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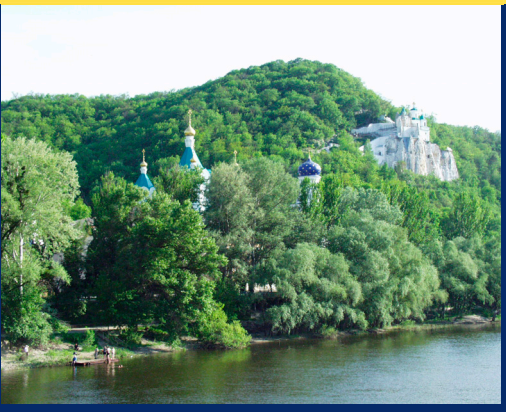

CAPACITY BUILDING IN DONETSK OBLAST FOR WASTE MANAGEMENT - UKRAINE

Report

Standards for the design and the construction of sanitary landfills

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1. Context

1.1. Principles

A lot of projects of new sanitary landfills are appearing. But a "sanitary landfill" is not only a concept or words. The principle of the "sanitary landfill" is to be able to control all the phenomena and to guarantee the protection of the environment, and by there, the protection of the public health. It may be called "total warranty".

Some obviousness must be recalled here.

The best landfill can be a disaster if it's not correctly operated. This will be developed in another approach about the management of the landfills. But the construction and the equipments of the landfills must be orientated to facilitate the operation. Human nature is so that the less it will be convenient, the less often it will be done and the less correctly it will be done. For instance, all discharges of liquids must be done by gravity because the pumps are always a source of troubles.

The main protection of the environment is made at the bottom: it's the protection of underground waters. When there will be put some tens meters of waste above the bottom, it will not be possible to repair it. So all precautions must be taken to guarantee the quality of the works on this bottom.

The hazard of a landfill can occur for a lot of years: 25 to 50 years of biodegradation of the organic matters, centuries if there's chemical or toxic waste. So all the works aiming at the protection of the environment should have enough lifetimes.

All catastrophic events must be integrated in the design and the construction as floods, landslips, earthquakes, as far they can be imagined as not impossible in the regional context.

But moreover, the promoter of the landfill must be able to guarantee. And it's not a moral clause. According to the European Directive, a guarantee fund must be independently managed in aim to face all necessary works in case the operator of the landfill is failing. So the promoter must do his best at each step of the life of the landfill: the design, the construction, the operation, the management after closure. The question is so: how to determine "to do his best"? The subsidiary question is: how to prove (to the authorities and to the public) the best has been done?

1.2. Norms and standards

There's a key difference between the former Soviet Union's approach and the international approach about norms and standards.

Historically, the notion of norm appeared in aim to favour a fair competition: how to compare products if they are not made with the same rules of art? So the norm is a consensus between the competitors agreeing that a product must be designed and manufactured according several criteria which are determining for the purpose of the product. So it became easy to for a manufacturer to advertise that his product was made according to the norm XXXX, and by the way comparable to the other competing products. This work of normalization has been entrusted to (and often refereed by!) public organisations, first national, then international. In parallel, anyone claiming he works according to a norm must be controlled by an independent organisation in aim to maintain the trust of the public toward the norms and the normalization.

Today, the normalisation organisation proposes to the market to establish norms for a subject. Then a committee of experts is named to prepare the project of norm. This project is submitted to the critics of anyone, improved, and at least approved by the committee. Often, the norm is published as experimental norm during 1 or 2 years before to be officially adopted.

National norms can be proposed to be international norms. There's 2 main organisations: CEN (European Committee of Normalisation) and ISO (International Standards Organisation). There are other international organisation specialized in particular domains (telecommunications, electricity, …). When a norm is adopted at the international level, it's applicable in all countries belonging to this organisation.

The norm is a consensus for the market. It's really the key-point in the Western economy. If I buy something, I can ask for products made according to the norm XXXX. The providers are free to propose or not products or services applying the norm. If they want to sell to me, they must prove they respect the

norm. The customer decides what he includes in his specifications and the provider is free to agree with them.

The knowledge evolves, the products evolve, the rules of art evolve, so the norms evolve. Some norms are periodically revised. New norms appear everyday. A key-point is the notion of rules of art. It's close to another concept largely developed in environment protection: the BAT = Best Available Technologies. The progress of the industry is constant but the innovation, although at the beginning, is often very expensive and the prices decrease when begins a mass production. The rules of art are what a good professional should reasonably do. A good professional must be a master in his domain. He must know all techniques in his domain and must be able to use it with a good level of quality and efficiency. The rules of art are a not-said consensus between good professionals. This notion appeared in the mid-age with the companions unions, if not as they claimed, with Master Hiram who is supposed to have built the Solomon's Temple. During centuries (if not millenniums) the rules of art have been very stable but the last two centuries have seen a faster and faster development of the science and the technology. So the rules of art must follow this faster evolution. It's a common drawback of the norms to be accused to fossilize the technique, and by the way, the market.

All these developments aim to say that the soviet approach of the norms was disconnected of the international movement of normalisation. The norm was the rule decided by the bureaucracy. Everything had to be done according to the norm until somebody decided to change the norm. The New Independent States have inherited of the former soviet organisation of the norms and almost all of them have not yet adhered to the international organisations. Globally, it can be also said that since the break of the Soviet Union, a lot of other priorities appeared and since 1991 nobody really took care to concretize in the national norms the catching up of the technical progress of the Western sphere. As comment, it was also necessary to protect the domestic market against the competition of foreign products and the norms were also a way to get that. In the context when everybody wants to adhere to the World Trade Organisation and/or to the European Union, and/or to the NATO, and/or to the OECD, the adhesion to the international organisations of normalisation will be a key-point. The most difficult will be to launch a "cultural revolution" as the norms are an expression of the free market and not a bureaucratic decision.

1.3. Norms for the landfills

The sanitary landfill is a concept developed primarily in North America. The first applications of the geomembranes were experienced in Canada and USA in the 80's. So a lot of norms have been developed by the ASTM which is introducing itself as:

ASTM International is one of the largest voluntary standards development organizations in the world-a trusted source for technical standards for materials, products, systems, and services. Known for their high technical quality and market relevancy, ASTM International standards have an important role in the information infrastructure that guides design, manufacturing and trade in the global economy.

ASTM International, originally known as the American Society for Testing and Materials (ASTM), was formed over a century ago, when a forward-thinking group of engineers and scientists got together to address frequent rail breaks in the burgeoning railroad industry. Their work led to standardization on the steel used in rail construction, ultimately improving railroad safety for the public. As the century progressed and new industrial, governmental and environmental developments created new standardization requirements, ASTM answered the call with consensus standards that have made products and services safer, better and more cost-effective. The proud tradition and forward vision that started in 1898 is still the hallmark of ASTM International.

Progressively, Europe developed also the sanitary landfill with its Directive but this last one only exposes principles and results to get. Several countries as France were more acute in the details. So today we can find more and more national norms applicable to the landfill design and construction, and progressively CEN and ISO norms.

The general objective is to apply the international "state of art" for the construction of new sanitary landfills in CIS countries. It's required both by the authorities and the IFIs that can help for the financing of these landfills. This report will review domain by domain which norms can be reasonably applied.

2. Generalities

2.1. Eurocodes

The structural Eurocodes are a set of unified international codes of practice for designing buildings and civil engineering structures, which will eventually replace national codes in the European Union.

The complete suite of structural Eurocodes are being produced by the Comité Européen de Normalisation (CEN), the European committee for standardisation. CEN presently has 28 members.

There are ten Eurocodes, each consisting a number of parts. EN 1990 gives all the operative material independent rules (e.g. partial factors for actions, load combination expressions for ultimate and serviceability limit states). EN 1997 developed on the base of the French ENV 1997-1 of 1994 concerns geotechnical design.

EN1997 Eurocode 7: Geotechnical design

EN1997 Eurocode 7 is in three parts.

- **Part 1: General rules**, covers The general basis for the geotechnical aspects of the design of buildings and civil engineering works, assessment of geotechnical data, use of ground improvement, ground reinforcement, dewatering and fill. Geotechnical design of spread foundations, piles, retaining structures, embankments and slopes. Calculation rules for actions originating from the ground e.g. earth and ground water pressures
- **Part 2: Design assisted by laboratory testing** covers requirements for the execution, interpretation and use of results of laboratory tests to assist in the geotechnical design of structures.
- **Part 3: Design assisted by field-testing** covers the requirements for the execution, interpretation and use of results of field tests to assist in the geotechnical design of structures.

EN 1997-1 June 2005 Eurocode 7: Geotechnique calculations- Part 1: General rules
Index of classification: P94-251-1

The EN 1997 standard must be used jointly with EN 1990:2002 standard, which defines the principles and the exigencies in matter of safety and aptitude to service, describes the basic principles of calculation and of checking of the structures and gives the directives on the aspects linked to their liability. The EN 1997 standard must be applied to the geotechnical aspects of the calculation of the buildings and civil survey works. It is divided in several parts (see 1.1.2 & 1.1.3). The EN 1997 standard treats the exigencies of resistance, stability, aptitude to service and durability of the works. The other exigencies, for instance those that concern the thermal or sound insulation, are not tackled. The numerical values of the actions on the buildings and civil works that are to take into account in the calculation are provided by the EN 1991 standard, according to the types of construction. The actions due to the terrain, as the earths pressures, must be calculated according to the rules of Eurocode 7. Separate European standards must be used for the treatment of questions of execution and work hand. They are noted in the concerned sections. In the EN 1997 standard, the execution is treated in the measure it is necessary in aim to ensure the conformity with the hypotheses of the rules of calculation. The EN 1997 standard doesn't treat the particular exigencies of the seismic calculations. The EN 1998 standard gives complementary rules for the seismic calculation that complete or adapt the rules of the present standard.

We want to headlight the following points of the EN1997.

Section 2 Bases of the geotechnical calculation

2.1 Exigencies of calculation

All work must be designed and calculated in conformity with the general principles of sizing given in

EN1991 Eurocode 1: Actions on structures.

The landfills belong to the Geotechnical category 2: This category includes the works and foundations classical types that don't offer abnormal risks or unusual conditions of ground or load or exceptionally difficult. The works of the geotechnical category 2 require geotechnical quantitative data and calculations that allow to justify that the fundamental requirements will be satisfied, but routine procedures can be used for on the field and laboratory tests as for the calculation and the execution of the works.

2.4 Geotechnical sizing by the calculation

The choice of the characteristic values of the properties of the soils and the rocks must be done from the results of tests in laboratory and on the field.

The choice of the characteristic values of the properties of the soils and the rocks must take into account the following elements:

- The geological documents and other information as data from previous projects;
- The variability of the values of the considered properties;
- The importance of the area of ground that governs the behaviour of the geotechnical work toward the considered limit-state;
- The influence of the quality of realization of the works on the brought or treated soils;
- The effects of the activities of construction on the properties of the ground in place.

2.8 Report of geotechnical calculation

The hypotheses, the data, the calculations and the results of the verification of the safety and the aptitude to service must be collected in a report of geotechnical sizing.

The level of detail of the report of geotechnical sizing will depend a lot of the type of project. It's advisable to include the following points in the report, with links to the report of general investigation of the field and other detailed documents:

- Description of the site and the neighbourhood;
- Description of the conditions of the field;
- Description of the projected work, including the actions;
- The values of calculation of the properties of the soils and rocks, including their justification, when it's appropriate;
- The list of the applied codes and norms;
- The statement of the admitted level of risks;
- The geotechnical calculations and drawings;
- The list of the points to be checked during the execution of the works or requiring maintenance or follow-up.

The report of geotechnical sizing must include a programme of control and monitoring when it's appropriate. The points which require verifications during the execution of the works or which require maintenance after the end of the construction works must be clearly identified in the report. When necessary verifications have been done during the execution of the works, they must be noted in a complementary report.

Section 3 Geotechnical data

3.3 Estimation of the geotechnical parameters

Characteristics of the soils

The soils and rocks must be identified. The material must be visually inspected and described according to a recognized nomenclature. The following properties can be checked:

- Granulometric curve

- Volumetric weight
- Natural water content
- Atterberg's limits
- Carbonates content
- Organic matters content
- Compacting degree (Proctor test)
- Resistance to shearing
- Permeability coefficient
- Inflating index
- Uniaxial compression resistance
- Triaxial compression resistance

Section 5 Embanking, lowering down of watertable, improvement or enhancement of the grounds

5.1 Generalities

The dispositions of this section apply when an adequate state of the ground is got by:

- Settling of embanking made of soil or granular material;

The situations where a soil or a granular material is settled for the construction of works of civil survey include:

- The sanitary landfills in general, including the hydraulic embankings, the embanking for the landscape management and the materials extracted from the borings;

And as a whole, the Section 12 must be applied.

Section 12 Embanking

12.1 Generalities

12.2 Limit-states

12.3 Actions and situations of calculation

12.4 Considerations relative to the calculation and the construction

12.5 Calculation at the ultimate limit-states

12.6 Calculation at the service limit-states

12.7 Monitoring

Number	Org.	Year	Title	Topic	Pages
2 Generalities					
NF P 94-500	Afnor	2000	Geotechnical missions - Classification and specifications	The present document defines the different missions that can be done by geotechnicians, on asking of a master of works or a constructor. It gives a classification of these missions. It specifies the content and defines the limits of the six geotechnical type-missions: realization of boreholes and tests, geotechnical feasibility study, geotechnical project study, geotechnical execution study, geotechnical execution control, and geotechnical diagnostic, with or without disaster, as the recommended chain of missions during the conception, the realization and the life of a work or a land arranging.	40
D3740-01	ASTM	2001	Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction	This practice establishes minimum qualifications for agencies engaged in the testing and inspection of soil and rock. Minimum requirements for field and laboratory personnel are defined. The practice also covers the establishment and maintenance of a quality system.	8
D5255-01	ASTM	2001	Standard Practice for Certification of Personnel Engaged in the Testing of Soil and Rock	This practice provides a guide for evaluation and certification procedures for personnel engaged in testing soil and rock in accordance with ASTM test methods and is intended for use by independent organizations providing certification services.	3
EN 1997-1	CEN	1993	Eurocode 7: Geotechnical design Part 1	This part covers The general basis for the geotechnical aspects of the design of buildings and civil engineering works, assessment of geotechnical data, use of ground improvement, ground reinforcement, dewatering and fill. Geotechnical design of spread foundations, piles, retaining structures, embankments and slopes. Calculation rules for actions originating from the ground e.g. earth and ground water pressures.	120
D6168-97e1	ASTM	1997	Standard Guide for Selection of the Minimum Set of Data Elements Required to Identify Locations Chosen for the Field Collection of Information to Describe Soil, Rock, and Their Contained Fluids	This guide covers factors to consider for the selection of the minimum set of data elements required for the accurate location and cataloguing of information collected for geological science (geoscience) investigations, which includes geo-ecology.	6
D6453-99	ASTM	1999	Standard Guide for Format of Computerized Exchange of Soil and Rock Test Data	This guide covers recommended data formats for the exchange of mechanical test data for soils and rocks. From this guide, a standardized file of data can be prepared that can be read by others who use this guide.	9

Number	Org.	Year	Title	Topic	Pages
D5549-94e1	ASTM	1998	Standard Guide for the Contents of Geostatistical Site Investigation Report	This guide covers the contents required for a complete report of a geostatistical site investigation. A complete report is understood here to be one that contains all the information necessary to the understanding and evaluation of the geostatistical site investigation by other geostatisticians.	5
D5714-95	ASTM	2002	Standard Specification for Content of Digital Geospatial Metadata	This specification covers the information content of metadata for a set of digital geospatial data. This specification provides a common set of terminology and definitions for concepts related to these metadata.	20
D5922-96e1	ASTM	1998	Standard Guide for Analysis of Spatial Variation in Geostatistical Site Investigations	This guide covers recommendations for analyzing, interpreting, and modelling spatial variation of regionalized variables in geotechnical and environmental site investigations.	4
D5923-96e1	ASTM	1998	Standard Guide for Selection of Kriging Methods in Geostatistical Site Investigations	This guide covers recommendations for selecting appropriate kriging methods based on study objectives, exploratory data analysis, and analysis of spatial variation.	4
D5924-96e1	ASTM	1998	Standard Guide for Selection of Simulation Approaches in Geostatistical Site Investigations	This guide covers the conditions that determine the selection of a suitable simulation approach for a site investigation problem. Alternative simulation approaches considered here are conditional and non-conditional, indicator and Gaussian, single and multiple realization, point, and block.	3
D6026-01e1	ASTM	2002	Standard Practice for Using Significant Digits in Geotechnical Data	This practice is intended to promote uniformity in recording significant digits for measured and calculated values involving geotechnical data. The guidelines presented are industry standard, and are representative of the significant digits that should generally be retained. The guidelines do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to commensurate with these considerations. It is beyond the scope of this practice to consider significant digits used in analysis methods for engineering design.	5
EN 1997-2	CEN		Eurocode 7: Geotechnical design Part 2	This part covers requirements for the execution, interpretation and use of results of laboratory tests to assist in the geotechnical design of structures.	90
D5522-99a	ASTM	1999	Standard Specification for Minimum Requirements for Laboratories Engaged in Chemical Analysis of Soil, Rock, and Contained Fluid	This specification covers specific criteria for evaluating the technical capabilities of laboratories involved in testing, measuring, inspecting, and calibrating activities related to chemical analysis of earth materials. In this specification, earth materials shall mean soil, rock, and contained fluids. For the sake of brevity, the term "laboratory" is used in this practice to represent all the above.	10

Number	Org.	Year	Title	Topic	Pages
D4753-02	ASTM	2002	Standard Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing	This guide provides minimum requirements for general-purpose scales, balances, and standard masses used in testing soil, rock, and related construction materials.	5
EN 1997-3	CEN		Eurocode 7: Geotechnical design Part 3	This part covers the requirements for the execution, interpretation and use of results of field tests to assist in the geotechnical design of structures.	147
D6106-97e1	ASTM	1998	Standard Guide for Establishing the Nomenclature of Ground-Water Aquifers	This guide offers a series of options but does not specify a course of action. It should not be used as the sole criterion or basis of comparison and does not replace or relieve professional judgement.	17
2.2. Site description					
2.2.1. Classification					
D5730-02	ASTM	2002	Standard Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Ground Water	This guide covers a general approach to planning field investigations that is useful for any type of environmental investigation with a primary focus on the subsurface and major factors affecting the surface and subsurface environment. Generally, such investigations should identify and locate, both horizontally and vertically, significant soil and rock masses and ground water conditions present within a given site area and establish the characteristics of the subsurface materials by sampling or in situ testing, or both. The extent of characterization and specific methods used will be determined by the environmental objectives and data quality requirements of the investigation. This guide focuses on field methods for determining site characteristics and collection of samples for further physical and chemical characterization. This guide does not address special considerations required for characterization of karsts and fractured rock terrain. In such hydrogeological settings refer to Quinlan and Guide D 5717.	32
D420-98	ASTM	1998	Standard Guide to Site Characterization for Engineering Design and Construction Purposes	This document is a guide to the selection of the various ASTM standards that are available for the investigation of soil, rock, and ground water for projects that involve surface or subsurface construction, or both.	7
NF P 94-010	Afnor	1996	Soils: investigation and testing - Geotechnical glossary - Definitions - Notations - Symbols	The present document defines the main terms used in the field of geotechnique, fixes the used symbols and specifies the physical dimensions and the units.	24
D653-02	ASTM	2002	Standard Terminology Relating to Soil, Rock, and Contained Fluids	Extensive list of definitions	35

Number	Org.	Year	Title	Topic	Pages
NF P 94-011	Afnor	1999	Soil: investigation and testing - Description - Identification - Appellation of soils - Terminology - Terms of classification	The present document concerns the description, the identification, the appellation of soils, used or worked in the field of works of civil survey and construction. It defines the used terms, the characteristic parameters measured by standard tests, fixes the used criteria for describing, identifying, calling the soils.	24
EN ISO 14688-1	ISO	2003	Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description	The present norm defines the principles of denomination and description of the soils aiming at their classification. It gives the definitions of the used terms. It describes the visual and manual methods allowing a first on site appreciation of the characteristics of soils.	17
EN ISO 14688-2	ISO	2002	Geotechnical engineering - Identification and classification of soil - Part 2: Classification principles and quantification of descriptive characteristics	The present norm, jointly with ISO 14688-1, establishes the fundamental principles of denomination, description, and classification of the soils, based on the characteristics of the material and its components the most often used for soils to be used for civil survey. The concerned characteristics may vary according to the projects or the materials; more detailed subdivisions of the description and classification terms may be indicated.	19
EN ISO 14689	ISO	2001	Geotechnique - Denomination and description of the rocks	The present norm concerns the denomination and the description of the materials and the mass of the rock on the base of the mineralogical composition. The present norm provides also rules for the description of other characteristics as for their designation.	51
D2487-00	ASTM	2000	Classification of Soils for Engineering Purposes (Unified Soil Classification System)	This standard describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.	12
D2488-00	ASTM	2000	Practice for Description and Identification of Soils (Visual-Manual Procedure)	This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.	11
D3584	ASTM		Practice for Indexing Papers and Reports on Soil and Rock for Engineering Purposes		
ISO 15903	ISO	2003	Soil quality - Format for recording soil and site information	This document aims to promote a high level of standardisation in terms of recording on-site results, sampling results and sample analyses conducted on site and in laboratories. This document therefore provides instructions that can be used to correctly specify the sizes and units used to express analysis results, the methods used and their reliability. It also provides information allowing the unique referencing of the sample, in laboratories and on site, to ensure traceability of results.	10

Number	Org.	Year	Title	Topic	Pages
D5980-96e1	ASTM	1998	Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring	This guide covers the use of existing wells for environmental site characterization and monitoring. It covers the following major topics: criteria for determining the suitability of existing wells for hydrogeological characterization and ground-water quality monitoring, types of data required to document the suitability of an existing well, and the relative advantages and disadvantages of existing large- and small-capacity wells.	10
D6000-96	ASTM	2002	Standard Guide for Presentation of Water-Level Information From Ground-Water Sites	This guide covers a series of options, but does not specify a course of action. It should not be used as the sole criterion or basis of comparison, and does not replace or relieve professional judgment.	16
D6036-96	ASTM	2002	Standard Guide for Displaying the Results of Chemical Analyses of Ground Water for Major Ions and Trace Elements - Use of Maps	This guide offers a series of options but does not specify a course of action. It should not be used as the sole criterion or basis of comparison and does not replace or relieve professional judgment.	8
2.2.2. Reconnaissance works					
D5088-02	ASTM	2002	Practice for Decontamination of Field Equipment Used at No radioactive Waste Sites	This practice covers the decontamination of field equipment used in the sampling of soils, soil gas, sludge, surface water, and ground water at waste sites which are to undergo both physical and chemical analyses.	5
2.2.3. Sampling					
NF P 94-202	Afnor	1995	Soil: investigation and testing – Soil sampling – Methodology and procedures	The present document defines classes of material sampling. It presents the processes and tools used in the techniques of sampling. It provides the optimal sampling class possible according to the nature of the material and the used technique of sampling.	44
D4220-95	ASTM	2000	Practices for Preserving and Transporting Soil Samples	These practices cover procedures for preserving soil samples immediately after they are obtained in the field and accompanying procedures for transporting and handling the samples.	10
D5911-96e1	ASTM	2002	Standard Practice for Minimum Set of Data Elements to Identify a Soil Sampling Site	This practice covers what information should be obtained to uniquely identify any soil sampling or examination site where an absolute and recoverable location is necessary for quality control of the study, such as a waste disposal project. The minimum set of data elements for sampling site identification (DEFFSI) was developed considering the needs for informational databases, such as geographic information systems (GIS). Other distinguishing details, such as individual site characteristics help in singularly cataloguing the site. For studies that are not environmentally regulated, such as for an agricultural or preconstruction survey, the data specifications established BY an agency or company may be different from that of the minimum set (see Guide D420 and Practice D5254).	7

Number	Org.	Year	Title	Topic	Pages
D5903-96	ASTM	2001	Standard Guide for Planning and Preparing for a Groundwater Sampling Event	This guide covers planning and preparing for a ground-water sampling event. It includes technical and administrative considerations and procedures. Example checklists are also provided as Appendices.	4
D6089-97e1	ASTM	1998	Standard Guide for Documenting a Groundwater Sampling Event	This guide covers what and how information should be recorded in the field when sampling a groundwater monitoring well. Following these recommendations will provide adequate documentation in most monitoring programs. In some situations, it may be necessary to record additional or different information, or both, to thoroughly document the sampling event. In other cases, it may not be necessary to record all of the information recommended in this guide. The level of documentation will be based on site-specific conditions and regulatory requirements.	3
D6517-00	ASTM	2000	Standard Guide for Field Preservation of Groundwater Samples	This guide covers methods for field preservation of ground-water samples. Laboratory preservation methods are not described in this guide.	5
D6564-00	ASTM	2000	Standard Guide for Field Filtration of Groundwater Samples	This guide covers methods for field filtration of ground-water samples collected from ground-water monitoring wells, excluding samples that contain non-aqueous phase liquids (either Dense Non-Aqueous Phase Liquids (DNAPLs) or Light Non-Aqueous Phase Liquids (LNAPLs)). Methods of field filtration described herein could also be applied to samples collected from wells used for other purposes. Laboratory filtration methods are not described in this guide.	5
2.2.4. Hydrogeology					
2.2.4.1. Identification of site					
D5254-92	ASTM	1998	Standard Practice for Minimum Set of Data Elements to Identify a Ground-Water Site	This practice specifies what information should be obtained for any individual ground-water site, also known as monitoring location or sampling station. As used in this practice, a site is meant to be a single point, not a geographic area or property. A ground-water site is defined as any source, location, or sampling station capable of producing water or hydrologic data from a natural stratum from below the surface of the earth. A source or facility can include a well, spring or seep, and drain or tunnel (nearly horizontal in orientation). Other sources, such as excavations, driven devices, bore holes, ponds, lakes, and sinkholes, that can be shown to be hydraulically connected to the ground water, are appropriate for the use intended.	6

Number	Org.	Year	Title	Topic	Pages
D5408-93	ASTM	1998	Standard Guide for Set of Data Elements to Describe a Ground-Water Site; Part One-Additional Identification Descriptors	This guide is Part One of three guides to be used in conjunction with Practice D5254 that delineates the data desirable to describe a ground-water data collection or sampling site. This guide describes additional information beyond the minimum set of data elements that may be needed to identify a ground-water site.	6
D5409-93	ASTM	1998	Standard Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two-Physical Descriptors	This guide is Part Two of three guides to be used in conjunction with Practice D5254 that delineates the data desirable to describe a ground-water data collection or sampling site. This guide identifies physical descriptors, such as construction and geologic elements, for a site.	16
D5410-93	ASTM	1998	Standard Guide for Set of Data Elements to Describe a Ground-Water Site; Part Three-Usage Descriptors	This guide is Part Three of three guides to be used in conjunction with Practice D5254 that delineates the data desirable to describe a ground-water data collection or sampling site. This guide identifies usage descriptors, such as monitoring, for an individual ground-water site.	12
D5474-93	ASTM	2000	Standard Guide for Selection of Data Elements for Ground-Water Investigations	This guide covers the selection of data elements for the documentation of ground-water sites. The data elements are described in four ASTM standards outlining information that may be collected at ground-water sites. Examples of specific investigations are given with the logic of why to select individual and combinations of data elements to meet the requirements of the studies.	12
2.2.4.2. Monitoring wells (piezometers)					
D4043-96e1	ASTM	1999	Standard Guide for Selection of Aquifer-Test Method in Determining of Hydraulic Properties by Well Techniques	This guide is an integral part of a series of standards that are being prepared on the in situ determination of hydraulic properties of aquifer systems by single- or multiple-well tests. This guide provides guidance for development of a conceptual model of a field site and selection of an analytical test method for determination of hydraulic properties. This guide does not establish a fixed procedure for determination of hydrologic properties.	6
D5092-02	ASTM	2002	Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers	This practice considers the selection and characterization (that is, defining soil, rock types, and hydraulic gradients) of the target monitoring zone as an integral component of monitoring well design and installation. Hence, the development of a conceptual hydrogeological model for the intended monitoring zone(s) is recommended prior to the design and installation of a monitoring well.	14
D5787-95	ASTM	2000	Standard Practice for Monitoring Well Protection	This practice identifies design and construction considerations to be applied to monitoring wells for protection from natural and man caused damage or impacts.	5

Number	Org.	Year	Title	Topic	Pages
D5717-95e1	ASTM	1998	Standard Guide for Design of Ground-Water Monitoring Systems in Karsts and Fractured-Rock Aquifers	Justification -This guide considers the characterization of karsts and fractured-rock aquifers as an integral component of monitoring-system design. Hence, the development of a conceptual hydrogeological model that identifies and defines the various components of the flow system is recommended prior to the design and implementation of a monitoring system.	18
D5521-94e1	ASTM	1998	Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers	This guide covers the development of screened wells installed for the purpose of obtaining representative ground-water information and water quality samples from granular aquifers, though the methods described herein could also be applied to wells used for other purposes. Other well-development methods that are used exclusively in open-borehole bedrock wells are not described in this guide.	17
D6724-01	ASTM	2001	Standard Guide for Installation of Direct Push Ground Water Monitoring Wells	This guide describes various direct push ground water monitoring wells and provides guidance on their selection and installation for obtaining representative ground water samples and monitoring water table elevations. Direct push wells are used extensively for monitoring ground water quality in unconsolidated formations. This guide also includes discussion of some groundwater sampling devices which can be permanently emplaced as monitoring wells.	9
D6725-01	ASTM	2001	Standard Practice for Direct Push Installation of Pre-packed Screen Monitoring Wells in Unconsolidated Aquifers	This practice is based on recognized methods by which direct push monitoring wells may be designed and installed for the purpose of detecting the presence or absence of a contaminant, and collecting representative ground water quality data. The design standards and installation procedures herein are applicable to both detection and assessment monitoring programs for facilities.	15
D5737-95	ASTM	2000	Standard Guide for Methods for Measuring Well Discharge	This guide covers an overview of methods to measure well discharge. This guide is an integral part of a series of standards prepared on the in-situ determination of hydraulic properties of aquifer systems by single- or multiple-well tests. Measurement of well discharge is a common requirement to the determination of aquifer and well hydraulic properties.	4
D6452-99	ASTM	1999	Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations	This guide covers methods for purging wells used for groundwater quality investigations and monitoring programs. These methods could be used for other types of programs but are not addressed in this guide.	6

Number	Org.	Year	Title	Topic	Pages
D6634-01	ASTM	2001	Standard Guide for the Selection of Purging and Sampling Devices for Groundwater Monitoring Wells	This guide describes the characteristics and operating principles of purging and sampling devices available for use in groundwater monitoring wells and provides criteria for selecting appropriate devices for specific applications. The selected device(s) should be capable of purging the well and providing valid representative samples of groundwater and any included dissolved constituents. The scope does not include procedures for purging or collecting samples from monitoring wells, sampling devices for non-aqueous phase liquids, diffusion-type sampling devices or sampling from devices other than monitoring wells.	14
D5978-96e1	ASTM	1998	Standard Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells	This guide covers an approach to selecting and implementing a well maintenance and rehabilitation program for ground-water monitoring wells. It provides information on symptoms of problems or deficiencies that indicate the need for maintenance and rehabilitation. It is limited to monitoring wells, that are designed and operated to provide access to, representative water samples from, and information about the hydraulic properties of the saturated subsurface while minimizing impact on the monitored zone. Some methods described herein may apply to other types of wells although the range of maintenance and rehabilitation treatment methods suitable for monitoring wells is more restricted than for other types of wells. Monitoring wells include their associated pumps and surface equipment.	7
D5299-99	ASTM	1999	Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities	This guide covers procedures that are specifically related to permanent decommissioning (closure) of the following as applied to environmental activities. It is intended for use where solid or hazardous materials or wastes are found, or where conditions occur requiring the need for decommissioning. The following devices are considered in this guide: 1.1.1 A borehole used for geo-environmental purposes (see Note 1), 1.1.2 Monitoring wells, 1.1.3 Observation wells, 1.1.4 Injection wells (see Note 2), 1.1.5 Piezometers, 1.1.6 Wells used for the extraction of contaminated ground water, the removal of floating or submerged materials other than water such as gasoline or tetrachloroethylene, or other devices used for the extraction of soil gas, 1.1.7 A borehole used to construct a monitoring well, and 1.1.8 Any other vadose zone monitoring device.	16

Number	Org.	Year	Title	Topic	Pages
2.2.4.3. Monitoring					
D4750-87	ASTM	2001	Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)	This test method describes the procedures for measuring the level of liquid in a borehole or well and determining the stabilized level of liquid in a borehole.	6
NF P 94-130	Afnor	2000	Soils: Investigation and testing - Pumping test	The present document is about the testing of pumping in an aquifer land with observation of the lowering of the level of the watertable by the means of piezometers. It specifies the characteristics of the used apparatus, fixes the operating mode of the testing and specifies the presentation of the results.	20
2.2.4.4. Porosity, permittivity					
NF P 94-157-1	Afnor	1996	Soils: investigation and testing – In situ pore pressure measurement – Part 1: piezometric tube	The present document defines the terminology, describes the apparatus and specifies the methods of measurement and specifies the results to be presented, for measures done in an open piezometric tube.	12
NF P 94-157-2	Afnor	1996	Soils: investigation and testing – In situ pore pressure measurement – Part 2: Pore pressure meter	The present document defines the terminology, describes the apparatus and specifies the methods of measurement and specifies the results to be presented, for a test of piezometric measurement by the mean of sounding rods of interstitial pressure disposed inside the earth.	16
D3404-91	ASTM	1998	Standard Guide for Measuring Matric Potential in the Vadose Zone Using Tensiometers	This guide covers the measurement of matric potential in the vadose zone using tensiometers. The theoretical and practical considerations pertaining to successful onsite use of commercial and fabricated tensiometers are described. Measurement theory and onsite objectives are used to develop guidelines for tensiometer selection, installation, and operation.	10
D4044-96	ASTM	2002	Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers	This test method covers the field procedure for performing an in situ instantaneous change in head (slug) test.	3
D4050-96	ASTM	2002	Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems	This test method describes the field procedure for selecting well locations, controlling discharge or injection rates, and measuring water levels used to analyse the hydraulic properties of an aquifer or aquifers and adjacent confining beds.	4
D4104-96	ASTM	1996	Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)	This test method covers the determination of transmissivity from the measurement of force-free (overdamped) response of a well-aquifer system to a sudden change of water level in a well. Force-free response of water level in a well to a sudden change in water level is characterized by recovery to initial water level in an approximate exponential manner with negligible inertial effects.	4

Number	Org.	Year	Title	Topic	Pages
D4105-96	ASTM	2002	Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method	This test method covers an analytical procedure for determining transmissivity and storage coefficient of a nonleaky confined aquifer under conditions of radial flow to a fully penetrating well of constant flux. This test method is a shortcut procedure used to apply the Theis nonequilibrium method. The Theis method is described in Test Method D 4106.	5
D4106-96	ASTM	2002	Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method	This test method covers an analytical procedure for determining the transmissivity and storage coefficient of a nonleaky confined aquifer. It is used to analyze data on water-level response collected during radial flow to or from a well of constant discharge or injection.	5
D4696-92	ASTM	2000	Standard Guide for Pore-Liquid Sampling from the Vadose Zone	This guide discusses equipment and procedures used for sampling pore-liquid from the vadose zone (unsaturated zone). The guide is limited to in-situ techniques and does not include soil core collection and extraction methods for obtaining samples.	32
D5220-02	ASTM	2002	Standard Test Method for Water Content of Soil and Rock In-Place by the Neutron Depth Probe Method	This test method covers the calculation of the water content of soil and rock by thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector are placed at the desired depth in the bored hole lined by an access tube.	6
D5269-96	ASTM	2002	Standard Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method	This test method covers an analytical procedure for determining the transmissivity of a confined aquifer. This test method is used to analyze data from the recovery of water levels following pumping or injection of water to or from a control well at a constant rate.	5
D5270-96	ASTM	2002	Standard Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers	This test method covers an analytical procedure for determining the transmissivity, storage coefficient, and possible location of boundaries for a confined aquifer with a linear boundary. This test method is used to analyze water-level or head data from one or more observation wells or piezometers during the pumping of water from a control well at a constant rate. This test method also applies to flowing artesian wells discharging at a constant rate. With appropriate changes in sign, this test method also can be used to analyze the effects of injecting water into a control well at a constant rate.	7

Number	Org.	Year	Title	Topic	Pages
D5785-95	ASTM	2000	Standard Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)	This test method covers determination of transmissivity from the measurement of the damped oscillation about the equilibrium water level of a well-aquifer system to a sudden change of water level in a well. Underdamped response of water level in a well to a sudden change in water level is characterized by oscillatory fluctuation about the static water level with a decrease in the magnitude of fluctuation and recovery to initial water level. Underdamped response may occur in wells tapping highly transmissive confined aquifers and in deep wells having long water columns.	5
D5786-95	ASTM	2000	Standard Practice for (Field Procedure) for Constant Drawdown Tests in Flowing Wells for Determining Hydraulic Properties of Aquifer Systems	This practice covers the methods for controlling drawdown and measuring discharge rates and head to analyze the hydraulic properties of an aquifer or aquifers.	3
D5855-95	ASTM	2000	Standard Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of a Confined Nonleaky or Leaky Aquifer by Constant Drawdown Method in a Flowing Well	This test method covers an analytical solution for determining transmissivity and storage coefficient of a leaky or nonleaky confined aquifier. It is used to analyze data on the flow rate from a control well while a constant head is maintained in the well.	5
D5881-95	ASTM	2000	Standard Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug)	This test method covers determination of transmissivity from the measurement of water-level response to a sudden change of water level in a well-aquifer system characterized as being critically damped or in the transition range from underdamped to overdamped. Underdamped response is characterized by oscillatory changes in water level; overdamped response is characterized by return of the water level to the initial static level in an approximately exponential manner. Overdamped response is covered in Guide D4043; underdamped response is covered in D5785.	9
D5912-96e1	ASTM	1996	Standard Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug)	This test method covers the determination of hydraulic conductivity from the measurement of inertial force free (overdamped) response of a well-aquifer system to a sudden change in water level in a well. Inertial force free response of the water level in a well to a sudden change in water level is characterized by recovery to initial water level in an approximate exponential manner with negligible inertial effects.	4
D5920-96	ASTM	1996	Standard Test Method [Analytical Procedure] for Tests of Anisotropic Unconfined Aquifers by Neuman Method	This test method covers an analytical procedure for determining the transmissivity, storage coefficient, specific yield, and horizontal-to-vertical hydraulic conductivity ratio of an unconfined aquifer. It is used to analyze the drawdown of water levels in piezometers and partially or fully penetrating observation wells during pumping from a control well at a constant rate.	9

Number	Org.	Year	Title	Topic	Pages
D6642-01	ASTM	2001	Standard Guide for Comparison of Techniques to Quantify the Soil-Water (Moisture) Flux	This guide describes techniques that may be used to quantify the soil-water (or soil-moisture) flux, the soil-water movement rate, and/or the recharge rate within the vadose zone. This guide is not intended to be all-inclusive with regard to available methods. However, the techniques described do represent the most widely used methods currently available.	11
2.2.4.5. Modelling					
D5718-95	ASTM	2000	Standard Guide for Documenting a Groundwater Flow Model Application	This guide covers suggested components to be included in documenting and archival of numerical groundwater flow model applications. Model documentation includes a written and graphical presentation of model assumptions and objectives, the conceptual model, code description, model construction, model calibration, predictive simulations, and conclusions. Model archival refers to a file or set of files (in both written and digital format) that contains logs of significant model simulations (that is, calibration, sensitivity and prediction simulations), supplemental calculations, model documentation, a copy of the model source code(s) or executable file(s) used, or both, and input and output data sets for significant model simulations.	5
D5490-93	ASTM	2002	Standard Guide for Comparing Ground-Water Flow Model Simulations to Site-Specific Information	This guide covers techniques that should be used to compare the results of ground-water flow model simulations to measured field data as a part of the process of calibrating a ground-water model. This comparison produces quantitative and qualitative measures of the degree of correspondence between the simulation and site-specific information related to the physical hydrogeological system.	8
D5609-94	ASTM	2002	Standard Guide for Defining Boundary Conditions in Ground-Water Flow Modelling	This guide covers the specification of appropriate boundary conditions that are an essential part of conceptualizing and modelling ground-water systems. This guide describes techniques that can be used in defining boundary conditions and their appropriate application for modelling saturated ground-water flow model simulations.	4
D5610-94	ASTM	2002	Standard Guide for Defining Initial Conditions in Ground-Water Flow Modelling	This guide covers techniques and procedures used in defining initial conditions for modeling saturated ground-water flow. The specification of initial conditions is an essential part of conceptualizing and modelling ground-water systems.	2
D5611-94	ASTM	2002	Standard Guide for Conducting a Sensitivity Analysis for a Ground-Water Flow Model Application	This guide covers techniques that should be used to conduct a sensitivity analysis for a ground-water flow model. The sensitivity analysis results in quantitative relationships between model results and the input hydraulic properties or boundary conditions of the aquifers.	5

Number	Org.	Year	Title	Topic	Pages
D5880-95	ASTM	2000	Standard Guide for Subsurface Flow and Transport Modelling	This guide covers an overview of subsurface fluid-flow (ground-water) modelling. The term subsurface fluid flow is used to reduce misunderstanding regarding ground water, soil water, vapours including air in subsurface pores, and non-aqueous phase liquids. Increased understanding of fluid-flow phenomena is the combined result of field investigations and theoretical development of mathematical methods to describe the observations. The results are methods for modelling viscous fluids and air flow, in addition to water, that are practical and appropriate.	6
D5979-96	ASTM	2002	Standard Guide for Conceptualization and Characterization of Ground-Water Systems	This guide covers an integrated, stepwise method for the qualitative conceptualization and quantitative characterization of ground-water flow systems, including the unsaturated zone, for natural or human-induced behavior or changes.	7
D5981-96	ASTM	2002	Standard Guide for Calibrating a Ground-Water Flow Model Application	This guide covers techniques that can be used to calibrate a ground-water flow model. The calibration of a model is the process of matching historical data, and is usually a prerequisite for making predictions with the model.	6
D6025-96	ASTM	2002	Standard Guide for Developing and Evaluating Ground-Water Modelling Codes	This guide covers a systematic approach to the development, testing, evaluation, and documentation of groundwater modelling codes. The procedures presented constitute the quality assurance framework for a ground-water modelling code. They include code review, testing, and evaluation using quantitative and qualitative measures. This guide applies to both the initial development and the subsequent maintenance and updating of ground-water modelling codes.	16
D6028-96	ASTM	1996	Standard Test Method (Analytical Procedure) for Determining Hydraulic Properties of a Confined Aquifer Taking into Consideration Storage of Water in Leaky Confining Beds by Modified Hantush Method	This test method covers an analytical procedure for determining the transmissivity and storage coefficient of a confined aquifer taking into consideration the change in storage of water in overlying or underlying confining beds, or both. This test method is used to analyze water-level or head data collected from one or more observation wells or piezometers during the pumping of water from a control well at a constant rate. With appropriate changes in sign, this test method also can be used to analyze the effects of injecting water into a control well at a constant rate.	9

Number	Org.	Year	Title	Topic	Pages
D6029-96	ASTM	1996	Standard Test Method (Analytical Procedure) for Determining Hydraulic Properties of a Confined Aquifer and a Leaky Confining Bed with Negligible Storage by the Hantush-Jacob Method	This test method covers an analytical procedure for determining the transmissivity and storage coefficient of a confined aquifer and the leakance value of an overlying or underlying confining bed for the case where there is negligible change of a water in storage in a confining bed. This test method is used to analyze water-level or head data collected from one or more observation wells or piezometers during the pumping of water from a control well at a constant rate. With appropriate changes in sign, this test method also can be used to analyze the effects of injecting water into a control well at a constant rate.	10
D6030-96	ASTM	2002	Standard Guide for Selection of Methods for Assessing Ground Water or Aquifer Sensitivity and Vulnerability	This guide covers information needed to select one or more methods for assessing the sensitivity of ground water or aquifers and the vulnerability of ground water or aquifers to water-quality degradation by specific contaminants.	8
D6033-96	ASTM	2002	Standard Guide for Describing the Functionality of a Ground-Water Modelling Code	This guide presents a systematic approach to the classification and description of computer codes used in ground-water modelling. Due to the complex nature of fluid flow and biotic and chemical transport in the subsurface, many different types of ground-water modelling codes exist, each having specific capabilities and limitations. Determining the most appropriate code for a particular application requires a thorough analysis of the problem at hand and the required and available resources, as well as a detailed description of the functionality of potentially applicable codes.	10
D6170-97e1	ASTM	1999	Standard Guide for Selecting a Ground-Water Modelling Code	This guide covers a systematic approach to the determination of the requirements for and the selection of computer codes used in a ground-water modeling project. Due to the complex nature of fluid flow and biotic and chemical transport in the subsurface many different ground-water modelling codes exist, each having specific capabilities and limitations. Furthermore, a wide variety of situations may be encountered in projects where ground-water models are used. Determining the most appropriate code for a particular application requires a thorough analysis of the problem at hand and the required and available resources, as well as detailed description of the functionality of candidate codes.	19

Number	Org.	Year	Title	Topic	Pages
D6171-97e1	ASTM	1998	Standard Guide for Documenting a Groundwater Modelling Code	This guide covers suggested components of the documentation of a ground-water modelling code consists of textural and graphical information recorded during its design, development, and maintenance regarding its capabilities, development history, theoretical foundation, operation, and verification. It is the principal instrument for those involved in its development and use, such as code development and maintenance staff, network managers, code users and project managers, to communicate regarding all aspects of the software.	4
D6312-98	ASTM	1998	Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs	This guide covers the context of ground water monitoring at waste disposal facilities, regulations have required statistical methods as the basis for investigating potential environmental impact due to waste disposal facility operation. Owner/operators must perform a statistical analysis on a quarterly or semi-annual basis. A statistical test is performed on each of many constituents (for example, 10 to 50 or more) for each of many wells (5 to 100 or more). The result is potentially hundreds, and in some cases, a thousand or more statistical comparisons performed on each monitoring event. Even if the false positive rate for a single test is small (for example, 1%), the possibility of failing at least one test on any monitoring event is virtually guaranteed. This assumes you have done the correct statistic in the first place.	14
2.2.4.6. Chemical analyses					
D6001-96	ASTM	2002	Standard Guide for Direct-Push Water Sampling for Geo-environmental Investigations	This guide covers a review of methods for sampling ground water at discrete points or in increments by insertion of sampling devices by static force or impact without drilling and removal of cuttings. By directly pushing the sampler, the soil is displaced and helps to form an annular seal above the sampling zone. Direct-push water sampling can be one time, or multiple sampling events. Methods for obtaining water samples for water quality analysis and detection of contaminants are presented.	15
D6771-02	ASTM	2002	Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Groundwater Quality Investigations	This practice covers the method for purging and sampling wells and devices used for groundwater quality investigations and monitoring programs known as low-flow purging and sampling. This method is also known by the terms minimal drawdown purging or low-stress purging. This method could be used for other types of groundwater sampling programs but these uses are not specifically addressed in this practice.	7

Number	Org.	Year	Title	Topic	Pages
D5738-95	ASTM	2000	Standard Guide for Displaying the Results of Chemical Analyses of Ground Water for Major Ions and Trace Elements-Diagrams for Single Analyses	This guide covers the category of water-analysis diagrams that use pictorial or pattern methods (for example, bar, radiating vectors, pattern, and circular) as a basis for displaying each of the individual chemical components that were determined from the analysis of a single sample of natural ground water (see Terminology).	25
D5754-95	ASTM	2000	Standard Guide for Displaying the Results of Chemical Analyses of Ground Water for Major Ions and Trace Elements-Trilinear Diagrams for Two or More Analyses	This guide describes the category of water analysis diagrams that use two-dimensional trilinear graphs as a technique for displaying the common chemical components from two or more complete analyses of natural ground water (see Section 3) on a single diagram. This category includes not only trilinear-shaped diagrams but also the diamond- or parallelogram-, rectangular-, or square-shaped graphs that have trilinear subdivisions.	25
D5877-95	ASTM	2000	Standard Guide for Displaying Results of Chemical Analyses of Ground Water for Major Ions and Trace Elements-Diagrams Based on Data Analytical Calculations	This guide covers methods that graphically display chemical analyses of multiple ground-water samples, discrete values and also those reduced to comprehensive summaries or parameters. Details required by the investigator to fully use the methods are found in the listed references. The methods included in this guide are many of the graphical procedures that were not discussed in two previous guides, Guides D5738 and D5754.	18

Number	Org.	Year	Title	Topic	Pages
3. Field investigations					
3.1. Boreholes					
EN1997	CEN			For the explorations relevant of the geotechnical category 2, the following points apply: ▪ For the embanked areas and the embankments, the minimal depth of reconnaissance must include all the layers of compressible soils that significantly contribute to the sinking. The depth of reconnaissance can be limited at a level under which the contribution to the sinking is < 10%. The distance between two close points of reconnaissance is normally from 100 to 200 m. The pressure of the underground water existing during the reconnaissance must be determined. The extreme levels of all extent of free water able to influence the pressure of the underground water must be determined and the level of the free waters during the reconnaissance must be metered.	
D6286-98	ASTM	1998	Standard Guide for Selection of Drilling Methods for Environmental Site Characterization	This guide provides descriptions of various drilling methods for environmental site characterization along with advantages and disadvantages associated with each method discussed. A comprehensive description of these drilling methods can be found in individual ASTM standards, see Section 2. This guide is intended to aid in the selection of drilling method(s) for environmental soil and rock borings and the installation of monitoring wells and other water-quality monitoring devices.	16
D6169-98	ASTM	1998	Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations	This guide covers guidance for the selection of soil and rock sampling devices used with drill rigs for the purpose of characterizing in situ physical and hydraulic properties, chemical characteristics, subsurface lithology, statigraphy, and structure, and hydrogeological units in environmental investigations.	19

Number	Org.	Year	Title	Topic	Pages
D6067-96e1	ASTM	2000	Standard Guide for Using the Electronic Cone Penetrometer for Environmental Site Characterization	The electronic cone penetrometer test often is used to determine subsurface stratigraphy for geotechnical and environmental site characterization purposes (1). The geotechnical application of the electronic cone penetrometer test is discussed in detail in Test Method D 5778, however, the use of the electronic cone penetrometer test in environmental site characterization applications involves further considerations that are not discussed.	7
D1452-80	ASTM	2000	Practice for Soil Investigation and Sampling by Auger Borings	This practice covers equipment and procedures for the use of earth augers in shallow geotechnical exploration.	2
D2113-99	ASTM	1999	Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation	This practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.	20
D5434-97	ASTM	1997	Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock	This guide describes the type of information that should be recorded during field subsurface explorations in soil and rock.	3
D5753-95e1	ASTM	1998	Standard Guide for Planning and Conducting Borehole Geophysical Logging	This guide covers the documentation and general procedures necessary to plan and conduct a geophysical log program as commonly applied to geologic, engineering, ground-water, and environmental (hereafter referred to as geotechnical) investigations. It is not intended to describe the specific or standard procedures for running each type of geophysical log and is limited to measurements in a single borehole. It is anticipated that standard guides will be developed for specific methods subsequent to this guide.	9
D5781-95	ASTM	2000	Standard Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geo-environmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how dual-wall reverse-circulation drilling may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	8
D5782-95	ASTM	2000	Standard Guide for Use of Direct Air-Rotary Drilling for Geo-environmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how direct (straight) air-rotary drilling procedures may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	7
D5783-95	ASTM	2000	Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geo-environmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how direct (straight) rotary-drilling procedures with water-based drilling fluids may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	7
D5784-95	ASTM	2000	Standard Guide for Use of Hollow-Stem Augers for Geo-environmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how hollow-stem auger-drilling systems may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	7

Number	Org.	Year	Title	Topic	Pages
D5872-95	ASTM	2000	Standard Guide for Use of Casing Advancement Drilling Methods for Geo-environmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how casing-advancement drilling and sampling procedures may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	8
D5875-95	ASTM	2000	Standard Guide for Use of Cable-Tool Drilling and Sampling Methods for Geo-environmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices	This guide covers cable-tool drilling and sampling procedures used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	9
D5876-95	ASTM	2000	Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geo-environmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices	This guide covers how direct (straight) wireline rotary casing advancement drilling and sampling procedures may be used for geo-environmental exploration and installation of subsurface water-quality monitoring devices.	11
D6151-97	ASTM	1997	Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling	This practice covers how to obtain soil samples using hollow-stem auger drilling methods for geotechnical exploration. This practice addresses how to obtain soil samples suitable for engineering properties testing.	13
D6167-97e1	ASTM	1997	Standard Guide for Conducting Borehole Geophysical Logging: Mechanical Calliper	This guide covers the general procedures necessary to conduct calliper logging of boreholes, wells, access tubes, caissons, or shafts (hereinafter referred as boreholes) as commonly applied to geologic, engineering, groundwater and environmental (hereinafter referred as geotechnical) investigations. Calliper logging for mineral or petroleum exploration and development are excluded.	6
3.2. Sampling					
ISO 10381-2	ISO	2002	Soil quality – Sampling - Part 2: Guidance on sampling techniques	This document provides guidance for soil sampling and storage techniques for sub-sequent examinations to obtain soil quality data. This document provides information on standard equipment used in specific sampling cases for correct sampling procedures and collection of representative samples. This guidance concerns the selection of equipment and techniques to be used to correctly take samples of disturbed and undisturbed soils at different depths.	30
D1587-00	ASTM	2000	Practice for Thin-Walled Tube Sampling of Soils	This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.	4

Number	Org.	Year	Title	Topic	Pages
D3550-01	ASTM	2001	Practice for Ring-lined Barrel Sampling of Soils	This practice covers procedure for thick wall, split barrel drive sampling of soil to obtain representative samples of soil for classification and laboratory testing. The sampler is considered to be a thick wall sampler with sharpened cutting shoe and ball check vent. The middle barrel section is often of split barrel design, but a solid barrel can be used and both may contain ring liners. The sampler is often driven, but can also be pushed in softer deposits. Penetration resistance data may be recorded. This standard uses procedures similar to Test Method D1586 on Penetration Resistance and Split Barrel Sampling of Soils. However, in this practice, differing hammer weights, drop heights, and different size samplers are used, so the data must not be reported as conforming to Test Method D1586 and cannot be used to determine Normalized penetration resistance data for sands in accordance with Practice D6066.	5
D4700-91	ASTM	1998	Guide for Soil Sampling from the Vadose Zone	This guide addresses procedures that may be used for obtaining soil samples from the vadose zone (unsaturated zone).	16
D4832-02	ASTM	2002	Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders	This test method covers procedures for the preparation, curing, transporting and testing of cylindrical test specimens of controlled low strength material (CLSM) for the determination of compressive strength.	5
D6282-98	ASTM	1998	Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations	This guide addresses direct push soil samplers, which also may be driven into the ground from the surface or through pre-bored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by a combination of static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or sidewall samplers. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment with incremental drill hole excavation. Other sampling standards, such as Test Methods D 1586 and D 1587 and Practice D 3550 apply to rotary drilling activities. This guide does not address advancement of sampler barrel systems with methods that employ cuttings removal as the sampler is advanced. Other drilling and sampling methods may apply for samples needed for engineering and construction applications.	19

Number	Org.	Year	Title	Topic	Pages
D6519-02	ASTM	2002	Standard Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler	This practice covers a procedure for sampling of cohesive, organic, or fine-grained soils, or combination thereof, using a thin-walled metal tube that is inserted into the soil formation by means of a hydraulically operated piston. It is used to collect relatively undisturbed soil samples suitable for laboratory tests to determine structural and chemical properties for geotechnical and environmental site characterizations.	8
3.3. Soils description					
3.3.1. Density					
D854-02	ASTM	2002	Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer	These test methods cover the determination of the specific gravity of soil solids that pass the 4.75-mm (N° 4) sieve, by means of a water pycnometer.	7
NF P 94-054	Afnor	1991	Soil investigation and testing – Determination of particle density – Pycnometer method	The present norm concerns the determination by water Pycnometer of the density of solid particles of soil, either intact or reworked, whose the size of the biggest elements doesn't exceed 2 mm.	8
NF P 94-053	Afnor	1991	Soil investigation and testing – Determination of density of fine soils – Cutting curb, mould and water immersion methods	The present norms aims to determine, in laboratory, the density of fine soils. This norm defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation ode and specifies the result to be presented.	
D2922-01	ASTM	2001	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)	This test method covers the determination of the total or wet density of soil and soil-rock mixtures by the attenuation of gamma radiation where the source and detector(s) remain on the surface (Backscatter Method) or the source or detector is placed at a known depth up to 300 mm (12 in.) while the detector(s) or source remains on the surface (Direct Transmission Method).	6
D2167-94	ASTM	2001	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method	This test method covers the determination of the in-place density and unit weight of compacted or firmly bonded soil using a rubber balloon apparatus.	6
D1556-00	ASTM	2000	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method	This test method may be used to determine the in-place density and unit weight of soils using a sand cone apparatus.	7
D2937-00e1	ASTM	2000	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method	This test method covers the determination of in-place density of soil by the drive-cylinder method. The test method involves obtaining a relatively undisturbed soil sample by driving a thin-walled cylinder and the subsequent activities for the determination of in-place density. When sampling or in-place density is required at depth, Test Method D1587 should be used.	5

Number	Org.	Year	Title	Topic	Pages
D4253-00	ASTM	2000	Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table	These test methods cover the determination of the maximum-index dry density/unit weight of cohesionless, free-draining soils using a vertically vibrating table. The adjective "dry before density or unit weight is omitted in the title and remaining portions of this standard to be consistent with the applicable definition given in Section 3 on Terminology.	14
D4254-00	ASTM	2000	Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density	These test methods cover the determination of the minimum index density/unit weight of cohesionless, free-draining soils. The adjective "dry" before density or unit weight is omitted in the title and remaining portions of this standards to be consistent with the applicable definitions given in Sections 3 on Terminology.	9
NF P 94-059	Afnor	2000	Soils: investigation and testing - Determination of minimal and maximal density of cohesionless soils	The present document concerns the determination of the minimal and maximal densities of non cohesive soils. It fixes the terminology, specifies the characteristics of the apparatus, describes the operation mode to fulfil in aim to obtain the conventional maximal and minimal compactness and specifies the parameters to calculate and the results to be presented.	24
D4564-02	ASTM	2002	Standard Test Method for Density of Soil in Place by the Sleeve Method	This test method covers the determination of the density of soil in place by the sleeve method.	9
D5030-89e1	ASTM	1994	Standard Test Method for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit	This test method covers the determination of the in-place density and unit weight of soil and rock using water to fill a lined test pit to determine the volume of the test pit. The use of the word "rock" in this test method is used to imply that the material being tested will typically contain particles larger than 3 in. (75 mm).	13
D5195-02	ASTM	2002	Standard Test Method for Density of Soil and Rock In-Place at Depths Below the Surface by Nuclear Methods	This test method covers the calculation of the density of soil and rock by the attenuation of gamma radiation, where the gamma source and the gamma detector are placed at the desired depth in a bored hole lined by an access tube.	5
NF P 94-061-1	Afnor	1996	Soils: Investigation and testing – Determination of density of materials on site – Part 1: Method employing gammadensitometer with point (direct transmission,)	The present document defines a test method for the point measure of the density of an *in situ* material. For this part 1 of the norm, it's the method of the gammadensitometer with point.	16
NF P 94-062	Afnor	1997	Soils: Investigation and testing – Measurement of density on site – Gamma-gamma ray log	The present document defines a test method by gammametering for the distribution of the wet or dry density of a material according to its depth.	12
NF P 94-061-2	Afnor	1996	Soils: Investigation and testing – Determination of density of materials on site – Part 2: Membrane densitometer method	The present document defines a test method for the point measure of the density of an *in situ* material. For this part 2 of the norm, it's the method of the membrane densitometer.	8

Number	Org.	Year	Title	Topic	Pages
NF P 94-061-3	Afnor	1996	Soils: Investigation and testing – Determination of density of materials on site – Part 3: Method with sand	The present document defines a test method for the point measure of the density of an *in situ* material. For this part 3 of the norm, it's the method with sand.	8
NF P 94-061-4	Afnor	1996	Soils: Investigation and testing – Determination of density of materials on site – Part 4: Method for large materials (D_{max} > 50 mm)	The present document defines a test method for the point measure of the density of an *in situ* material. For this part 4 of the norm, it's a method usable with coarse materials (D_{max} > 50 mm).	8
D5550-00	ASTM	2000	Standard Test Method for Specific Gravity of Soil Solids by Gas Pycnometer	This test method covers the determination of the specific gravity of soil solids by means of a gas pycnometer. Particle size is limited by the dimensions of the specimen container of the particular pycnometer being used.	4
3.3.2. Granulometry					
D422-63	ASTM	1998	Standard Test Method for Particle-Size Analysis of Soils	This test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the N° 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data.	8
NF P 94-056	Afnor	1996	Soils: investigation and testing – Granulometric analysis – Dry sieving method after washing	The present document defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	16
NF P 94-057	Afnor	1992	Soils: investigation and testing – Granulometric analysis – Hydrometer method	The present norms concerns the determination of the weight distribution of the sizes of the particles smaller than 80 µm. this norm fixes the terminology, the apparatus and the operation mode of this test.	20
NF P 94-041	Afnor	1995	Soils: investigation and testing - Granulometric description - Wet sieving method	The present document is about the identification for the classification of a material depending the size of the grains. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	12
NF P 94-040	Afnor	1993	Soils: investigation and testing - Practical method for identifying the 0/50 mm fraction of a granular material - Determination of particle size and blue value	The present document defines a simplified method of identification of the 0/50 mm fraction of a granulated material. The application of this method doesn't exclude the use of other methods aiming at separately determining the parameters of classification of the norm NF P 11-300.	12

Number	Org.	Year	Title	Topic	Pages
NF P 18-597	Afnor	1990	Aggregates - Determination of the cleanness of sands: equivalent to sand at 10 % thin particles	The test of equivalent to sand at 10 % thin particles, allowing to measure the cleanness of a sand, is done on the fraction of an aggregate passing the square 2 mm sieve and whose the proportion of particles passing the square 0.08 mm sieve has been got back to 10 % help to a correcting sand (if this rate is >11 %). It globally reports the quality of the thin elements by expressing a conventional volumetric rate between the sandy elements that sediment and the thin elements that flocculate.	5
NF P 18-598	Afnor	1991	Aggregates: Sand equivalent	The present norms aims to define a characteristic of sands called "equivalent to sand" and to fix the method allowing to determine this characteristic.	8
D1140-00	ASTM	2000	Standard Test Methods for Amount of Material in Soils Finer Than the N° 200 (75-µm) Sieve	These test methods cover determination of the amount of material finer than a 75-µm (N° 200) sieve by washing.	4
D2217-85	ASTM	1998	Standard Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants	This practice covers the wet preparation of soil samples as received from the field for particle-size analysis and determination of soil constants.	3
D4221-99	ASTM	1999	Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer	This test method, when used in conjunction with a test performed by Method D422 on a duplicate soil sample, provides an indication of the natural dispersive characteristics of clay soils.	3
D6572-00	ASTM	2000	Standard Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test	These test methods provide a qualitative indication of the natural dispersive characteristics of clayey soils.	4
NF P 94-068	Afnor	1998	Soils : Investigation and testing - Measuring of the methylene blue adsorption capacity of a rocky soil - Determination of the methylene blue of a soil by means of the stain test	The present document aims to precise the determination method of the value of methylene blue of soil or a rock by the means of the methylene blue stain test. The methylene blue value (MBV) measures the capacity of absorption of a soil or a rocky material. It constitutes one of the identification parameters of the classification of soils described in the NF P 11-300 norm.	8
D4404-84e1	ASTM	1998	Standard Test Method for Determination of Pore Volume and Pore Volume Distribution of Soil and Rock by Mercury Intrusion Porosimetry	This test method covers the determination of the pore volume and the pore volume distributions of soil and rock by the mercury intrusion porosimetry method. The range of apparent diameters of pores for which this test method is applicable is fixed by the operant pressure range of the testing instrument. This range is typically between apparent pore entrance diameters of about 100 µm and 2.5 nm (0.0025 µm). Larger pores must be measured by another method.	6
D4542-95	ASTM	2001	Standard Test Method for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer	This test method covers a rapid procedure for squeezing pore water from fine-grained soils for the purpose of determining the amount of soluble salts present in the extracted pore water.	5

Number	Org.	Year	Title	Topic	Pages
D4546-96	ASTM	1996	Standard Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils	These test methods cover three alternative laboratory methods for determining the magnitude of swell or settlement of relatively undisturbed or compacted cohesive soil.	7
D4647-93e1	ASTM	1998	Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test	This test method presents a direct, qualitative measurement of the dispersibility and consequent colloidal erodibility of clay soils by causing water to flow through a small hole punched in a specimen. This test method is complemented by Test Method D4221.	11
D4718-87	ASTM	2001	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles	This practice presents a procedure for calculating the unit weights and water contents of soils containing oversize particles when the data are known for the soil fraction with the oversize particles removed.	3
D4829-95	ASTM	1995	Standard Test Method for Expansion Index of Soils	This test method provides an index to the expansion potential of compacted soils when inundated with distilled water.	4
D4914-99	ASTM	1999	Standard Test Methods for Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit	These test methods cover the determination of the in-place density and unit weight of soil and rock using a pouring device and calibrated sand to determine the volume of a test pit. The word "rock" in these test methods is used to imply that the material being tested will typically contain particles larger than 3 in. (75 mm).	14
3.3.3. Moisture					
D1558-99	ASTM	1999	Standard Test Method for Moisture Content Penetration Resistance Relationships of Fine-Grained Soils	This test method is for establishing the moisture-penetration resistance relationships of fine-grained soils as determined by the soil penetrometer.	3
D0425-88	ASTM	2001	Standard Test Method for Centrifuge Moisture Equivalent of Soils	This test method covers the determination of the moisture equivalent of soil in the laboratory by means of a centrifuge technique.	4
D2216-98	ASTM	1998	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass	This test method covers the laboratory determination of the water (moisture) content by mass of soil, rock, and similar materials where the reduction in mass by drying is due to loss of water except as noted in 1.4, 1.5, and 1.7. For simplicity, the word "material" hereinafter also refers to either soil or rock, whichever is most applicable.	5
D2325-68	ASTM	2000	Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus	This test method covers the determination of capillary-moisture relationships for coarse- and medium-textured soils as indicated by the soil-moisture tension relations for tensions between 10 and 101 kPa (0.1 and 1 atm). Under equilibrium conditions, moisture tension is defined as the equivalent negative gage pressure, or suction, corresponding to a soil moisture content. This test method determines the equilibrium moisture content retained in a soil subjected to a given soil-water tension. This test method is not suitable for very fine-textured soils.	6

Number	Org.	Year	Title	Topic	Pages
D3152-72	ASTM	2000	Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus	This test method covers the determination of capillary-moisture properties of fine-textured soils as indicated by the moisture content - moisture tension relationships determined by pressure-membrane apparatus using tensions between 1 and 15 atm (101 and 1520 kPa). Moisture tension (matrix suction) is defined as the equivalent negative gage pressure, or suction, in soil moisture. The test result is a moisture content which is a measure of the water retained in the soil subjected to a given soil - water tension (or at an approximately equivalent height above the water table).	6
D3017-01	ASTM	2001	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)	This test method covers the determination of water content of soil and rock by the thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector both remain at the surface.	5
D4643-00	ASTM	2000	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method	This test method outlines procedures for determining the water (moisture) content of soils by incrementally drying soil in a microwave oven.	5
NF P 94-049-1	Afnor	1996	Soil: Survey and testing – Determination of water content on a mass basis – Part 1: Microwave oven drying method	The present document concerns the determination of the rate of weighting water of a sample of material by drying with a microwave oven. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	12
NF P 94-049-2	Afnor	1996	Soil: Survey and testing – Determination of water content on a mass basis – Part 2: Heating plate or radiating panel method	The present document concerns the determination of the rate of weighting water of a sample of material by drying with a heating plate or a radiating panel. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	12
NF P 94-050	Afnor	1995	Soil: Survey and testing – Determination of moisture content– Oven drying method	The present document concerns the determination of the rate of weighting water of a sample of soil or material by heating. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	8
D4944-98	ASTM	1998	Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method	This test method outlines procedures for determining the water (moisture) content of soil by chemical reaction using calcium carbide as a reagent to react with the available water in the soil producing a gas. A measurement is made of the gas pressure produced when a specified mass of wet or moist soil is placed in a testing device with an appropriate volume of reagent and mixed.	4
D4959-00	ASTM	2000	Standard Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating	This test method covers procedures for determining the water (moisture) content of soils by drying with direct heat, such as using a hotplate, stove, blowtorch, etc.	4

Number	Org.	Year	Title	Topic	Pages
NF P 94-123	Afnor	1999	Soil: Investigation and testing - Well logging - Neutron probe method	The present document is about a test that allows to estimate the volumic water content of an on place material by the mean of a probe equipped with a radioactive source. It defines the employed terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operating mode and specifies the results to be presented.	12
D5472-93e1	ASTM	1999	Standard Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well	This test describes a procedure for conducting a specific capacity test, computing the specific capacity of a control well, and estimating the transmissivity in the vicinity of the control well. Specific capacity is the well yield per unit drawdown at an identified time after pumping started.	4
D5473-93	ASTM	2000	Standard Test Method for (Analytical Procedure for) Analyzing the Effects of Partial Penetration of Control Well and Determining the Horizontal and Vertical Hydraulic Conductivity in a Nonleaky Confined Aquifer	This test method covers an analytical solution for determining the horizontal and vertical hydraulic conductivity of an aquifer by analysis of the response of water levels in the aquifer to the discharge from a well that partially penetrates the aquifer.	16
D5879-95e1	ASTM	1998	Standard Practice for Surface Site Characterization for On-Site Septic Systems	This practice covers procedures for the characterization of surface conditions at a site for evaluating suitability for an on-site septic system for disposal and treatment of wastewater. This practice provides a method for identifying potentially suitable areas for soil absorption of septic tank wastewater.	4
D5921-96e1	ASTM	1998	Standard Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems	This practice covers procedures for the characterization of subsurface soil conditions at a site as part of the process for evaluating suitability for an on-site septic system. This practice provides a method for determining the usable unsaturated soil depth for septic tank effluent to infiltrate for treatment and disposal.	16
D5925-96e1	ASTM	1998	Standard Practice for Preliminary Sizing and Delineation of Soil Absorption Field Areas for On-Site Septic Systems	This practice covers procedures for estimating the dimensions and marking the boundaries of a soil absorption area for an on-site septic system involving residential-strength wastewater. It can also be used to estimate the dimensions of commercial on-site septic systems where wastewater strengths are similar to residential wastewater.	7

Number	Org.	Year	Title	Topic	Pages
3.3.4. Miscellaneous					
D4373-02	ASTM	2002	Standard Test Method for Rapid Determination of Carbonate Content of Soils	This test method covers the determination of carbonate content of soils and soft rock which can be readily broken down by mechanical effort. It is a gasometric method that utilizes a simple portable apparatus. Results should be clearly stated as the calcite equivalent in percent because different carbonate species cover a wide range of percent calcite equivalent as shown below for a number of carbonates: Species / Cation / Calcite Equivalent, % Magnesite / Mg / 117.0 Dolomite / Ca, Mg / 108.6 Calcite / Ca / 100.0 Aragonite / Ca / 100.0 Rhodocrosite / Mn / 87.1 Siderite / Fe / 86.4 Smithsonite / Zn / 79.8 Witherite / Ba / 50.7 Cerrusite / Pb / 37.5	5
D4972-01	ASTM	2001	Standard Test Method for pH of Soils	This test method covers the measurement of the pH of soils for uses other than for corrosion testing. Such measurements are used in the agricultural, environmental, and natural resources fields. This measurement determines the degree of acidity or alkalinity in soil materials suspended in water and a 0.01 *M* calcium chloride solution. Measurements in both liquids are necessary to fully define the soil's pH. This variable is useful in determining the solubility of soil minerals and the mobility of ions in the soil and assessing the viability of the soil-plant environment. A more detailed discussion of the usefulness of this parameter is not warranted here; however, it can be found in many discussions of the subject. A few such discussions are given as Refs (1-6) at the end of the text.	3

Geotechnique

The household waste sanitary landfill is an earthwork that must keep its properties for several decades (for chemical waste it's several centuries). So a particular attention will be paid to (i) the characteristics of the materials that will be used for the construction; (ii) the rules of art to take into account these characteristics for the design of the works. It's the object of a science: geotechnique. We reproduce hereafter a table of the French Geotechnical Union that is the syndicate of the companies specialized in geotechnical studies.

Pursued Objectives	Boreholes		Laboratory testing		In situ testing	
Geology	Rotary hollow drill Benoto[1] Mechanical shovel Auger Destructive drilling with sampling	R R R S S	Identification test	R		
Stratigraphy	Rotary hollow drill Benoto Mechanical shovel Auger Destructive drilling with sampling Destructive drilling with diagraphies	R R R S S Q			Piezocone Static penetrometer Dynamic penetrometer	S S Q
Identification, Classification, Re-use	Representative intact or rejigged sample, sampled in the previous conditions	R	Identification tests Proctor test, treatment tests	R R		
Bearing capacity	Rotary hollow drill + intact sample + Labo	S	Triaxial shearing Simple compression Direct shearing	S S S	Pressuremeter Static penetrometer Standard Penetration Test Dynamic penetrometer Phicometer Scissometer	R R S Q Q Q
Parameters of deformation and calculations of sinking	Rotary hollow drill + intact sample + Labo	R	Œdometer Triaxial test Modulus, simple compression	R R R	Pressuremeter Static penetrometer	R Q
Level of watertables					Open piezometer with selective hollow Interstitial pressure cell (IPC)	R R
Permeability of soils	Water drilling + Piezometers Rotary hollow drill + intact sample + Labo	R S	Permeability in laboratory	S	Pumping test Permeability test in situ	R S
Specific problems Shearing Shrinking, swelling Liquefaction	 Intact sample Intact sample Intact sample	 R R R	 Triaxial, rectilinear shearing Shrinking, swelling Triaxial cyclic Granulometry	 R R R R	 Scissometer Phicometer Piezocone Standard Penetration Test Static penetrometer	 R S R R S

R: Recommended boreholes/tests **S: Satisfying** boreholes/tests **Q: Qualitative** boreholes/tests

The state of art is based on a catastrophe scenario: the landfill is forgotten and it progressively fills of water that becomes contaminated by the waste. These leachates will try to migrate vertically toward the watertable and horizontally toward the outside of the landfill. This water will weaken the dykes constituting the rows that can then collapse. The layer of clay must support the geomembrane (which will be loaded by tens metres of waste) without deformation that could punch the geomembrane. During the operation of the landfill, the top of the dykes is used as operation lane for the trucks. So, unfortunately, all these parameters are pertinent for the design of a sanitary landfill.

Number	Org.	Year	Title	Topic	Pages
3.4. Geotechnique tries - Mechanical properties					
3.4.1. General tests					
3.4.1.1. On the field					
NF P 94-113	Afnor	1991	Soils: investigation and testing – Standard penetration test	The present document defines the terminology, specifies the characteristics of the apparatus, fixes the operating mode for practicing the static penetration test and specifies the results to be presented.	12
D3441-98	ASTM	1998	Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil	This test method covers the determination of end bearing and side friction, the components of penetration resistance which are developed during the steady slow penetration of a pointed rod into soil. This test method is sometimes referred to as the "Dutch Cone Test," or "Cone Penetration Test" and is often abbreviated as the "CPT."	5
NF P 94-119	Afnor	1995	Soil: investigation and testing – Piezocone test - CPTU	The present document is about the piezocone test that measures on place the interstitial pressure as the characteristics of the soil as in a test of classical static penetrometer. It defines the terminology, specifies the characteristics of the apparatus, fixes the operating mode and specifies the results to be presented.	24
D5778-95	ASTM	2000	Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils	This test method covers the procedure for determining the resistance to penetration of a conical pointed penetrometer as it is advanced into subsurface soils at a slow, steady rate.	19
EN ISO 22476-2	ISO	2003	Geotechnical investigation and testing - Field testing - Part 2: Dynamic probing	This European norm specifies the exigencies for the indirect investigations of the land by tests of dynamic penetration within the frame of the geotechnique reconnaissance according to EN 1997.	40
EN ISO 22476-3	ISO	2002	Geotechnical investigation and testing - Field testing - Part 3: Standard penetration test = ASTM D1586-99	This European norm specifies the exigencies for the indirect investigations of the land by tests of standard penetration within the frame of the geotechnique reconnaissance according to EN 1997.	18
D1586-99	ASTM	1999	Test Method for Penetration Test and Split-Barrel Sampling of Soils =EN ISO 22476-3	This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.	5

Number	Org.	Year	Title	Topic	Pages
D4633	ASTM	No R	Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems		
3.4.1.2. In laboratory					
NF P 94-093	Afnor	1999	Soils: Investigation and testing - Determination of the compaction characteristics of a soil - Standard Proctor test - Modified Proctor test	The present document concerns the characteristics of compaction of a material: rate of water and optimal Proctor normal and Proctor modified volumetric mass.	20
D2168-02	ASTM	2002	Standard Test Methods for Calibration of Laboratory Mechanical-Rammer Soil Compactors	These test methods for the calibration of mechanical soil compactors are for use in checking and adjusting mechanical devices used in laboratory compacting of soil and soil-aggregate in accordance with Test Methods D 698, D 1557 and other methods of a similar nature which might specify this method. Calibration for use with one method does not qualify the equipment for use with another method.	6
D6393-99	ASTM	1999	Standard Test Method for Bulk Solids Characterization by Carr Indices	This test method covers the apparatus and procedures for measuring properties of bulk solids, henceforth referred to as Carr Indices. Test A-Measurement of Carr Angle of Repose Test B-Measurement of Carr Angle of Fall Test C-Calculation of Carr Angle of Difference Test D-Measurement of Carr Loose Bulk Density Test E-Measurement of Carr Packed Bulk Density Test F-Calculation of Carr Compressibility Test G-Measurement of Carr Cohesion Test H-Measurement of Carr Uniformity Test I-Measurement of Carr Angle of Spatula Test J-Measurement of Carr Dispersibility	7
3.4.2. Bearing capacity					
3.4.2.1. On the field					
D1194-94	ASTM	1994	Standard Test Method for Bearing Capacity of Soil for Static Load and Spread Footings	This test method covers estimation of the bearing capacity of soil in place by means of field loading tests. This test method can be used as part of a procedure for soil investigation for foundation design. It gives information on the soil only to a depth equal to about two diameters of the bearing plate, and takes into account only part of the effect of time.	3
NF P 94-117-1	Afnor	2000	Soils : investigation and testing - Formation level bearing capacity - Part 1: Plate test static deformation modulus (EV2)	The present document defines a testing method allowing to estimate the bearing capacity of a plat-form submitted to a static load by the way of a rigid plate. The measured parameter is called "Modulus under static load with plate" of the platform.	8

Number	Org.	Year	Title	Topic	Pages
NF P 94-117-2	Afnor	2003	Soils : investigation and testing - Formation level bearing capacity - Part 2: Plate test dynamic deformation modulus	The present document is about the determination of the modulus said "Modulus under dynamic load with Dynaplaque" of a platform. It describes the principle, the apparatus, the operating mode and the presentation of the results of the test of dynamic solicitation of a soil under a rigid plate. The test applies to the infrastructures realized with the materials defined in the norm NF P 11-300, whose the D_{max} is <200 mm.	15
D4429	ASTM	No R	Test Method for CBR (California Bearing Ratio) of Soils in Place		
3.4.2.2. In laboratory					
D1883-99	ASTM	1999	Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils	This test method covers the determination of the CBR (California Bearing Ratio) of pavement subgrade, subbase, and base/course materials from laboratory compacted specimens. The test method is primarily intended for but not limited to, evaluating the strength of cohesive materials having maximum particle sizes less than 3/4 in. (19 mm).	8
NF P 94-078	Afnor	1997	Soils: investigation and tests – CBR after immersion – Immediate CBR – Immediate bearing ration – Measurement on sample compacted in CBR mould	The present document describes the methods of test for the measure of the following indices: - index CBR after immersion; - index CBR immediate; - Immediate Bearing Index (IBI)	12
D2166-00	ASTM	2000	Standard Test Method for Unconfined Compressive Strength of Cohesive Soil	This test method covers the determination of the unconfined compressive strength of cohesive soil in the undisturbed, remoulded, or compacted condition, using strain-controlled application of the axial load. This test method provides an approximate value of the strength of cohesive soils in terms of total stresses. This test method is applicable only to cohesive materials which will not expel or bleed water (water expelled from the soil due to deformation or compaction) during the loading portion of the test and which will retain intrinsic strength after removal of confining pressures, such as clays or cemented soils. Dry and crumbly soils, fissured or varved materials, silts, peats, and sands cannot be tested with this method to obtain valid unconfined compression strength values.	6
NF P 94-077	Afnor	1997	Soils: Investigation and testing – Uniaxial compressive test	The present document concerns the test of uniaxial compressive test, also called simple compressive test. It defines the used terms, specifies the characteristics of the apparatus, fixes the process of testing, provides the method of determination of the different parameters and specifies the results to be presented.	12

Number	Org.	Year	Title	Topic	Pages
3.4.3. Sinking					
3.4.3.1. On the field					
D4394-84	ASTM	1998	Test Method for Determining the In Situ Modulus of Deformation of Rock Mass Using the Rigid Plate Loading Method	This test method covers the preparation, equipment, test procedure, and data reduction for determining in situ modulus of deformation of a rock mass using the rigid plate loading method.	9
D4395-84	ASTM	1998	Test Method for Determining the In Situ Modulus of Deformation of Rock Mass Using the Flexible Plate of Deformation of Rock Mass Using the Flexible Plate	This test method covers the preparation, equipment, test procedure, and data reduction for determining in situ modulus of deformation of a rock mass using the flexible plate loading method.	9
D4506-02	ASTM	2002	Test Method for Determining the In Situ Modulus of Deformation of Rock Mass Using a Radial Jacking Test	This test method is used to determine the in situ modulus of deformation of rock mass by subjecting a test chamber of circular cross section to uniformly distributed radial loading; the consequent rock displacements are measured, from which elastic or deformation moduli may be calculated. The anisotropic deformability of the rock can also be measured and information on time-dependent deformation may be obtained.	7
D4553-02	ASTM	2002	Test Method for Determining the In Situ Creep Characteristics of Rock	This test method covers the preparation, equipment, test procedure, and data documentation for determining in situ creep characteristics of a rock mass using a rigid plate subjected to controlled loading.	6
D4555-01	ASTM	2001	Test Method for Determining Deformability and Strength of Weak Rock by an In Situ Uniaxial Compressive Test	This test method covers the measurement of the deformability and strength of large in situ specimens of weak rock by a uniaxial - compressive test. The test results take into account the effect of both intact material behaviour and the behaviour of discontinuities contained within the specimen block.	4
D4729-87	ASTM	1997	Test Method for In Situ Stress and Modulus of Deformation Using the Flatjack Method	The flatjack test measures stress at a rock surface. The modulus of deformation and the long-term deformational properties (creep) may also be evaluated.	6

Number	Org.	Year	Title	Topic	Pages
D6758-02	ASTM	2002	Standard Test Method for Measuring Stiffness and Apparent Modulus of Soil and Soil-Aggregate In-Place by an Electro-Mechanical Method	This method covers the measurement by electro-mechanical means of the in-place stiffness of soil or soil-aggregate mixtures so as to determine a Young's modulus based on certain assumptions. The apparatus and procedure provide a fairly rapid means of testing so as to minimize interference and delay of construction. The test procedure is intended for evaluating the stiffness or modulus of materials used in earthworks and roadworks. Rapid in-place stiffness testing supports U.S. federal and state efforts to specify the in-place performance of construction materials based on modulus. Results obtained from this method are applicable to the evaluation of granular cohesionless materials. They are also applicable to the evaluation of silty and clayey materials with more than 20 % fines that are not subject to a change in moisture content. If the silty and clayey material experiences a change in moisture content, then moisture content shall be taken into account if the results of this method are to be applicable. The stiffness measured with this method is influenced by boundary conditions, specifically the support offered by underlying layers as well as the thickness and modulus of the layer being tested. Since this method approximates the layer(s) being evaluated as a half-space, then the modulus measured is also approximate.	5
3.4.3.2. In laboratory					
NF P 94-090-1	Afnor	1997	Soil: investigation and testing –Œdometric test – Part 1: Compressibility test on quasi saturated fine grained soil with loading in increments	The present document concerns the determination in laboratory of the characteristics of compressibility of a sample of saturated fine grained soil in a closure forbidding any radial movement during a loading by increments. It describes the apparatus, fixes the operation mode of the test, provides the methods of calculation of the different parameters and specifies the results to be presented.	24
NF P 94-091	Afnor	1995	Soil: investigation and testing – Swelling test with œdometer – Determination of deformations by loading several test pieces	The present document defines the terminology, specifies the characteristics of the apparatus, fixes the operation mode to realize a swelling test with œdometer by loading of several test pieces and specifies the presentation of the results.	16
D3999-91	ASTM	1996	Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus	These test methods cover the determination of the modulus and damping properties of soils in either undisturbed or reconstituted states by either load or stroke controlled cyclic triaxial techniques.	14

Number	Org.	Year	Title	Topic	Pages
D4015-92	ASTM	2000	Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method	These test methods cover the determination of shear modulus, shear damping, rod modulus (commonly referred to as Young's modulus), and rod damping for solid cylindrical specimens of soil in the undisturbed and remoulded conditions by vibration using the resonant column. The vibration of the specimen may be superposed on a controlled ambient state of stress in the specimen. The vibration apparatus and specimen may be enclosed in a triaxial chamber and subjected to an all-around pressure and axial load. In addition, the specimen may be subjected to other controlled conditions (for example, pore-water pressure, degree of saturation, temperature). These test methods of modulus and damping determination are considered non-destructive when the strain amplitudes of vibration are less than 10^{-4} rad (10^{-4} in./in.), and many measurements may be made on the same specimen and with various states of ambient stress.	21
D4186-89	ASTM	1998	Standard Test Method for One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading	This test method covers the determination of the rate and magnitude of consolidation of soil when it is restrained laterally and drained axially and subjected to controlled-strain loading.	6
D4767-95	ASTM	1995	Standard Test Method for Consolidated Un-drained Triaxial Compression Test for Cohesive Soils	This test method covers the determination of strength and stress-strain relationships of a cylindrical specimen of either an undisturbed or remoulded saturated cohesive soil. Specimens are isotropically consolidated and sheared in compression without drainage at a constant rate of axial deformation (strain controlled).	11
D6276-99a	ASTM	1999	Standard Test Method for Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization	This test method covers a means for estimating the soil-lime proportion requirement for stabilization of a soil. The optimum soil-lime proportion for soil stabilization is determined by tests of specific characteristics of stabilized soil such as unconfined compressive strength or plasticity index.	4
3.4.4. Permeability measures					
3.4.4.1. On the field					
D2434-68	ASTM	2000	Standard Test Method for Permeability of Granular Soils (Constant Head)	This test method covers the determination of the coefficient of permeability by a constant-head method for the laminar flow of water through granular soils. The procedure is to establish representative values of the coefficient of permeability of granular soils that may occur in natural deposits as placed in embankments, or when used as base courses under pavements. In order to limit consolidation influences during testing, this procedure is limited to disturbed granular soils containing not more than 10% soil passing the 75-µm (No. 200) sieve.	5

Number	Org.	Year	Title	Topic	Pages
D3385	ASTM	No R	Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers		
D4630-96	ASTM	2002	Test Method for Determining Transmissivity and Storativity of Low Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test	This test method covers a field procedure for determining the transmissivity and storativity of geological formations having permeabilities lower than 10^3 µm^2 (1 millidarcy) using constant head injection.	6
D4631-95	ASTM	2000	Test Method for Determining Transmissivity and Storativity of Low Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test	This test method covers a field procedure for determining the transmissivity and storativity of geological formations having permeabilities lower than 10^{-3} µm^2 (1 millidarcy) using the pressure pulse technique.	7
NF X 30-424	Afnor	2002	Waste - Determination of the permeability coefficient of field by an infiltration test under constant load during a boring	The present document concerns the principle of the testing method, the description of the operating processes, and the conditions of examination of a test of variable charge of hydraulic shock type, realized in a closed cavity made by boring (pulse test).	38
NF P 94-131	Afnor	1994	Soil: investigation and testing – Lugeon water test	The present document concerns the Lugeon water test realised in boring on site. It aims to specify the conditions of preparation of the test and the characteristics of the used apparatus, to fix the operating mode and to specify the presentation of the results.	16
D4719-00	ASTM	2000	Test Method for Pressuremeter Testing in Soils	This test method covers pressuremeter testing of soils. A pressuremeter test is an in-situ stress-strain test performed on the wall of a borehole using a cylindrical probe that is expanded radially. To obtain viable test results, disturbance to the borehole wall must be minimized.	9
NF X 30-423	Afnor	2002	Waste - Determination of the permeability coefficient of piece of land by variable load test in an open cased well	The present document concerns the principle of the testing method, the description of the operating processes, and the conditions of examination of a test of variable charge of hydraulic shock type, realized in an open cased well.	33
NF X 30-425	Afnor	2002	Waste - Determination of the permeability coefficient of field by a varying load test in a covered boring	The present document concerns the principle of the testing method, the description of the operating processes, and the conditions of examination of a test of variable charge of hydraulic shock type, realized in a closed cavity made by boring (pulse test).	39
NF P 94-132	Afnor	2000	Soils: Investigation and testing - Lefranc test	The present document defines the terminology, specifies the conditions of preparation of the test and the characteristics of the apparatus. It fixes the operating mode to follow for realizing a Lefranc water testing and specifies the presentation of the results. This testing applicable to all fine and grainy soils under the watertable, is a mean of reconnaissance of the ground on place and allows to estimate an hydraulic characteristic of the soil by the determination of a local coefficient of permittivity, so called permittivity Lefranc.	20

Number	Org.	Year	Title	Topic	Pages
D5093-02	ASTM	2002	Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring	This test method describes a procedure for measuring the infiltration rate of water through in-place soils using a double-ring infiltrometer with a sealed inner ring.	7
NF X 30-420	Afnor	1999	Waste - Determination of the permeability of a permanent geological formation of added or artificially reconstituted materials - Closed-type, single- or double-ring infiltrometers	The present document allows the determination in situ of the permeability to water of a material, on place or brought, help to a closed-type double-ring infiltrometer. It defines the used terms, the measured parameters and the specifications of calculation.	36
NF X 30-418	Afnor	1998	Waste - Determination of the permeability of an existing geological formation of added or artificially reconstituted materials - Open-type, double-ring infiltrometers	The present document allows the determination in situ of the permeability to water of a material, on place or brought, help to a open-type double-ring infiltrometer. It defines the used terms, the measured parameters and the specifications of calculation.	44
D5126-90	ASTM	1998	Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone	This guide provides a review of the test methods for determining hydraulic conductivity in unsaturated soils and sediments. Test methods for determining both field-saturated and unsaturated hydraulic conductivity are described.	11
D6391-99	ASTM	1999	Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole	This test method covers field measurement of limiting values for vertical and horizontal hydraulic conductivities (also referred to as coefficients of permeability) of porous materials using the two-stage, cased borehole technique. These limiting hydraulic conductivity values are the maximum possible for the vertical direction and minimum possible for the horizontal direction. Determination of actual hydraulic conductivity values requires further analysis by qualified personnel.	12

Number	Org.	Year	Title	Topic	Pages
3.4.4.2. In laboratory					
D5084-00e1	ASTM	2000	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter	These test methods cover laboratory measurement of the hydraulic conductivity (also referred to as *coefficient of permeability*) of water-saturated porous materials with a flexible wall permeameter at temperatures between about 15 and 30°C (59 and 86°F). Temperatures outside this range may be used, however, the user would have to determine the specific gravity of mercury and R_T (see 10.3) at those temperatures using data from *Handbook of Chemistry and Physics*. There are six alternate methods or hydraulic systems, that may be used to measure the hydraulic conductivity. These hydraulic systems are as follows: *Method A*-Constant Head *Method B*-Falling Head, constant tailwater elevation *Method C*-Falling Head, rising tailwater elevation *Method D*-Constant Rate of Flow *Method E*-Constant Volume-Constant Head (by mercury) *Method F*-Constant Volume-Falling Head (by mercury), rising tailwater elevation	23
D5856-95	ASTM	2002	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mould Permeameter	This test method covers laboratory measurement of the hydraulic conductivity (also referred to as < of>) of laboratory-compacted materials with a rigid-wall, compaction-mould permeameter.	8
D6527-00	ASTM	2000	Standard Test Method for Determining Unsaturated and Saturated Hydraulic Conductivity in Porous Media by Steady-State Centrifugation	This test method covers the determination of the hydraulic conductivity, or the permeability relative to water, of any porous medium in the laboratory, in particular, the hydraulic conductivity for water in subsurface materials, for example, soil, sediment, rock, concrete, and ceramic, either natural or artificial, especially in relatively impermeable materials or materials under highly unsaturated conditions. This test method covers determination of these properties using any form of steady-state centrifugation (SSC) in which fluid can be applied to a specimen with a constant flux or steady flow during centrifugation of the specimen. This test method only measures advective flow on core specimens in the laboratory.	10

Number	Org.	Year	Title	Topic	Pages
3.4.5. Shearing					
3.4.5.1. On the field					
D2573-01	ASTM	2001	Standard Test Method for Field Vane Shear Test in Cohesive Soil	This test method covers the field vane test in saturated clay and silt soils for determination of un-drained shear strength. Knowledge of the nature of the soil in which each vane test is to be made is necessary for assessment of the applicability and interpretation of the test. The test is not applicable for sandy soils which may allow drainage during the test.	8
NF P 94-112	Afnor	1991	Soils: investigation and testing – Vane test	The present norm concerns the shearing test done in the soil in place. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operating mode of the test and specifies the results to be presented.	20
D4554-02	ASTM	2002	Test Method for In Situ Determination of Direct Shear Strength of Rock Discontinuities	This test method covers the measurement of peak and residual direct shear strength of in situ rock discontinuities as a function of stress normal to the sheared plane. This sheared plane is usually a significant discontinuity which may or may not be filled with gouge or soil-like material.	7
NF P 94-120	Afnor	1997	Soil: investigation and testing – Phicometer shearing test	The present norm concerns a test of shearing of soil on place realised by the mean of a cylindrical probe, radially dilated under a controlled pressure. The shearing of the soil at the periphery of the probe is obtained by toothing of the probe along its axial direction. This document defines the used terms as the measured parameters while specifying the characteristics of the apparatus. It fixes the operating mode of the test, provides the method of calculation of the different parameters and specifies the results to be presented.	36
3.4.5.2. In laboratory					
D3080-98	ASTM	1998	Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions	This test method covers the determination of the consolidated drained shear strength of a soil material in direct shear. The test is performed by deforming a specimen at a controlled strain rate on or near a single shear plane determined by the configuration of the apparatus. Generally, three or more specimens are tested, each under a different normal load, to determine the effects upon shear resistance and displacement, and strength properties such as Mohr strength envelopes.	6
D4648-00	ASTM	2000	Standard Test Method for Laboratory Miniature Vane Shear Test for Saturated Fine-Grained Clayey Soil	This test method covers the miniature vane test in very soft to stiff saturated fine-grained clayey soils ($\varphi = 0$). Knowledge of the nature of the soil in which each vane test is to be made is necessary for assessment of the applicability and interpretation of the test results.	7

Number	Org.	Year	Title	Topic	Pages
D6128-00	ASTM	2000	Standard Test Method for Shear Testing of Bulk Solids Using the Jenike Shear Cell	This method covers the apparatus and procedures for measuring the cohesive strength of bulk solids during both continuous flow and after storage at rest. In addition, measurements of internal friction, bulk density, and wall friction on various wall surfaces are included.	19
NF P 97-070	Afnor	1994	Soils: investigation and testing – Shear strength tests with triaxial test apparatus – Generalities - Definitions	The present document concerns the shearing tests done with a deformation speed imposed to the revolving triaxial apparatus. It defines the used terms according to the nature of the soils, the different states of the constraints according to the deformation of the test pieces. This document gives the general principles of realisation and of the examination of the current tests.	24
NF P 94-074	Afnor	1994	Soils: investigation and testing – Shear strength tests with revolving triaxial test apparatus – Apparatus – Preparation of test specimens – Unconsolidated and undrained (UU) test – Consolidated and undrained (CU + u) test with measurement of the interstitial pressure – Consolidated, drained (CD) test	This document defines the required characteristics of the apparatus for the realisation of tests of shearing with compression revolving triaxial apparatus, specifies the conditions of preparation and mounting of the test pieces and provides the modes of realisation of the test (UU) unconsolidated undrained, of the test (CU + u) consolidated undrained with measurement of the interstitial pressure and the test (CD) consolidated drained.	36
D6467-99	ASTM	1999	Standard Test Method for Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils	This test method provides a procedure for performing a torsional ring shear test under a drained condition to determine the residual shear strength of cohesive soils. An undisturbed specimen can be used for testing. However, obtaining a natural slip surface specimen, determining the direction of field shearing, and trimming and properly aligning the usually non-horizontal shear surface in the ring shear apparatus is difficult. As a result, this test method focuses on the use of a remoulded specimen. This test method is performed by deforming a pre-sheared, remoulded specimen at a controlled displacement rate until the constant minimum drained shear resistance is offered on a single shear plane determined by the configuration of the apparatus. An unlimited amount of continuous shear displacement can be achieved to obtain a residual strength condition. Generally, three or more normal stresses are applied to a test specimen to determine the drained residual failure envelope. A separate test specimen may be used for each normal stress.	5
NF P 94-071-1	Afnor	1994	Soils: investigation and testing – Direct shear test with shearbox apparatus – Part 1: Direct shear	The present document concerns the direct rectilinear shearing test, with shearbox, of consolidated test pieces and sheared in drained conditions. It defines the measured parameters and specifies the characteristics of the apparatus. It fixes the operating mode, provides the method f determination of the different parameters and specifies the results to be presented.	16

Number	Org.	Year	Title	Topic	Pages
NF P 94-071-2	Afnor	1994	Soils: investigation and testing – Direct shear test with shearbox apparatus – Part 2: Cyclic test	The present document concerns the alternated rectilinear shearing test, with shearbox. It defines the measured parameters and specifies the characteristics of the apparatus. It fixes the operating mode, provides the method f determination of the different parameters and specifies the results to be presented.	16
NF P 94-072	Afnor	1995	Soils: investigation and testing – Laboratory vane test	The present document concerns the Vane test done on sample in laboratory. It provides the method of determination of the maximal resistance to shearing and the resistance to shearing after a big deformation. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operating mode and specifies the results to be presented.	16
D6528-00	ASTM	2000	Standard Test Method for Consolidated Un-drained Direct Simple Shear Testing of Cohesive Soils	This test method defines equipment specifications and testing procedures for the measurement of constant volume strength and stress-strain characteristics of cohesive soils after one-dimensional consolidation using a constant rate of simple shear deformation mode of loading. The constant volume condition is equivalent to the un-drained condition for saturated specimens.	9
3.4.6. Shrinking, swelling					
3.4.6.1. On the field					
3.4.6.2. In laboratory					
D427-98	ASTM	1998	Test Method for Shrinkage Factors of Soils by the Mercury Method (Atterberg's limit)	This test method provides a procedure for obtaining the data which are used to calculate the shrinkage limit and the shrinkage ratio. The liquid limit, plastic limit, and shrinkage limit are often collectively referred to as the Atterberg Limits in recognition of their formation by Swedish soil scientist, A. Atterberg. These water contents distinguish the boundaries of the several consistency states of cohesive soils.	4
NF P 94-060-1	Afnor	1997	Soil: investigation and testing – Shrinkage test – Part 1: Determination of shrinkage characteristic on remoulded soil passing a 400 µm test sieve	The present document concerns the determination by heating of the moisture at limit state of shrinkage of the <400µm part of a sample of material. It defines the used terms and the measured parameters, specifies the characteristics of the apparatus, fixes the operation mode and specifies the results to be presented.	8
NF P 94-060-2	Afnor	1997	Soil: investigation and testing – Shrinkage test – Part 2: Determination of effective shrinkage characteristic on undisturbed soil sample	The present document concerns the drying and the characteristics of shrinkage of undisturbed sample. It fixes the terminology, describes the apparatus and the operation mode relative to realize the test on a representative sample and states the results to be presented.	12

Number	Org.	Year	Title	Topic	Pages
D4943-02	ASTM	2002	Standard Test Method for Shrinkage Factors of Soils by the Wax Method	Given the concern that mercury is a hazardous substance, this test method is offered as an alternative to Test Method D 427, which is used to determine the shrinkage limit and other shrinkage factors of soils using mercury (see Caution statement in Test Method D 427). The shrinkage limit along with the liquid limit and plastic limit of soils are often collectively referred to as the Atterberg limits	5
3.4.7. Liquefaction					
3.4.7.1. On the field					
D6066-96e1	ASTM	1998	Standard Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential	This practice outlines a procedure to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy for estimating soil liquefaction potential during earthquakes. The normalized penetration resistance determined in this practice may be useful for determination of other engineering properties of sands.	16
3.4.7.2. In laboratory					
D4318-00	ASTM	2000	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg's limits)	These test methods cover the determination of the liquid limit, plastic limit, and the plasticity index of soils	14
NF P 94-051	Afnor	1993	Soil: investigation and testing – Determination of Atterberg's limits – Liquid test using Casagrande apparatus – Plastic limit test on rolled thread	The document fixes the terminology, describes the apparatus and the operation mode relative to the determination of two Atterberg's limits: limit of liquidity with cup and limit of plasticity with roll.	16
NF P 94-052-1	Afnor	1995	Soil: investigation and testing – Atterberg's limits Determination – Part 1: Liquid limit – Cone penetrometer method	The present document fixes the terminology, describes the apparatus and the operation mode relative to the determination of the limit of liquidity with cone penetrometer and states the results to be presented.	12
D1698-00a	ASTM	2000	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (600 kN-m/m^3)	These test methods covers laboratory compaction methods used to determine the relationship between water content and dry unit weight of soils (compaction curve) compacted. (Test Proctor)	11
D1557-00	ASTM	2000	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m^3))	These test methods cover laboratory compaction methods used to determine the relationship between water content and dry unit weight of soils (compaction curve) compacted in a 4- or 6-in. (101.6 or 152.4 mm) diameter mould with a 10-lbf. (44.5-N) rammer dropped from a height of 18 in. (457 mm) producing a compactive effort of 56,000 ft-lbf/ft^3 (2,700 kN-m/m^3).	10

Number	Org.	Year	Title	Topic	Pages
D2435-96	ASTM	1996	Standard Test Method for One-Dimensional Consolidation Properties of Soils	This test method covers procedures for determining the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. Two alternative procedures are provided as follows: ▪ Test Method A -This test method is performed with constant load increment duration of 24 h, or multiples thereof. Time-deformation readings are required on a minimum of two load increments. ▪ Test Method B-Time-deformation readings are required on all load increments. Successive load increments are applied after 100% primary consolidation is reached, or at constant time increments as described in Test Method A.	10
D2664-95a	ASTM	1995	Standard Test Method for Triaxial Compressive Strength of Un-drained Rock Core Specimens Without Pore Pressure Measurements	This test method covers the determination of the strength of cylindrical rock core specimens in an un-drained state under triaxial compression loading. The test provides data useful in determining the strength and elastic properties of rock, namely: shear strengths at various lateral pressures, angle of internal friction, (angle of shearing resistance), cohesion intercept, and Young's modulus. It should be observed that this method makes no provision for pore pressure measurements. Thus the strength values determined are in terms of total stress, that is, not corrected for pore pressures.	4
D2850-95	ASTM	1999	Standard Test Method for Unconsolidated-Un-drained Triaxial Compression Test on Cohesive Soils	This test method covers determination of the strength and stress-strain relationships of a cylindrical specimen of either undisturbed or remoulded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. No drainage of the specimen is permitted during the test. The specimen is sheared in compression without drainage at a constant rate of axial deformation (strain controlled).	6
D5311-92	ASTM	1996	Standard Test Method for Load Controlled Cyclic Triaxial Strength of Soil	This test method covers the determination of the cyclic strength (sometimes called the liquefaction potential) of saturated soils in either undisturbed or reconstituted states by the load-controlled cyclic triaxial technique.	10
D5333-92	ASTM	1996	Standard Test Method for Measurement of Collapse Potential of Soils	This test method covers the determination of the magnitude of one-dimensional collapse that occurs when unsaturated soils are inundated with fluid.	3

Number	Org.	Year	Title	Topic	Pages
4. Control of civil works					
4.1. Materials					
D1241-00	ASTM	2000	Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses	This specification covers the quality and grading of the following materials for use in the construction of sub-base, base, and surface courses: sand-clay mixtures; gravel; stone or slag screenings; sand; crusher-run coarse aggregate consisting of gravel, crushed stone, or slag combined with soil mortar; or any combination of these materials. The requirements are intended to cover only materials having normal or average specific gravity, absorption, and gradation characteristics. Where other materials are to be used, appropriate limits suitable to their use must be specified.	3
NF P 11-301	Afnor	1994	Earthworks: Terminology	The present norm defines the main terms relative to the execution of earthworks: geotechnique, nature and geometry, earthworks equipments, hydrology, drainage.	20
NF P 11-300	Afnor	1992	Earthworks: Classification of materials for use in the construction of embankments and capping layers of road infrastructures	The present norm aims to define a classification of the materials used for construction of embankments and capping layers of road infrastructures according to the problems issuing from their use.	21
D4380-84	ASTM	2001	Standard Test Method for Density of Bentonitic Slurries	This test method covers the determination of the density of slurries used in slurry construction techniques, such as are used for barriers to control the horizontal movement of liquids. This test method is modified from API Recommended Practice 13B.	2
D4381-84	ASTM	2001	Standard Test Method for Sand Content by Volume of Bentonitic Slurries	This test method covers the determination of the sand content of bentonitic slurries used in slurry construction techniques. This test method has been modified from API Recommended Practice 13B.	2
D5268-92	ASTM	1997	Standard Specification for Topsoil Used for Landscaping Purposes	This specification covers a physical evaluation of an inorganic soil containing a limited amount of organic material, relative to its use as a topsoil for horticultural purposes in construction. For classification, a full agricultural textural classification may be used.	2
D5971-01	ASTM	2001	Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material	This practice explains the procedure for obtaining a representative sample to test of freshly mixed controlled low-strength material (CLSM) as delivered to the project site (Note 1). This practice includes sampling from revolving-drum truck mixers and from agitating equipment used to transport central-mixed CLSM.	2

Number	Org.	Year	Title	Topic	Pages
4.2. Compaction					
D2844-01	ASTM	2001	Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils	This test method covers the procedure for testing both treated and untreated laboratory compacted soils or aggregates with the stabilometer and expansion pressure devices to obtain results indicative of performance when placed in the base, subbase, or subgrade of a road subjected to traffic.	8
D5080-00	ASTM	2000	Standard Test Method for Rapid Determination of Percent Compaction	This test method describes the procedure for rapidly determining the percent compaction and the variation from optimum moisture content of an in-place soil for use in controlling construction of compacted earth. These values are obtained by developing a three-point compaction curve at the same moisture content as the in-place soil without knowing the value of the moisture content. The soil used for the compaction curve is normally the same soil removed from the in-place density test. For the remainder of this designation, this test method will be referred to as the rapid method.	8
NF P 94-063	Afnor	1997	Soils: Investigation and testing – Compaction quality control – Constant energy dynamic penetration test method – Principles and method for calibrating penetrodensitographs – Exploitation of results - Interpretation	The present document defines a test method with dynamic penetrometer with constant energy for the control of the quality of the compacting of soils.	28
NF P 94-105	Afnor	2000	Soils : investigation and testing - Inspection of compaction quality - Method using a variable energy dynamic penetrometrer - Principle and method for calibrating the penetrometer - Exploitation of results - Interpretation	The present document defines for the control of the quality of the compacting of soils a test method with dynamic penetrometer with variable energy.	36
D5874-02	ASTM	2002	Standard Test Method for Determination of the Impact Value (IV) of a Soil	This test method covers the determination of the Impact Value (IV) of a soil either in the field or a test mould. By performing laboratory test correlations for a particular soil using the 4.5 kg (10 lbm) hammer, IV may be correlated with an unsoaked California Bearing Ratio (CBR) or may be used to infer percentage compaction.	9

5. Geosynthetics

The first step is usually to choose which geomembrane will be used and to order it. So a first norm[2] summarizes the criteria of specification of a geomembrane.

EUROPEAN STANDARD EN 13968 Geomembranes - Product Specification

This norm summarizes the norms applicable to the use of geomembranes for the pertinent characteristics and the methods of test.

The geomembranes must be submitted to test accordingly the method of test specified in the present section according to the pertinent characteristics for the planned use. These characteristics are specified in the norms relevant to the different applications (prEN 13361, prEN 13362, prEN 13491, prEN 13492 et prEN 13393). A general summary of the characteristics of the geomembranes is given Table 2.

NOTE: the Table 1 gives a summary of the pertinent methods of test by number of reference. The details or the modifications of these methods of test are specified in the paragraphs 4.1 to 4.3.

As they are used for the construction of landfill, we have reproduced the paragraphs concerning the thermoplastic or elastomer based geomembranes. The clay geosynthetic based felts (as commercial brand BENTOMAT) may be used for the enhancement of the watertightness or in for the construction of leachates treatment ponds. In such a case, the corresponding norms exist.

4.1 Pertinent characteristics of the product and methods of test for the thermoplastic or elastomer based geomembranes

4.1.1 Dimensional characteristics of the rolls

The length and the width of the rolls, indicated by the manufacturer, must be determined according to prEN 1848-2.

4.1.2 Thickness

The thickness must be determined according to the prEN 1849-2. If an external layer is present and made of the same polymer than the internal layer of the geomembrane, the thickness of this external layer must be included in the effective thickness.

4.1.3 Mass by surface unit

The mass by surface unit must be determined according to the prEN 1849-2.

4.1.4 Index of inflating

This characteristic is not pertinent for the thermoplastic or elastomer based geomembranes.

4.1.7 Permeability to liquids

The permeability to liquids must be determined according to the WI 00189067.

4.1.8 Permeability to gases

The permeability to gases must be determined according to the ASTM D 1434.

4.1.9 Resistance to the traction

The resistance to the traction must be determined in the lengthwise and the widthwise of the geomembrane according to the prEN 12113-2. The method A must be used for the reinforced membranes. The method B, with a test speed of 100 mm/mn or 500 mm/mn, must be used for the homogenous geomembranes.

4.1.10 Elongation at the maximal load

The elongation at the maximal load must be determined in the lengthwise and the widthwise of the geomembrane according to the prEN 12113-2. The method A must be used for the reinforced membranes. The method B, with a test speed of 100 mm/mn or 500 mm/mn, must be used for the homogenous geomembranes.

4.1.11 Resistance to the static puncture

The resistance to the static puncture must be determined according to the EN ISO 12236.

4.1.12 Resistance to the bursting

The resistance to the bursting must be determined according to the WI 00189064.

4.1.13 Resistance to the tearing

The resistance to the tearing must be determined according to the ISO 34, Method B, procedure (a), with a test speed of 500 mm/mn.

4.1.14 Friction (direct shearing)

The characteristics of friction (method of direct shearing) must be determined according to the prEN ISO 12957-1.

4.1.15 Friction (inclined plane)

The characteristics of friction (method of inclined plane) must be determined according to the prEN ISO 12957-2.

4.1.16 Damages during the construction

The resistance to the damages during the construction must be determined according to the NF P 84-510.

4.1.17 Resistance to shocks

The resistance to shocks must be determined according to the WI 00189014.

4.1.18 Properties of tensile creep and creep rupture behaviour

The properties of tensile creep must be determined according to the EN ISO 13431.

4.1.19 Properties of relaxation

The properties of relaxation must be determined according to the DIN 53441.

4.1.20 Permeability to water of the joints

This characteristic is not pertinent for the thermoplastic or elastomer based geomembranes. Pertinent data are provided by the test of resistance to shearing of the joints (4.1.21).

4.1.21 Resistance to shearing of the joints

The resistance to shearing of the joints must be determined according to the prEN 12317-2. The quality of the joint must be determined by the results constraint – deformation of the tests, by the mode and the places of rupture.

4.1.22 Behaviour at low temperature

The behaviour at low temperature (folding at low temperature) must be determined according to the prEN 495-5.

4.1.23 Thermal dilatation

The thermal dilatation must be determined according to the ASTM D 696.

4.1.24 Resistance to ageing

The resistance to UV ageing must be determined according to the ENV 12224. For the applications provoking short time exposures, a test of ageing of 500 hours is recommended. For the applications provoking long time or permanent exposures, a test of ageing of 7000 hours is recommended.

4.1.25 Chemical resistance

The chemical resistance of a thermoplastic or elastomer based geomembrane must be determined according to the EN 14030. When a geomembrane is used as a part of a watertight layer or a watertight cover of a landfill, specific tests must be done with a saturated calcium hydroxide solution, 5 % sulphurous acid and 10% sodium chloride.

4.1.26 Resistance to microorganisms

The resistance to microorganisms must be determined according to the ENV 12225.

4.1.27 Resistance to oxidation

The resistance to oxidation must be determined according to the ENV ISO 13438 at 100 °C during 16 weeks.

4.1.28 Fissuring of constraint

The resistance to the fissuring due to environing constraints must be determined according to the ASTM D 5397.

4.1.29 Leaching of soluble elements in water

If the geomembrane contains elements soluble in water, for instance plasticizers, the quantity of soluble in water elements must be determined according to the SIA 280, part 13.

4.1.30 Resistance to the cycles of moisturizing - drying

This characteristic is not pertinent for the thermoplastic or elastomer based geomembranes.

4.1.31 Resistance to the cycles of frosting - defrosting

This characteristic is not pertinent for the thermoplastic or elastomer based geomembranes.

4.1.32 Resistance to the penetration of the root

The resistance to the penetration of the root must be determined according to the SIA 280, part 11.

		Method of test		
N°	Characteristic	Thermoplastic or elastomer based geomembranes	Bituminous Geomembranes	Clay geosynthetic based felts
1	Dimensional characteristics	prEN 1848-2	prEN 1848-1	EN ISO 10320 (length, width) of the rolls
2	Thickness	prEN 1849-2	prEN 1849-1	EN 964-1
3	Mass per unit of surface	prEN 1849-2	prEN 1849-1	WI 00189066
4	Index of inflating	NP	NP	ASTM D 5890
5	Content of montmorillonite	NP	NP	Annex A of the present norm
6	Absorption of water by the clay	NP	NP	DIN 18132
Hydraulic properties				
7	Permeability to liquids	WI 00189067	WI 00189067	ASTM D 5887
8	Permeability to gases	ASTM D 1434	ASTM D 1434	ASTM D 5887
Mechanical properties				
9	Resistance to the traction	prEN 12113-2	prEN 12331-1	EN ISO 10319
10	Elongation at the maximal load	prEN 12113-2	prEN 12331-1	EN ISO 10319
11	Resistance to the static puncture	EN ISO 12236	EN ISO 12236	EN ISO 12236
12	Resistance to the bursting	WI 189064	WI 189064	WI 189064
13	Resistance to tearing	ISO 34-2	prEN 12310-1	NP
14	Friction (direct shearing)	prEN ISO 12957-1	prEN ISO 12957-1	prEN ISO 12957-1
15	Friction (inclined plane)	prEN ISO 12957-2	prEN ISO 12957-2	prEN ISO 12957-2
16	Damages during the construction	NF P 84-510	NF P 84-510	NF P 84-510
17	Resistance to shocks	WI 00189014	WI 00189014	WI 00189014
18	Tensile creep	EN ISO 13431	EN ISO 13431	EN ISO 13431
19	Relaxation	DIN 53441	DIN 53441	DIN 53441
Performances of the joints				
20	Permeability to water of the joints	NP	NP	ASTM D 5887
21	Resistance to shearing of the joints	prEN 12317-2	prEN 12317-1	NP
Thermal properties				
22	Behaviour at low temperature	prEN 495-5	prEN 1109	NP
23	Thermal dilatation	ASTM D 696	ASTM D 696	ASTM D 696
Durability and chemical resistance				
24	Resistance to ageing	ENV 12224	ENV 12224	ENV 12224
25	Chemical resistance	EN 14030	EN 14030	ISO 12960
26	Resistance to micro-organisms	ENV 12225	ENV 12225	ENV 12225
27	Resistance to oxidation	ENV ISO 13438	ENV ISO 13438	ENV ISO 13438
28	Fissuring of constraint	ASTM D 5397	NP	NP
29	Leaching of soluble elements in water	SIA 280-13	SIA 280-13	SIA 280-13
30	Resistance to the cycles of moisturizing - drying	NP	NP	Annex B of the present norm

				(under preparation)
31	Resistance to the cycles of frosting - defrosting	NP	NP	Annex C of the present norm
32	Resistance to the penetration of the root	SIA 280-11	SIA 280-11	SIA 280-11
	NP = Non Pertinent			

Table 1: Pertinent characteristics and methods of test of the geomembranes

Pertinent characteristics of the geomembranes according to the planned use

The data relative to the specified characteristics in Table 2 must be obtained according to the pertinent methods of test of the section 4. If data relative to complementary characteristics are necessary, only the methods of test specified in section 4 must be used.

Characteristic	Dams & dykes	Canals	Tunnels & underground works	Liquid Waste	Solid Waste
Designation of the product					
Dimensional characteristics (length, width) of the rolls			x		
Thickness	x	x	x		
Mass per unit of surface					
Index of inflating					
Content of montmorillonite					
Absorption of water by the clay					
Hydraulic properties					
Permeability to liquids	x	x	x	x	x
Permeability to gases				x	x
Mechanical properties					
Resistance to the traction	x	x	x	x	x
Elongation at the maximal load					
Resistance to the static puncture	x	x			
Resistance to the bursting				x	x
Resistance to tearing					
Friction (direct shearing)	x	x		x	x
Friction (inclined plane)	x	x		x	x
Damages during the construction	x	x		x	x
Resistance to shocks			x		
Tensile creep				x	x
Relaxation				x	x
Performances of the joints					
Permeability to water of the joints	x	x		x	x
Resistance to shearing of the joints	x	x	x	x	x
Thermal properties					
Behaviour at low temperature			x		
Thermal dilatation	x	x			
Durability and chemical resistance					
Resistance to ageing	x	x			
Chemical resistance			x	x	x
Resistance to micro-organisms	x	x			
Resistance to oxidation				x	x
Fissuring of constraint					
Leaching of soluble elements in water	x	x	x		
Resistance to the cycles of moisturizing - drying	x	x			
Resistance to the cycles of frosting - defrosting	x	x			
Resistance to the penetration of the root					x

Table 2: Pertinent characteristics of the geomembranes according to the planned use

Number	Org.	Year	Title	Topic	Pages
5.1. Geomembranes					
5.1.1. Specifications of the geomembranes					
NF P 84-500	Afnor	1998	Geomembranes - Terminology	The present method applies to establish the terminology about the whole geomembranes. It gathers the terms by theme: generalities, structure, manufacturing, assembling, raw materials and physico-chemical behaviour, chemical designation.	20
NF P 84-504	Afnor	1993	Geomembranes - Sampling	The present norm applies to all geomembranes conditioned in rolls or panels or operated in a work.	12
EN 13416	CEN	2001	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Rules for sampling		
NF P 84-520	Afnor	1994	Geomembranes - On-site identification	The present norm defines the data necessary to identification of a geomembrane.	4
5.1.1.1. Dimensional characteristics					
EN 13968	CEN	2000	Geomembranes - Product Specification	The present European norm specifies the pertinent characteristics and the relevant methods of test for the manufactured geomembranes and used a waterproofing barriers to steam and liquids in the domain of civil survey or environment as for instance: dams, dykes, channels, tunnels, landfills and storage of liquid or solid waste. The present norm covers all types of geomembranes: thermoplastic or elastomer based sheets, bituminous sheets, or clay geosynthetics.	37
NF P 84-514	Afnor	1994	Geomembranes - Determination of mass per unit area	The present document defines the test method allowing to measure the mass per unit area of the geomembranes for the identification and the test sheets.	4
EN 14196	CEN	2001	Geosynthetics - Methods of test for the determination of the mass per unit area of the bentonitic geosynthetic barriers	The present method applies to the determination of the mass per unit of surface of a sample of bentonitic geosynthetic barrier as received. The mass of the clay can be obtained by deducting of the total mass of the bentonitic geosynthetic barrier the mass of the geosynthetic component as indicated by the manufacturer.	10
EN 13956	CEN	2005	Flexible sheet for waterproofing - Plastic and rubber sheets for roof waterproofing - Definitions and characteristics		

Number	Org.	Year	Title	Topic	Pages
EN 13967	CEN	2004	Flexible sheets for waterproofing - Plastic and rubber damp proof sheets including plastic and rubber basement tanking sheet - Definitions and characteristics		
EN 13493	CEN	2005	Geosynthetic barriers - Characteristics required for use in the construction of solid waste storage and disposal sites		
EN ISO 9862		2005	Geosynthetics - Sampling and preparation of test specimens (ISO 9862:2005)		
EN 1848-2	CEN	2001	Flexible sheets for waterproofing - Determination of length, width, straightness and flatness - Part 2: Plastic and rubber sheets for roof waterproofing		8
EN 1849-2	CEN	2001	Flexible sheets for waterproofing - Determination of thickness and mass per unit area - Part 2: Plastic and rubber sheets for roof waterproofing		10
EN 1850-2	CEN	2001	Flexible sheets for waterproofing - Determination of visible defects - Part 2: Plastic and rubber sheets for roof waterproofing		
5.1.1.2. Hydraulic properties					
EN 13111	CEN	2001	Flexible sheets for waterproofing - Underlays for discontinuous roofing and walls - Determination of resistance to water penetration		
00189122 prEN 14150	CEN		Geosynthetic barriers - Determination of permeability to liquids (2006-07)		
NF P 84-515	Afnor	1998	Geomembranes - Measurement of the conventional tightness level of geomembranes	The present norm specifies a method allowing to characterize the tightness level of a geomembrane of 1 to 10 mm thickness. The method indicates if the flow across the geomembrane is minor or not to a conventional threshold (fixed to 10^{-4} .m^3 .m^{-2} .j^{-1}) for a difference de pressure of 100 kPa.	12
EN 1928	CEN	2000	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of watertightness		
WI 00189067					
ASTM D1434	ASTM				
EN 12113-2	CEN				

Number	Org.	Year	Title	Topic	Pages
D6766-02	ASTM	2002	Standard Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids	This test method covers laboratory measurement of both flux and hydraulic conductivity (also referred to as *coefficient of permeability*) of geosynthetic clay liner (GCL) specimens permeated with chemical solutions and leachates utilizing a flexible wall permeameter.	9
NF P 84-703	Afnor	2002	Bentonitic geosynthetics - Determination of the swelling capacity of clay in bentonitic geosynthetics	The present document describes a test in laboratory allowing to determine the index of swelling to de-mineralized water or any other liquid of the clay present in bentonitic geosynthetics, hereinafter so called "bentonite".	6
NF P 84-704	Afnor	2002	Bentonitic geosynthetics - Determination of the water absorption capacity of a clay	The test method consists to measure under negative hydraulic load the volume of water absorbed by suction by a determined quantity of clay.	8
NF P 84-705	Afnor	2002	Bentonitic geosynthetics - Determination of the swelling characteristics using an œdopermeameter - Absorption - Water permeability under stress	The present document describes the apparatus and the procedures of test allowing to determine the kinetics of swelling and absorption of water, as the permeability to water, of bentonitic geosynthetics under normal stress and imposed hydraulic load. It defines the used terms, the measured parameters and specifies the result to present.	16
5.1.1.3. Mechanical properties					
NF P 84-501	Afnor	1992	Geomembranes - Geomembranes lining system - Determination of tensile properties	The present norm describes a method of determination of the characteristics of the geomembranes solicited in traction. This method is applicable to all geomembranes, reinforced or not, composed or not, what ever is the thickness; but remind that a geomembrane has a functional thickness ≥1 mm.	16
EN ISO 9863-1	ISO	2005	Geosynthetics - Determination of thickness at specified pressures - Part 1: Single layers (ISO 9863-1:2005)		
NF P 84-512-1	Afnor	1996	Geomembranes - Geomembranes lining system (GLS) - Part 1: Determination of thickness – Case of smooth geomembranes	The present document defines the test method allowing to measure the thickness of a sample of smooth geomembrane. The character smooth or no-smooth is defined in the norm NF P 84-512-2.	8
NF P 84-512-2	Afnor	1998	Geomembranes - Geomembranes lining system (GLS) - Part 2: Determination of thickness -Case of no-smooth geomembranes	The present document defines the test method allowing to measure the thickness of a sample of no-smooth geomembrane. This method is particularly applicable to the geomembranes with surface profile and surface motif, as to composed geomembranes. It can also be applied to the multi-layer geomembranes in aim to measure the thickness of different aspects layers.	8
EN 1107-2	CEN	2001	Flexible sheets for waterproofing - Determination of dimensional stability - Part 2: Plastic and rubber sheets for roof waterproofing		

Number	Org.	Year	Title	Topic	Pages
NF P 84-511-2	Afnor	1995	Geomembranes – Determination of the characteristics of flexibility – Part 2: tri-dimensional approach	The present document specifies a method of determination of the characteristics of flexibility of the geomembranes and geomembrane lining systems by the way of a test of tri-dimensional deformation under standardised conditions of conditioning and test.	8
EN 12310-2	CEN	2000	Flexible sheets for waterproofing - Determination of resistance to tearing - Part 2: Plastic and rubber sheets for roof waterproofing		
EN 12311-2	CEN		Flexible sheets for waterproofing - Determination of tensile properties - Part 2: Plastic and rubber sheets for roof waterproofing		
00189123 prEN 1897-1 rev	CEN		Geosynthetics - Determination of compression behaviour - Part 1: Compressive creep properties (2007-05)		
00189124 prEN 1897-2	CEN		Geosynthetics - Determination of compression behaviour - Part 2: Determination of short term compression behaviour (2008-05)		
EN 12730	CEN	2001	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of resistance to static loading		
EN ISO 12236	ISO	1996	Geosynthetics - Static puncture test (CBR test) (ISO/DIS 12236:2004) (2005-08)		13
NF P 84-507	Afnor	1996	Testing of geomembranes – Determination of the static puncture resistance of geomembranes and geomembrane lining systems – Case of cylindrical punch without support	This norm defines an operating mode of test aiming to determine a conventional characteristic of resistance to puncture of the geomembranes and the geomembrane lining systems according to the terminology defined by the norm NF P 84-500	8
EN 14574	CEN	2004	Geosynthetics - Determination of the pyramid puncture resistance of supported geosynthetics Based on the norm ASTM D 5494-93	The present norm describes a reference method of test for the determination of the pyramid puncture resistance of a geosynthetic on a rigid support. This method allows by simulation to estimate the efficiency of a geosynthetic to protect geosynthetics barrier or any other contact surface against the rigid and sharp elements under a load at short term.	25
NF P 84-506	Afnor	1992	Geomembranes - Geomembranes lining system - Determination of dynamic puncture resistance - Rigid support: pendulum method	The present norm defines the method of test allowing to measure the resistance to dynamic puncture of geomembrane lining system put on a rigid support (concrete, masonry, high thickness steel, …) when it is submitted to shocks from rigid objects offering sharp edges.	12
NF P 84-510	Afnor	2002	Geomembranes - Geomembrane lining systems - Determination of puncture resistance to aggregates on a rigid support	The present norm allows to determine the constraint of puncture under which a waterproof device made of a geomembrane covered of a layer of aggregates stays waterproof. The test applies only to geomembrane lining systems made of a geomembrane and eventually of one or two geotextiles put at its contact.	8

Number	Org.	Year	Title	Topic	Pages
EN 14576	CEN	2003	Geosynthetics - Test method for determining the resistance of polymeric geosynthetic barriers to environmental stress cracking	This norm describes a method of test allowing to estimate the resistance of polymeric geosynthetic barriers to stress-cracking. This test applies to polypropylene based and polyethylene based barriers as to any polymeric geosynthetic barrier offering a partially crystalline structure.	26
EN ISO 13428	ISO	2005	Geosynthetics - Determination of the protection efficiency of a geosynthetic against impact damage (ISO 13428:2005)		
EN 12691	CEN	2001	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of resistance to impact		
EN ISO 12957-1	ISO	2005	Geosynthetics - Determination of friction characteristics - Part 1: Direct shear test (ISO 12957-1:2005)		16
EN ISO 12957-2	ISO	2005	Geosynthetics - Determination of friction characteristics - Part 2: Inclined plane test (ISO 12957-2:2005)		20
NF P 84-522	Afnor	1994	Geomembranes – Measurement of the geomembrane lining systems slipping angle by means of an inclined plane test	The present document allows to measure the angle of slipping between the elements of a Geomembrane Lining System in the case of low normal constraints.	12
ISO 34-2	ISO	1996	Determination of the resistance to tearing: small test pieces		14
NF P 84-510	Afnor	2002	Determination of puncture resistance to aggregates on a rigid support		8
EN ISO 13431	ISO	1999	Determination of tensile creep and creep rupture behaviour		20
WI 189064					
WI 00189014					
DIN 53441	DIN				
D6768-02	ASTM	2002	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners	The test method establishes the procedures for the measurement of tensile strength of Geosynthetic Clay Liner (GCL). This test method is strictly an index test method to be used to verify the tensile strength of GCLs. Results from this test method should not be considered as an indication of actual or long-term performance of the geosynthetic(s) in field applications.	3
5.1.1.4. Performances of the joints					
EN 12316-2	CEN	2000	Flexible sheets for waterproofing - Determination of peel resistance of joints - Part 2: Plastic and rubber sheets for roof waterproofing		

Number	Org.	Year	Title	Topic	Pages
NF P 84-502-2	Afnor	1993	Geomembranes – Joints testing – Part 2: determination of the tensile-peel strength	The present norm specifies a method of determination of the tensile-peel resistance of the joints on geomembranes by the way of strip test samples. It applies to all types of geomembranes.	16
EN 12317-2	CEN	2000	Flexible sheets for waterproofing - Determination of the shear resistance of joints - Part 2: Plastic and rubber sheets for roof waterproofing		10
NF P 84-502-1	Afnor	1993	Geomembranes – Joints testing – Part 1: determination of tensile-shear properties	The present norm specifies a method of determination of the tensile characteristics of the joints on geomembranes by the way of unique geometry test sample called "dumb-bell" within standardized conditions of conditioning and test. It applies exclusively to synthetic and bituminous geomembranes.	12
NF P 84-706	Afnor	2002	Bentonitic geosynthetics - Determination of the liquid flowrate for overlap length unit	The present document describes a test method allowing to determine the flowrate of water able to cross the areas of overlap of bentonitic geosynthetics under normal stress and imposed hydraulic load. It defines the used terms, the measured parameters and specifies the operation modes relative to the applied techniques.	20
NF P 84-707	Afnor	2002	Bentonitic geosynthetics - Permeability to gases of partially saturated bentonitic geosynthetics	The present document describes the apparatus and the test procedure allowing to determine the permeability to gases of partially saturated bentonitic geosynthetics under imposed normal stress.	14
NF P 84-708	Afnor	2002	Bentonitic geosynthetics - Quantification of the self-regenerating capacity	The present document describes the test procedure allowing to determine the characteristics of swelling, of permeability to water and the hydraulic load of breakdown of a bentonitic geosynthetic in which a hole of a given diameter is done; it allows to characterize the capacity of the product to self-regenerate.	16
5.1.1.5. Thermal properties					
EN 13897	CEN	2004	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Determination of watertightness after stretching at low temperature		
EN 495-5	CEN	2000	Flexible sheets for waterproofing - Determination of foldability at low temperature - Part 5: Plastic and rubber sheets for roof waterproofing		
D696	ASTM				
5.1.1.6. Durability and chemical resistance					
00189131	CEN		Durability of geosynthetics with service lives greater than 25 years (2007-03)		

Number	Org.	Year	Title	Topic	Pages
EN 12224	CEN	2002	Determination of the resistance to weathering		11
EN 1296	CEN	2000	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roofing - Method of artificial ageing by long term exposure to elevated temperature		
EN 1297	CEN	2004	Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roof waterproofing - Method of artificial ageing by long term exposure to the combination of UV radiation, elevated temperature and water		
EN 14576	CEN	2005	Geosynthetics - Test method for determining the resistance of polymeric geosynthetic barriers to environmental stress cracking		
EN 14415	CEN	2004	Geosynthetic barriers - Test method for determining the resistance to leaching		
NF P 84-509	Afnor	1994	Geomembranes – Behaviour in water – Accelerated test and long term test – Gravimetric survey	The present norm principally applies to geomembranes of plasticized PCV; in such a case the gravimetric losses measured during the test correspond to the losses of plasticizer.	8
EN 14575	CEN	2005	Geosynthetic barriers - Screening test method for determining the resistance to oxidation	This norm describes a method of test allowing to characterize the resistance to oxidation of the geosynthetic barrier, either polymeric or bituminous.	14
ENV ISO 13438	ISO	2004	Screening test method for determining the resistance to oxidation		18
EN 1844	CEN	2001	Flexible sheets for waterproofing - Determination of resistance to ozone - Plastic and rubber sheets for roof waterproofing		
EN 1847	CEN	2001	Flexible sheets for waterproofing - Plastic and rubber sheets for roof waterproofing - Methods for exposure to liquid chemicals, including water		
EN 14030	CEN	2003	Screening test method for determining the resistance to acid and alkaline liquids		14
EN 14414	CEN	2004	Geosynthetics - Screening test method for determining chemical resistance for landfill applications		
00189084 CEN/TS 14416	CEN	2005	Geosynthetic barriers - Test method for determining the resistance to roots (2005-10)		
EN 12225	CEN	2002	Method for determining the microbiological resistance by a soil burial test		10

Number	Org.	Year	Title	Topic	Pages
ASTM D5397	ASTM				
SIA V280		1996	Swiss norm for flexible sheets for waterproofing: test N° 13 (OGU)		
SIA V280		1996	Swiss norm for flexible sheets for waterproofing: test N° 11 (OGU)		
5.1.2. Application of the geomembranes					
5.2. Geotextiles					
5.2.1. Characterisation of geotextiles					
D6461-99	ASTM	1999	Standard Specification for Silt Fence Materials	This specification covers requirements and test methods for geotextile fabrics and associated components used in temporary silt fence applications. This is a material purchasing specification based on AASHTO M288.	3
5.2.1.1. Dimensional characteristics					
EN ISO 10318	ISO	2005	Geosynthetics - Terms and definitions (ISO 10318:2005)		
EN ISO 9863-2	ISO	1996	Geotextiles and geotextile-related products - Determination of thickness at specified pressures - Part 2: Procedure for determination of thickness of single layers of multilayer products (ISO 9863-2:1996)		
EN ISO 9864	ISO	2005	Geosynthetics - Test method for the determination of mass per unit area of geotextiles and geotextile-related products (ISO 9864:2005)		
EN 13257	CEN	2000	Geotextiles and geotextile-related products - Characteristics required for use in solid waste disposals		
EN 13257:2000/A1	CEN	2005	Geotextiles and geotextile-related products - Characteristics required for use in solid waste disposals		
EN 13257:2000/AC	CEN	2003	Geotextiles and geotextile-related products - Characteristics required for use in solid waste disposals		

Number	Org.	Year	Title	Topic	Pages
5.2.1.2. Hydraulic properties					
EN 13252	CEN	2000	Geotextiles and geotextile-related products - Characteristics required for use in drainage systems		
EN 13252:2000/A1	CEN	2005	Geotextiles and geotextile-related products - Required characteristics for use in drainage systems		
EN ISO 12956	ISO	1999	Geotextiles and geotextile-related products - Determination of the characteristic opening size (ISO 12956:1999)		
EN ISO 11058	ISO	1999	Geotextiles and geotextile-related products - Determination of water permeability characteristics normal to the plane, without load (ISO 11058:1999)		
EN 13562	CEN	2000	Geotextiles and geotextile-related products - Determination of resistance to penetration by water (hydrostatic pressure test)		
EN ISO 12958	ISO	1999	Geotextiles and geotextile-related products - Determination of water flow capacity in their plane (ISO 12958:1999)		
D6767-02	ASTM	2002	Standard Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test	This test method covers the determination of the pore size distribution of geotextile filters with pore sizes ranging from 1 to 500 m.	6
5.2.1.3. Mechanical properties					
EN ISO 10319	ISO	1996	Geotextiles - Wide-width tensile test (ISO 10319:1993)		
EN 1897	CEN	2001	Geotextiles and geotextile-related products - Determination of the compressive creep properties		
EN 918	CEN	1995	Geotextiles and geotextile-related products - Dynamic perforation test (cone drop test)		
00189091 prEN ISO 13433	ISO		Geotextiles and geotextile related products - Dynamic perforation test (cone drop test) (ISO/DIS 13433:2004) (2005-08)		
EN ISO 12236	ISO	1996	Geotextiles and geotextile-related products - Static puncture test (CBR-Test) (ISO 12236:1996)		
EN ISO 13427	ISO	1998	Geotextiles and geotextile-related products - Abrasion damage simulation (sliding block test) (ISO 13427:1998)		

Number	Org.	Year	Title	Topic	Pages
ENV ISO 10722-1:1998	ISO		Geotextiles and geotextile-related products - Procedure for simulating damage during installation - Part 1: Installation in granular materials (ISO 10722-1:1998)		
00189095 prEN ISO 10722-1	ISO		Geotextiles and geotextile-related products - Procedure for simulating damage during installation - Part 1: Installation in granular materials (ISO/DIS 10722-1:2004) (2006-04)		
EN ISO 13431:1999	ISO		Geotextiles and geotextile-related products - Determination of tensile creep and creep rupture behaviour (ISO 13431:1999)		
5.2.1.4. Performances of the joints					
EN ISO 13426-1:2003	ISO		Geotextiles and geotextile-related products - Strength of internal structural junctions - Part 1: Geocells (ISO 13426-1:2003)		
EN ISO 13426-2:2005	ISO		Geotextiles and geotextile-related products - Strength of internal structural junctions - Part 2: Geocomposites (ISO 13426-2:2005)		
EN ISO 10321:1996	ISO		Geotextiles - Tensile test for joints/seams by wide-width method (ISO 10321:1992)		
5.2.1.5. Thermal properties					
5.2.1.6. Durability and chemical resistance					
CR ISO 13434:1998	ISO		Guidelines on durability of geotextiles and geotextile-related products		
EN 13719:2002	CEN		Geotextiles and geotextile-related products - Determination of the long term protection efficiency of geotextiles in contact with geosynthetic barriers		
EN 13719:2002 /AC:2005	CEN		Geotextiles and geotextile-related products - Determination of the long term protection efficiency of geotextiles in contact with geosynthetic barriers		
EN 12447:2001	CEN		Geotextiles and geotextile-related products - Screening test method for determining the resistance to hydrolysis in water		
EN 12224:2000	CEN		Geotextiles and geotextile-related products - Determination of the resistance to weathering		

Number	Org.	Year	Title	Topic	Pages
EN ISO 13438:2004	ISO		Geotextiles and geotextile-related products - Screening test method for determining the resistance to oxidation (ISO 13438:2004)		
EN 14030:2001	CEN		Geotextiles and geotextile-related products - Screening test method for determining the resistance to acid and alkaline liquids (ISO/TR 12960:1998, modified)		
EN 14030:2001 /A1:2003	CEN		Geotextiles and geotextile-related products - Screening test method for determining the resistance to acid and alkaline liquids (ISO/TR 12960:1998, modified)		
EN 12225:2000	CEN		Geotextiles and geotextile-related products - Method for determining the microbiological resistance by a soil burial test		
5.2.2. Applications of geotextiles					
EN ISO 10320:1999	ISO		Geotextiles and geotextile-related products - Identification on site (ISO 10320:1999)		
CEN/TR 15019:2005	CEN		Geotextiles and geotextile-related products - On-site quality control		
EN 12226:2000	CEN		Geotextiles and geotextile-related products - General tests for evaluation following durability testing		
EN ISO 13437:1998	ISO		Geotextiles and geotextile-related products - Method for installing and extracting samples in soil, and testing specimens in laboratory (ISO 13437:1998)		
EN 13738:2004	CEN		Geotextiles and geotextile-related products - Determination of pullout resistance in soil		
D6462-99	ASTM	1999	Standard Practice for Silt Fence Installation	This practice covers common installation requirements for temporary silt fence applications. This practice is based on AASHTO M288.	3

6. Pipes and drains

On a sanitary landfill, the drainage and collection networks of the biogas and the leachates are made of HDPE (High Density PolyEthylene). It's a key-point for the protection of the environment. The following norms can be usefully applied for the construction of these networks.

DIN 16961-2, Publication date: 2000-03
Pipes and fittings of thermoplastics materials with profiled wall and smooth pipe inside - Part 2: Technical delivery specifications

DIN 16963-1, Publication date: 1980-08
Pipe Joints and Elements for High Density Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Pipe Bends of Segmental Construction for Butt-welding, Dimensions

DIN 16963-2, Publication date: 1983-02
Pipe joint assemblies and fittings for types 1 and 2 high-density polyethylene (HDPE) pressure pipes; tees and branches produced by segment inserts and necking for butt welding; dimensions

DIN 16963-3, Publication date: 1980-08
Pipe Joints and Elements for High Density Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Pipe Bends for Butt-welding, Dimensions

DIN 16963-4, Publication date: 1988-11
Pipe joint assemblies and fittings for high-density polyethylene (PE-HD) pressure pipes; adaptors for fusion jointing, flanges and sealing elements; dimensions

DIN 16963-8, Publication date: 1980-08
Pipe Joints and Elements for High Density Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Injection Moulded Elbows for Socket-welding, Dimensions

DIN 16963-9, Publication date: 1980-08
Pipe Joints and Elements for High Density Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Injection Moulded Tee Pieces for Socket-welding, Dimensions

DIN 16963-10, Publication date: 1980-08
Pipe Joints and Elements for High Density Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Injection Moulded Sockets and Caps for Socket-welding, Dimensions

DIN 16963-13, Publication date: 1980-08
Pipe Joints and Elements for High Pressure Polyethylene (HDPE) Pressure Pipelines, Types 1 and 2; Turned and Pressed Reducing Sockets for Butt-welding, Dimensions

DIN 16963-14, Publication date: 1983-06
Pipe joint assemblies and fittings for types 1 and 2 high-density polyethylene (HDPE) pressure pipes; injection moulded reducers and nipples for socket welding; dimensions

DIN 16963-15, Publication date: 1987-06
Pipe joint assemblies and fittings for high-density polyethylene (HDPE) pressure pipes; pipe couplings; dimensions

DIN 19535-10, Publication date: 2000-01
High-density polyethylene (PE-HD) pipes and fittings for hot-water resistant waste and soil discharge systems (HT) inside buildings - Part 10: Fire behaviour, quality control and installation recommendations

DIN 19537-1, Publication date: 1983-10
High density polyethylene (HDPE) pipes and fittings for drains and sewers; dimensions

DIN 19537-2, Publication date: 1988-01
High-density polyethylene (HDPE) pipes and fittings for drains and sewers; technical delivery conditions

ASTM F 2136, Publication date: 2005
Standard Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe

ASTM F 2160, Publication date: 2005
Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

DVGW G 477, Publication date: 1983-04
Manufacture, quality assurance and testing of pipes of PVC rigid (polyvinyl chloride rigid) and HDPE (polyethylene rigid) for gas lines and requirements on pipe couplings and pipeline parts

DVGW W 320, Publication date: 1981-09
Manufacture, quality assurance and testing of pipes of PVC rigid (polyvinyl chloride rigid), HDPE (polyethylene rigid) and LDPE (polyethylene soft) for water supply and requirements on pipe couplings and pipeline parts

ISO 3458:1976
Assembled joints between fittings and polyethylene (PE) pressure pipes - Test of leakproofness under internal pressure

ISO 3459:1976
Polyethylene (PE) pressure pipes - Joints assembled with mechanical fittings - Internal under-pressure test method and requirement

ISO 3501:1976
Assembled joints between fittings and polyethylene (PE) pressure pipes - Test of resistance to pull out

ISO 3503:1976
Assembled joints between fittings and polyethylene (PE) pressure pipes - Test of leakproofness under internal pressure when subjected to bending

ISO 3663:1976
Polyethylene (PE) pressure pipes and fittings, metric series - Dimensions of flanges

ISO 4059:1978
Polyethylene (PE) pipes - Pressure drop in mechanical pipe-jointing systems - Method of test and requirements

ISO 8772:1991
High-density polyethylene (PE-HD) pipes and fittings for buried drainage and sewerage systems - Specifications

ISO 8779:2001
Polyethylene (PE) pipes for irrigation laterals - Specifications

ISO 9625:1993
Mechanical joint fittings for use with polyethylene pressure pipes for irrigation purposes

ISO 10146:1997
Crosslinked polyethylene (PE-X) pipes - Effect of time and temperature on the expected strength

ISO 10147:2004
Pipes and fittings made of cross-linked polyethylene (PE-X) - Estimation of the degree of cross-linking by determination of the gel content

ISO 10837:1991
Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings

ISO 11413:1996
Plastics pipes and fittings - Preparation of test piece assemblies between a polyethylene (PE) pipe and an electrofusion fitting

ISO 11414:1996
Plastics pipes and fittings - Preparation of polyethylene (PE) pipe/pipe or pipe/fitting test piece assemblies by butt fusion

ISO/TR 11647:1996
Fusion compatibility of polyethylene (PE) pipes and fittings

ISO 12176-1:1998
Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 1: Butt fusion

ISO 12176-2:2001
Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 2: Electrofusion

ISO 12176-3:2000
Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 3: Operator's badge

ISO 12176-4:2003
Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 4: Traceability coding

ISO 13480:1997
Polyethylene pipes - Resistance to slow crack growth - Cone test method

ISO 13761:1996
Plastics pipes and fittings - Pressure reduction factors for polyethylene pipeline systems for use at temperatures above 20 degrees C

ISO 13953:2001
Polyethylene (PE) pipes and fittings - Determination of the tensile strength and failure mode of test pieces from a butt-fused joint

ISO 13954:1997
Plastics pipes and fittings - Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm

ISO 13955:1997
Plastics pipes and fittings - Crushing decohesion test for polyethylene (PE) electrofusion assemblies

ISO 13957:1997
Plastics pipes and fittings - Polyethylene (PE) tapping tees - Test method for impact resistance

ISO 14236:2000
Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems

ISO 14531-1:2002
Plastics pipes and fittings - Cross-linked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels - Metric series - Specifications - Part 1: Pipes

ISO 14531-2:2004
Plastics pipes and fittings - Cross-linked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels - Metric series - Specifications - Part 2: Fittings for heat-fusion jointing

ISO 15594:2003
Plastics piping systems for industrial applications - Polybutene (PB), polyethylene (PE) and polypropylene (PP) - Specifications for components and the system - Metric series

ISO 15875-1:2003
Plastics piping systems for hot and cold-water installations - Cross-linked polyethylene (PE-X) - Part 1: General

ISO 15875-2:2003
Plastics piping systems for hot and cold-water installations - Cross-linked polyethylene (PE-X) - Part 2: Pipes

ISO 15875-3:2003
Plastics piping systems for hot and cold-water installations - Cross-linked polyethylene (PE-X) - Part 3: Fittings

ISO 15875-5:2003
Plastics piping systems for hot and cold-water installations - Cross-linked polyethylene (PE-X) - Part 5: Fitness for purpose of the system

ISO 15875-7:2003
Plastics piping systems for hot and cold-water installations - Cross-linked polyethylene (PE-X) - Part 7: Guidance for the assessment of conformity

ISO 16241:2005
Notch tensile test to measure the resistance to slow crack growth of polyethylene materials for pipe and fitting products (PENT)

ISO/TR 19480-2005
Polyethylene pipes and fittings for the supply of gaseous fuels or water - Training and assessment of fusion operators (available in English only)

EN 12007-2 (2000)
Gas supply systems - Gas pipelines for maximum operating pressure up to and including 16 bar - Part 2: Specific functional recommendations for polyethylene (MOP up to and including 10 bar)

EN 12099 (1997)
Plastics piping systems - Polyethylene piping materials and components - Determination of volatile content

EN 12106 (1997)
Plastics piping systems - Polyethylene (PE) pipes - Test method for the resistance to internal pressure after application of squeeze-off

EN 12201-1 (2003)
Plastics piping systems for water supply - Polyethylene (PE) - Part 1: General

EN 12201-2 (2003)
Plastics piping systems for water supply - Polyethylene (PE) - Part 2: Pipes

EN 12201-3 (2003)
Plastics piping systems for water supply - Polyethylene (PE) - Part 3: Fittings

EN 12201-5 (2003)
Plastics piping systems for water supply - Polyethylene (PE) - Part 5: Fitness for purpose of the system

EN 13244-1 (2003)
Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage - Polyethylene (PE) - Part 1: General

EN 13244-2 (2003)
Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage - Polyethylene (PE) - Part 2: Pipes

EN 13244-3 (2003)
Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage - Polyethylene (PE) - Part 3: Fittings

EN 13244-5 (2003)
Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage - Polyethylene (PE) - Part 5: Fitness for purpose of the system

NF T54-070 (1978)
High density polyethelene (PE-HD) pipes and fittings. Chemical resistance with respect to fluids to be conveyed

Notes

[1] The Benoto system is the forerunner of large diameter bored piles. A double-walled casing is pressed into the ground during alternate turning (cork-screw motion). Special joints have been developed to transfer the high torque applied during casing installation. When the desired depth has been reached (or while the tube is being installed), the soil is removed with a hammer grab or auger. After the casing has been filled with concrete it is pulled up in short intervals in an oscillating motion. After each extraction step, the casing is pushed down a few centimetres. This process compacts the concrete and improves the contact between the concrete and the soil. The diameter of the pile can vary from 0.50 m up to 2.00 m. The pile can be raked to 14 degrees.

[2] In June 2005, this norm has been replaced by the EN 13967 Flexible sheets for waterproofing - Plastic and rubber damp proof sheets including plastic and rubber basement tanking sheet - Definitions and characteristics