACCEPTANCE CRITERIA FOR LANDFILLS AND PRE-TREATMENT OF WASTE If waste is mirrorcode or ends with 99, and there is a risk of hazardous properties and they have been documented, go to part for WASTE ACCEPTANCE CRITERIA FOR LANDFILLS AND PRE-TREATMENT OF WASTE If waste is mirrorcode or ends with 99, and there is a risk of hazardous properties or properties is not known or documented, then the landfill operator should not accept the waste for landfilling before the wasteproducer have supplemented data about the properties of the waste.
120199	Blasting material	-	-	-	yes					
200307	Fly ash (oil)	yes								
170504	Soil from conterminated site			yes						
190805	Sluge waste watertreatment		yes							

Figure 10: Selection of waste streams in the checklist

Sampling of waste

Preparing an inspection comprises as a main issue to define the scope of “what to inspect”:

- Check Landfill documentation: find out particular /typical types of waste (waste streams) deposited at the site for an in-depth assessment (waste where a higher degree of sampling /a more sophisticated sampling normally is necessary or expected);
- Check sampling plan of the respective waste (deposited at the landfill) well ahead of a site visit in order to verify the correct use of sampling methodology according to national / EU legislation (e.g. EN 14899 et. al);
- Prepare site visit protocol (according to Checklist see Annex);
- Prepare technical equipment for site visit.

4.5. On-site Inspection

Acceptance criteria for landfills

Use the checklist for the on-site inspection. Take pictures when you suspect that something is not according to the permit or national binding rules. When there is a discussion on the kind of waste that may accepted and/or has been accepted take samples (I hope in your country you have the facility to do this or hire someone).

Waste classification

- Ask to see the basic characterisation (BC) for the waste stream(s) chosen.

- Check if there is information on the risk of hazardous properties, fill in the checklist, see below:
- If waste is mirror-code or ends with “99” and there is a risk of hazardous properties or properties are not known or documented, then the landfill operator must not accept the waste for land filling before the waste producer have supplied data about the properties of the waste.
- For fully documented wastes or if the waste is assigned to an absolute hazardous or non-hazardous code, go to the next step in checklist: “Criteria for landfills and pre-treatment of waste”.

1. CLASSIFICATION OF WASTE									
Chosen wastes									
Waste code	Name of waste	Absolute Hazardous or non-hazardous?		Mirror-code?	Code that ends with -99?	Risk of hazardous properties? Properties is:			In compliance?
		Yes Hazardous	Yes non-hazardous	Yes	Yes	not documented	not known	documented	no risk of hazardous properties	If waste is absolute hazardous or non-hazardous go to part for WASTE ACCEPTANCE CRITERIA FOR LANDFILLS AND PRE-TREATMENT OF WASTE If waste is mirrorcode or ends with 99, and there is a risk of hazardous properties and they have been documented, go to part for WASTE ACCEPTANCE CRITERIA FOR LANDFILLS AND PRE-TREATMENT OF WASTE If waste is mirrorcode or ends with 99, and there is a risk of hazardous properties or properties is not known or documented, then the landfill operator should not accept the waste for landfilling before the wasteproducer have supplemented data about the properties of the waste.
120199	Blasting material	-	-	-	yes		yes			
200307	Fly ash (oil)	yes						yes		
170504	Soil from conterminated site			yes		yes				
190805	Sluge waste watertreatment		yes						yes	

Figure 11: Example of checklist to be used for waste classification (see Annex 2)

Sampling of waste

All the checks listed are necessary to complete the checklist.

- Ask to see all documents regarding waste accepted at the landfill, in particular sampling plans & sampling records (protocols and affiliated data). In case of insufficient time frame an inspector may select parts of a sampling plan in order to perform a “short check”. Checking these parts should enable an inspector to find hints of the probability that the sampling was conducted in a satisfactory manner or something is not correct.
  These selected parts of a sampling plan could be:
  - The population size representing a sample and how the waste is produced (as a heap/stockpile, from a falling stream or from excavation
  - Number of sub-samples (increments) depending on homogeneity or heterogeneity of the waste
  - Size of the sample(s) taken (a minimum amount /mass of a sample as defined in national /international standards)
  - Who has conducted the sampling? (qualification of certified /accredited person /institution)
- Check sampling plans against national and EU legislation requirements (statistical approach, number of samples taken, correct use of forms, standards etc.)
- Ask for a on-site demonstration to check if sampling is done properly

- Check storage of replicate samples (storage facility, correct labelling, correct handling)
- Check sampling equipment and other technical facilities (if available and sampling is done at the landfill).

Figure 12: Replicate storage facility at Lower Austrian landfill

4.6. Existing guidelines

Acceptance criteria for landfills

- Guideline on the treatment of waste before landfill: Treatment of waste before landfill
- Guideline on waste acceptance on landfill: Acceptance at landfill

Waste classification

- Report are available on the website of the European Commission: Waste classification - Environment - European Commission (see chapter 4.3)

Sampling of waste

Among the existing guidance available 3 documents contain good advice to create a suitable sampling plan:

A. *Nordtest Method (NT ENVIR 004, of Nordic Countries, approved 1996-05; published by NORDTEST, Finland)*

A well established test methodology on sampling of solid waste and particulate materials. The scope of this guidance covers the probabilistic approach of (random) sampling of solid residues (i.e. ashes, slags and similar residues) up to 80mm particle size based on classical statistics.

Importance is laid on the technical differences when sampling has to be performed at different locations (from conveyor belt stopping/moving, falling stream or at a stationary position (e.g. containers, vehicles or from a stockpile).

NT ENVIR 004 also gives an overview of fundamental statistics (distribution models, sample variance) as well as strategies (probabilistic, random – simple, stratified, systematic) for collection of samples. A 2-page example of a sampling plan is provided and furthermore examples of sampling equipment. The following table gives an example how to define the number of primary samples:

Table 3: Minimum number of primary samples to be collected from a lot/sampling unit containing 30 tons or less

Designation	Heterogeneity	n. of primary samples
A	Homogeneous solid residues, such as coal fly ash sampled from a falling stream	5
B	Heterogeneous solid residues, such as bottom ash from mass burn incinerators sampled from a falling stream	7
C	Very heterogeneous or stratified solid residues, such as residues in wagons, vehicles, stockpiles	10

B. *Waste Sampling – Appendix D of Waste Classification: Guidance on the classification and assessment of waste (Technical Guidance WM2 - 1st edition 2015; published by UK Environment Agency,)*

A recently published update of a 5-step methodology based on current European and British standards (e.g. EN 14889). Starting with Preparatory Steps such as identifying parties, objectives, technical goals, background information, level of testing plus health & safety precautions) technical goals from the objective define population to be sampled. After assessing variability and defining the scale practical sampling instructions are determined (statistical approach, sampling approach, type, number & size of samples and finally a sampling technique chosen. The procedure is finished with the documentation of a sampling plan.

Special interest is laid on Step 3 - the determination of practical instructions in order to choose the right statistical and sampling approach plus the number & sample size (pp D11 – D25). A 2-page sampling plan form is provided for documentation purposes.

C. *Austrian Standards OeNORM S 2126 (published 01-12-2010 by Austrian Standards Institute) and S 2127 (published 01-11-2011)*

Both technical standards were issued to set the benchmark for waste sampling and eventually became part of Austrian legislation (landfill ordinance) defining the minimum requirements for sampling. The approach is to have a simple but yet sufficient system to secure that any kind of waste possible can be tested in a way that the average content of pollutants and the leaching

behaviour is determined and the waste finally can be assigned to a certain landfill class (quality class).

Both standards include several Annexes for documenting the waste information by the waste owner (to the independent external qualified expert/laboratory), a sampling plan form, sampling record form and other information on randomized sampling and technical advice to determine mass, volume and density of waste.

5. Biogas control

5.1. Law requirements

The Landfill Directive sets regulations about biogas control and reduction measures. Landfill gas means all the gases generated from the landfilled waste.

Measures should be taken to reduce the production of methane gas from landfills, inter alia, in order to reduce global warming through the reduction of the landfill of biodegradable waste and the requirements to introduce landfill gas control (16).

Further provisions about landfill gas are set in Article 13, Annex I and III of the Landfill Directive:

Article 13: Closure and after-care procedures

Member States shall take measures in order that, in accordance and where appropriate, within the permit:

(d) for as long as the competent authority considers that a landfill is likely to cause a hazard to the environment and without prejudice to any Community or national legislation as regards liability of the waste holder, the operator of the site shall be responsible for monitoring and analysing landfill gas and leachate from the site and the groundwater regime in the vicinity of the site in accordance with Annex III.

Annex I General requirements for all classes of landfills

4. Gas control

4.1 Appropriate measures shall be taken in order to control the accumulation and migration of landfill gas (Annex III).

4.2 Landfill gas shall be collected from landfills receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared.

4.3 The collection, treatment and use of landfill gas under paragraph 4.2 shall be carried on in a manner which minimises damage to or deterioration of the environment and risk to human health.

Annex III Control and monitoring procedures in operation and after-care phases

3. Emission data: water, leachate and gas control

Gas monitoring must be representative for each section of the landfill. The frequency of sampling and analysis is listed in the following table:

	Operating phase	After-care phase
Potential gas emissions and atmospheric pressure (CH_4, CO_2, O_2, H_2S, H_2, etc).	MONTHLY - H_4, CO_2, O_2, regularly other gasses according to the composition of the waste deposited with a view to reflecting its leachate properties.	EVERY SIX MONTHS - Efficiency of the gas extraction system must be checked regularly.

The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, buried, etc). This has to be specified in the permit.

5.2. Description

The Landfill Directive defines landfill gas (LFG) as 'all the gases generated from the landfilled waste'. Landfill gas, therefore includes gaseous emissions arising from all physical, chemical and biological processes occurring within the waste, e.g. microbial production, chemical reactions and direct volatilisation.

Landfill gas (LFG) is generated in all landfills where organic waste is disposed of. LFG is a natural by-product of the anaerobic biological decomposition of the organic portion of solid waste. Landfill gas consists primarily of Methane (CH_4) and Carbon Dioxide (CO_2), but may contain many other constituents in small quantities, including nitrogen, oxygen, sulphides, disulphides, mercaptans, volatile organic compounds (VOCs), ammonia, hydrogen, carbon monoxide, water vapour, and many other organic gases. By volume, landfill gas typically contains 40% to 60% methane and 40% to 60% carbon dioxide.

Decomposition of waste in a landfill occurs in several distinct phases, related to conditions in the landfill, during which different groups of bacteria break down complex organic substances such as carbohydrates, proteins and lipids into successively simpler compounds.

The primary phases are:

Phase I – Aerobic

Phase II – Anaerobic Non-Methanogenic (Acetogenic)

Phase III – Anaerobic Methanogenic (a non-steady phase)

Phase IV – Anaerobic Methanogenic

Phase V - Aerobic

Figure 13 illustrates the production of gas from a body of waste over time in an idealised manner:

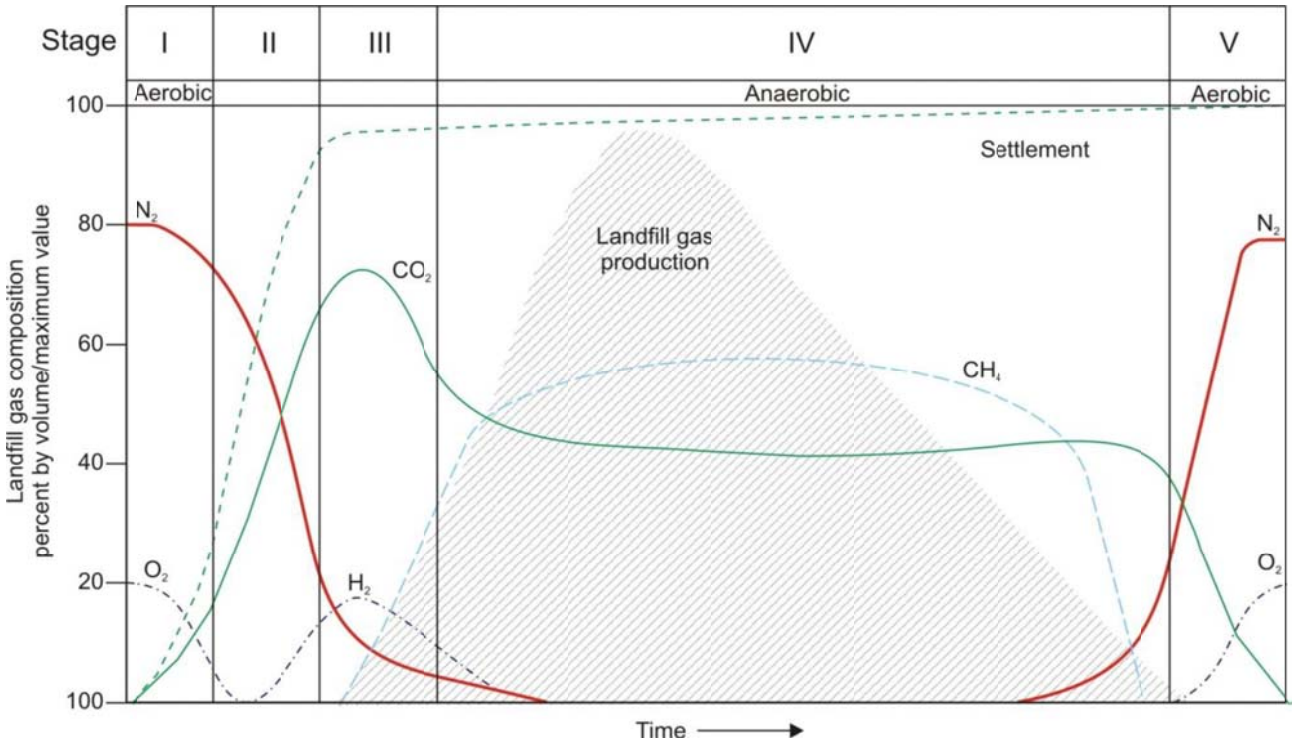


Figure 13: Production of landfill gas

The rate at which LFG is produced is primarily a function of the types of waste involved, e.g: rapidly decomposing food waste versus longer-lasting paper, cardboard or other organic waste. The overall rate of decomposition for all refuse components in a given section of a landfill also is influenced by a variety of other factors, such as moisture content, refuse particle size, site configuration, compaction and pH. Basically, the better the conditions within a landfill are for the anaerobic bacteria the faster the decomposition will take place. This will result in a faster overall LFG generation rate build-up.

LFG collection typically begins after a portion of the landfill (known as a “cell”) is closed to additional waste placement. Collection systems can be configured as either vertical wells or horizontal trenches.

The most common method of LFG collection involves drilling vertical wells in the waste and connecting those wellheads to lateral piping that transports the gas to a collection header using a blower or vacuum induction system. Another type of LFG collection system uses horizontal piping laid in trenches in the waste. Horizontal trench systems are useful in deeper landfills and in areas of active filling. Some collection systems involve a combination of vertical wells and horizontal collectors.

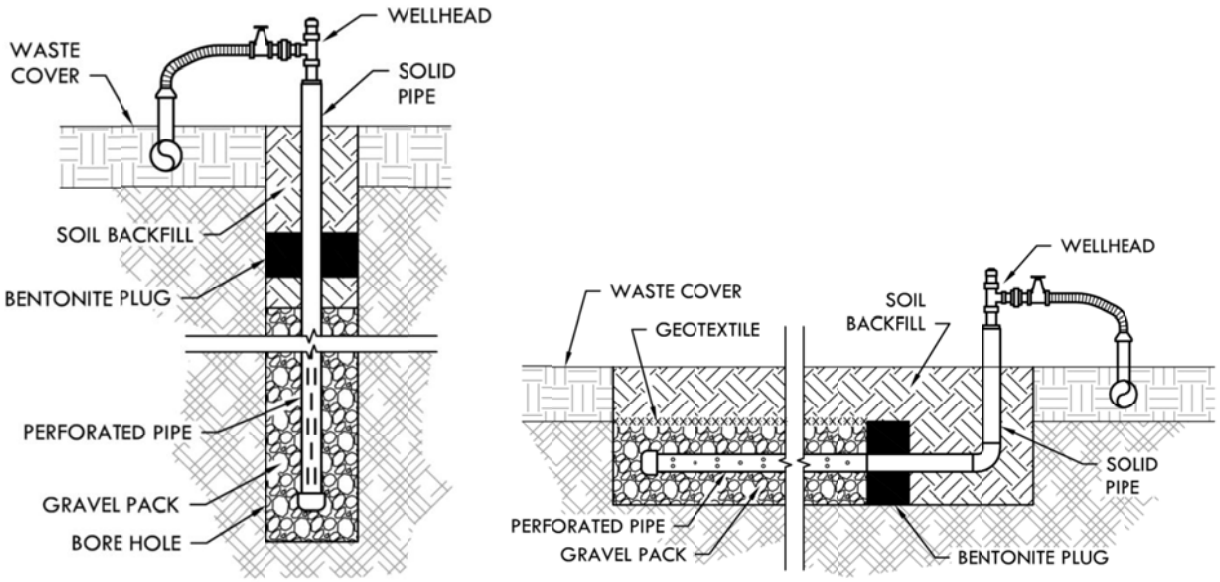


Figure 14: Landfill gas collection system

Figure 15: Landfill gas collection boreholes

Landfill gas shall be collected from all landfills receiving biodegradable waste and the landfill gas must be treated and used.

Landfill gas must be collected from landfills receiving biodegradable waste unless the landfill operator can prove to the competent authority that it is not necessary to do so.

This proof must be based on a demonstration that the waste types accepted will not produce more than negligible amounts of landfill gas and can be supported by evidence such as from monitoring of the landfill. If the gas collected cannot be used to produce energy, it must be flared.

Depending on the quality of the landfill gas it can be used to produce energy or must be flared. Energy can be produced by feeding a gas motor, a furnace or a boiler. Landfill gas also can be cleaned to fulfill the quality requirements of natural gas. Landfill gas that cannot be used must be flared.

Landfill gas use depends on the minimal quality requirements and flow to guarantee stable performance to keep the system at stable conditions. The process control has to be adjusted periodically. Sources (wells) with a low concentration of methane or high oxygen concentration will have to be closed more and sources (wells) with high methane concentration have to open more. The possibility to open and close underlines the necessity of control valves in the system with which the sources (wells) can be controlled individually.

The technology of a landfill gas flare is conceptually very simple: landfill gas is brought into contact with a supply of air and ignited. A variety of configurations of conduits and chambers can be used for the purpose. Whatever the exact design of the flare, however, it will comprise a number of basic elements, in addition to piping, valves and the body of the flare.

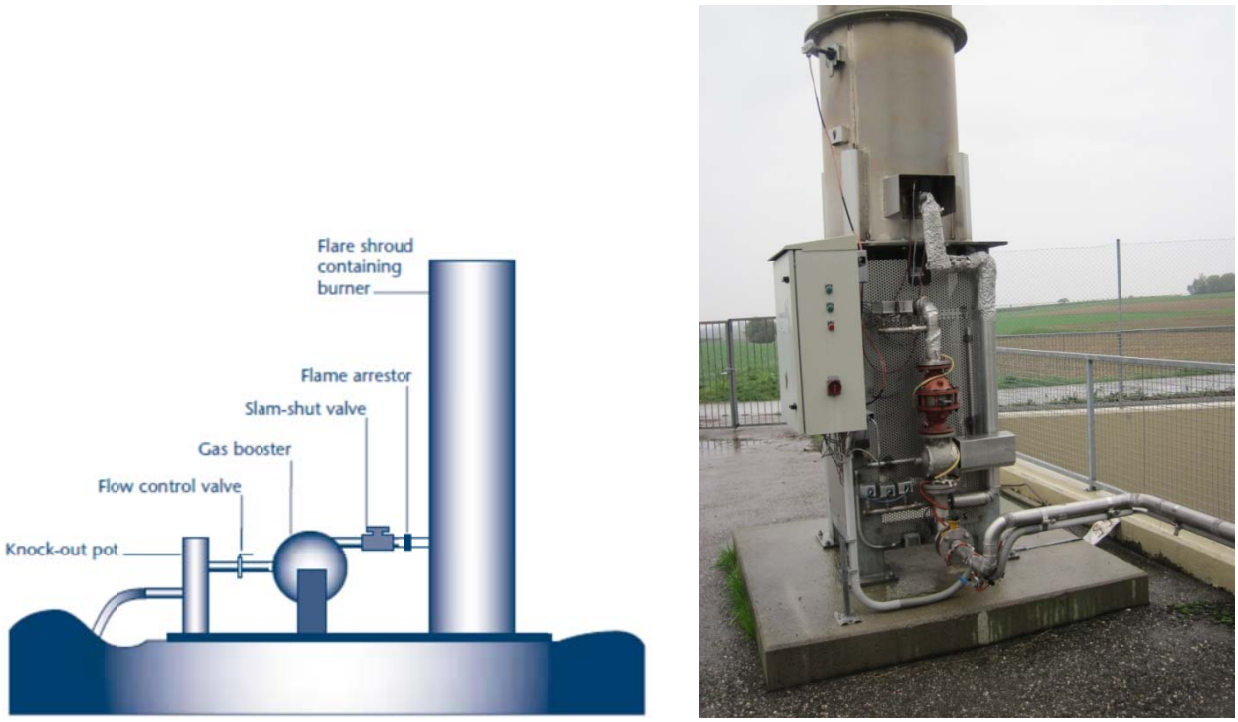


Figure 16: Landfill gas flare

Flare designs include open (or candlestick) flares and enclosed flares. Enclosed flares are more expensive but may be preferable (or required by state regulations) because they provide greater control of combustion conditions, allow for stack testing and might achieve slightly higher combustion efficiencies (higher methane destruction rates) than open flares. They can also reduce noise and light nuisances.

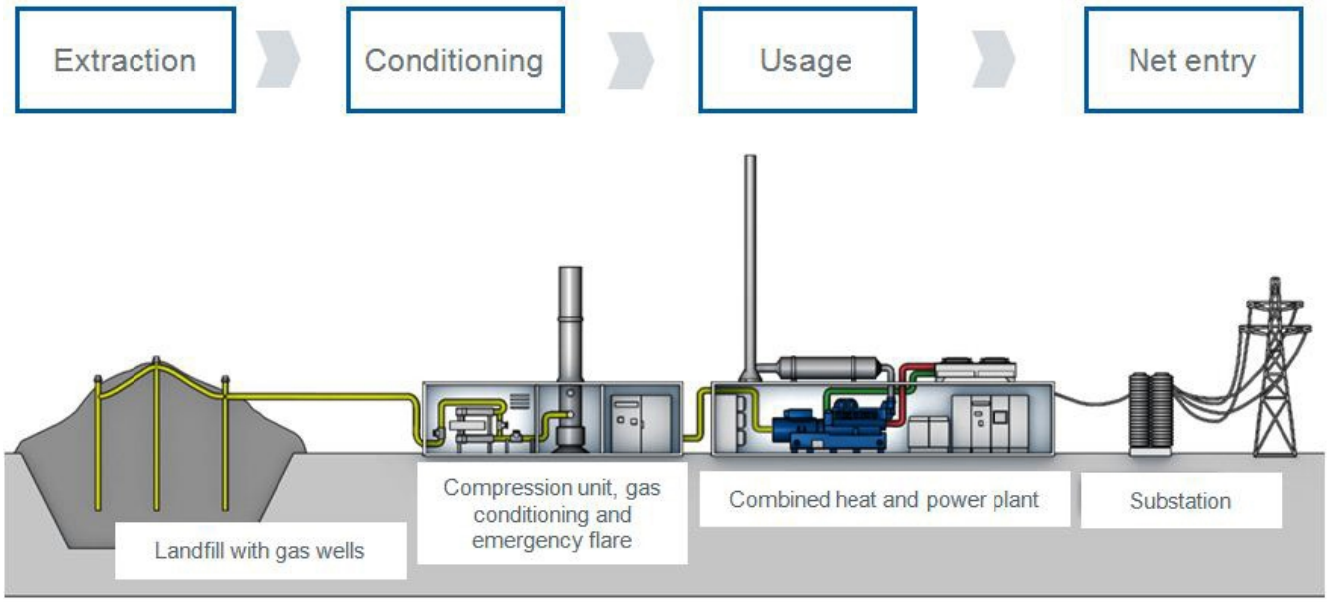
Landfill gas is flared at a temperature above 850°C (usually in the range between 1000 – 1200°C) to remove minor constituents in the landfill gas. For adequate destruction, combustion retention time is typically between 0.3 and 0.6 seconds. Continuous measurements of flow and temperature of biogas is usually required.

Figure 17: Landfill gas flares examples

In the landfill gas control hierarchy, gas collection with energy recovery is preferred to enclosed flaring. Though LFG can present a hazard to human health and safety and the environment, it can also be a very significant asset in relation to the energy potential of the CH_4 that it contains, and hence its potential for use as a fuel. The primary utilisation modes for LFG which have been implemented successfully on a broad-scale is on-site generation of electric power using LFG as a fuel within an internal combustion engine, gas turbine or steam turbine generator.

Using LFG in an energy recovery system usually requires some treatment of the LFG to remove excess moisture, particulates and other impurities. The type and extent of treatment depend on site-specific LFG characteristics and the type of energy recovery system employed.

Flares are a component of each energy recovery option because they may be needed to control LFG emissions during startup and downtime of the energy recovery system and to control gas that exceeds the capacity of the energy conversion equipment.



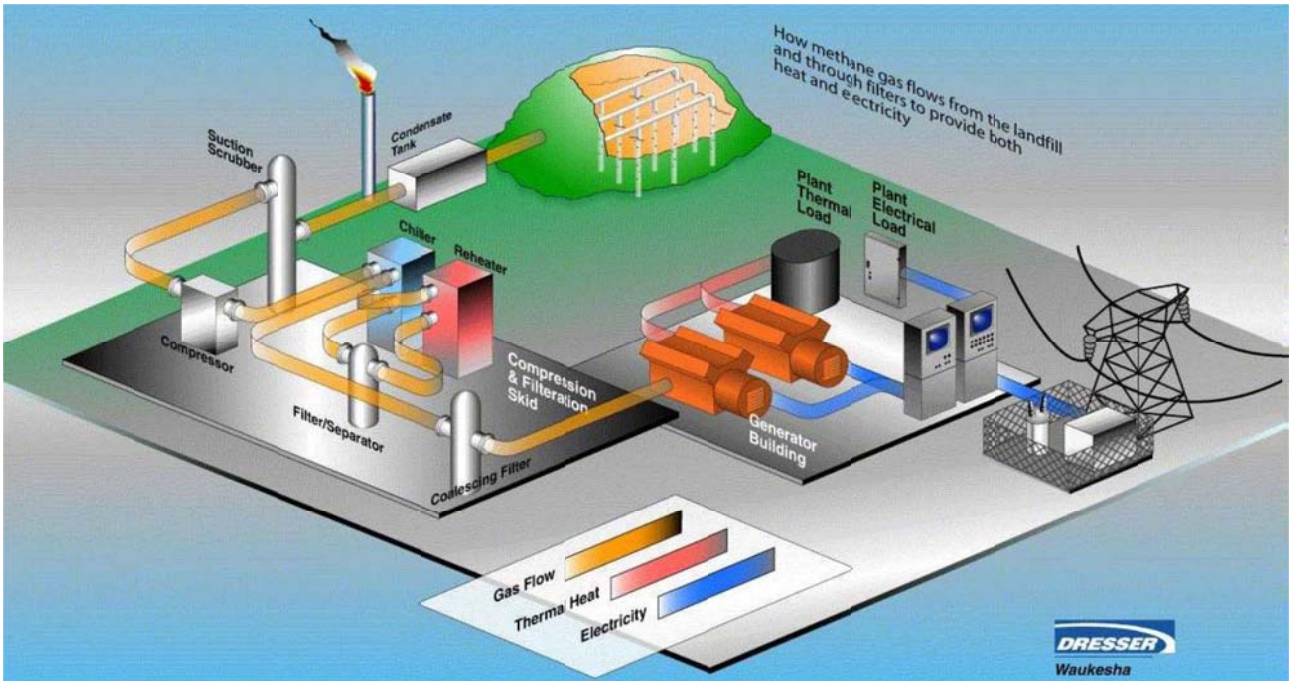


Figure 18: Energy recovery scheme

Under the requirements of the Landfill Directive the operator must assess the potential for utilising landfill gas produced on site and if appropriate make outline proposals for its utilisation. The ability of a facility to produce gas that can be utilised is dependent on:

- The type of waste accepted at the facility (therefore the requirement for energy utilisation principally applies to landfill accepting biodegradable waste);
- The volume of waste and the rate and type of degradation within the facility
- The size of the facility.

The first step in developing an energy use project is to determine whether the landfill is likely to produce enough methane to support an energy recovery project.

If it is determined that the energy recovery option is viable, then it is important to estimate the amount of recoverable gas that will be available over time. Softwares as US EPA's LandGEM or GasSim (developed by Golder Associates for the Environment Agency of England and Wales) simulates the fate of landfill gas arising from managed or unmanaged landfill sites.

Once the LFG and methane generation amounts are estimated, the next step is to estimate the amount of LFG that can be collected.

Collection efficiency is a measure of the ability of a gas collection system to capture LFG generated at the landfill. The LFG generation estimate produced by the model is multiplied by the collection efficiency to estimate the volume of LFG that can be recovered for flaring or use in an LFG energy project.

A landfill gas management system has the overall objective to collect all gas produced from the waste and treat it accordingly in order to minimise odours and emissions from the landfill. Specific objectives include the following:

- Minimise the risk of gas migration beyond the boundary of the site
- Minimise the risk of gas migration into buildings/services on site
- Minimise impact on air quality through reduction of greenhouse gas emission
- Reduction of nuisance potential to surrounding environment (odour)
- To allow energy recovery where feasible.

If not properly monitored and controlled, landfill gas can give rise to flammability, toxicity, asphyxiation and other hazards including vegetation dieback. In addition to its explosive properties landfill gas is also an asphixiant when found in a closed space. It is therefore important to manage and control the gas generated within the waste to ensure that the risks associated with its movement are minimised.

The minimum explicit monitoring requirements for landfill gas from the Landfill Directive and Regulations relate to:

- the monitoring of gas within the waste (source);
- the efficiency of the gas extraction system;
- atmospheric pressure (during borehole/well monitoring at the site)

monitoring at the site).A gas-monitoring programme has to be in place to establish whether gas production at the site is giving rise to a hazard or nuisance and to determine the effectiveness of the landfill gas management system. Landfill gas monitoring should be undertaken for the following main components:

- source
- emissions
- air quality
- meteorology.

Landfill gas can be monitored from the gas extraction boreholes within the waste body and in gas wells around the perimeter of the landfill.

The following control methods can be performed:

- continuous measurement of the amount of landfill gas that is extracted;

- continuous measurement of the oxygen concentration in the gas with an alarm detecting system;
- periodical measurement of the concentration of methane and CO in the landfill gas;
- periodical measurement of the under pressure and of the concentration of methane, oxygen and CO_2 in the sources (wells);
- periodic inspections of the waste that is landfilled on indications of gas leaking, as for example cracks in the slope, odour and vegetation damage[1].
- periodic estimation of pumping system efficiency, by means of periodical measurement of the quality of the air surrounding the landfill and of the monitoring of surface gas emission.

Emissions to air of landfill gas can occur as either process gases from abatement plant or fugitive emissions from waste degradation. These can be effectively managed to minimise fugitive emissions, e.g., covering waste with cover material to minimise fugitive landfill gas emissions, effective gas collection, or controlling combustion conditions on a flare or utilisation plant.

The mass balance of gas in a landfill can be summarised by the following equation:

Total Gas Generated = Gas Utilised + Gas Flared + Lateral Emissions + Surface Emissions (including methane oxidation in the cap) +/- Short Term Storage

Figure 19: Energy power plants

Figure 10: Landfill gas piping

5.3. Best practices

BAT is to have a Landfill Gas Management Plan and system to prevent uncontrolled escape of gas from the landfill facility.

The procedures for demonstrating the effectiveness of the landfill gas controls are described in Annex III and may include monitoring of soil gas outside of the landfilled waste and monitoring of fugitive emissions in addition to monitoring of the landfill gas conditions within the landfill (see the requirements in Annex III of the Directive).

The following BAT can be identified:

Controlling the process

- Assess capacity of system (Engine/Flare & Booster capacity) and assess well coverage & performance (Extraction Well coverage and assess performance of wells). The landfill gas extraction system should be monitored and adjusted regularly to maximise the collection of landfill gas and minimise the ingress of air into the waste mass. The performance of the system should be monitored over time and steps taken to remediate any deterioration in performance and maintain landfill gas collection efficiency.
- Operator audits of the gas collection system should be undertaken annually to assess the efficiency of the system and to develop a programme of improvements.
- Assess LFG production (model used to estimate the gas production during the years).
- Prevent condensate build-up in gas collection network.
- Carry out regular balancing of gas wells.
- Regularly monitor and balance gas extraction wells.
- Use automatic alert system to notify of utilisation plant failure, where applicable.
- Backup power system for enclosed flares.
- Manage condensate to prevent emissions.

Controlling accumulation and migration

- Minimize landfill gas production potential by pre-treating the waste prior to acceptance for landfilling.
- Prevent landfill gas from migrating through the ground in both gaseous and dissolved states and prevent emissions of methane to the atmosphere. Maintenance of negative air pressure in the landfill gas extraction wells. Appropriate measures for landfill gas control are outlined in Section 3 of Annex I of the Directive. These include:
  - Lining of the landfill base and sides to create a low permeable barrier to sub-surface gas flow.
  - Surface sealing including impermeable mineral layers and gas drainage layers.
- Use of horizontal and vertical gas collection pipework in the waste body.
- Selection of appropriate cell sizes.
- Use of appropriate materials for temporary cover, interim and final capping.
- Landfill gas extraction should start as soon as possible following the deposit of the waste.
- All landfill infrastructure that protrudes through the surface of the waste or capping layer, such as leachate or gas wells, should be sealed to prevent emissions of landfill gas.

Monitoring

To provide for the requirements of the Landfill Directive, landfill gas monitoring should be undertaken. The monitoring of landfill gas is an essential factor in the management of any landfill site. A monitoring and sampling plan must be prepared and set out within the Landfill gas management Plan. The monitoring plan should provide objectives and describe a site-specific programme of monitoring to be undertaken at the landfill site. This will incorporate:

- the type of monitoring to be undertaken;
- the methods of monitoring (including detection limits, accuracy, etc.);
- monitoring locations;
- frequency of monitoring;
- appropriate action/trigger levels necessitating action;
- appropriate action plans to be implemented should any levels greater than the trigger levels be recorded.

Regular monitoring (which may include monitoring of fugitive gas emissions) and immediate remediation should take place for all sealing systems (e.g. caps) and landfill infrastructure to ensure that leaks are detected and repaired as soon as possible.

Monitoring data must be reviewed on a regular basis against the initial objectives of the Landfill gas Management Plan. The monitoring frequency must not be regarded as fixed for any site.

Landfill gas monitoring should be undertaken for the following main components:

- source
- emissions
- air quality
- meteorology.

The aim of source monitoring is to characterise the quantity and quality of the gas in each section of the landfill. Routine monitoring to determine the composition of this gas is typically undertaken

using portable hand-held instruments. These instruments measure the bulk components within the landfill gas and associated physical parameters Two different types of source monitoring points are found on landfill sites: collection wells and monitoring wells.

Emissions monitoring on landfill sites will typically consist of:

- surface emissions
- lateral emissions
- combustion emissions.

VOC surface emissions surveys can be a fast, reliable and cost effective method for identifying significant emission sources of landfill gas from a landfill surface, and for demonstrating compliance after remediation of such emission sources.

VOC surface emission measurements can provide the following information:

- The location of the main sources of surface emissions on the site,
- identify faults in the gas management system and to prioritise the remediation required,
- Whether previous remediation effort has been successful,
- Where significant amounts of landfill gas that could otherwise have been flared or beneficially used for power generation are being lost,
- Measure the total emissions from the site of methane, an important greenhouse gas involved in global warming
- Where the licensee may need to focus remediation efforts to improve the gas collection efficiency.

A qualitative estimate of methane emissions through a surface cap can be made using a hand-held instrument such as a flame ionisation detector (FID). However, very low flux cannot normally be detected and localised on a landfill cap. Extensive research suggests that the flux box is currently the most cost effective technique for the verification of the range of surface emission sources typically found on a landfill site. Flux boxes are enclosed chambers used to measure the rate of change in methane concentrations above a specific, small area of the landfill surface. By measuring the flux at a number of representative sampling points, an estimate can be made of the total emissions from a zone.

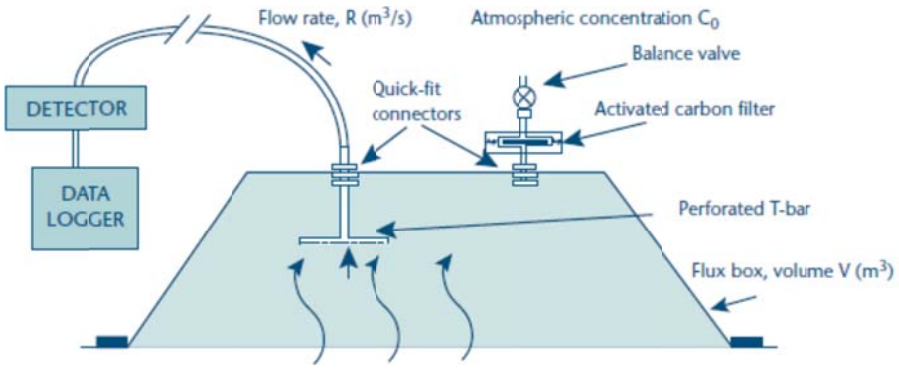


Figure 21: Flux box

To record surface concentrations of methane walk-over surveys can be produced using GPS data logging and handheld instruments that enable areas of high methane concentration or emission to be identified; they do not quantify flux.

Figure 22: Methane walk-over surveys

The monitoring of lateral emissions is undertaken using gas monitoring boreholes outside the perimeter of the deposited waste. These boreholes can be located both on-site and off-site. They provide information on the movement of landfill gas below the surface of the landfill from the waste mass. The monitoring of external boreholes is essential to demonstrate the efficient management of gas within the site and to detect any gas migrating from the site.

The monitoring of air quality within and around landfill sites is becoming increasingly important.

Figure 11: Air quality monitoring system

Use and estimation of the LFG

- Collect all landfill gas and, where feasible, utilise it to produce energy.
- Where energy generation from landfill gas is not possible, it should be burned in an enclosed flare; control the combustion conditions of enclosed flares, in terms of the carbon monoxide concentration, temperature and retention time by ensuring that combustion occurs at 1,000°C with a product retention time of 0.3 seconds within the combustion zone.
- Follow the hierarchy of landfill gas treatment options: (i) landfill gas utilisation for energy recovery, (ii) enclosed flaring, (iii) venting with open flaring as odour control measure.

The operator should model and estimate the generation of landfill gas throughout the lifecycle of the site as guide to the design and phasing of the gas extraction scheme. There are a variety of gas generation models commercially available which can predict landfill gas generation based on the types and quantities of waste accepted at the site. The model should be kept up to date using site specific data such as actual waste inputs.

5.4. Inspection preparation: desk study

During the desk study, the following preliminary check should be performed in order to collect the necessary information for a complete inspection of the topic:

Permit and permit application

- Provisions of the permit: collecting system, biogas parameters
- Gas extraction system efficiency: check conditions in the permit and description in permit application
- Gas flaring torch: check conditions in the permit and description in permit application
- Gas trigger level: check conditions in the permit and description in permit application
- Risk assessment results
- Results of the LFG diffusion model.

Self monitoring Report

- Assess compliance with all Self monitoring requirements
- Emissions results: check compliance with ELV for engines (energy use)
- Comparing the model and the real flux and composition
- Monitoring data - Diffuse emissions from the body of the landfill – sampling methodology
- Organic amount in the waste
- Odour measurements results.

5.5. On site Inspection

During the in situ inspection, the inspector should assess and check that the landfill gas control system is properly well constructed, operated and maintained. The landfill gas extraction is installed as soon as possible in order to minimise the release of uncontrolled landfill gas emissions.

The inspector will check if a landfill gas management plan is implemented in conjunction with good operational practices (e.g. not leaving odorous waste uncovered).

Flares should be operative at any moment. The presence of perimeter landfill gas monitoring boreholes should be checked to monitor gas migration.

Operational data, such as flow rate, pressure, temperature and inlet gases will be registered.

5.6. Existing guidelines

Organisation	Title of document	Link to website
Environment Agency (UK)	Guidance on the management of landfill gas Guidance on monitoring trace components in landfill gas Guidance for monitoring enclosed landfill gas flares Guidance on gas treatment technologies for landfill gas engines Guidance on monitoring landfill gas surface emissions Guidance for monitoring landfill gas engine emissions Guidance on landfill gas flaring	http://www.environment-agency.gov.uk/business/sectors/108918.aspx
EU Commission	Landfill Gas Control -Guidance on the landfill gas control requirements of the Landfill Directive	http://ec.europa.eu/environment/waste/landfill/pdf/guidance%20on%20landfill%20gas.pdf
INOGATE Technical Secretariat & Integrated Programme in support of the Baku Initiative and the Eastern Partnership energy objectives	Capacity strengthening of the SWMCG by introducing applicable methods for assessing landfill gas potential at the existing dumpsites in Georgia	http://www.inogate.org/documents/Guidelines.pdf
EPA Ireland	Air Guidance Note 6 (AG6) Surface VOC Emissions Monitoring on Landfill Facilities	https://www.epa.ie/pubs/advice/air/emissions/AG6.pdf
US EPA	LFG Energy Project Development Handbook	https://www3.epa.gov/lmop/publications-tools/handbook.html
ISWA	Landfill operational guidelines 2nd edition	http://www.iswa.org/index.php?eID=tx_bee4mememberships_download&fileUid=98
EU LIFE+ project	ACUMEN project report - Managing landfill gas at closed and historic sites	https://landss.soton.ac.uk/sites/default/files/151203%20ACUMEN%20Project%20Report%20(3.6MB).pdf

6. Water management

In this chapter all water sources in and on landfills are mentioned. It concerns the following types of water:

- Groundwater
- Leachate
- Surface water
- Rainwater
- Run-off water
- Meteoric water

For these types of water apply the following definitions:

Groundwater: the water beneath the surface of the ground.

Leachate: any liquid that, in the course of passing through matter, extracts soluble or suspended solids, or any other component of the material through which it has passed.

Surface water: water on the surface of the planet such as in a stream, river, lake, wetland.

Rainwater: water fallen as rain.

Run-off water: that part of the precipitation, snow melt, or irrigation water that appears in uncontrolled (not regulated by a dam upstream) surface streams, rivers, drains or sewers.

Meteoric water: ground water that has recently originated from the atmosphere.

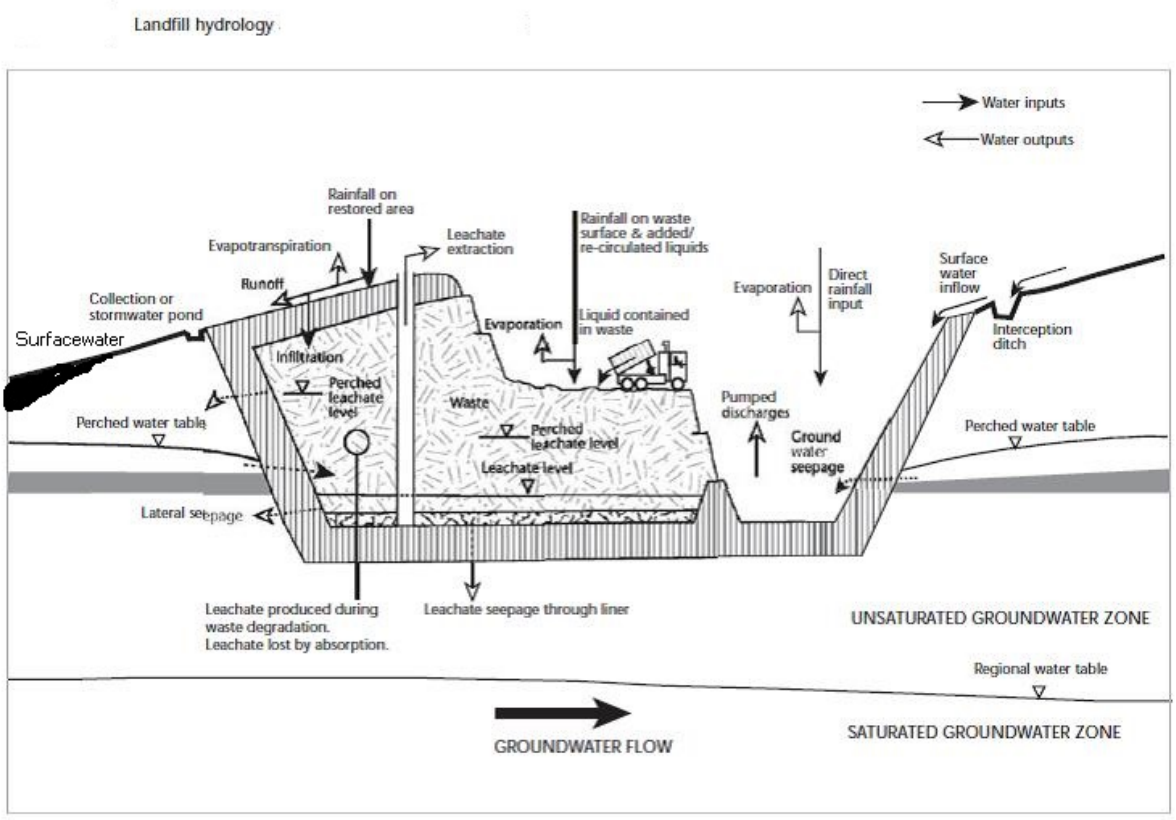


Figure 12: Landfill hydrology (source: Landfill Guidance, Environment Agency UK, February 2003)

6.1. Law requirements protection of soil and groundwater

In the landfill directive the following articles and annexes contain conditions on protection of soil and groundwater in a landfill.

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste Annex 1 section 2 and 3 and Annex III section 2, 3 and 4.

In the landfill directive the following articles and annexes contain conditions on protection of soil and groundwater in a landfill.

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste Annex 1 section 2 and and III section 2 and 3

Annex I

2. Water control and leachate management

Appropriate measures shall be taken, with respect to the characteristics of the landfill and the meteorological conditions, in order to:

- control water from precipitations entering into the landfill body,
- prevent surface water and/or groundwater from entering into the land filled waste,
- collect contaminated water and leachate. If an assessment based on consideration of the location of the landfill and the waste to be accepted shows that the landfill poses no potential hazard to the environment, the competent authority may decide that this provision does not apply,

treat contaminated water and leachate collected from the landfill to the appropriate standard required for their discharge

3. Protection of soil and water

3.1 A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachate as and when required according to section 2. Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a top liner during the passive phase/post closure.

3.2 The geological barrier is determined by geological and hydro geological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to soil and groundwater.

The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to the one resulting from the following requirements:

- landfills for hazardous waste: K <= 1,0 x 10^{-9} m/s; thickness > 5 m
- landfills for non-hazardous waste: K<= 1,0 x 10^{-9} m/s >; thickness> = 1 m
- landfills for inert waste K <= 1,0 x 10^{-7} m/s; thickness >= 1 m

m/s = meter/second

Where the geological barrier does not naturally meet the above conditions it can be completed artificially and reinforced by other means giving equivalent protection. An artificially established geological barrier should be no less than 0,5 metres thick.

3.3 In addition to the geological barrier described above a leachate collection and sealing system must be added in accordance with the following principles so as to ensure that leachate accumulation at the base of the landfill is kept to a minimum:

Leachate collection and bottom sealing

Leachate collection and bottom sealing

Landfill category	non hazardous	hazardous
artificial sealing liner	required	required
drainage layer	required	required

Member states may set general or specific requirements for inert waste landfills and for the characteristics of the

abovementioned technical means.

If the competent authority after a consideration of the potential hazards to the environment finds that the prevention of leachate formation is necessary, a surface sealing may be prescribed. Recommendations for the surface sealing are as follows:

Landfill category	non hazardous	hazardous
gas drainage layer	required	not required
artificial sealing liner	not required	required
impermeable mineral layer	required	required
drainage layer> 0,5 M	required	required
top soil cover > 1 M	required	required

3.4 If on basis of an assessment of environmental risks taking into account in particular Directive 80/86/EEC (until 22 December 2013 then replaced by Directive 2006/118/EC) the competent authority has decided in accordance with section 2 that collection and treatment of leachate is not necessary or it has been established that the landfill posed no potential hazard to soil, groundwater or surface water the requirements in paragraphs 3.2 and 3.3 above may be reduced accordingly. In the case of landfills for inert waste these requirements may be adapted by national legislation.

3.5 The method to be used for the determination of the permeability coefficient for landfills in the field and for the whole extension of the site is to be developed and approved by the Committee set up under Article 17 of this directive.

The observation must be evaluated by means of control charts which with established control rules and levels for each down gradient well. The control levels must be determined from local variations in groundwater quality.

Annex III

Protection of groundwater

A. Sampling

The measurements must be such as to provide information on groundwater likely to be affected by the discharging of waste, with at least one measuring point in the groundwater inflow region and two in the outflow region. This number can be increased on the basis of a specific hydro geological survey and the need for an early identification of accidental leachate release in the groundwater.

Sampling must be carried out in at least three locations before the filling operations in order to establish reference values for future sampling.

B. Monitoring

The parameters to be analysed in the samples taken must be derived from the expected composition of the leachate and the groundwater quality in the area. In selecting the parameters for analysis account should be taken of mobility in the groundwater zone. Parameters could include indicator parameters in order to ensure an early recognition of change in water quality

	Operation phase	After-care phase
Level of groundwater	every six months	every six months
Groundwater composition	site-specific frequency	site-specific frequency

C. Trigger level

Significant adverse environmental effects, as referred to in Articles 12 and 13 of this Directive should be considered to have occurred in the case of groundwater, when an analysis of a groundwater sample shows a significant change in water quality. A trigger level must be determined taking account of the specific hydro geological formations in the location of the landfill and groundwater quality. The trigger level must be laid down in the permit whenever possible.

Emission data: water, leachate

Sampling of leachate and surface water if present must be collected at representative points. Sampling and measuring

(volume and composition) of leachate must be performed separately at each point at which leachate is discharged from the site.

Monitoring of surface water if present shall be carried out at no less then two points, one upstream from the landfill and one downstream.

For leachate and water, a sample representative of the average composition shall be taken for monitoring.

The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, burried etc). This has to be specified in the permit

	Operating phase	After-care phase
2.1 Leachate volume	monthly	every six months
2.2 Leachate composition	quarterly	every six months
2.3. Volume and composition of surface water	quarterly	every six months

6.2. Description

A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachate as and when required according to section 2.

Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a top liner during the passive phase/post closure.

In addition to the geological barrier leachate collection and sealing system must be added to ensure that leachate accumulation at the base of the landfill is kept to a minimum.

Figure 25: Lagoon for treated leachate water at Landfill in Romania

In order to check if all measures taken are in order, inspection and monitoring is essential. It is legally required to monitor discharged leachate, quality of surfacewater (up- and downstream) and quality of groundwater (up- and downstream of the landfill).

6.3. Best practices

In order to prevent pollution of ground- and surfacewater a landfill has to meet a number of requirements. The goal is to keep pollutions inside the landfill and to treat polluted water before discharging it.

In order to achieve these requirements these are best practices:

- A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water. In order to achieve this it is necessary to carry out an hydrological risk assessment and repeat periodically (e.g. every 6 years GB). This is essential as a base for the environmental permit. Important is also the stage of the landfill (starting operating or closure) and/or parts of the landfill. In the building phase of a landfill soil, surface and groundwater must be protected by building a construction under the landfill which prevents entering water from underneath the landfill into the landfill and leaving water out of the landfill. Simultaneously the landfill must contain systems to control water which enters the landfill, like rainwater. Also a monitoring system is necessary.
- To prevent run-off water to spread into the environment it's best practice to construct a landfill in such way so the run-offwater from polluted areas flows into the bottom liner.
- It's also best practice to construct a leachate collecting system and the pipes for unclogging the leachate colleting system in a way so it doesn't has to go through the bottom liner. In this way there are no weak spots in het bottom liner. The most important factor is to avoid creating leachate. For example work with small cells and separate leachate collection from cells of hazardous and non-hazardous waste. By collection different leachate streams the leachate can be treated specifically. Depending on the Member State and on the Competent Authority, leachate recirculation in the landfill body is allowed or not. On the one hand leachate recirculation results in the benefits of a faster stabilization of the landfill, and enhanced gas production as it restores the content of humidity in the waste; on the other hand, the recirculation of excess leachate, where additional leachate no longer provides any benefit, is seen as leachate disposal at a landfill and is not an appropriate option for managing it. The collected leachate must be treated before discharging into surface water.
- To prevent smell from collected leachate in leachate basins it's best practice to cover the surface with a liner.

Protection of soil and groundwater

It is important to keep the groundwater out of the landfill and contaminated water in the landfill.

If the soil is not covered with a mineral or other layer contaminations can enter the soil. A bottom layer can also get damaged whereby groundwater can get contaminated if it enters the landfill. The contaminated water can than enter the soil. Leachate can also penetrate the soil if the covering is not present or if it's damaged. Through this way contaminations can (eventually) reach the groundwater.

How we can protect the groundwater?

- Very important is before starting an landfill make a Hydrological Risk Assessment to determine what measures are necessary to protect the groundwater when building a landfill.
- The geological conditions where a landfill is build are very important. What is the risk of contamination of the groundwater? Keep the minimum standards for a geological barrier as stated in the Landfill Directive 1999. Is an under seal necessary?
- Create a monitoring plan with a map with boreholes for monitoring groundwater level and quality. Determine the trigger levels based on the risk assessment.

- Placing boreholes (based on the HRA) up and downstreams to monitor groundwater levels and groundwater
- Determine groundwater level and quality before starting a landfill.
- State maximum groundwater levels and trigger levels of groundwater quality in the permit. In some member states trigger levels are stated in national legislation.
- State an action plan in the permit in case of exceeding stated groundwater levels or groundwater quality trigger levels.

Figure 26: Groundwater monitoring in Spain

Leachate management

Wastes which are put into landfills contain water. Rainwater also penetrates non-covered landfills. This water will sink through the waste that is put into the landfill and will eventually reach the bottom of the landfill. Water which runs through waste is called leachate. Leachate contains all sorts of contaminations from the waste.

Most important is that the amount of leachate must be kept to a minimum.

- Work with small cells for landfilling the waste. Compact and cover as soon as possible completed cells.
- Collect the leachate with a drainage system in a basin. If possible (leachate from non hazardous waste) recycle the leachate to optimize the biogas production or dust control.

When it isn't possible to recycle the leachate we have to discharge of the leachate.

- Collect the leachate and check the quality of the leachate.
- If it is necessary treat the leachate before discharging.
- Discharge of the leachate into a public sewer or surface water if permitted.
- Check the quality and quantity of the leachate periodically.

Figure 27: Leachate monitoring in Malta

Surfacewater

Surfacewater is water on the surface of the planet such as in a stream, river, lake, wetland.

Treated leachate, groundwater and run-off water can eventually reach surface water if it's in the surroundings of the landfill. If these different types of water are contaminated it can potentially pollute the surface water. To prevent pollution of the surface water the sources should be monitored at a discharging point. At the discharging points of surface water should laid down in the permit.

Rainwater

Rainwater can enter a landfill site when it is not covered. In this case rainwater becomes leachate. It can also run off through roads and slopes of the landfill. In that case this water is mostly slightly polluted. When we want to discharge this water, it has to be treated. Light treatment will be sufficient.

Run-off water

To minimise the risk that Run-off water is very polluted and has to be treated before discharging. It is important to cover the completed cells. If run of water has been in contact with the waste we need to monitor if treatment is necessary.

Meteoric water

Meteoric water becomes groundwater over time. See groundwater for 'description of activity'.

6.4. Inspection preparation: desk study

Before starting the on-site inspection you have to prepare your inspection by a desk study. You have to check the following components for inspection on water management on a landfill:

- What is stated in the permit about:

- What measures are described in the permit and/or permit application about water issues?
- Groundwater monitoring (trigger levels, monitoring frequency)
- Treating and discharging of leachate
- Run-off water

- Is a risk assessment of the landfill part of the permit?
- Is an action plan stated in the permit in case of exceeding the groundwater trigger levels?
- What are the results of the monitoring of the groundwater?
- Is leachate monitored? What are the results of the monitoring?
- Check pervious reports of inspection.
- Check if there are complains.

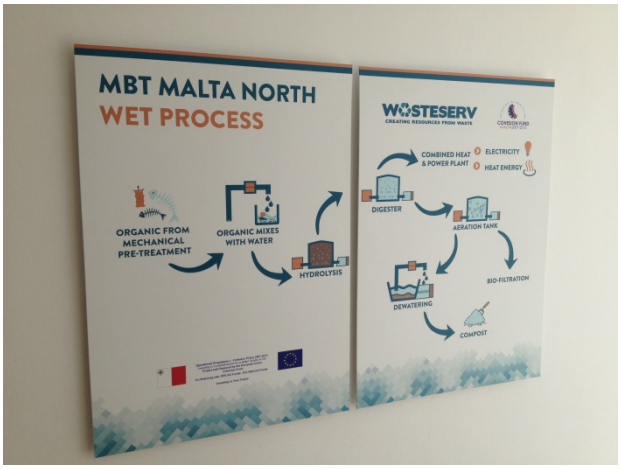


Figure 28: Process flow-chart in Malta

Use all of the above information to check if all the necessary actions are taken by the holder of the permit. With this information you can check if all taken measurements are in order and well maintained

Goal is to ensure that the landfill doesn't threaten the quality of the groundwater or near surface water.

6.5. On site Inspection

During the on-site inspection you check if all necessary measures are taken by the holder of the permit to meet the permit requirements. Information which during the deskstudy is found is also checked during the on-site inspection.

What can you check during an on-site inspection?

Groundwater:

During the inspection you can check the following points:

- The boreholes for groundwater sampling are present at the right spots.

- Make a comparison between groundwater quality up and downstream of the landfill to check if groundwater is polluted by water coming out of the landfill.
- Check the monitoring results if they are available on the landfill.
- Groundwater quality can be checked by taking samples up- and downstream of the landfill. Depending on national legislation you can perform it yourself or it is performed by or commissioned by the landfill owner. Depending on legislation and national policy you have to be certified to perform sampling and analyzing.

Leachate:

- Check if the leachate collecting system can be unclogged.
- Does the holder of the permit regularly check if the collecting system works properly?
- Check the level of the leachate in the landfill? Are pumps working like they should be? The leachate collection system must always perform normally to prevent a buildup of leachate in the landfill. If leachate can't be drained from the landfill in some moment in time it will cause problems like instability of the site or groundwater pollution. Therefore it should be possible to unclog a leachate collection system to prevent a buildup of leachate.
- The quality of the leachate should be monitored regularly.
- This is necessary to determine if the leachate has to be treated, or to determine if re-use is a possibility.
- The quality of the leachate has to be determined regularly to determine which treatment it needs to re-use it or to determine how it has to be treated before discharging it.
- In case leachate is treated you can check if the treatment plant works properly.

Figure 29: Leachate-collection in England

Surface water

- Check if you can take samples at discharging points of (treated) leachate and other wastewaters.

- If possible take samples of water that is discharged from the landfill into the surface water to determine if permit regulations are not violated.
- Check if surface water can't enter the landfill.
- Check if the holder of the permit control that all precautions are functioning in the right way.

Run-off water

- Check if the run-off water can be collected to prevent for running uncontrolled into a surface water.
- Are ditches or collecting canals build to catch run-off water?
- Is the run-off water collected and checked before discharging it?
- Is in the run-off collection system a first flush made so the more heavily contaminated water is discharged into a sewer?
- Are slopes of the landfill constructed in a way so run-offwater flows into the bottom liner of the landfill?

6.6. Existing guidelines

Organisation	Title of document	Link to website
Environmental Agency (UK)	Monitoring of landfill leachate, groundwater and surface water and other relevant literature	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321602/LFTGN02.pdf
Swedish Environmental Protection Agency	Landfilling of waste Handbook 2004:2 with guidelines to the Ordinance (2001:512) on the Landfill of Waste and to Chapter 15, 34 § of the Environmental Code (1998:808)	Handbok on ordinance on landfill: http://www.naturvardsverket.se/upload/in-english/legislation/handbook-landfilling/handbook-landfill-of-waste.pdf

7. Top and bottom layers

7.1. Law requirements

In the Landfill Directive the following articles an annexes contain conditions about building and closing phase in a landfill

Article 8 Conditions of the permit

(c) Prior to commencement of disposal operations, the competent authority shall inspect the site in order to ensure that it complies with the relevant conditions of the permit. This will not reduce in any way the responsibility of the operator under the conditions of the permit.

Article 13 Closure and after care procedures

(b) A landfill or part of it may only be considered as definitely closed after the competent authority has carried out a final on-site inspection, has assessed all the reports submitted by the operator and has communicated to the operator for approval for the closure. This shall not in any way reduce the responsibility of the operator under the conditions of the permit.

(c) After landfill has been definitively closed, the operator shall be responsible for its maintenance, monitoring and control in the alter-care phase for as long as may be required by the competent authority, taking into account the time during which the landfill could present hazards.

ANNEX I: GENERAL REQUIREMENTS FOR ALL CLASSES OF LANDFILLS

3. Protection of soil and water

3.1. A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachate as and when required according to Section 2. Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a bottom liner during the operational/active phase also by the combination of a geological barrier and a top liner during the passive phase/post closure.

3.3. In addition to the geological barrier described above a leachate collection and sealing system must be added in accordance with the following principles so as to ensure that leachate accumulation at the base of the landfill is kept to a minimum:

Member States may set general or specific requirements for inert waste landfills and for the characteristics of the abovementioned technical means.

If the competent authority after a consideration of the potential hazards to the environment finds that the prevention of leachate formation is necessary, a surface sealing may be prescribed. Recommendations for the surface sealing are as follows:

3.4. If, on the basis of an assessment of environmental risks taking into account, in particular, Directive 80/68/EEC(1), the competent authority has decided, in accordance with Section 2 ("Water control and leachate management"), that collection and treatment of leachate is not necessary or it has been established that the landfill poses no potential hazard to soil, groundwater or surface water, the requirements in paragraphs 3.2 and 3.3 above may be reduced accordingly. In the case of landfills for inert waste these requirements may be adapted by national legislation.

6. Stability

The emplacement of waste on the site shall take place in such way as to ensure stability of the mass of the waste and associated structures, particularly in respect of avoidance of slippages. Where an artificial barrier is stablished it must be ascertained that the geological substratum, considering the morphology of the landfill, is sufficiently stable to prevent settlement that may cause damage to the barrier.

7.2. Description

The construction of a landfill and it's subsequent closure must ensure the dual objective of holding safely waste and not cause any pollution to the environment, both in the phase of operation thereof as once it closed.

The Council Directive 1999/31/EC establish that it is necessary to indicate clearly the requirements with which landfill sites must comply as regards location, conditioning, management, control closure and preventive and protective measures to taken against any threat to the environment in the short as well as in the log-term perspective, and more specially against the pollution of groundwater by leachate infiltration into the soil

So, the landfill needs a specific permit. To obtain a landfill permit the operator has to present among other documents a building project that includes at least:

- The engineering design with the submission of construction proposals: constructive solution
- Construction Quality Assurance Plan (QAP) - Supervised by an independent third part (with the agreement of the authority) (UK, Spain)
- Specifications
- Drawings.

Once permission has been granted, the building phase must start. From this moment the work of inspection begins. Why to inspect a landfill in the building and closing phases?

To determinate whether a landfill are performed as designed. This requires not only one inspection before the start of activity and another one before the approval of the closure (Article 8 c and 13 c of the Council Directive 1999/31/EC, respectively). Different stages of the building and closing phases shall be inspected.

It should be noted that this is the phase in which it may be verified that all measures to prevent pollution and to ensure safety have been adopted. It is at this time when the existence of the drainage of groundwater, the execution of leachate collection systems, surface water, the inclination of the slopes and has provided the entire package of waterproofing can be verified.

The purpose of the inspections during the building phase is:

- To ensure protection of soil and water (surface and ground water),
- To ensure stability,
- To check the sealing system, the surface water, groundwater and leachate collection systems and biogas collecting system, if necessary.

The purpose of the inspections during the closing phase is:

- To verify that the final work of sealing has successfully executed,
- To ensure that the operator has adopted the necessary measures for the maintenance, monitoring and control of the landfill in the after-care phase, special attention to:
    - Leachate collecting system

- Biogas collecting system, if necessary.

7.3. Best practices

Building phase: prior to the commencement of disposal operations, the competent authority shall inspect the site in order to ensure that complies with the relevant conditions of the permits.

Closure phase: a landfill or part of it may only be considered as definitely closed after the competent authority has carried out a final on-site inspection, has assessed all the reports submitted by the operator and has communicated to the operator its approval for the closure.

In both building and closing phases, the construction requirements shall be verified by the competent authority. A final report is needed.

In order to facilitate this work more than one inspection (articles 8 and 13 of Council Directive 1999/31/EC) has to performed, so it is necessary:

- To define the most important stages to inspect during the building and closing phases: two kinds of inspections (several during the building/closing phase and one final inspection at the end of the works) (see preparation of the inspection: desk study).
- To have a great knowledge of the permit: constructive solution, specifications and drawings.
- To perform inspections in the different stages of the building and closing phases.
- To have special training for the inspectors is needed: training plans developed by MS.

7.4. Inspection preparation: desk study

A indepth knowledge of the permit and also the project (constructive solution, specifications and drawings) is needed to be able to perform an inspection The inspector has to:

- Review of the conditions of the permit (IPPC or others) for the construction and management and for the closure of the landfill
- Collect the construction project documentation.

These are the key topics:

- Description excavation work, compaction and conditioning of the base of the landfill.
- Description of collection systems groundwater, if it exists.
- Description of the systems of collection and drain of surface water.
- Characteristics of bottom sealing and slopes of the landfill.
    - Bottom sealing.
    - Anchoring bottom sealing.
- Description of the systems of collection and treatment of leachate.
- Description of catchment systems and treatment of biogas.
- Type closure in order to prevent free access to facilities.
- Operating Plan. Works initial operation of the landfill (Protection package landfill background).

- Construction Quality Assurance (CQA) plan for the Construction of lining system.
- The inspector checks the CQA plan of geosynthetics was developed by an independent third party (with national appropriate accreditation).
- The inspector finds that there is a validation report on completion on works to (good execution) conclude that the installation of geosynthetics was completed according to the specifications of CQA plan ensuring that this plan was monitored according to criteria of absolute independence.
- Once executed the plan quality control of geosynthetics and checked the certificate of final work and, if any, changed the construction project, inspection final check of the work will be done before use.

7.5. On site Inspection

Initial inspection

Control of the preparation of suitable land (Morphology landfill). The support surface of geosynthetics.

Preparation of support:

Regular and uniform: the support material should be uniform, with continuous grain size, and the absence of large sizes that may cause breakage.

Compact. Will be achieved by strong compaction reach 95% Proctor soil used (UNE 103500), in the bottom and on slopes of the cell.

Checking the inner slope of the cell, according to the project.

Figure 30: Bottom and slope of the cell

Groundwater collection network, if any, checking existence and connections.
There has been a drainage system and channeling the water table.
Problems that can cause → Withdrawal of the geomembrane.

Figure 31: Groundwater collection network

Figure 32: Keys to control and connections

Intermediate inspections

a. Checking base liner systems[2]:

Bottom sealing	Slope
Waste	Waste
Geotextile filter Drainage layer (Gravel) Geotextile protection	Composite drainage
Artificial sealing liner (Geomembrane (HDPE))	Artificial sealing liner (Geomembrane (HDPE))
Impermeable mineral layer (Geosynthetic clay liners (GCL) or clay)	Impermeable mineral layer (Geosynthetic clay liners (GCL or clay)
Compacted natural ground with drainage of groundwater	Compacted natural ground

[2] Base liner system model: It complies with Council Directive 1999/31/EC Annex I.

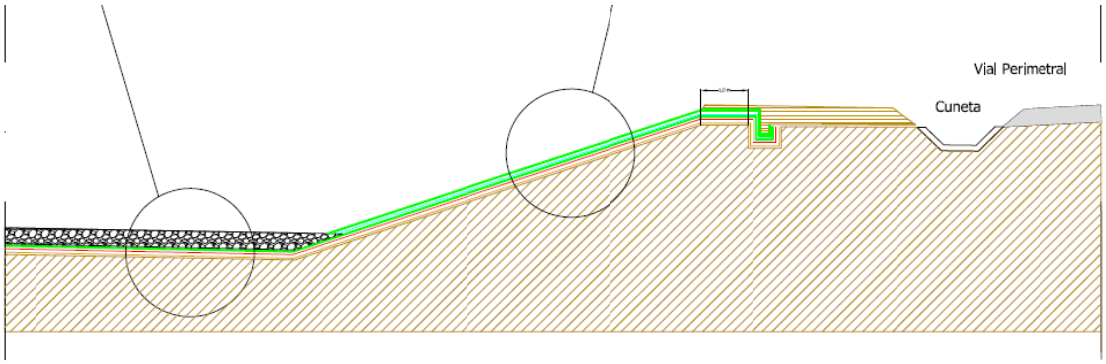


Figure 33: Base liner

b. Checking existence of bottom layers

Figure 34: Bottom layer

c. Checking existence of anchor sheets

Figure 35: Trenches in coronation slope

- Anchor trench, in coronation slope.
- Anchor berm, by overweights.
- Anchor singular elements, by attaching the sheet to the element.

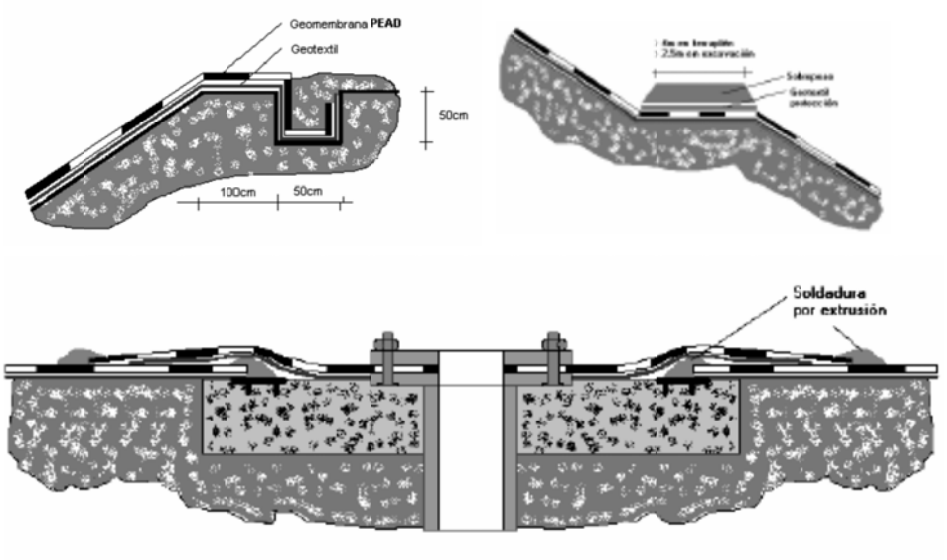


Figure 36: Anchoring systems

d. Clay, checking existence

Figure 37: Clay thickness

Figure 38: Clay layer

e. Geosynthetic clay liners (GCL), checking existence and overlap between panels

Figure 39: Geosynthetic clay liners

f. Geomembrane (HDPE)

Figure 40: Geomembrane

g. Geotextile protection

Figure 41: Geotextile protection

h. Gravel, checking the thickness

Figure 42: Thickness of gravel layer

i. Geotextile filter

Figure 43: Geotextile filter

j. Composite drainage

Exceptions may be granted for the installation of the composite drainage, in this case it is installed with advancing operation.

Figure 44: Preparing the bottom - materials

k. Leachate collection network, checking existence and connections.

Figure 45: Leachate collection network

I. Structures in cells to minimize leachate generation can be performed.

Figure 46: Cell construction

Final inspection

Once executed the plan quality control of geosynthetics and checked the certificate to final work and, if any, changed the construction project (As built project), inspection final check of the work will be done before use.

Operation system, for example:

a. Extraction systems

Figure 47: Extraction system

b. Access ramp

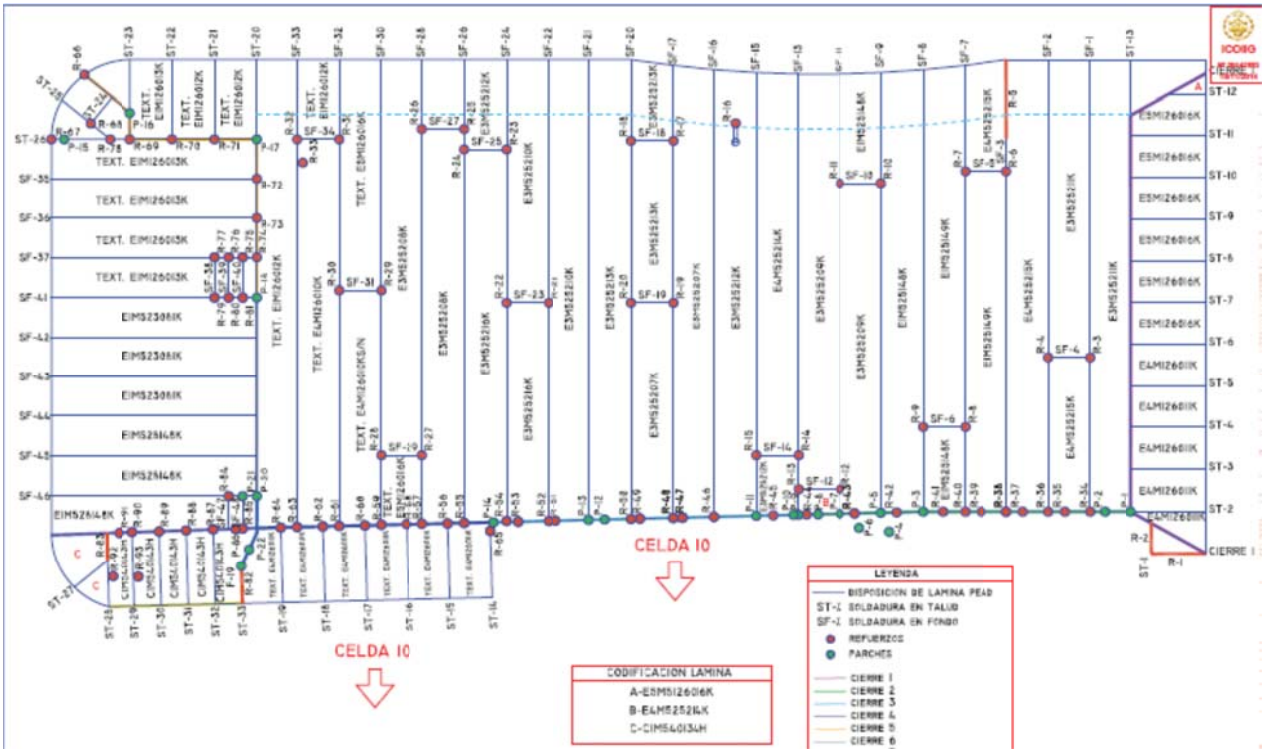
Figure 48: Access ramp

c. Rainwater collection network, checking existence and connections.

Figure 49: Ditch perimeter of rainwater

- Detailed report of the repairs made.
- Detail layout sheets welds and patches.


NW28


CELDA I0
CELDA I0
CODIFICACION LAMINA
A-E3MS126016K
B-E4MS2524K
C-CIMS4013H
LEYENDA
DISPOSICION DE LAMINA PEAD
SOLDADURA EN TALUD
SOLDADURA EN FONDO
REFUERZOS
PARCHES
CIERRE 1
CIERRE 2
CIERRE 3
CIERRE 4
CIERRE 5
CIERRE 6

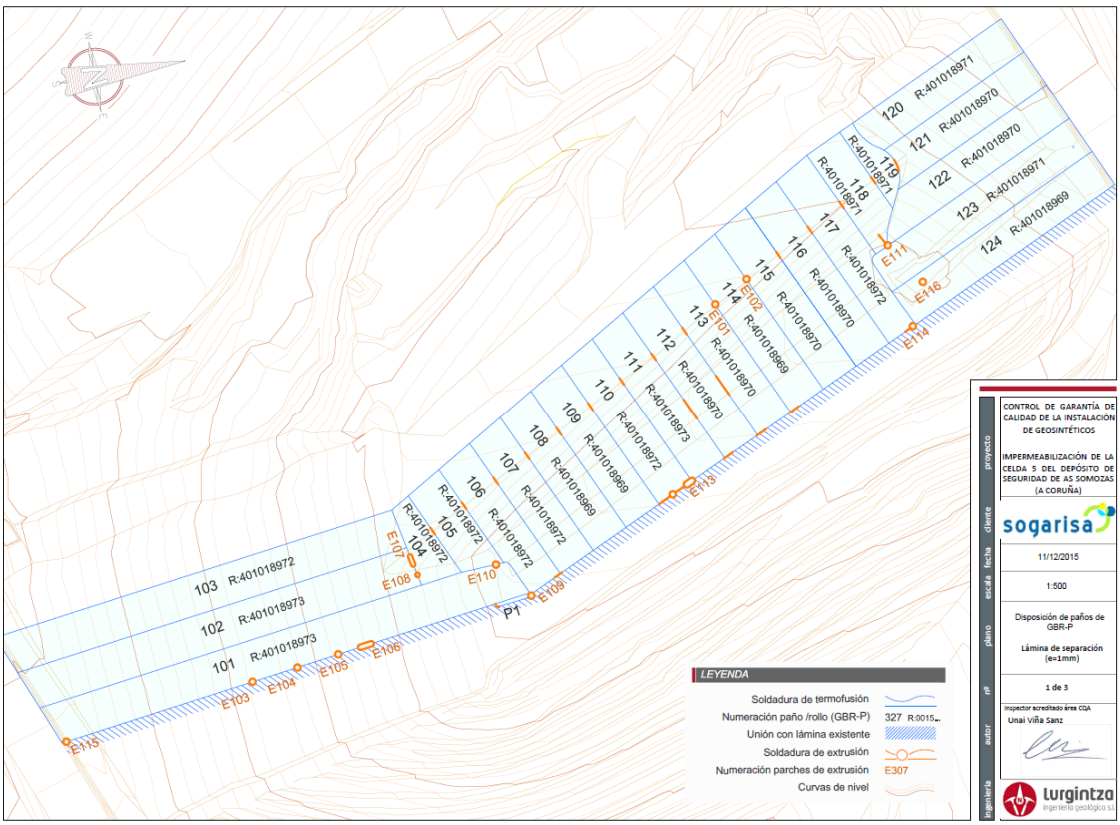


Figure 50: Layout sheets welds and patches

After the start of the operation

After the approval of the competent authority with the work to prompt the operator in monitoring documenting, through photographic reportage, the start of the operation and placement of geocomposite drainage.

a. Start operating

Figure 51: Operation start

b. Attaching the composite drainage during operation

Figure 52: Attaching the composite drainage

Annex 1: Desk study checklist - inspection preparation

To have an indepth knowledge about the landfill is the most important condition for the successful preparation of the inspection.

This Annex gives an overview of the different documents to study according to the type of landfill to inspect and of the purposed of the inspection.

The key documents to study posted below are listed in three categories:

1. Revision of documents (first approach)

    1.a) Permit review of imposed conditional on authorization (IPPC or others)
    1.b) Specific conditions (3.1-3.6)
    1.c) Project
    1.d) Drawings
    1.e) Environmental monitoring plan (EMP)
    1.f) Results of environmental monitoring plan

2. Deeper analysis of the documents (on depend on the type of inspection)

    2.a) Waste acceptance criteria: depending on the type of landfill (hazardous, non-hazardous, inert,…) (3.1)
    2.b) Systems of collection of gas, if case.(3.2)
    2.c) Systems of collection and drain of surface water.(3.3)
    2.d) Systems of collecting groundwater, if case.(3.4)
    2.f) Systems of collection and treatment of leachate (3.5)
    2.f) Building phase and closure phase (Bottom sealing, anchoring, Construction Quality assurance -CQA-,…)(3.6)

3. Other documents (accidents, incidents and complaints)

    3.a) Gathering all the information about the accident/incident/complaints
    3.b) Which activity of the landfill (3.1-3.6) *is the accident/incident/complaint connected with?*
    3.c) revise the documents related with the accident/incident/complaint

Check list (general)

		Desk Study (documents to review)														
Type of inspection:		**1. Revision of documents (first approach)**						**2.. Revision of documents (deeper analysis)**						**3. Others documents)**		
		1.a)	1.b)	1.c)	1.d)	1.e)	1.f)	2.a)	2.b)	2.c)	2.d)	2.e)	2.f)	3.a)	3.b)	3.c)
Initial																
	Pre-operational															
Regular																
	Announce on-site inspection															
	Not announce inspection (following an inspection plan)								X		X		X			
Others																
	Accidents															
	Incident															
	Complaints															

Example: Regular not announce inspection (inspection plan). Focus on leachate water ad biogas.

		Desk Study (documents to review)														
Type of inspection:		**1. Revision of documents (first approach)**						**2.. Revision of documents (deeper analysis)**						**3. Others documents)**		
		1.a)	1.b)	1.c)	1.d)	1.e)	1.f)	2.a)	2.b)	2.c)	2.d)	2.e)	2.f)	3.a)	3.b)	3.c)
Initial		X	X	X	X	X	X									
	Pre-operational															
Regular																
	Announce on-site inspection															
	Not announce inspection (following an inspection plan)								X		X		X			
Others																
	Accidents															
	Incident															
	Complaints															

Annex 2: Checklist ON SITE inspection

Landfill permitting and inspection

Reinforcement program in inspection skills according to landfill directive in IMPEL member countries

NON HAZARDOUS WASTE LANDFILL ENVIRONMENTAL INSPECTIONS: CHECKLIST

1. WASTE ACCEPTANCE CRITERIA FOR LANDFILLS
2. GAS CONTROL
3. PROTECTION OF SOIL AND GROUNDWATER
4. SURFACE WATER CONTROL AND LEACH ATE MANAGEMENT
5. BUILDING AND CLOSING LANDFILL

GENERAL DATA

Date of inspection:	
Inspection typology:	*Routine or non-routine environmental inspections*
Installation:	
Address:	
IPPC category:	
n. of permit:	
IPPC referent:	
E-mail:	
Phone number:	

1 CLASSIFICATION OF WASTE										
1.1 Chosen wastes streams										
Waste code	Name of waste	Absolute Hazardous (HZ) or non-hazardous		Mirror-code?	Code that ends with -99?	Risk of hazardous properties? Properties is:				In compliance?
		HZ	NHZ			Not docu.	Not known	Documented	No risk of haz. Prop.	
120199	Blasting material	-	-	-	Yes		Yes			If waste is absolute hazardous or non-hazardous go to part for "Waste acceptance criteria for landfills and pre-treatment of waste" in the guidance. If waste is mirror code or ends with 99, and there is a risk of hazardous properties and they have been documented, go to part for "Waste acceptance criteria for landfills and pre-treatment of waste" in the guidance. If waste is mirror code or ends with 99, there is a risk of hazardous properties or properties is not known or documented, then the landfill operator should not accept the waste for landfilling before the waste producer have supplemented data about the properties of the waste
200307	Fly ash (oil)	Yes						Yes		
170504	Soil from contaminated site			Yes		Yes				
190805	Sludge waste water treatment		Yes						Yes	

2. WASTE ACCEPTANCE CRITERIA FOR LANDFILLS AND PRE-TREATMENT OF WASTE	
2.1 Kind of landfill	
Hazardous waste	☐
Non-hazardous waste (these landfills may be used for (i) municipal waste (ii) non-hazardous waste of any orgin, which fulfil the criteria for the acceptance of waste at landfill for non-hazardous waste set out in accordance with annex II (and Council decision 2002/33/EC) iii) stable, non-reactive hazardous waste (e.g. solidified, vitrified) with leaching behaviour equivalent to those of the non-hazardous waste referred to in point (ii) which fulfil the relevant acceptance criteria set out in accordance with Annex II (and Council decision 2002/33/EC). These hazardous waste shall not be deposited in cells destined for biodegradable non-hazardous waste)	☐
Inert waste	☐
Other.....	☐
2.2 Selected waste streams to be supervised	
Method of inspection can be to make a selection of different kind of waste streams that the landfill may accept according to the permit. For the streams selected all the steps in this checklist can be checked to verify if the landfill is in compliance with the acceptance criteria defined.	
Waste streams selected: (from 1.1)	
Waste code and name: 1.120199 Blasting material 2.200307 Fly ash (oil) 3.170504 Soil from contaminated site 4.190805 Sludge waste water treatment **Description:** **1.**	

2. **3.** 4.		
2.3 Record of incoming information		
	In compliance?	
	YES	**NO**
Period for which records with required information are kept		
The operator shall keep records of information required for a period to be defined by the Member State. In your member state this . . (Regulation in which this is required is prescribed by national regulations) Are the basic characterisation documents kept according to the period determined in your national legislation ?		

2.4 Registration of data fundamental requirements for basic characterisation of the waste in records		
Do the records contain the following information ? (1.1.2. Council Decision of 19 December 2002)	**YES**	**NO**
(A) The source and origin of the waste **1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**
(B) Information on the process producing the waste (description and characteristics of raw/input materials and products) **1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**
(C) Description of the waste treatment applied in compliance with Article 6(a) of the Landfill Directive, or a statement of reasons why such treatment is not considered necessary *treatment: means physical, thermal, chemical or biological processes, including sorting that change the characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery* Is there a description of the treatment / No pre-treatment of waste necessary ? **1.** **2.** **3.** **4.** Does the pre treatment involves appropriate selection of different waste fractions and the stabilization of the organic fraction of	**1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**

waste? **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**
(D) Data on the composition of the waste and the leaching behaviour, where relevant: Is the number of protocol used for analysis mentioned in the basic characterization of waste made by the producer ? **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**
(E) (physical) Appearance of the waste (odour, colour, physical form) **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**
(F) Code according to the European waste list (EWC) 1.120199 Blasting material 2.200307 Fly ash (oil) 3.170504 Soil from contaminated site 4.190805 Sludge waste water treatment	 **1. Yes** **2. Yes** **3. Yes** **4. Yes**	 **1.** **2.** **3.** **4.**

(G) For hazardous waste in case of mirror entries: the relevant hazard properties according to Annex III to Annex III to Directive 2008/98/EC: Please add information (H-codes) In case of non-hazardous waste, does the bulletin contains the analysis of leach ate and analysis of hazardous properties? 1. - 2. - 3.170504 Soil from contaminated site (MIRROR-CODE) **4. -**	**1. -** **2. -** **3.** **4. -**	**1. -** **2. -** **3. No** **4. -**
(H) Information to prove that the waste does not fall under the exclusions of Article 5(3) of the Landfill Directive Information about dry matter? Waste that falls within the scope of article 5 (3) is : (a) liquid waste (b) waste which in conditions of landfills is explosive, corrosive, oxidising, highly flammable or flammable (c) hospital and other clinical wastes arising from medical or veterinary establishments, which are infectious as defined (property H9 in Annex III) by directive 2008/98/EC and waste falling within category 14 (Annex I.A) of that directive (d)whole used tyres (2003) excluding tyres used as engineering material and shredded used tyres (2006) excluding in both instances bicycle tyres and tyres with an outside diameter above 1 400 mm) (e) any other type of waste which does not fulfil the acceptance criteria determined in accordance with Annex II. **1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**
(I) If necessary, additional precautions to be taken at the landfill **1.** **2.** **3.**	**1.** **2.** **3.**	**1.** **2.** **3.**

4.	4.	4.
(J) Check if the waste can be recycled or recovered: 1. 2. 3. 4.	 1. 2. 3. 4.	 1. 2. 3. 4.
(K) Check on location one or several documents from this year to ensure that they comply with the demands. 1. 2. 3. 4.	 1. 2. 3. 4.	 1. 2. 3. 4.

2.5 Testing Basic characterisation (1.1.3 Council Decision of 19 December 2002)		
2.5.1 Stable, non-reactive waste		
Check if they are allowed in the landfill and what the operator and inspection authority check (leaching test, chemical-physical treatment…) Stable non-reactive means that the leaching behaviour of the waste will not change adversely in the long-term, under landfill design conditions or foreseeable accidents: - in the waste alone (for example, by biodegradation), - under the impact of long-term ambient conditions (for example, water, air, temperature, mechanical constraints), - by the impact of other wastes (including waste products such as leach ate and gas). Did the Member States set criteria to ensure that hazardous monolithic wastes are stable and non-reactive before acceptance in landfills for non-hazardous waste? ..... Are any of the wastes stable, non-reactive? Information about TOC or loss of ignition? 1. 2. 3. 4.	**1.** **2.** **3.** **4.**	**1.** **2.** **3.** **4.**

2.5.2 Basic characterisation

Waste must be tested to obtain the necessary information for basic characterisation (See D above). In addition to the leaching behaviour, the composition of the waste must be either know or determined by testing. The scope of (basic) characterisation, the extent of laboratory testing required and the relationship between characterisation and compliance testing depends on the type of waste. A differentiation can be made between:

A. Wastes regularly generated in the same process

(individual and consistent wastes regularly generated in the same process, where: the installation and the process generating the waste are well known and the input materials to the process and the process itself are well defined the operator of the installation provides all necessary information and informs the operator of the landfill of changes to the process (especially changes to the input material). The process will often be from a single installation but the waste can also be from different installations, if it can be identified as a single stream with common characteristics within known limits/facilities (e.g. bottom ash from the incineration of municipal waste)

B. Wastes that are not regularly generated

These wastes are not regularly generated in the same process in the same installation and are not part of a well-characterised waste stream. Each batch produced of such waste will need to be characterised. The basic characterisation shall include the fundamental requirements for basic characterisation. As each batch produced has to be characterised, no compliance testing is needed

C. Cases where testing is not required

(a) When the waste is on a list of wastes not requiring testing as laid down in section 2 of this Annex being:

10.11.03 (waste glass-based fibrous materials), 15.01.07 (glass packaging glass), 17.01.01 (concrete), 17.01.02 (bricks), 17.01.03 (tiles and ceramics), 17.01.07 (mixtures of concrete, bricks, tiles and ceramics), 17.02.02 (glass), 17.05.04 (soil and stones), 19.12.05 (glass), 20.01.02 (glass), 20.02.02 (soil and stones)

(b) All the necessary information, for the basic characterisation, is known and duly justified to the full satisfaction of the competent authority

(c) Certain waste types where testing is impractical or where appropriate testing procedures and acceptance criteria are unavailable. This must be justified and documented, including the reasons why the waste is deemed acceptable at this landfill class.

For the selected waste stream : do you agree with the way the waste stream has been categorised in (a) regularly generated (b) not regularly generated (c) or cases where testing is not required by the installation owner ? For the waste stream which you have selected for the inspection, has it been classified in the right class? **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**	 **1.** **2.** **3.** **4.**

2.5.3 Compliance testing - waste producer(1.2. Council Decision of 19 December 2002)

When a specific waste is qualified for a certain landfill class on the basis of basic characterisation it shall subsequently be subject to compliance testing to determine if its complies with the results of the basic characterisation and the relevant acceptance criteria. The directive makes a difference in:

2.1 criteria for landfills for inert waste

2.2.criteria for landfills for non-hazardous waste

2.3 criteria for hazardous waste acceptable at landfills for non-hazardous waste pursuant article 6(c)iii

2.4.criteria for waste acceptable at landfills for hazardous waste

2.5 criteria for underground storage)

The Member States shall determine which of the test methods and corresponding limit values in the table should be used. Your national legislation in which this is implemented is:

	IN COMPLIANCE	
	YES	**NO**
For the selected waste streams has compliance testing been performed? selected waste stream : **1.** **2.** **3.** **4.**	 **1.** **2.** **3.**	 **1.** **2.** **3.**

	4.	4.
Are all the tests of the compliance testing in agreement with the ones used in the basic characterisation procedure? 1. 2. 3. 4.	1. 2. 3. 4.	1. 2. 3. 4.
Is a batch leaching test done in agreement with the sampling and testing methods (section 3 of the Council Decision of 19 December 2002) ? 1. 2. 3. 4.	1. 2. 3. 4.	1. 2. 3. 4.
Do the results of the analyse test show that the waste meets the limit values for critical parameters and may the waste be accepted at this landfill? 1. 2. 3. 4.	1. 2. 3. 4.	1. 2. 3. 4.
Is the frequency of compliance testing in agreement with the frequency of the basic characterisation? 1. 2. 3. 4. If not how often is the compliance test performed? 1.	1. 2. 3. 4.	1. 2. 3. 4. 1.

2. **3.** **4.**	**1.** **2.** **3.** **4.**	**2.** **3.** **4.**
Records (data) of the analytical results shall be kept for a period that will be determined by the Member States legislation; are the records kept for the time required ? 5 Years.....	Yes	

2.5.4 On-site verification (1.3. Council Decision of 19 December 2002)		
Each load (batch) of waste delivered to a landfill shall be visually inspected before and after unloading. The documentation required shall be checked. During the visual inspection on the landfill focus on the way the waste is visually checked and who is responsible for this. Is there physical space to perform an inspection of a waste delivery?		
The waste may be accepted at the landfill, if it has the same composition as is the waste that has been subjected to the basic characterisation procedure and the compliance testing and the descriptions in the accompanying documents. If this is not the case, the waste may not be accepted.		
Are records (data) kept of waste that has not been accepted at the landfill ? .		
Member States shall determine the testing requirements for on-site verification, including rapid test methods where appropriate. Legislation in member state? ..... Is this part of the acceptance procedures in compliance with this legislation		

Upon delivery, samples (the operators compliance testing) shall be taken periodically. The samples taken shall be kept after acceptance of the waste for a period that will be determined by the Member State (see Article 11(b) of the Landfill Directive not less than one month) Period that sample shall be kept according to legislation is :		

3. SAMPLING OF WASTE		
Sampling and test methods (according to Council Decision of 19 December 2002; 2003/33/EC)	**In compliance?**	
	YES	**NO**
Check if testing complies with sampling and test methods indicated in Council Decision of 19/12/2002 (see Annex chapter 3) *Sampling and testing for basic characterisation and compliance testing shall be carried out by independent and qualified persons and institutions. Laboratories shall have proven experience in waste testing and analysis and have an efficient quality assurance system.* *Member States may decide that:* - *the sampling maybe carried out by producers of waste or landfill operators under the condition that sufficient supervision of independent and qualified persons or institutions ensures that the objectives as set out in this Decision are achieved;* - *the testing of the waste maybe carried out by producers of waste or operators if they have set up an appropriate quality assurance system including periodic independent checking.* **For sampling** Sampling performed by independent certified /accredited person /institution according to national / EN technical standards. **For analyses** Certified / accredited laboratory perform analyses according to national / EN technical standards ,		

SAMPLING CHECK (preparation (desk study) & on-site visit)	**What kind of information is to be checked ?**	**Compliant Yes / No ?**
Ask for **complete Landfill Documentation** (since last assessment)	**data available ?**	
Select waste type for check (see the above selected types of waste)	**Waste stream ?** **single batch waste ?**	
Ask for sampling plan of selected waste	Check if the data is complete	Compliant Yes / No ?
Does a sampling plan & additional information (photos, tables) exist ?		Y/N ?
In-depth check of sampling plan:		Compliant yes/no ?
Project name, waste owner, contact person, document identification		Y/N
Was the sampling plan prepared by an authorised person /institution ? (Check certificate /accreditation against national legislation)		Y/N
Accreditation certificate issued by authority (name) ?		Y/N
Purpose of sampling ?		
	for basic characterisation of waste ?	Y/N
	for landfill purpose ? *(is the purpose of sampling that the waste is finally going to a landfill)*	Y/N
	for recovery of waste ?	Y/N
Is a waste code assigned (according to EWC or national standards)	waste code number	Y/N

Does the waste code represent the quality of the waste ?		Y/N
Origin of waste ? (Production process, waste collection, treatment)	Information sufficient /reliable ?	Y/N
Relevant input materials (especially when waste was processed/treated)	Information sufficient /reliable ?	Y/N
Description of waste quality	Material not contaminated ?	Y/N
	Material obviously contaminated ?	Y/N
	Contamination very likely / to be expected ?	Y/N
Background information on the waste in question	Previous investigations /analysis available ?	Y/N
Document signed /approved by waste owner (other) ?		Y/N
Statistical approach according to legislation		
Waste mass (kg, tons, m³)		Y/N
Density ?		Y/N
Size of population sampled	According to national /EU standards ?	Y/N ?
Number of samples taken	According to national / EU legislation & technical standards ?	Y/N ?
Mass (size) of samples taken	Is the (minimum) amount defined by legislation	Y/N ?
	or computed according to technical standards	Y/N ?
Sampling plan	Content **according to Annex A table A.1 of EN 14889** or national legislation (if more comprehensive)	Y/N

Sampling protocol	Content according to **Annex A table B.1 of EN 14889** or national legislation (if more comprehensive)	Y/N
Is the sampling plan compliant to national /EU legislation (e.g. according to EN 14899 standard) ?		Y/N
On-site assessment		
On-site demonstration of sampling	Who is in charge of this ? landfill operator ? waste owner / waste producer ? certified lab on behalf of operator ? certified lab on behalves of waste producer?	 Y/N Y/N Y/N
Check sampling equipment used	Is the equipment /machinery according to the sampling method required ?	Y/N
Who is in charge of equipment ? landfill owner /other ?	Landfill operator?	Y/N
	external qualified expert ?	Y/N
	other ?	Y/N
On-site demonstration of sampling	performed according to sampling plan and technical standards ?	Y/N
Replicate samples	replicate samples taken ?	Y/N
Storage of replicate samples	On-site storage facility available ?	Y/N
	or storage at certified lab ?	Y/N

2. GAS CONTROL			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance?**
Gas extraction system efficiency		Compare the quantities extracted with those expected by the model. Self monitoring results – trends for each of the wells (flux and composition). LFG flow rate, composition and Energy production registration. Check flow rate, pressure, temperature and monitor inlet gases. Equipment installed reflects the approved design? Check O_2 % - High O_2 implies a leaking system or over-extraction.	
Diffuse emissions		Check if the landfill area has been investigated to identify areas where biogas is not captured. Check if diffuse emissions monitoring outside the body of the landfill has been performed. Diffuse emissions mapping.	
Gas flaring torch		In case the torch is turned off identify the reasons (technical problems, voluntary interception of the piping, etc.). Check the destination of the condensate water. Does the flame temperature match the specification? Can the residence time be ascertained?	

2. GAS CONTROL			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance?**
Gas trigger level		Check if trigger levels of biogas in the soil and subsoil have been defined. Check if a risk assessment has been performed to identify measures to be implemented in case of exceeding of trigger levels.	
Observation during inspections		Did you observe indications of gas leaking (for example cracks in slopes on the landfill), odour or vegetation damage? Register of maintenance of biogas system and safety measures.	
Monitoring		Check monitoring frequencies. Check monitoring methods. Check monitoring points (Gas collection system at well control valve, manifolds (if applicable) and strategic points on gas system) Which parameters are measured? Is this in agreement with the permit conditions?	
Gas extraction system arrangement		Well maintenance and construction according to CQAP (Construction Quality Assurance Plan)	

3. WATER CONTROL AND LEACHATE MANAGEMENT	
Topic	**General questions**
Groundwater	Design and conditions to prevent pollution of soil and groundwater. • Bottom sealing/ geological barrier • Collection of leach ate • Control of taken measures Are measuring points made to determine groundwater levels and for taking samples of the groundwater to determine the quality of groundwater. Are the measuring points in the right place Are trigger levels designed to determine when action has to be taken to prevent groundwater pollution Are groundwater samples taken regularly and are the right parameters analyzed
Leachate	Is the landfill designed to collect leachate and treat it before discharging Is the landfill covered to prevent rainwater to enter the landfill Is the leachate collecting system fit for purpose Can the leachate collecting system be cleaned and unclogged Is the wastewater treatment designed to treat the leachate so it can be discharged Are trigger levels designed before discharging the treated leachate in sewer or surface water
Surface water	Which actions are taken to prevent pollution of surface water For treatment of leachate and rainwater from areas that can be polluted: are trigger levels determined for water before discharging?
Run-off water	Is the quality of run-offwater determined if derived from polluted areas.
Soil	For all activities that can cause soil contamination: are measurements taken to prevent contamination of soil and groundwater. Meet these measurements legal requirements?

3. WATER CONTROL AND LEACHATE MANAGEMENT			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
Trucks washing water (water in polluted areas?)		Check the presence and use of the platform of trucks washing water, before leaving the landfill, and that the water is sent to an appropriate treatment. The landfill shall be equipped so that dirt originating from the site is not dispersed onto public roads and the surrounding land	
Groundwater: Trigger levels		Check that trigger levels have been determined taking account of the specific hydrogeological formations in the location of the landfill and groundwater quality. Trigger level should be laid down in the permit. (whenever possible)	
		Check the analyses rapports of the samples of the boreholes. Is there a significant change?	
		Check the operational actions to be implemented in case of exceeding of trigger levels. Is there an action plan available, when the trigger levels are exceeded?	
Groundwater level measurement		Does the permit require a monitoring system to monitor the groundwater level and quality in the landfill? - Monitor the groundwater level inside and outside the landfill What is the frequency in which the level of groundwater is measured inside and	

3. WATER CONTROL AND LEACHATE MANAGEMENT			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
		outside the landfill?	
		How is the waterlevel measured? Manual or automated?	
		Does the operator regulary submit monitoring reports? How often?	
Groundwater monitoring		Monitoring of groundwater - Parameters analysed in the groundwater - Frequency of analysing groundwater composition Piezometer: check the technical features of the piezometer	
		Check one or several document/s from this year to ensure that the comply with the demands of monitoring.	
		Check that a campaign of groundwater monitoring is performed before operating in the new landfill. Take a sample of groundwater.	
		Is it necessary to prevent ground water from entering into the land filled waste: does the permit require this?	

3. WATER CONTROL AND LEACHATE MANAGEMENT			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
		Is it necessary to control the groundwater level in the landfill; what are the requirement to discharge in the case of an excess of groundwater? Does the permit takes account of excesses?	
		Who is responsible for the sampling: the operator of the landfill or the inspectorate (or another competent authority)?	
		How are the monitoring reports checked and how do the Competent Authority receive them?	
Leachate collection		Check points where leachate is discharged from the site.	
		Check that leachate accumulation at the base of the landfill is kept to a minimum (pumping system operation). Check the service date of the pumps.	
		Are the drainage and pumping system regularly maintained? Receipt seen of the last service check. Can the leachate drainage system be unclogged?	
		In case of an interruption of the electric current, make sure the leachate is not discharged untreated. Which	

3. WATER CONTROL AND LEACHATE MANAGEMENT			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
		emergency solution has been adopted?	
Leachate monitoring		Is the volume and composition monitored at the discharge points? When the flowmeter was calibrated for the last time?	
		What is the frequency of monitoring volume (at least monthly) and composition (at least quarterly) ?	
		Which parameters are analysed?	
		What is the average compositions of the leachate and is this in agreement with permit conditions? How is the composition of the leachate checked in relation with the permit.	
		Is it necessary to treat the leachate before discharging?	
Surface water		Which water does the inspectorate consider as surface water? **What is the reason for this question?** Does the permit set limit values for surface water discharge?	
		Check how surface water is prevented from entering into the landfilled waste (when this is required according to the permit). Check also that leachate is prevented to enter the surface water.	

3. WATER CONTROL AND LEACHATE MANAGEMENT			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
		Check if the surface water is monitored at least at two points: - upstream from the landfill - downstream from the landfill Although it's mentioned in EU legislation this monitoring will not help to prevent environmental damage: better monitoring: groundwater-, leachate- and surface water leakage	
		What are the parameters analyzed?	
		What is the frequency of monitoring the volume (at least quarterly) and composition of the surface water (at quarterly) ?	

4. BUILDING AND CLOSING LANDFILL			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
Design criteria		Check through testing and studies produced by the operator (or by direct analysis) if the landfill meets the design criteria set out in Dir. 1999/31 Annex II and in particular: - verify natural geological barrier permeability and the thickness and permeability of artificial layers; - verify (through specific surveys and geotechnical testing) that the geological substratum should not be subject to failures that might damage the protective systems of the landfill; - detect the height of the bottom of the landfill. Check for biogas and leachate collection system.	
Permeability		What method is used to measure the permeability and thickness requirements of the mineral layer of the landfill base and sides. Does the permeability meet the requirements according to the permit or national legislation?	
Closing activities		Check that closing activities comply with the procedures defined in the EMS or Recovery Plan.	

4. BUILDING AND CLOSING LANDFILL			
Topic	**What has been observed during the inspection?**	**What information needs to be checked in the administration of the installation owner**	**In compliance ?**
Coverages		Check that permanent and temporary coverages comply with the one stated in the approved project and in particular: - thickness of the layers of coverage - heght of the final coverage - maintenance of coverage in order to allow the run-off of surface water and to minimize infiltration into the landfill.	
Maintenance		Check that the operator is executing maintenance, monitoring and control actions in the after-care phase for as long as is required by the competent authority. In particular, check that analysis of biogas, leachate and groundwater are guaranteed	

Initial inspection	YES	NOT	DOESN´T APPLY	OBSERVATION
Control of the preparation of suitable land (Morphology landfill)				
Technicians work have given approval to the supporting surface?				
It is regular and uniform?				
It is compacted?				
Checking the inner slope of the cell, according to the project				
Groundwater collection network, if any, checking existence and connections.				
There has been a drainage system and channeling the water table?				
It is installed?				
It is connected?				
Extraction by gravity				
Extraction by pump				
Control of rainwater during construction				
Are spillages of sewage taking place for the works?				
Is it necessary to construct a settling pond?				
Is it necessary pave the roads?				
Land excavation				
Complies with the provisions of the project construction				
Does it need to manage earthworks?				

Intermediate inspections	YES	NOT	DOESN´T APPLY	OBSERVATION
Checking base liner systems:				
- Checking existence of bottom layers				

- Checking existence of anchor trench				
- Clay, checking existence				
- Geosynthetic clay liners (GCL), checking existence and overlap				
- Geomembrane (HDPE)				
- Geotextile protection				
- Gravel, checking the thickness				
- Geotextile filter				
- Composite drainage				
Exceptions may be granted for the installation of the composite drainage in slopes, in this case the geotextile is installed with advancing operation.				
- Leachate collection network, checking existence and connections.				
It is installed?				
It is connected?				
Extraction by gravity				
Extraction by pump				
- Have been implemented in cell separation systems waste water and clean water?				
They were in the project?				
If it was not, check the planes are delivered with the certificate to work for final inspection				

Final inspection	**YES**	**NOT**	**DOESN´T APPLY**	**OBSERVATION**
Once executed the plan quality control of geosynthetics and checked the certificate to final work and, if any, changed the construction project (As built project), inspection final check of the work will be done before use.				
- Operation system.				
Access ramp or other system				
Are extraction systems executed (Groundwater, Leacheate, Biogas)				
- Connecting the networks to endpoint				
- Are treatment systems or disposal described in the project executed?				

Groundwater				
Leachate (Ponds, reservoirs, treatment systems)				
Leachates are stored so they do not mix with rainwater?				
Where leachate sample taken?				
Biogas (Degassing chimneys, torch, recovery of biogas)				
Rainwater				
- Rainwater collection network, checking existence and connections.				
It is installed?				
It is connected?				
Extraction by gravity				
Extraction by pump				
- Bookmark with GPS elevation vessel background and points infrastructure connections. (If the inspector considers import)				
- Detailed report of the repairs made				