Appendix 4 to SPCR 141

Polymeric waste degradable by abiotic and subsequent biological degradation (A+B degradable) – Requirements and test methods

This appendix treats requirements and associated test methods to certify polymeric materials and products intended to be degraded abiotically in defined applications and thereafter biodegraded in specific disposal environments. This appendix is based on ASTM D 6954, CEN/TR 15822 and some parts of SS-EN 13432. A flowchart on the last page of this appendix gives an overview of the procedure for judgement.

1. Definitions

Polymeric waste refers to polymeric materials, polymeric products and composite polymeric products. For definitions of these three types, see the main document SPCR 141.

Polymeric waste referred to as degradable by abiotic and subsequent biological degradation **(A+B degradable)** is defined as waste that degrades abiotically (without living organisms) e.g. by hydrolysis or oxidation with or without sunlight and thereafter the residues resulting from the abiotic degradation are bio-assimilated by microorganisms in a specific disposal environment.

Disposal environment can be soil, aqueous environment, or any other defined biological active environment.

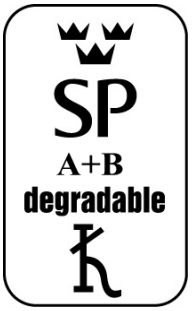
For definitions concerning biodegradable and compostable plastics we refer to documents CEN/TR 15351 “Plastics – Guide for vocabulary in the field of degradable and biodegradable polymers and plastic items” and ISO 14021 “Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)”.

2. Methods, certification and requirements

Certification can be obtained for the following oxobiodegradable (OBD) items:

2.1 Prodegradant system (PDS) or masterbatch (MB)
2.2 Material (M)
2.3 Final product (FP)

Approved OBD items can be marked with the SP´s symbol for the “A+B degradability” (see pictures below) along with a clarifying text.



Examples of SPs symbol (English and Swedish versions)

Any addition or exception from the requirements in this Appendix is specified separately for each OBD item under the respective headline.

During an initial test of a new OBD item, all the tests stated under the respective headline for each type shall be performed. PDS or MB shall be tested in a final material with a directed composition and thickness.

If nothing else is specified, the validity period for an achieved certificate is five to ten years depending on how exact the composition of a OBD item can be stated. . Surveillance inspection is performed according to the conditions stipulated in an ongoing inspection agreement between SP and the commissioner. During the validity period of the certificate, all parts of a complete initial test shall be performed before prolonging of the certificate can be made.

3. Chemical composition and characterization

All included components such as polymers, organic additives (plasticizers, impact modifiers, fibres, etc), inorganic fillers, pigments, stabilizers, pro-oxidants, etc shall be declared with chemical name and trade name, CAS-number and percentage of each component if possible. None of the included components present in more than 0,1 % of the dry weight of the final product may be officially classified as environmentally hazardous. In addition, a quantitative specification stating the following components is demanded for the final material or product:

3.1 total quantity of inorganic (inert) material
3.2 elements with the following high limit values according to EN 13432:

Element	mg/kg of dry substance	Element	mg/kg of dry substance
Zn	150	Cr	50
Cu	50	Mo	1
Ni	25,0	Se	0,75
Cd	0,5	As	5
Pb	50	F	100
Hg	0,5		

3.3 Unambiguous physical-chemical characterization of the material for reference. Suitable methods are for example one or several of the following methods: IR, UV-VIS, SEC, GC-MS, TGA, DSC, ICP-MS/OES, mechanical strength, etc.

Tier 1. Abiotic degradability

An abiotic degradation test shall simulate or accelerate the degradation processes likely to occur in a chosen application and disposal environment. Hydrolysis and thermal or photo-oxidation processes under dry or humid conditions are the most common.

If certification regards a PDS or MB, a final material or product with a directed composition and thickness shall be sent to SP by the applicant/manufacturer for the tests.

The extent of degradation shall be evaluated by measuring the loss in mechanical properties, decrease in molecular weight by SEC (size exclusion chromatography) and determination of gel content.

Type of test	**Standard**	**Requirements**
Abiotic degradation UV or thermal in dry or humid conditions, water, salt solution etc	E.g. ASTM D 6954 Tier 1, BS 8472, ISO 4611, ISO 4892-2	Average molecular weight Mw < 10 000, gel fraction < 10 %, elongation at break ≤ 5 % of the original value

The abiotic degradation must be sufficiently rapid in the chosen application so that the resulting material constitutes demonstrable biodegradable residues. However, under no circumstance the period of thermal peroxidation at 70 °C may exceed 4 weeks. The material shall not create harmful or persistent residues under defined disposal conditions.

Tier 2. Biodegradation

Prodegradant system (PDS) or masterbatch (MB) shall be tested according to the clause A. Material (M). Abiotically degraded material to be used in the subsequent biodegradability test shall be examined for the total quantity of organic and inorganic carbon (C) prior to the test.

A. Material (M)

A.1. Biodegradability

After the abiotic degradation process, the entire test material shall be examined for the ultimate biodegradability during optimal conditions in a simulated disposal environment. The test methods to be used may either be aerobic aqueous biodegradation according to ISO 14852, ultimate aerobic biodegradability in soil according to ISO 17556 or a particularly defined biological active environment.

Under mesophilic conditions in soil, materials shall biodegrade to at least 90 % within 24 months. If a material consisting of a single polymer (homopolymer or random copolymer) fails to reach 90 % during the period of maximum 24 months but reaches more than 60 % (absolute) without reaching a plateau this is considered to be a proof that the material is biodegradable.

Type of analysis (most frequent)	**Standard**	**Requirements**
Aerobic aquatic biodegradation - Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium – Method by analysis of evolved carbon dioxide	Based on ISO 14852	Biodegradation > 60 % or 90 % within 24 months
Biodegradation in soil Determination of the ultimate aerobic biodegradability in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved	Based on ISO 17556	Biodegradation > 60 % or 90 % within 24 months

Natural polymeric raw materials

Chemically unmodified natural polymeric materials like starch, cellulose etc. do not need to be tested for biodegradability. Chemical characterization shall be performed according to Part 1.1.

B. Polymeric products

B.1. Disintegration (decomposition)

All components included in the product shall be declared according to Clause 3. Polymeric materials that constitute more than 1,0 % by mass of the product shall fulfil the requirements in Clause "A.1." A final product with a thickness exceeding 0,2 mm shall also be tested for disintegration in a biologically active disposal environment.

A product or pieces of a product with the original thickness shall be subjected to the abiotic degradation process according to Tier 1of this document. The degraded pieces are than subjected to a disintegration test on a laboratory scale under conditions simulating a specific, biologically active disposal environment. The test may be performed in soil, aerobic aqueous environment or a particularly defined biological active environment. If nothing else is specified for a particular application, the product tested shall disintegrate within 24 months to fragments < 2 mm. Non-disintegrated residues that can be sieved out shall not constitute more than 10 % of the original mass. In case of the same product occurring in different thickness it is sufficient to demonstrate that the thickest one has passed the disintegration test.

Type of analysis	Standard/method	Requirements
Disintegration in laboratory scale – Plastics - Determination of the degree of disintegration of plastic materials under simulated composting conditions in a laboratory-scale test	e.g. ISO 20200 under mesophilic condition	≥ 90 % disintegrated into < 2 mm pieces after 2 years

B.2. Composite polymeric products

All polymeric materials included in a product must fulfil requirements according to A and B. If technically possible the product shall be tested for disintegration in the form intended for use. Exceptions can be made where biodegradable materials comprise easily separable parts of a combined product. In such a case, clear information about which part of the product the labelling is intended for and under what circumstances the label is valid must be added. SP shall approve the formulation of the label and the attached information.

B.3. Test of function

The products must be suitable for their purpose and not cause any damage or inconvenience. A control of the finished product shall be made when appropriate at intervals necessary to secure that the product fulfils functional demands and is decided upon in each individual case.

Tier 3. Quality of soil/water: Test methods for analysis of negative effects

The impact of the biodegraded or disintegrated material on the environment is important especially in respect to any negative effect that the degradation products may exhibit in the final disposal place such as soil, water, etc.

After biodegradation or disintegration test in a chosen environment, the residual solids should be removed. The soil or water obtained shall be prepared in accordance with a suitable standard (e.g. ASTM D 5951) for subsequent toxicity test following biodegradation or disintegration. Thereafter, tests are performed to guarantee that no negative effects on different plants can be observed. The tests consist of germination- and growth tests with at least 2 higher plants according to SP method 4149.

Methods for investigation of environmentally hazardous substances	SP method 4149 *based on:* OECD guideline 208 + annex E in EN 13432	> 90% germination and biomass for both plants compared to controls

Flow chart to Appendix 4 of SPCR 141