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Plastics — Determination of the degree of disintegration of plastic materials in marine habitats under real field conditions

Plastiques — Détermination du degré de désintégration des matériaux plastiques dans les habitats marins en conditions réelles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Environmental aspects*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Even though plastics that are biodegradable according to established land-based treatment standards are not and never were intended as a solution to marine littering, the United Nations Environment Programme (UNEP) recognizes that "biodegradability in seawater" can be part of the solution (EuBP, 2016; UNEP, 2016). Hence, plastic materials that are biodegradable might be used as a potential alternative option in order to reduce the residence time of plastic waste in case of dispersion. Thus, the degree and rate of disintegration is of interest in order to determine the durability of products when exposed to the marine environment and the physical disappearance of waste in case of dispersal.

This document describes a disintegration test performed in two different marine habitats under real field conditions. The relative durability of plastic materials of the same size and form may vary depending on the location of the exposure, seasonal variations, the climatic conditions, water movement, tides, availability of nutrients, and diversity and density of the competent microbial community. Hence, it is recommended to perform the disintegration test in regions where the plastic material is likely to end up in the coastal environment for accidental or deliberate reasons.

This document describes a disintegration test and not a biodegradation test, as the conversion of the plastic materials is not determined by means of measuring the O_2-consumption or the CO_2-evolution.

The assessment of the intrinsic aerobic biodegradability of plastic materials exposed to marine environment is covered by ISO 22403.

The determination of the degradation and durability of plastic materials floating on the surface of seawater or partially or completely immersed in coastal shallow seawater under real field conditions is covered by ISO 15314.

Plastics — Determination of the degree of disintegration of plastic materials in marine habitats under real field conditions

1 Scope

This document specifies test methods for the determination of the degree of disintegration of plastic materials exposed to marine habitats under real field conditions.

The marine areas under investigation are the sandy sublittoral and the sandy eulittoral zone where plastic materials can either be placed intentionally (e.g. biodegradable fishing nets) or end up as litter due to irresponsible human behaviour. This depends on their physical characteristics, form and size of the materials, and on water currents and tidal movements.

This document specifies the general requirements of the apparatus, and the procedures for using the test methods described.

The determination of the level of disintegration of plastic materials exposed to pelagic zones such as the sea surface or the water column above the seafloor are not within the scope of this document.

This document is not suitable for the assessment of disintegration caused by heat or light exposure.

The described field test is a disintegration test and not a biodegradation test. Therefore, it cannot be used for demonstrating biodegradation or for making unqualified claims such as “biodegradable in marine environment” and similar.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3310-2, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*

ISO 4591, *Plastics — Film and sheeting — Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)*

ISO 4593, *Plastics — Film and sheeting — Determination of thickness by mechanical scanning*

ISO 5667-3, *Water quality — Sampling — Part 3: Preservation and handling of water samples*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
biodegradation
degradation (3.2) caused by biological activity, especially by enzymatic action, leading to a significant change in the chemical structure of a material

[SOURCE: ISO 472:2013, 2.1680]

3.2
degradation
irreversible process leading to a significant change in the structure of a material, typically characterized by a change of properties (e.g. integrity, molecular mass or structure, mechanical strength) and/or by fragmentation, affected by environmental conditions, proceeding over a period of time and comprising one or more steps

[SOURCE: ISO 472:2013, 2.262]

3.3
disintegration
physical breakdown of a material into small fragments

[SOURCE: ISO 472:2013, 2.1757]

3.4
pelagic zone
water body above the seafloor

Note 1 to entry: Also referred to as the open water or the water column.

Note 2 to entry: The surface of the pelagic zone is moved by wind-driven waves. It is in contact with the atmosphere and exposed to sunlight. With increasing depth pressure increase, temperature decreases, and light and surface wave energy are attenuated.

3.5
sublittoral zone
coastal seafloor that is permanently immersed and extends from the low-water line to the continental shelf edge at 200 m water depth

Note 1 to entry: The seafloor can consist of solid rock, or fragments that form sediments of different particle size, from coarse blocks and pebbles, to permeable sands, silt and clay. Sediments can form from fragmented rock or consist of fragments of biogenic origin (algae, shells, coral, etc.), or be a mixture of these compounds.

3.6
tidal zone
borderline between sea and land that extends from the high tide line, which is rarely inundated with water, to the low tide line, which is typically always covered with water

Note 1 to entry: The tidal zone is frequently a sandy area that is kept constantly damp by the lapping of the waves.

Note 2 to entry: Stony and rocky shorelines also exist.

Note 3 to entry: Synonyms are: eulittoral zone, midlittoral zone, mediolittoral zone, intertidal zone, foreshore.

[SOURCE: ISO 22404:2019, 3.1]

3.7
total dry solids
amount of solids obtained by taking a known volume of test material or compost and drying at about 105 °C to constant mass

[SOURCE: ISO 472:2013, 2.1872]

3.8
volatile solids
amount of solids obtained by subtracting the residues of a known volume of test material or compost after incineration at about 550 °C from the *total dry solids* (3.7) content of the same sample

Note 1 to entry: The volatile solids content is an indication of the amount of organic matter present.

[SOURCE: ISO 472:2013, 2.1889]

4 Principle

The disintegration test is a real field test performed under natural environmental conditions in two different coastal regions. Concerned habitats are the eulittoral and the sublittoral zone where plastic materials can end up once dispersed in the sea.

NOTE Plastic materials predominately floating in pelagic zone are not covered by this document.

The test material, preferably in the form of a film, is fixed in non-degradable plastic frames and both sides of the material are protected by a plastic mesh with limited defined mesh size (2 mm) in order to avoid sample loss once the disintegration process has started. Several frames with fixed test specimens are exposed to the eulittoral zone where the material is subjected to the tides and severely fluctuating weather conditions, and to the seawater - sediment interface in the sublittoral zone where less rough environmental conditions are likely to be expected.

The disintegration is determined and reported after an exposure period of three years. However, the disintegration can be investigated in additional samples with exposure periods below or beyond three years, provided that the test procedure and the test evaluation are in accordance with this document.

At the end of the exposure period, the disintegration of the test material is measured by means of removing the protection mesh and sieving the remaining material through 2 mm mesh sieve. The disintegration of the test material is evaluated by comparing the residual material (total dry solids) retained by the 2 mm sieve by the amount introduced (total dry solids).

Alternatively, the disintegration of the test material can be determined as area loss (%) by means of image analysis (photogrammetry). Images of sampled test material specimen are analysed for the ratio between the disintegrated area versus total area of exposed film.

Even if results from different exposure periods are available indicating a constant increase of the disintegration of a test material, it is not allowed to extrapolate the degree of disintegration beyond the maximum exposure period.

5 Test procedure

5.1 Test material

Use the test material preferably in the form of film in an identical form (e.g. shape, thickness) as for the intended final use. The thickness of a film shall be either determined according ISO 4591 or ISO 4593.

Other forms than films, for instance articles such as foams or plates, can also be tested if test procedure and test evaluation are in accordance with this document.

5.2 Reference material

A poly(3-hydroxybutyrate-co-hexanoate) (PHBH) film[1)] of 25 µm to 30 µm thickness shall be used as a positive control. As a negative control a low-density polyethylene (PE-LD) film of 25 µm to30 µm thickness shall be used.

5.3 Preparation of test and reference materials

Test samples shall not be subjected to conditions or procedures, such as a pretreatment by heat and/or an exposure to radiation, designed to accelerate disintegration prior to testing according to this document.

A plastic material preferably in the form of a film is cut into pieces of 260 mm × 200 mm in size. A test specimen is covered with a non-degradable plastic mesh with a 2 mm × 2 mm mesh size on both sides to prevent eventual fragments from being lost. Use meshes of suitable shape with a screen of 2 mm as specified for instance in ASTM E11. The specimen covered by the meshes is then fixed between two non-degradable plastic frames of 260 mm × 200 mm and 200 mm × 160 mm external and internal dimension, respectively (see Figure 1). Typical non-biodegradable meshes are made of polyamide, polyethylene or polypropylene. The surface area of the film specimen which is exposed to the marine habitats is 320 cm^2.

Film specimen that is 200 mm × 160 mm in size (surface area 320 cm^2) can be used as an alternative fitting in the inner part of the plastic frame not fixed between two non-degradable plastic frames. The film is still covered by non-degradable plastic mesh preventing the loss of material during the exposure period.

Figure 1 — Film specimen covered with a non-degradable plastic mesh and fixed between two non-degradable plastic frames

5.4 Number of replicates

Provide a sufficient number of samples prepared according to 5.3, at least:

— five frames for the test material (F_T 1-5)

— five frames for the positive reference material (F_{pR} 1-5)

1) Supplier of PHBH-pellets: www.kaneka.be/documents/PHBH-brochure-11-2017.pdf. Use pellets to blow a film of 25 µm to 30 µm thickness. PHBH-pellets from Kaneka are an example of a suitable reference material. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the supplier named.

— five frames for the negative reference material (F_{nR} 1-5)

The frames shall be marked by appropriate means to ensure a clear and permanent allocation of each sample even after an exposure period of three years (see Figure 2).

Figure 2 — Code identifying that the sample is attached with a cable tie to the frame

The same number of replicates is requested if other forms than film, e.g. formed articles such as foams or plates, are tested.

The above outlined number of replicates is sufficient for the determination of the disintegration at the end of the exposure period after three years. Prepare the same number of replicates per sampling if samples with exposure periods below or beyond three years are planned, e.g. to better characterize the disintegration of a plastic material over time.

As this is a field test in different marine habitats, mechanical damage of test samples fixed between two plastic frames and protected by a 2 mm × 2 mm protection mesh cannot be excluded during the exposure period, possibly due to the erosive power of tides and sediment and activity of animals. Hence, it is recommended to increase the number of replicates for each material to compensate any loss of test specimens.

5.5 Exposure to marine habitats

The exposure of test specimens (see 5.3) to the seawater — seafloor interface at the sublittoral zone shall be performed according to the procedure described in Annex A.

The exposure of test specimens (see 5.3) to the eulittoral zone shall be performed according to one of the two procedures described in Annex B.

5.6 Termination of the field test

The disintegration is determined and reported after an exposure period of three years.

If test results from samples with exposure periods below three years are available revealing that no more than 10 % of the original mass (dw) of the exposed surface area (see Figure 1) remains in the oversize fraction after sieving through a 2 mm sieve (see 6.2), then the field test can be terminated before the three-year exposure period has been reached and the degree of disintegration can be determined. This also applies if the disintegration is determined by means of image analysis (photogrammetry) and more than 90 % of exposed surface area is lost.

Samples are carefully removed from the eulittoral and the sublittoral zone, rinsed in ambient seawater from the same exposure site, packed singly in zip-lock bags under wet conditions using the seawater from the same exposure site and stored in sealed containers for the transportation to the laboratory. After delivery, conserve the samples at low temperature (approximately 4 °C) until processing. It is recommended that the samples are analysed within 2 days after sampling. Record storage time and conditions.

6 Analysis and monitoring of the field test

6.1 Photographic documentation

The state and appearance of each replicate is documented by means of photographs at the beginning and the end of the field test.

NOTE Photographs can be used for documentation purposes and rating of the extent of biofouling.

6.2 Determination of disintegration

6.2.1 General

The degree of disintegration is determined either by means of a sieving procedure (see 6.2.2) or by means of image analysis (photogrammetry) (see 6.2.3).

Each test sample including the plastic frame and the 2 mm × 2 mm protection mesh is carefully checked for any possible mechanical damage. If mechanical damage is observed, in particular with the 2 × 2 mm protection mesh, the sample shall be discarded and not used for the determination of the disintegration.

6.2.2 Sieving procedure

6.2.2.1 General

Screen the samples for residual particles of the test material as follows.

If test specimen of 260 mm × 200 mm in size fixed between two non-degradable plastic frames have been used (see 5.3) in the field test, then the following procedure applies: it is recommended that the two plastic frames are not disassembled, as the part of a test specimen which is fixed between the two plastic frames and that was not directly exposed to seawater, is not considered in the calculation of the disintegration. The material of the exposure area including the meshes is quantitatively removed from the plastic frame by appropriate means, e.g. using a razor blade or applying any other suitable method. This procedure is not necessary if film specimen of 200 mm × 160 mm in size (surface area 320 cm^2) not fixed between two non-degradable plastic frames (see 5.3) have been used.

Carefully remove the 2 mm × 2 mm protection meshes and collect all visible plastic material attached to them.

Use sieves of suitable shape with screens of 2 mm and 10 mm mesh (as specified for instance in ISO 3310-2).

To exclude major errors adhering particles and/or fouling organisms shall be carefully removed from the remaining specimen material. If biofouling has been observed, sieve each of the samples through a standard 10 mm sieve, search the overflow carefully for particles in which pieces of test material remain. If necessary, break these up and collect the plastic material. Separate the sieved material further by sieving through a standard 2 mm sieve. From the 2 mm to 10 mm fraction thus obtained, pick out all particles of the test material, place them on a separate 2 mm sieve and clean carefully, if possible by washing them under running deionized water. Dry the cleaned particles at 105 °C (or at 40 °C for test materials with melting temperatures below 105 °C) until constant mass is reached. The mass of the test material not exposed to marine habitats is determined using film of 200 mm × 160 mm in size which corresponds to 320 cm^2. From the mass of total dry solids thus obtained, calculate the degree of disintegration as indicated in 6.2.2.2.

6.2.2.2 Calculating degree of disintegration

Add up the mass of the retrieved test material particles of all selected > 2 mm fractions (see 6.2.2.1) and compare it to the mass of the initial test material input (see 6.2.2.1). Calculate the degree of disintegration of the material, D_i, on the basis of the respective total dry solids using Formula (1):

$$D_i = \frac{m_1 - m_2}{m_1} \times 100 \quad (1)$$

where

D_i is the degree of disintegration of the test material, expressed in per cent (%);

m_1 is the mass of total dry solids in the test material input, expressed in grams (g);

m_2 is the mass of total dry solids in the retrieved test material, expressed in grams (g).

NOTE 1 D_i is, in practice, a measurement of mass loss where the lost mass is represented by all particles with dimensions < 2 mm. As such it can also be referred as mass loss percentage.

NOTE 2 The disintegration of plastic materials can be underestimated if small proportion of a biofilm (biofouling) cannot be completely removed from plastic debris.

6.2.3 Image analysis (photogrammetry)

6.2.3.1 General

The test specimen is secured between two protective meshes, fixed by two plastic frames (see 5.3). For photogrammetric analysis, the frames and the meshes are removed and a well-contrasted image of the specimen is produced by scanning the specimen on a flat-bed scanner or by planar photography. If the specimen is too fragile to be moved, only one protective mesh is removed, and the specimen is photographed lying on the other mesh.

If loose fragments occur, take care to include all fragments larger than the size of the protective 2 mm mesh. If fragments stick to both meshes, photograph both meshes and combines areas of non-disintegrated test specimen.

Using an image processing software, e.g. ImageJ (URL) or GIMP (URL) or similar, two regions of interest (*ROI*) are manually marked within the totally exposed area (*TEA*, i.e. the area exposed to the marine matrix, not covered by the frame): (1) ROI_{dis} is the area of disintegrated polymer where no test specimen is left, and, if applicable, (2) ROI_{fold} is the area where the polymer is folded either during the exposure period or during sample handling. Each *ROI* is marked in a distinct colour for later analysis. Disintegration is only considered for holes larger than one mesh unit (2 mm × 2 mm). If fouling organisms mask parts of the *TEA*, area is only considered to be disintegrated, if there is clearly no test specimen below the masked parts (see Figure C.1).

6.2.3.2 Calculating degree of disintegration

To calculate the disintegration in per cent, the folded area (ROI_{fold}) is subtracted from the disintegrated area (ROI_{dis}), which then is compared to the totally exposed area (*TEA*) [see Formula (2)].

$$D_i = \frac{ROI_{dis} - ROI_{fold}}{TEA} \times 100 \quad (2)$$

where

D_i is the degree of disintegration of the test material, expressed in per cent (%);

ROI_{dis} is the sum of all areas where the test specimen is marked as disintegrated, expressed in e.g. square centimetre (cm^2);

ROI_{fold} is the sum of all areas where the film is folded either during the exposure period or during sample handling, expressed in e.g. square centimetre (cm^2);

TEA is the totally exposed area, expressed in e.g. square centimetre (cm^2).

NOTE This method ignores the three-dimensionality of the polymer film, reducing it to a two-dimensional image. Disintegration is thought to start at the polymer surface proceeding to the interior of the material, rendering the specimen film thinner in the first instant, even if holes are not yet discernible. Thus, although the disintegration process has started, there will be no measurable disintegration before the thinning of the material has led to the formation of holes in the film.

An example of image analysis (photogrammetry) is shown in Annex C.

6.3 Analysing characteristics of plastic materials (optional)

If there is enough material left from the real field test at the end of the test period, test specimens that have been exposed to the different marine habitats may be analysed to monitor changes in other relevant physical (e.g. thickness in comparison with the original thickness), mechanical or chemical properties.

In addition, degradation rates such as mass loss rate, erosion rate and half-life ($t_{1/2}$) of the plastic material can be estimated using mathematical modelling. A prerequisite is the availability of sufficient data throughout the exposure period.

6.4 Monitoring environmental parameters (optional)

Environmental parameters have a great impact on the kinetics of the disintegration of plastic materials. Therefore, it is recommended that the relevant parameters listed in Table 1 are monitored in seawater samples to better characterize the marine habitats which the test specimens are exposed.

Table 1 — Monitoring of environmental parameters in seawater samples from the same marine habitats which the test specimens are exposed

Environmental parameter	Test method	Sampling interval
water temperature (°C)		
sandy sublittoral zone	manually or automatic data logger	at test start, monthly, at test end
tidal (eulittoral) zone		
salinity (PSU)	follow instructions of a conductivity (salinity) meter	at test start, half-yearly, at test end
pH	ISO 18191 or ISO 10523	
O_2-concentration (mg/L or %)	ISO 5814 or ISO 17289	
nutrient related data		
nitrogen (total-N, mg/L)	ISO 11261	
total carbon (TC; mg/L)	EN 1484	
total phosphorus (total-P; mg/L)	ISO 6878	

7 Demonstration of a biologically active marine environment (optional)

A 40 % disintegration of the positive control after three years is considered to satisfactorily demonstrate that the field test takes place in a biologically active marine environment.

This applies to both marine habitats, the eulittoral zone and the sublittoral zone.

It is recommended that the field test is to be repeated in another location if the positive sample has not been disintegrated by 40 % after 3 years.

8 Test report

The test report shall provide all relevant information in accordance with ISO/IEC 17025, particularly the following:

a) a reference to this document, i.e. ISO 22766:2020;

b) all information necessary to identify and describe the test material and the positive and negative reference materials such as total dry (at 105 °C) or volatile (at 550 °C) solids content, organic carbon content, mass-to-surface ratio, melt flow index, density, applied thickness, shape and visual appearance and trade or brand name (if available);

c) precise description of the test set-up used for exposure of test material in the eulittoral and the sublittoral zone;

d) geographical position of the eulittoral and the sublittoral zone including coordinates;

e) water depth at the sublittoral zone;

f) date of start of the exposure and test period (days);

g) observations made during the field test at the exposure sites;

h) applied maintenance operations during the exposure;

i) applied sampling and storage conditions;

j) photographs from test specimen (test item, positive and negative control) at the beginning and at the termination of the exposure to the eulittoral and sublittoral zone;

k) results obtained from photogrammetric methods (if applicable);

l) results obtained for disintegration of test specimen (test item, positive and negative control) in eulittoral and sublittoral zone. Residual amount of test materials and degree of disintegration (%) after an exposure period of three years (expressed in days), and — if applicable — after exposure periods below or beyond three years (expressed in days);

m) test method used to determine the degree of disintegration;

n) measured environmental parameters listed in Table 1 (if applicable);

o) mean water temperature of sandy eulittoral and sandy sublittoral zone [arithmetic mean, standard deviation (SD)];

p) measured characteristics of plastic materials (if applicable);

q) reasons for rejection of any test results;

r) any deviations from the test conditions described in this document.

Annex A
(normative)

Exposure to the sublittoral zone

A.1 Selection of exposure site in sandy sublittoral zone

The sublittoral zone (see 3.5) is the marine seafloor that starts below the tidal zone with shallow water and ends at the edge of the continental shelf. It is the test system where the plastic material is in contact with seawater and sediment as matrices. To guarantee that the test specimen is permanently covered by seawater and is exposed to a more stable situation with less erosive power, less exposure to light and less extreme temperature fluctuations compared to tidal (eulittoral) zone, the exposure on the seafloor shall take place at approximately 20 m to 200 m water depth.

As maintenance and sampling is easily done by means of self-contained underwater breathing apparatus (SCUBA) diving, it is recommended to perform tests between 20 m and 40 m water depth.

The exposure site shall not be contaminated by pollutions (e.g. oil, pesticides), or in close proximity of, for example, sewage treatment plant outflows or fish farm fallout. However, a continuous exchange of seawater at the exposure site by water currents will contribute to a sufficient oxygen and nutrient supply, supporting the disintegration and biodegradation of plastic materials by marine microorganisms.

A.2 Exposure of test specimens at seawater — Sediment interface

Film specimen that are fixed between two non-degradable plastic frames and covered with a non-degradable plastic mesh (see 5.3 and see Figure A.1) are anchored on the seafloor of the sublittoral zone by appropriate means: For example, as shown in Figure A.2, the requested number of film specimens (F_T, F_{pR}, F_{nR}; see 5.4) are randomly fixed to racks, and these in turn are mounted immovable on the seafloor. The distance between two specimen frames shall be at least 2 cm.

All materials and constructions used for the exposure of plastic materials shall be resistant to corrosion and shall not interact with or contaminate the specimens being exposed.

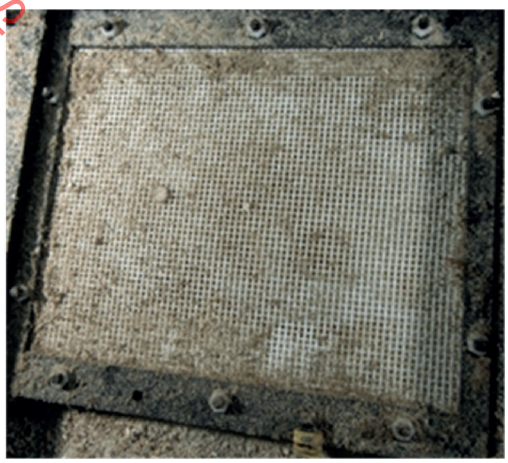


Figure A.1 — Film specimen fixed between two plastic frames and covered with plastic mesh (2 mm × 2 mm)

NOTE Specimen frames are fixed to a rack. The rack is anchored on the seafloor.

Figure A.2 — Specimen frames fixed to a rack

A.3 Monitoring and maintenance work

Experience has shown that, occasionally, sediment will move onto the samples, possibly by substantial water movement and activity of animals. This can lead to the situation that part of replicates is covered by sediment, while others are not. Also, under some of the samples marine organisms may make burrows over time, so that the samples do not touch the sediment anymore. It should be noted, however, that this document describes a test under real field conditions and not a laboratory test performed under standardized test conditions. Hence, the above-mentioned observations shall not be regarded as artefacts but as natural phenomenon. There is no obligation to exclude such affected samples from the determination of the disintegration according to 6.2. Any kind of such observations shall be documented in the report. Also, any applied maintenance work shall be reported.

It is recommended that seawater and sediment samples are taken at regular intervals to measure the environmental parameters specified in Table 1. Sampling, preservation, handling, transport and storage of liquid samples shall be in accordance with ISO 5667-3.

Test specimen are analysed according to 6.1 and 6.2.

Annex B
(normative)

Exposure to the eulittoral zone

B.1 Selection of exposure site in sandy eulittoral zone

This test system mimics an intertidal sandy beach in which plastic material is buried and experiences changing conditions, like wetness and dryness as a result of fluctuations in tides and waves.

To avoid destruction of the test setup, it is recommended to place the field test in an area protected against natural forces like extreme waves and storms by for instance a seawall, while still connected to the open sea, e.g. in a lagoon.

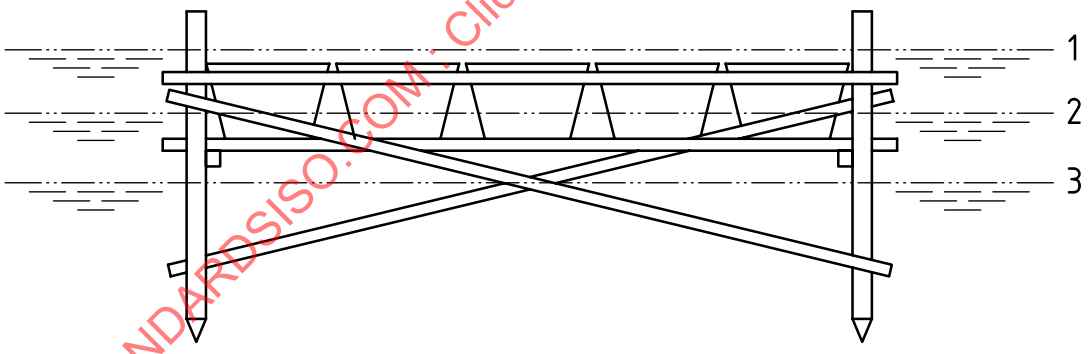
Plastic materials shall not be exposed at contaminated sites, such as in close proximity of sewage treatment plant outflows, fish farm fallout or at sites contaminated by severe pollutions like oil or pesticides.

Two alternative methods are described in B.2.

B.2 Exposure of test specimens at eulittoral zone

B.2.1 Exposure of test specimens under semi-controlled field conditions

Plastic (PP) bins of approximately 90 l volume are placed on a plastic rack in order to position the test specimens in the mid-water line (see Figure B.1).



Key

1 high water level
2 mid-water line
3 low water level

Figure B.1 — Schematic view of test setup: groups of 90 l-bins are fixed on a plastic rack

The bottom of the bins is perforated to allow ambient water to infiltrate. Two layers of plastic mesh (PVC-covered glass fibre 1 mm × 1 mm and polyamide gauze 280 µm × 280 µm, or equally functional materials) are placed above the holes to prevent loss of sediments.

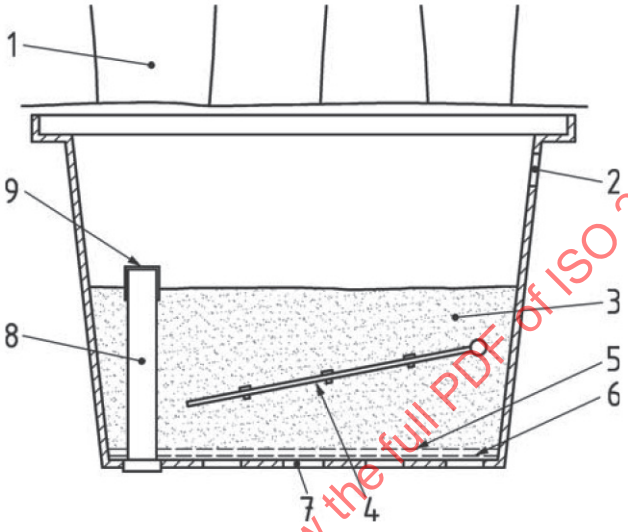
Each bin is filled with a layer of 15 cm to 20 cm of sand from the local beach. Specimen frames (see 5.3 and 5.4) are buried at a sediment depth of approximately 10 cm ± 5 cm with an inclination of about

10° ± 3° from horizontal to allow the overlaying water to run off after each flood event (see Figure B.2). To support this process, the minimum distance between two specimen frames shall be 2 cm.

Each bin is fitted with one test material (F_T), one positive reference material (F_{pR}) and one negative reference material (F_{nR}) frame.

The rack structures and bins may be covered by barbed-wire to prevent disturbance from birds.

All materials used for the exposure of plastic materials shall be resistant to corrosion and shall not interact with or contaminate the specimens being exposed.



Key

1 barbed-wire to deter birds
2 90 L-plastic bin
3 sand from the local beach (layer of 15 cm to 20 cm)
4 test item frame (buried at a sediment depth of ca. (10 ± 5) cm with an inclination of ca. (10 ± 3)° from the horizontal)
5 fine non-degradable mesh (280 µm mesh)
6 PVC-covered glass fibre 1mm × 1 mm and polyamide gauze 280 µm × 280 µm
7 perforations in bottom of the bin
8 equilibration pipe to facilitate drainage
9 fine mesh (280 µm mesh) on the top of pipe to allow for seawater outflow at high tide

Figure B.2 — Schematic view of test setup: technical equipment of a 90 l-bin

B.2.2 Exposure by direct embedding of samples in beach sand

The specimen frames (see 5.3 and 5.4) are randomly placed in an approximately (10 ± 5) cm deep pit on the beach with an inclination of about (10 ± 3)° from horizontal to allow the overlaying water to run off after each flood event. Frames are held in place by appropriate means, e.g. by fixing them on a rack which is anchored by metal supports. The pit is refilled with sand from the beach.

All materials and constructions used for the exposure of plastic materials shall be resistant to corrosion and shall not interact with or contaminate the specimens being exposed.