



BAM

Bundesanstalt für
Materialforschung
und -prüfung

**Guidelines for the Certification
of Geotextiles for Filtration and Separation
in Landfill Sealing Systems**

issued by
Division 4.3 "Contaminant Transfer and Environmental Technologies"

5th Edition, February 2015

These Certification Guidelines and the list of certified geotextiles for filtration and separation, as well as additional Guidelines for geosynthetics and leak-detection systems based on the Landfill Regulations and lists of products certified under these Guidelines, can be downloaded as pdf files from the internet sites:

www.bam.de/en/service/amt_mitteilungen/abfallrecht/index.htm.

www.bam.de/de/service/amt_mitteilungen/abfallrecht/index.htm.

For the certification procedure the requirements of the actually valid German version of the Certification Guidelines are mandatory.

Foreword

The new Landfill Ordinance (DepV) came into force on 16 July 2009. It was amended by clause 7 of the ordinance for the implementation of the industrial emission directive, for the modification of the ordinance about environmental inspections and for the enactment of the “Bekanntgabeverordnung”, dated 02 May 2013. The current version stipulates in Annex 1 no. 2.1 of the Landfill Ordinance that materials, components or systems may be used in the sealing system only if they comply with the state of the art in accordance with Annex 1 no. 2.1.1 and if this has been demonstrated to the responsible authority. For geosynthetics, polymers and serially produced seal-monitoring systems, certification by the BAM (Federal Institute for Materials Research and Testing) according to Annex 1 No. 2.4 is proof that these materials, components or systems satisfy this requirement.

Notwithstanding this, materials, components or systems which have been declared on the basis of harmonized European technical specifications for the EU Construction Products Directive may be used in landfill-liner systems if the material, component and system characteristics specified in the harmonized technical specifications are substantially equivalent to those arising from the requirements of the Landfill Ordinance as regards state of the art. At present there are no harmonized European technical specifications which fulfill the state-of-the-art requirements of the Landfill Ordinance, in particular as regards long-term performance.

In addition, materials, components or systems can be used in landfill-liner systems if they have been legally manufactured or placed on the market in another EU Member State or in Turkey in accordance with the regulations or requirements in force there, or if they have been legally manufactured and placed on the market in another Signatory State to the Agreement on the European Economic Area in accordance with the regulations or requirements in force there, if the tests and inspections in the country of manufacture confirm that the material, component and system characteristics guarantee in the long-term a level of protection equivalent to that required by the DepV Landfill Ordinance. When considering relevant evidence, the competent authorities may contact BAM for technical support.

The procedure for certification is laid down in No. 2.4 of Annex 1 of the DepV. The tasks of the BAM in No. 2.4.1 include the definition of test criteria, the adoption of additional provisions into the certification and in particular the determination of requirements for professional installation and for quality management. As outlined in No. 2.4.4, an Advisory Committee is involved in establishing appropriate certification guidelines.

After the Landfill Ordinance came into force on October 16, 2009, the Advisory Council was constituted and established a working group which has drawn up these new Guidelines for the Certification of geotextiles for filtration and separation in landfill-sealing systems. The present edition is a revised version, which was approved by the Advisory Committee.

The following persons took part in the discussions:

1. The members of the Advisory Committee:

Dipl.-Ing. K.-H. Albers, *G quadrat Geokunststoffgesellschaft mbH*; Dipl.-Ing. W. Bräcker, *Staatliches Gewerbeaufsichtsamt Hildesheim*; Dipl.-Ing. R. Drewes, *Landesamt für Umwelt, Gesundheit und Verbraucherschutz Brandenburg*; Dipl.-Ing. K. J. Drexler, *Bayerisches Landesamt für Umwelt (LfU)*; H. Ehrenberg, *NAUE GmbH & Co. KG*; Dipl.-Ing. A. Elsing, *HUESKER Synthetic GmbH*; Dr.-Ing. B. Engelmann, *Umweltbundesamt*; Dipl.-Geoöko. K. Heinke, *Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie (LfULG)*; Dr.-Ing. D. Heyer, *TU München, Zentrum Geotechnik*; Dipl.-Ing. M. Müller, *Landesamt für Umweltschutz Sachsen-Anhalt*; Dr. rer. nat. W. Müller, *BAM Bundesanstalt für Materialforschung und –prüfung*; Dr.-Ing. E. Reuter, *IWA Ingenieurgesellschaft für Wasser- und Abfallwirtschaft*; Dipl.-Ing. P. Riegl, *GSE Lining Technology GmbH*; Dipl.-Ing. G. P. Romann, *AGAS Arbeitsgemeinschaft Abdichtungstechnik e.V.*; Prof. Dr.-Ing. F. Saathoff, *Geotechnik und Küstenwasserbau, Universität Rostock*; Dipl.-Ing. T. Sasse, *Umtec | Prof. Biener |*

Sasse | Konertz; Prof. Dr. F.-G. Simon, *BAM Bundesanstalt für Materialforschung und -prüfung*; Dr.-Ing. M. Tiedt, *Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen*; Dipl.-Ing. L. Wilhelm, *Thüringer Landesanstalt für Umwelt und Geologie*; Dipl.-Ing. Ch. Witolla, *Ingenieurbüro Geoplan GmbH*; Prof. Dr.-Ing. K. J. Witt, *Fakultät Bauingenieurwesen, Bauhaus-Universität Weimar*; Dipl.-Ing. A. Wöhlecke, *BAM Bundesanstalt für Materialforschung und -prüfung*; Dipl.-Ing. K. Wohlfahrt, *Bonar GmbH & Co. KG*; Dipl.-Ing. H. Zanzinger, *SKZ Süddeutsches Kunststoff-Zentrum*.

2. Other members of the Working Group:

Dr. J. Köhrich, *Hafemeister GeoPolymere GmbH*; Dipl.-Min. W. Ruthmann, *GGU Gesellschaft für Grundbau und Umwelttechnik mbH* und Dipl.-Ing. C. Tarnowski, *GSE Lining Technology GmbH*

.

1. Legal Basis, Area of Validity and Regulations.....	6
2. Objects Certified	7
2.1. General.....	7
2.2. Material and Properties of the Geotextile Pre-Products	8
2.3. Properties of the Geotextiles	8
2.4. Dimensions.....	9
2.5. Marking	9
2.6. Manufacturing Plant and Manufacturing Process	9
3. Testing Procedures and Requirements	9
3.1. General physical and mechanical Properties	9
3.2. Durability and Aging	10
3.2.1. Resistance to Chemicals	10
3.2.2. Resistance to Aging	10
3.2.3. Resistance to Weathering.....	10
3.2.4. Resistance to Micro-Organisms	11
3.2.5. Environmental Compatibility of Additives and Processing Aids	11
4. In-House and Third-Party Production Quality Control.....	11
4.1. Goods-received Controls and Tests	11
4.2. In-House Production Quality Control.....	11
4.3. Third-Party Inspection.....	12
4.4. Shipping Documents	12
5. Requirements for Installation	12
5.1. Verification of Stability	13
5.2. Measures against Stressing caused by Installation and Construction.....	13
5.3. Quality Management, Third-party Inspection.....	13
6. Design	14
7. Changes, Notification of Defects and Period of Validity.....	14
8. Tables of Requirements	15
Table 1: Characteristic Properties ¹ of the Pre-Products (e.g. fibers, tapes etc.).....	15
Table 2: Characteristic Properties of Nonwovens for Filtration and Separation, and of Wovens for Separation.....	16
Table 3a: Requirements for the Durability of the Geotextiles	17
Table 3b: Requirements for Resistance to Aging Processes in the Geotextiles ¹	18
Table 4: Measures for Quality Assurance and Material Identification	20
Table 5: Type and Extent of Tests within the Scope of Third-Party Inspection	21
Table 6: Type and Extent of Tests on Geotextiles within the Scope of Third-Party Inspection	21
Table 7: Quality Assurance for the Installation of Geotextiles for Filtration and Separation	22
9. List of Standards.....	24
10. Annexes to Certification Document, List of State Codes, Testing and Inspection Bodies.....	26

1. Legal Basis, Area of Validity and Regulations

The protection of people and the environment against the generation and management of waste is now regulated by the new Waste Management and Product Recycling Act (KrWG) introduced on February 24, 2012. On 16 July 2009, a new Landfill Ordinance (DepV) was brought into force on the basis of the Recycling and Waste Management Act (KrW / AbfG). This was amended by clause 7 of the ordinance for the implementation of the industrial emission directive, for the modification of the ordinance about environmental inspections and for the enactment of the "Bekanntgabeverordnung". Annex 1, No. 2.1 of the DepV permits the use in sealing systems only of state-of-the-art geosynthetics (geomembranes, protection layers, plastic drainage elements, geosynthetic reinforcing grids, etc.), of polymers, and of serially produced leak-detection systems which correspond to No. 2.1.1 and which have been certified by BAM according to No. 2.4.

In accordance with No. 2.4.1 and on the basis of its own investigations and those of accredited bodies, BAM is responsible for the testing and certification of geosynthetics, polymers and seal-monitoring systems for use in base and cap sealing of landfills. In this context, it has the following tasks:

- the definition of test criteria,
- the inclusion of additional provisions in the certification, and
- the establishment of requirements for proper installation and quality management.

On this legal basis, and taking into account the requirements referred to in No. 2.1.1 of Annex 1 of the DepV regarding state of the art, these Guidelines describe the requirements for the Certification of geotextiles for filtration and separation in landfill-sealing systems. The Guidelines are the technical basis on which BAM, at the request of the manufacturer, tests the geotextiles and then confirms their suitability by issuing a Certification document.

Landfill sealings must be executed according to the current state of the art. These Guidelines therefore also describe the requirements to be met for the in-

stallation of the certified geotextiles for filtration and separation so that the final sealing system corresponds to the state of the art. These requirements are explicitly indicated in the certificate. The competent (federal) State authorities must ensure that these additional provisions form part of the approval and are therefore legally binding. Only if this condition is fulfilled can the BAM certificate be used as proof of the suitability of state-of-the-art sealing systems constructed with the geotextiles.

The certification is issued expressly subject to revocation. Grounds for revocation are given if the manufacturer deviates from the procedures specified in the test reports and appendices of the Certification document, from the raw materials as used in the sample tested or from other requirements specified in the Certification document. Should this be the case, further production of any geotextile using the BAM Certification number is prohibited.

Changes in either the raw material or production process of the geotextiles or dispositions for in-house quality control (QC) and third-party inspection of production require new certification. If procedures used by the manufacturer or the installation methods used by contractors do not prove themselves in practice and this can be demonstrated by new technical findings, i.e. if the factual situation, the state of the art and the legal situation have changed such that no further Certification can be issued, then this too is grounds for revocation.

In the event of revocation the manufacturer is obligated to return the Certification document immediately to the Certification Authority.

The certifications are based on the following laws, regulations and guidelines in their currently valid versions:

- Act for the Promotion of Recycling of Materials and the environmentally compatible Disposal of Waste (Waste Management and Product Recycling Act KrWG) of 24 February 2012, Bundesgesetzblatt Part I, No. 10. pp. 212-264.
- Regulation on Landfills and long-term Storage (Landfill Ordinance – DepV); Article 1 of the Regulation on the Simplification of Landfill Legislation of 27 April 2009 (Federal Law Gazette I No. 22 of 29 April 29 2009 p. 900), most recently

amended on 02.05.2013 by clause 7 of the ordinance for the implementation of the industrial emission directive, for the modification of the ordinance about environmental inspections and for the enactment of the "Bekanntgabeverordnung", dated 17 October 2011 (BGBl. I No. 21 of 02. Mai 2013 p. 973).

- First Regulation amending the Landfill Ordinance of 17.10.2011; Federal Law Gazette 2011, Part I, No. 52, pp. 2066-2079.
- Guidelines for the Qualification Requirements and the Tasks of third-party Inspectors in the Installation of Plastic Components and -Parts in Landfill-Sealing Systems (Guidelines for External Inspectors), BAM Federal Institute for Materials Research and -Testing.
- Guidelines for Requirements on Specialist Contractors for the Installation of Geomembranes, other Geosynthetics and Plastic Components in Landfill-Sealing Systems (Guidelines -Installation Contractors), BAM Federal Institute for Materials Research and Testing.
- Guidelines for the Certification of Seal-Monitoring Systems for Convection Barriers in Landfill Cap-Sealing Systems (Certification Guidelines Leak-Detection -Systems), BAM Federal Institute for Materials Research and -Testing.
- Guidelines for the Certification of Separation and Filter Geotextiles in Landfill-Sealing Systems (Certification Guidelines Geotextiles), BAM Federal Institute for Materials Research and -Testing.
- Guidelines for the Certification of Geomembranes in Landfill-Sealing Systems (Certification Guidelines GM), BAM Federal Institute for Materials Research and -Testing.
- Guidelines for the Certification of Geosynthetic - Drainage Elements in Landfill Cap-Sealing Systems (Certification Guidelines -Drainage -Composites), BAM Federal Institute for Materials Research and Testing.
- Guidelines for the Certification of Protection Layers for Geomembranes in Landfill-Sealing Systems (Certification -Guidelines Protection - Layers), BAM Federal Institute for Materials Research and -Testing.

- Provisional Guidelines for the Certification of Geosynthetic Reinforcement Grids for Landfill Cap-Sealing Systems (Provisional Certification Guidelines -Geogrids), BAM Federal Institute for Materials Research and -Testing.

The relevant dates of issue of the quoted standards are specified in section 9.

2. Objects Certified

2.1. General

The Certification applies to geotextiles for filtration and separation in landfill-sealing systems. A precondition for the use of the geotextiles is that the mean temperature in the vicinity of the installed product does not exceed 20° C. In the lower zone of a layer of soil at least 1 m thick, a continuous temperature of 15° C is only rarely exceeded under the climatic conditions pertaining in Germany. In the transition zone of the sealing components to the recultivation layer, the temperature requirement will be generally fulfilled, even if it is assumed that temperatures up to 30° C may occasionally occur in the sealing components themselves.

The certified geotextiles can therefore be used without restriction above the sealing components of surface sealings. In and below the surface-sealing components, and in the base sealing, they are only suitable if the requirement on mean temperature is met on account of the nature of the waste, its installation, and the surrounding conditions. For use in the base sealing, a high chemical resistance (see Section 3.2.1) must additionally be ensured.

Nonwoven fabrics are used for filtration, nonwovens or wovens for separation.

The Certification can also encompass a product family. The product family consists of nonwovens such as products of different mass per unit area, which however were made using the same pre-products with the same production process.

There are various interfaces between the system components of landfill-sealing systems where, in principle, geotextiles can be used for filtration and separation. Geotextile separators can also fulfill a useful function as part of the sealing components.

As a matter of principle, a geotextile certified on the basis of these Guidelines is also suitable for use in securing contaminated sites and in the surface-sealing of landfills which are not subject to the Landfill Ordinance.

The object certified must be factory manufactured with defined, reproducible properties.

The applicant and Certification Holder is the manufacturer of the geotextile. The geotextile must be fully and unmistakably described by the applicant. This includes a description of the geotextile production process and of the pre-products used, details of the type and specification of materials and the type and quantity of polymer-bound additives (masterbatch) or other additives used in the production of pre-products and the product itself, and information on the characteristic properties of the product.

In the Certification Document, the object certified is described exactly by its dimensions as well as by the information detailed below.

The geotextile must have a CE mark referring to DIN EN 13257. Its production must be subject to internal and third-party inspection within the framework of a quality management system certified according to DIN EN ISO 9001.

The Certification Authority must be notified of and approve any changes in the above. Should such changes not be notified, the Certification becomes invalid

2.2. Material and Properties of the Geotextile Pre-Products

The Certification Document includes details on the resin manufacturer and on the resin (type designation) used in the pre-product (e.g. fibers, filaments, tapes, fibrillated tapes, multifilament yarns etc.) from which the geotextile is manufactured; in addition, it gives the manufacturer's specification for density, melt-flow index and, if relevant, for carbon-black content. Other confidential information on the resins (molecular mass distribution, additives) and on the polymer-bound additives (manufacturer, type designation and exact formulation of the masterbatch) or other additives, as well as sample material must be deposited with the Certification Authority. Additional details must be disclosed if these are necessary for the unambiguous definition of the material.

There must be a legally binding agreement between

the manufacturers of the pre-products and the geotextile manufacturer concerning the specification of all materials used. In an Annex to the Certificate, the Certification Holder must submit a legally binding statement of the materials used. The clear definition of the materials, the verifiability by the Certification Authority of the information given, and the possibility of verification testing against the specified values is required as a matter of principle before Certification can be awarded.

The type of pre-products, their designation, where appropriate information on the specification (mean value, threshold values and permissible tolerances) of selected properties (e.g. titer and mechanical properties) and, where appropriate, the manufacturer, are specified in the Certification Document. Details of further essential properties must be confidentially deposited with the Certification Authority. The properties listed in the certification document are checked in the in-house QC of the pre-product manufacturer, and in the goods-received control, the in-house QC and the external quality control of the manufacturer of the geotextiles (see Table 4).

The essential properties of fibers, filaments, tape yarns, fibrillated yarns, multifilament yarns are specified in Table 1. Other pre-products may have different essential properties, which may be stipulated on a case-to-case basis based on this Table.

2.3. Properties of the Geotextiles

The characteristics (hydraulic and mechanical properties) of the geotextiles are indicated in the Certification Document based on DIN EN 13257 (see Table 2). These properties are checked in the in-house and third-party quality control of the production of the geotextile. To this end, the characteristic values for the assessment in the context of in-house and third-party inspection are laid down in the Certification Document. The characteristic values are derived from the mean and the permissible tolerance, these being specified by the manufacturer on the basis of a statistical evaluation of his own measurement results, or taking into account safety factors based on experience. Since geotextiles have a CE-marking with respect to DIN EN 13257, some of the characteristic values can be taken from the CE accompanying documents.

Section 3 details the approval requirements for certain characteristic properties.

The data sheet of the geotextile must document at least the data relevant for in-house quality control.

2.4. Dimensions

The typical roll length of the geotextile, its width and thickness are stipulated in the Certification Document

2.5. Marking

The certified product must be marked at regular intervals in accordance with DIN EN ISO 10320, and it must be packaged. As a minimum in the case of single-product Certification, the marking must show the product name and the certification number; for the Certification of a product family, it must show the product name and the family certification number. The marking must be printed so that it is permanently legible. It must in particular be sufficiently durable to withstand transport, storage and the installation stress. Each roll must carry a label in accordance with DIN EN ISO 10320 which gives the manufacturer, the type of product or the product name, the dimensions, the weight, as well as an internal company code (e.g. roll number), and from which directly or indirectly the date of production can be read and which enables the results and documentation of quality assurance procedures to be assigned to the delivery unit in a unique way. Further information can be required in individual cases. An example of the label is attached to the Approval Certificate as an annex.

2.6. Manufacturing Plant and Manufacturing Process

The manufacturing plant and a manufacturer's description of the manufacturing process are fixed and form part of the Certification Document. Relevant confidential details on the manufacturing process are deposited with the Certification Authority. Prior to issuing certification, the Certification Authority will visit the manufacturing sites of both geosynthetics and primary products to verify the information provided on the manufacturing process and machines and to verify that qualified staff, rooms, test and other equipment on the manufacturing plant and in the

testing laboratories ensure flawless production and in-house manufacturing QC in line with requirements.

In individual cases, the manufacturer must demonstrate how potential production defects resulting from the chosen manufacturing process are prevented by applying appropriate measures in the production process and in quality management.

3. Testing Procedures and Requirements

The following describes the testing and Certification requirements on the properties of geotextiles, see also GDA-Recommendation E 2-9 "Application of Geotextiles in Landfill Construction"¹. The tests are carried out by BAM in Division 4.3, "Contaminant Transfer and Environmental Technologies", and in test institutes approved by BAM (see Section 10). Tests are carried out on the mechanical properties, on the filtration properties, and on durability and aging. In substantiated individual cases the certifying body may institute special regulations which supplement or vary from the technical requirements defined in these Guidelines. These special technical requirements are drawn up after consultation and discussion with the Advisory Committee.

3.1. General physical and mechanical Properties

Table 2 lists the main filter and mechanical properties of the geotextiles, and related tests. These are used as identifiers, as benchmarks in the scope of quality assurance, and in the design of filtration and separation layers.

Nonwovens are used for filtration. The filter function also always includes a separation function. The mass per unit area of these nonwoven fabrics must be at least 300 g/m², the thickness at least 3 mm, CBR force at least 2.5 kN and the plunger displacement in the CBR test at least 50 mm. In addition, the thickness of the nonwoven must be at least 30 times the characteristic opening size O₉₀. As a matter of

¹ The GDA recommendations are available on the website www.gdaonline.de.

principle, the design of any construction project must apply the filter rules of the DVWK Advisory Guideline². In accordance with the Certification Document, the characteristics of the certified nonwoven fabric for a single construction project can be varied to some extent in order to achieve an optimum adaptation. The minimum requirements must however be complied with.

Geotextiles (nonwovens and wovens) used only separators must belong to geotextile-robustness class (GRK) 5. The plunger displacement at maximum CBR force must be at least 50 mm. The characteristic opening size should be in the range 0.06 to 0.2 mm.

The water permeability normal to the plane is usually determined in accordance with DIN EN ISO 11058 in the course of factory- and third-party inspection. For Certification purposes, test results according to DIN 60500-4 must also be submitted.

3.2. Durability and Aging

3.2.1. Resistance to Chemicals

As a matter of principle, it is assumed that landfill gases will have an influence on the geotextiles. The geotextiles must therefore be resistant to organic chemicals. The resistance is tested in an immersion test based on DIN EN 14414 (see Table 3a No. 3.1). More information on the test procedures is given on the BAM Internet site³. The chemicals are selected from the listed list of concentrated media given here. The selection of the test media focuses on the damage mechanisms (aging processes under exposure to chemicals) relevant to the particular material under landfill conditions. Usually, the resistance against benzenes, aromatic hydrocarbons, paraffin, lubricating and fuel oils, diesel fuels and aliphatic hydrocarbons is tested.

Only geotextiles resistant to all media detailed in the

list (see Certification Document) may be used in the base sealing. An aqueous solution containing 25 vol.-% concentrated nitric acid is used as the oxidizing inorganic acid.

3.2.2. Resistance to Aging

The resistance to oxidative degradation for geotextiles made of polyolefins is tested in oven aging tests in an forced air oven based on DIN EN ISO 13438, and in water immersion tests based on DIN EN 14415 each at 80 °C storage temperature (see Table 3b No. 3.4 and 3.5)⁴. The storage period must be at least one year. The change in mechanical characteristics (tensile strength and elongation at given tensile strength) are investigated, as are the stabilizer content and the crystallinity. The content of antioxidants is determined by UV-Spectroscopy or HPLC analysis on an extract obtained from a solid-liquid extraction; alternatively it can be determined indirectly by OIT measurements on the product itself. The method selected depends on the type of stabilization. The crystallinity is determined by DSC measurement. The requirements are set out in Table 3.

Requirements for other raw materials/product types (e.g. polyester, polystyrene; PVC etc.) are set in analogy by transferring the requirements for resistance to oxidative degradation. In Table 3b No. 3.7 and 3.8, for example, the immersion tests for determining the resistance to hydrolytic degradation of polyester geotextiles are described⁵.

In the Certification Document, additional requirements for the more permissible environmental conditions (such as the pH value) can be stipulated for the application of the geotextiles.

3.2.3. Resistance to Weathering

The test is performed according to the DIN EN 12224 test method (see Table 3a No. 3.2).

As a matter of principle, geotextiles should be ex-

² Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (Pub.): DVWK Merkblatt 221, Anwendung von Geotextilien im Wasserbau. Hamburg und Berlin: Verlag Paul Parey, 1992, 31 pages (out of print). See also Krug, M. and Heyer, D., "Geotextile Filter im Erd-, Straßen- und Deponiebau", *Geotechnik*, 21(1998), No. 4, pp. 314-326.

³http://www.bam.de/de/service/amtl_mitteilungen/abfallrec ht/index.htm

⁴ Müller, W. W., Jakob, I., Li, C. S. und Tatzky-Gerth, R.: Durability of polyolefin geosynthetic drains. *Geosynthetics International*, 16(2009), H. 1, pp. 28-42.

⁵ Schröder, H. F.: Ermittlung des Einflusses der alkalischen Hydrolyse auf die Langzeitbeständigkeit von hochfesten Polyester (PET)-Garnen für Geotextilien (Determination of the influence of alkalitic hydrolysis on the long-term durability of high-tenacity polyester (PET) yarns for geotextiles). Fraunhofer IRB Verlag, 1999.

posed as little as possible to UV radiation, since this usually has a marked effect on plastics. UV-radiation degrades the stabilization and can initiate autocatalytic reactions which then continue even after covering. Deviating from DIN EN 12224, the basic rule is therefore that all products, even those with high weathering resistance, must be covered at the end of each working day if possible, but no later than one week after installation.

3.2.4. Resistance to Micro-Organisms

The resistance to the possible soil microbial attacks soil-burial tests is determined according to DIN EN 12225 in microbially active earth checks (see Table 3a No. 3.3). This test is generally unnecessary for geotextiles made of polyolefins, PET and polyamide.

3.2.5. Environmental Compatibility of Additives and Processing Aids

Leachable or water-soluble additives and processing aids (e.g. finishes) must be environmentally friendly. This must be demonstrated according to the procedure given in the FGSV leaflet⁶ Section 6.28.

4. In-House⁷ and Third-Party Production Quality Control

In accordance with Annex 1 no. 2.1 of the Landfill Ordinance, DepV, regular in-house and third-party inspection must be carried out to ensure consistent quality of both the production of the pre-products and of the geotextile. These activities must be incorporated in a quality-management system certified in accordance with DIN EN ISO 9001.

As a matter of principle, the in-house QC or "the sys-

⁶ M Geok E - Merkblatt über die Anwendung von Geokunststoffen im Erdbau des Straßenbaues mit den Checklisten für die Anwendung von Geokunststoffen im Erdbau des Straßenbaues (C Geok E).

M Geok E - Note on the application of geosynthetics in road-construction earthworks with checklists for the application of geosynthetics in road-construction earthworks (C Geok E).

⁷ In the construction industry (Construction Products Directive), in-house quality control is now termed factory production control (FPC).

tem of factory production control" in the production of the geotextile must comply with the requirements of DIN EN 13257 Section 5.4 and Annex A.

The valid certification document, the organigram detailing responsibilities, and the manufacturer's quality-management manual including testing schedules must be submitted to the Certification Authority.

Table 4 describes the extent and the interlocking of goods-received controls, the tests of in-house QC and of third-party inspection. The type and frequency of testing must be agreed with the certifying body and described in the Annex to the Certificate of Approval.

4.1. Goods-received Controls and Tests

The relevant manufacturer of the pre-products must check that the resins and additives – e.g. the base polymer and the additive batches – used in the pre-products are the same as those used in the production of test samples for the Certification procedure and must issue a corresponding acceptance test certificate 3.1 based on DIN EN 10204. The test results must be documented for each pre-product delivery by an inspection certificate 3.1.

The type and frequency of the incoming QC checks and tests on the pre-products required of the geotextile manufacturer are stipulated based on Tables 4 and 5 in the Annex to the Certification Document.

4.2. In-House Production Quality Control

In the scope of the in-house manufacturing QC of the geotextile, specific characteristic properties must be checked. Table 5 describes procedures and specifies frequencies for tests which must be carried out.

The type and frequency of the tests required of the geotextile manufacturer are stipulated based on Tables 4 and 5 in the Annex to the Certification Document. Here, the product-related requirements and tolerances specified in the Certification Document must be achieved.

The test data must be archived for 10 years so as to provide traceability of the test results for any given delivered unit. This test data must be made available to the Certification Authority upon demand.

An acceptance test certificate 3.1 based on DIN EN 10204 must be issued for each shipment. It must be possible to assign the test values in the acceptance test certificate to the rolls on which they were measured.

4.3. Third-Party Inspection

Production of the geotextile must be subject to inspection by a neutral third-party institute approved by BAM (see Section 10). This institute must have sufficient qualified personnel, possess the necessary test equipment, fulfill the requirements of the DIN EN ISO/IEC 17025 and of the DIN EN ISO/IEC 17020 standards and be approved by the certification body as a third-party inspector. A prerequisite for this approval is accreditation for the standard tests conducted in third-party inspection. Tests for which the testing and inspection body is not accredited may be carried out by an accredited laboratory as a subcontractor. The valid inspection contract between manufacturer and inspection agency must be submitted to BAM.

The inspection includes a material identification, verification and control of pre-products and the testing of the properties of the geotextiles, as well as audits of their manufacture and the factory production control. For monitoring purposes, DIN 18200 and the inspection contract are authoritative documents. The inspection contract must take the following requirements into account:

- At the start of production, the third-party inspector must satisfy himself that the prerequisites for proper manufacturing and appropriate in-house QC are fulfilled.
- In the third-party monitoring of the production of the pre-products and the geotextile, the tests listed in the Annex to the Certification Document for the identification and the properties of the pre-products and the geotextile must be performed (see Table 4). During the inspection visit, the laboratory and production must be visited and the records examined to monitor the in-house QC system and its extent.
- The third-party inspection must be carried out twice per year. Material sampling for the production test must be carried out by the third-party

inspector. When a product family is monitored, one product from the family must be checked every six months. The third-party inspector selects the product in accordance with production planning. He should ensure that different products are included in the inspection.

The inspection visits must normally be unannounced. Proof that third-party inspection has been carried out is confirmed by the current inspection report, in which the external monitoring body presents its test results. The report is sent to the manufacturer being inspected on a regular basis.

In the event that defects are discovered, the third-party inspection institute will decide what measures must be taken. Should repeated or serious deficiencies be discovered, the inspection institute must inform BAM accordingly.

4.4. Shipping Documents

The requirements of in-house and third-party inspection also dictate the requirements on the nature and extent of the papers which must be included with a shipment of the geotextile to document its quality. A delivery note with details of the manufacturer, the product-type designation, a list of roll numbers and dimensions is required. This includes an acceptance test certificate 3.1 based on DIN EN 10204 for the geotextile with information on the lot numbers of materials processed in the pre-products. The third-party inspection certificate and the full Certification Document must be available on the site; in its annex this document contains the requirements for in-house and third-party inspection, and the transport, storage and installation instructions.

5. Requirements for Installation

Certified geotextiles for filtration and separation may be installed only by specialist installation contractors who meet the requirements of the BAM Certification Guidelines for Installation Contractors. Proof of the required qualifications, equipment and experience can be demonstrated e.g. by the recognition as a specialist contractor by the quality-supervisory society of an industrial association demanding full

compliance with the requirements of the Guidelines and inspection by an independent test institute recognized for its expertise and experience⁸.

This requirement must in any case always be met whenever other geosynthetics (geomembranes and geosynthetic drainage elements) are installed in the sealing system by specialist installation contractors. In all other cases, installation personnel must be trained in advance by a qualified specialist. This includes an introduction to dealing with the installation drawings, to the type and handling of transportation devices, to the laying and fixation technique, to the design of transverse and longitudinal joints and penetration jointing techniques, to the requirements of the quality assurance plan and sampling for measures of self-inspection of the installation contractor and finally to the handling of the devices and the procedure for the installation over geotextiles already laid. Content, participants, time and duration of the training must be documented and be checked by the third-party inspector.

5.1. Verification of Stability

A verification of the stability of the sealing system must be carried out for each individual landfill project in accordance with recognized engineering practice. This applies in particular to the slip planes between the geotextile and the soil or the drainage layer. In the installed state, the geotextiles may not be subjected to any permanent tensile stress resulting from forces acting down the slope, from lateral spreading forces, etc. The verification of stability must therefore particularly demonstrate that such stressing will not occur. The geotextile may not be used as reinforcement.

To this end shear tests according to DIN EN ISO 12957-1 must where appropriate be

⁸ The German trade associations of geomembrane manufacturers and installation companies, the Arbeitskreis Grundwasserschutz e.V. (AK GWS) (industrial association of geomembrane manufacturers and installers), and the Arbeitsgemeinschaft Abdichtungssysteme eV. (AGAS e.V.) (committee on waterproofing systems) have established a quality-supervision system of this type based on the BAM recommendations. The quality supervision is realized by auditing and inspection of specialist installation contractors by BAM. The companies which have undertaken to be quality supervised by AK GWS e. V. or AGAS e. V. meet the requirements of this Directive.

carried out under the particular conditions of the project to determine the friction parameters.. Taking into account the reduction factors for material reactions and the safety factors for the actions, it must then be verified that stability is ensured with the required degree of safety.

To verify the stability of the sealing structure both under construction, at any particular intermediate stages and in its finished state, and to determine friction parameters, refer to the GDA--recommendations E 2-7 "Stability of sealing systems opposite sliding", E 2-21 "Verification of safety opposite lateral spread and deformation estimation for the landfill base" and E 3-8 "Frictional behavior of geosynthetics".

5.2. Measures against Stressing caused by Installation and Construction

The placing of soils and the coarse gravel of the drainage layers gives rise to particular loading of the geotextiles. The construction procedures must be chosen such that the geotextiles are not damaged. The placing of granular materials must avoid any drawing or distortion of the geotextiles and not lead to the formation of folds.

Individual geotextile rolls must overlap by at least 50 cm.

The geotextile may not be directly trafficked. The first layer of material should be placed by front-dumping, and then distributed without sliding the material over the geotextile; only after this should it then be compacted. This first layer should be at least 30 cm thick. For the delivery and distribution of the material, appropriate haul roads with a thickness of at least 1 m should be built in the same way. Other placement methods can be used if their suitability is verified in a trial installation.

The geotextile must be covered at the end of each working day if possible, but no later than one week after installation.

5.3. Quality Management, Third-party Inspection

The geotextiles are part of the landfill-liner system. Their installation is therefore regulated by the quali-

ty-management measures required in the DepV. The DepV foresees a three-part system of quality management in which the self-inspection of the installer responsible for the quality of his work, the third-party testing by an independent third party, and the monitoring by the competent authority ensure that the landfill-liner system is constructed with the designed quality characteristics (see also the GDA recommendation E 5-5 "Quality Monitoring for Geosynthetics")

The quality-management measures are based on the quality-management plan, which must include the installation of the geotextiles. Quality-assurance plans are an integral part of the quality-management plan for the auditing of the individual components of the sealing system. In establishing the quality-assurance plan for the geotextiles and in their installation as well as in the related verification tests, the terms and conditions of the Certification Document and the transport, storage and installation instructions specified in the Annex to the Certification Document for the geotextiles must be observed. Standard quality-assurance plans for geosynthetic products can be found on the BAM Internet page.

The preparation of an installation plan is one of the features of the quality-management measures. Unambiguous information on the location and type of the geotextiles placed must be included in the installation plan.

Third-party inspection must be carried out by a qualified and experienced organization with adequate personnel and equipment. The requirements that must be fulfilled with regard to the qualifications and duties of the third-party inspector are described in the BAM Guidelines for Third-Party Inspectors. The choice of the third-party inspector and the extent of his duties must be agreed with the responsible authorities. The costs of third-part inspection are borne by the Landfill Operator. The third-party inspector works closely with the responsible authority. The quality-assurance measures and the type and extent of tests on geotextiles in the scope of third-party inspection are listed in Tables 6 and 7.

The third-party testing body should be consulted at the planning stage to ensure that the design of geosynthetics is both professional and takes account of specific material characteristics, and that the state of

the art is taken into account in the specification documents and the quality-assurance plan.

6. Design

The design of the mechanical (soil-retention capacity) and hydraulic filter effectiveness (water permeability of the soil-infiltrated geotextile) must be carried out according to the rules and regulations of the DVWK Advisory Guideline⁹. There is no written set of rules for geotextile separation layers. Advice can be found in the FGSV Advisory Guideline¹⁰.

7. Changes, Notification of Defects and Period of Validity

Changes to the object certified, i.e. to the materials, the pre-products, the geotextiles, the dimensions, the production process, the production location, or the intended use, require a new Certification or a supplement thereto. If the requirements, terms, and conditions of approval are violated in the production, transportation or installation, the filtration or separation layer thus manufactured and placed is not suitable for purpose and not certified. The third-party production inspector and/or the authorities responsible for approving installation must report to BAM any repeated or serious deficiencies discovered in the manufacture and installation of the geotextiles, and any failures of landfill-liner systems associated with the object certified.

⁹ Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (Pub.): DVWK Merkblatt 221, Anwendung von Geotextilien im Wasserbau. Hamburg und Berlin: Verlag Paul Parey, 1992, 31 pages (out of print). See also Krug, M. and Heyer, D., "Geotextile Filter im Erd-, Straßen- und Deponiebau", *Geotechnik*, 21(1998), No. 4, pp. 314-326.

¹⁰ M Geok E - Merkblatt über die Anwendung von Geokunststoffen im Erdbau des Straßenbaues mit den Checklisten für die Anwendung von Geokunststoffen im Erdbau des Straßenbaues (C Geok E).
M Geok E - Note on the application of geosynthetics in road-construction earthworks with checklists for the application of geosynthetics in road-construction earthworks (C Geok E).

8. Tables of Requirements

Table 1: Characteristic Properties¹ of the Pre-Products (e.g. fibers, tapes etc.)

No.	Property	Requirement	Test method ²
1.1	Pre-product type	Exact description, e.g. type of fibers, type of yarns, production process, finish, post-treatment etc.	-
1.2	Titer	Manufacturer's specification	DIN EN ISO 1973-1: 2005
1.3	Maximum tensile strength	Manufacturer's specification	DIN EN ISO 5079-1: 2005
1.4	Elongation at Maximum tensile strength	Manufacturer's specification	DIN EN ISO 5079-1: 2005
1.5	OIT	Manufacturer's specification	ISO 11357-6: 2013
1.6	Density	Manufacturer's specification	DIN EN ISO 1183-1; Measurement on extrudate, anneal 1 h at 100° C in water bath
1.7	Melt flow rate	Manufacturer's specification	DIN EN ISO 1133-1: 2005
1.8	Enthalpy of fusion and melting point, glass-transition temperature	Manufacturer's specification	ISO 11357-3: 2013
1.9	Carbon-black content	Manufacturer's specification	Thermogravimetric analysis based on DIN EN ISO 11358 or determined in accordance with ASTM D 4218 or ASTM D 1603.
1.10	Stabilizer content	Manufacturer's specification	Solid/liquid extraction; UV-Spectroscopy or HPLC Analysis on the extract. In-house procedure
1.11	Content of carboxyl end groups	Manufacturer's specification	Based on GRI GG7 and ASTM D 7409 or in-house procedure.
1.12	Solution viscosity	Manufacturer's specification	GRI GG8

¹⁾ The selection of the test attributes depends on the material of the pre-products. Supplemental information may be necessary.

²⁾ Information and explanations on the tests can be found on the Internet site www.bam.de/de/service/amtl_mitteilungen/abfallrecht/index.htm.

Table 2: Characteristic Properties of Nonwovens for Filtration and Separation, and of Wovens for Separation

No.	Property	Requirement ¹	Test method
2.1	Type of geotextile	Exact description, e.g. type of fibers, type of yarns, type of bonding, type of weave, picks per inch, post-treatment etc.	-
2.2	Mass per unit area	$(\bar{x} - s) \geq 300 \text{ g/m}^2$ (For nonwovens) $(\bar{x} - s) \geq 250 \text{ g/m}^2$ (for wovens made from slit-tape or fibrillated fibers) $(\bar{x} - s) \geq 550 \text{ g/m}^2$ (for wovens made from multifilament yarns)	DIN EN ISO 9864, 10 specimens
2.3	Thickness	Manufacturer's specification	DIN EN ISO 9863-1, 10 specimens, Test pressure = 2 kPa
2.4	Tensile strength	$(\bar{x} - s) \geq 50 \text{ kN/m}$ (for wovens made from slit-tape or fibrillated fibers) $(\bar{x} - s) \geq 250 \text{ kN/m}$ (for wovens made from multifilament yarns)	DIN EN ISO 10319, 5 specimens
2.5	Elongation at tensile strength	Manufacturer's specification	DIN EN ISO 10319-1: 2005, 5 specimens
2.6	Static-puncture resistance	$(\bar{x} - s) \geq 2.5 \text{ kN}$ (for nonwovens)	DIN EN ISO 12236, 5 specimens
2.7	Plunger displacement at CBR force	$(\bar{x} - s) \geq 50 \text{ mm}$	DIN EN ISO 12236-1: 2005, 5 specimens
2.8	Dynamic-puncture behavior	Manufacturer's specification	DIN EN ISO 13433-1: 2005, 5 specimens
2.9	Characteristic opening size	Manufacturer's specification	DIN EN ISO 12956-1: 2005
2.10	Permeability normal to the plane	Manufacturer's specification	DIN 60500-4 ($i = 1: 20$ and 200 kPa load on filter, constant water head) and DIN EN ISO 11058

$(\bar{x} - s)$: = mean - standard deviation

Table 3a: Requirements for the Durability of the Geotextiles

No.	Property	Test Attribute	Requirement	Test and Test Conditions
3.1	Resistance to chemicals ¹ (concentrated liquid solutions) ²	Relative change in mass per unit area m	$\delta m \leq 25 \%$	Immersion tests based on DIN EN 14414. Storage temperature 23 ° C; Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Samples must be stored for at least 90 days and in any case until no further change in weight is measured. Tensile test and sampling ² according to DIN EN 12226.
		Relative change in mean values of tensile strength T_{max} and elongation at max. tensile strength ϵ_{max} .	$\delta T_{max} \leq 25 \%$ $\delta \epsilon_{max} \leq 25 \%$	
3.2	Weathering resistance	Relative change in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	High resistance to weathering	DIN EN 12224: 2005
3.3	Resistance to Micro-Organisms	Relative change in mass per unit area m and	$\delta m \leq 10 \%$ $\delta n \leq 10 \%$	DIN EN 12225, soil-burial testing in microbe-active soil. Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Tensile test and sampling ² according to DIN EN 12226.
		Relative change in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	$\delta T_{max} \leq 10 \%$ $\delta \epsilon_{max} \leq 10 \%$	

¹⁾ Additional information and explanations on the tests can be found on the Internet site www.bam.de/de/service/amtl_mitteilungen/abfallrecht/index.htm.

²⁾ The orientation of sampling is chosen such that tensile testing is performed on the most critical component of the geotextile as regards aging.

Table 3b: Requirements for Resistance to Aging Processes in the Geotextiles¹

No.	Property	Test Attribute	Requirement	Test and Test Conditions
3.4	Resistance to thermal oxidative degradation in air	Change in external appearance	no pronounced changes	Air-oven aging based on DIN EN 13438; storage temperature 80° C; Storage time 1 year and a minimum of 4 withdrawals. Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Tensile test and sampling according to DIN EN 12226. Analytical methods for the measurement of change in stabilization; DSC for measurement of crystallinity.
		Relative change in crystallinity n	$\delta n \leq 10 \%$	
		Relative change in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	$\delta T_{max} \leq 50 \%$ $\delta \epsilon_{max} \leq 50 \%$	
		Relative change ² in the mass fraction of antioxidants c_s	$\delta c_s \leq 85 \%$	
3.5	Resistance to extraction	Change in external appearance	no pronounced changes	Hot-water storage based on DIN EN 14415. Water temperature 80° C; Storage time 1 year and a minimum of 4 withdrawals. Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Tensile test and sampling according to DIN EN 12226. Analytical method for measurement of change in stabilization. DSC for measurement of crystallinity.
		Relative change in crystallinity n	$\delta n \leq 10 \%$	
		Relative change ² in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	Phenolic antioxidants: $\delta T_{max} \leq 25 \%$ $\delta \epsilon_{max} \leq 25 \%$ HAS: $\delta T_{max} \leq 50 \%$ $\delta \epsilon_{max} \leq 50 \%$	
		Relative change ² in the mass fraction of antioxidants c_s	$\delta c_s \leq 85 \%$	

¹⁾ Additional information and explanations on the tests can be found on the Internet page of BAM at www.bam.de/de/service/amt_l_mitteilungen/abfallrecht/index.htm.

²⁾ In the case of nonwovens, depending on the mass per unit area, there may be a rapid decrease in the levels of antioxidants before a stable level is achieved. Such effects may have to be taken into account in the assessment.

Table 3b: (Contd.) Requirements for Resistance to Aging Processes in the Geotextiles¹

No.	Property	Test Attribute	Requirement	Test and Test Conditions
3.7	Hydrolysis in water (internal hydrolysis)	Change in external appearance	No pronounced changes	Hot-water storage based on DIN EN 12447; at least four temperatures (e.g. 55, 65, 75, 85° C). Storage time: at least one year and a minimum of 4 withdrawals. Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Tensile test and sampling according to DIN EN 12226. Analytical methods for the determination of the carboxyl end-group content or the solution viscosity. DSC to measure crystallinity and glass-transition temperature.
		Relative change of crystallinity n and glass transition temperature	$\delta n \leq 10 \%$	
		Relative change in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	Extrapolation in Arrhenius plot: $\delta T_{max} \leq 20 \%$ $\delta \epsilon_{max} \leq 20 \%$	
		Relative change of mean molecular weight δN	Extrapolation in Arrhenius plot: $\delta N \leq 50 \%$	
3.8	Hydrolysis in an alkaline medium (outer hydrolysis)	Change in external appearance	no pronounced change	hot-water storage based on DIN EN 12447. Gypsum suspension, hydroxyl ion concentration: 5×10^{-4} mol/l (corresponds to pH 11 at 20° C). Storage temperature 60° C. Storage time: at least one year and a minimum of 4 withdrawals. Storage of samples from which at least 5 test pieces for the tensile tests can be punched out. Tensile test and sampling according to DIN EN 12226. Analytical methods for the determination of the carboxyl end group content or the solution viscosity. DSC to measure crystallinity and glass-transition temperature.
		Relative change of crystallinity n and glass transition temperature	$\delta n \leq 10 \%$	
		Relative change in mean values of tensile strength T_{max} and elongation at tensile strength ϵ_{max}	$\delta T_{max} \leq 25 \%$ $\delta \epsilon_{max} \leq 25 \%$	
		Relative change of mean molecular weight δN	$\delta N \leq 50 \%$	

¹⁾ Additional information and explanations on the tests can be found on the Internet page of BAM at www.bam.de/de/service/amtI_mitteilungen/abfallrecht/index.htm.

Table 4: Measures for Quality Assurance and Material Identification

No.	Property and Test Attribute	Acceptance test certificates for primary products	Inspection of incoming goods and in-house monitoring	Third-party Quality Control	Certification Testing
	Resin				
4.1	Melt flow rate	■			■
4.2	Density	■			■
4.3	Molecular-weight distribution				c.d.
4.4	Additives				c.d.
4.5	Carboxyl end-group content or solution viscosity				c.d.
	Masterbatch				
4.6	Formulation				c.d.
	Finish				
4.7	Formulation				c.d.
	Primary products				
4.8	Melt flow rate		■	■	■
4.9	Density				■
4.10	Dimensions or titer	■	■		■
4.11	Strength and elongation	■	■		■
4.12	OIT or analytical determination of stabilizer content		■ ¹	■ ¹	■
4.13	Carboxyl end-group content or solution viscosity			■ ¹	■
	Geotextile				
4.14	Mass per unit area		■	■	■
4.15	Thickness		■	■	■
4.16	Maximum tensile strength/elongation		■	■	■
4.17	Static-puncture resistance (geosynthetic CBR test)		■	■	■
4.18	Characteristic opening size		■	■	■
4.19	Permeability normal to the plane		■	■	■
4.20	Check on needle breakage		■		

c.f. = confidentially filed

¹⁾ Once per production year, and for one product from the product family. The choice of the identification test depends on the base material.

Table 5: Type and Extent of Tests within the Scope of in-house QC

No	Characteristic	Test method	Test frequency ¹
5.1	Mass per unit area	see Table 2	every 3,000 m ²
5.2	Thickness	see Table 2	every 3,000 m ²
5.3	Tensile strength and elongation at tensile strength	see Table 2	every 15,000 m ²
5.4	Static-puncture force and plunger displacement	see Table 2	every 15,000 m ²
5.5	Cone-drop test	see Table 2	In accordance with the provisions for the CE-marking.
5.6	Characteristic opening size	see Table 2	every 50,000 m ²
5.7	Permeability normal to the plane	DIN EN ISO 11058	every 50,000 m ²

Proposed values; peculiarities in the production process and harmonized test frequencies are considered in individual cases.

Table 6: Type and Extent of Tests on Geotextiles within the Scope of Third-Party Inspection on the construction site

No.	Test Attribute	Test	Frequency	Requirement and Tolerances
8.1	Thickness	DIN EN ISO 98631	at least every 5,000 m ²	Requirement defined in certification report
8.2	Mass per unit area	DIN EN ISO 9864	at least every 5,000 m ²	Requirement defined in certification report
8.3	Tensile strength and elongation at tensile strength ¹	DIN EN 29073-3: 2001	at least every 5,000 m ²	Requirement defined in certification report
8.4	Static-puncture force and plunger displacement	DIN EN ISO 12236	at least every 5,000 m ²	Requirement defined in certification report
8.5	Characteristic opening size	DIN EN ISO 12956	Once based on the total shipment for the construction phase.	Requirement defined in Certification Document

¹⁾ For the evaluation of the test results, the correlation between the test results according to DIN EN 29073-3 and those according to DIN EN ISO 10319 must be determined.

Table 7: Quality Assurance for the Installation of Geotextiles for Filtration and Separation

No.	Date and time of test	Parameters	Test method	Requirements	Sampling grid	Testing by	
						FPC	SI/TPI
7.1	Bid submission	Proof of suitability, Data sheets Certification Document	Checking on validity/completeness and conformity	Certification Document Third-party inspection contract, date of last monitoring results	The products foreseen	-	SI (CD) TPI (A)
7.2	4 weeks before commencement of construction	Filter effectiveness	Check for completeness	GDA E 2-9, DVWK 221, FGSV	All relevant sections	-	SI (CD) TPI (A)
		Sliding-stability verification, shear parameters	Check for completeness and compliance with project specifications	Verification of sliding stability according to GDA E 2-7 during and after construction, shear parameters according to GDA E 3-8 project-related	All relevant sections	-	SI (CD) TPI (A)
		Installation plans, manufacturer's installation instructions	specialist review as regards completeness	Taking into account major and subordinate gradients, installation base	each plan	-	SI (CD) TPI (A)
7.3	Delivery	Delivery protocols Factory-inspection reports	Check for completeness and compliance with project specifications; Identification	According to data sheet, Bill of Quantities, Certification Document EN 10204-3.1 B	every delivery	(A)	SI (CD) TPI (A)
		Appearance	Visual inspection	No transport errors, intact packaging, proper Marking	every delivery	(A)	SI (A) TPI (RS)
		Transport and Storage	Visual inspection	Storage area meets requirements, professional transportation	every delivery		SI (A) TPI (RS)

FPC = factory production control; SI = self-inspection (site); TPI = third-party inspection (site); A = active inspection; RS = random sampling; CD = check of documentation

Table 7: Quality Assurance for the Installation of Geotextiles for Filtration and Separation

No.	Date and time of test	Parameters	Test method	Requirements	Sampling grid	Testing by	
						FPC	SI/TPI
7.4	Installation	<i>Geotextile:</i> Identity in accordance with manufacturer's specification	Visual inspection	Conformity with delivery documents	every unit installed	-	SI (CD) TPI (CD)
		Placement by slope-direction or layout plan	Visual inspection, measuring	Installation instructions, installation plan	every geotextile, random samples	-	SI (A) TPI (RS)
		Overlap	Visual inspection, measuring	≥0.5 m	every overlap;	-	SI (A) TPI (A)
		External appearance	Visual inspection	Integrity	every geotextile;	-	SI (A) TPI (A)
7.5	Cover layer	Placement of soil layer	Visual inspection, measuring	Installation immediately after release, no displacements/distortions and folds in the geotextile; no direct trafficking, haul roads ≥ 1 m, installation by "front-dumping"	first layer placed	-	SI (A) TPI (A)

FPC = factory production control; SI = self-inspection (site); TPI = third-party inspection; A = active inspection; RS = random sampling; CD = check of documentation

9. List of Standards

The currently valid version of the standard is applicable.

ASTM D 1603;	Standard Test Method for Carbon-Black Content in Olefin Plastics
ASTM D 7409;	Standard Test Method for Carboxyl End Group Content of Polyethylene Terephthalate (PET) Yarns
DIN 18200: 2000	Assessment of conformity for construction products - Certification of construction products by certification body – factory production control, third-party inspection and certification of products
ISO 60500-4: 2007	Geotextiles and geotextile-related products – Part 4: Determination of water permeability normal to the plane under load at constant hydraulic head
DIN EN 10204: 2005	Metallic products – Types of inspection documents
DIN EN 12224: 2000	Geotextiles and geotextile-related products – Determination of resistance to weathering
DIN EN 12225: 2000	Geotextiles and geotextile-related products – Test methods for determining the microbiological resistance by a soil burial test
DIN EN 12226: 2012	Geosynthetics - General test methods for assessment after durability tests
DIN EN 12447: 2002	Geotextiles and geotextile-related products – Test methods for determining the resistance to hydrolysis in water
DIN EN 13257: 2010	Geotextiles and geotextile-related products – required properties for application in the disposal of solid waste
DIN EN 14414: 2004	Geosynthetics – Screening test method for determining chemical resistance in landfill applications
DIN EN 14415: 2004	Geosynthetic barriers - Test method for determining the resistance to leaching
DIN EN 29073-3: 1992	Textiles; Test methods for nonwoven fabrics; Part 3: Determination of the maximum tensile strength and the elongation at maximum strength
DIN EN ISO 1133-1:2012	Plastics – Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics
DIN EN ISO 1183-1:2013	Plastics - Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pycnometer method and titration method
DIN EN ISO 1973:1995	Textiles - determination of linear density – gravimetric method and vibroscope method
DIN EN ISO 5079:1996	Textiles - Fibers - Determination of breaking force and elongation at break of individual fibers
DIN EN ISO 9001:2008	Quality-management systems - Requirements
DIN EN ISO 9863-1:2014	Geosynthetics – Determination of thickness at specified pressures – Part 1:
DIN EN ISO 9864:2005	Geosynthetics - Test method for determination of the mass per unit area of geotextiles and geotextile-related products
DIN EN ISO 10319: 2013	Geosynthetics - Wide-width tensile test
DIN EN ISO 10320:1999	Geotextiles and geotextile-related products – Identification on site
DIN EN ISO 11058:2010	Geotextiles and geotextile-related products - Determination of water permeability characteristics normal to the plane, without load
DIN EN ISO 11358-1:2014	Plastics – Thermogravimetry (TG) of polymers - General principles
DIN EN ISO 12236:2006	Geosynthetics – Static puncture test (CBR test)
DIN EN ISO 12956:2010	Geotextiles and geotextile-related products – Determination of the characteristic opening size
DIN EN ISO 12957-1:2005	Geosynthetics – Determination of friction properties – Part 1: Shear-box test
DIN EN ISO 13433:2006	Geosynthetics - Dynamic perforation test (cone-drop test)
DIN EN ISO 13438:2005	Geotextiles and geotextile-related products - Screening test method for determining the resistance to oxidation
DIN EN ISO/IEC 17020: 2012	Conformity assessment – Requirements for the operation of various types of bodies performing inspection
DIN EN ISO/IEC 17025: 2003	General requirements for the competence of testing and calibration laboratories
DVWK-M 221:1992	Applications of geotextiles in hydraulic engineering
FGSV – M Geok E-StB:2005	Note on the application of geosynthetics in road-construction earthworks
GDA E 2-7:2008	Sliding stability of the sealing systems
GDA E 2-9:2005	Application of geotextiles in landfill construction
GDA E 2-21:1997:	Stability against lateral spreading and deformation estimation for landfill base

GDA E 3-8:2005	Friction behavior of geosynthetics
GDA E 5-5:2010	Quality monitoring for geotextiles
GRI-GG7:2012	Carboxyl end group content of PET Yarns
GRI-GG8:2012	Determination of the Number Average Molecular Weight of PET Yarns Based on Relative Viscosity Value
ISO 11357-3: 2011	Plastics - Differential scanning calorimetry (DSC) - Part 3: Determination of melting and crystallization temperature and of the enthalpy of melting and crystallization
ISO 11357-6: 2008	Plastics - Differential scanning calorimetry (DSC) - Part 6: Oxidation induction time (isothermal OIT) or temperature (isodynamic OIT)

10. Annexes to Certification Document, List of State Codes, Testing and Inspection Bodies

Annex to Certification Document

- Annex 1: Requirements and tolerances for in-house and third-party inspection,
- Annex 2: Exact designation of the manufacturer with production sites
- Annex 3: Description of the manufacturing process
- Annex 4: Manufacturer's raw-material declaration (resin type, carbon-black percentage, use of process recycled material, pre-products)
- Annex 5: Description of marking system and arrangement
- Annex 6: Description of location of markings
- Annex 7: Description of roll labels
- Annex 8: Description of quality-assurance measures
 - a) In-house inspection
 - b) Third-party inspection
- Annex 9: Manufacturer's storage and transport instructions

State Codes

(from Bundesarbeitsblatt 4/91, page 61):

Baden-Württemberg	01	Lower Saxony	07
Bavaria	02	North Rhine-Westphalia	08
Berlin	03	Rhineland Palatinate	09
Brandenburg	12	Saarland	10
Bremen	04	Saxony	14
Hamburg	05	Saxony-Anhalt	15
Hesse	06	Schleswig-Holstein	11
Mecklenburg-Vorpommern	13	Thuringia	16

Testing and notified bodies for suitability testing and production QC

Kiwa TBU GmbH
Gutenbergstr. 29
48268 Greven
Tel.: 02571 9872-0, Fax: 02571 9872-99, e-mail: tbu@tbu-gmbh.de

Materialforschungs- und -prüfanstalt Weimar (MFPA)
Fachgebiet Geotechnik
Coudraystr. 4
99423 Weimar
Tel.: 03643 564-0, Fax: 03643 564-201, e-mail: info@mfpa.de

Materialprüfanstalt für Werkstoffe und Produktionstechnik (MPA) Hannover
An der Universität 2
30823 Garbsen
Tel.: 0511 762-4362, FAX.: 0511 762-3002; e-mail: info@mpa-hannover.de

SKZ – TeConA GmbH
Friedrich-Bergius-Ring 22
97076 Würzburg
Tel.: 0931 4104-142, Fax: 0931 4104-273, e-mail: tecona@skz.de