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اللدائن ــ رقائق الأغطية المتلدنة بالحرارة والقابلة للاسترجاع بعد الاستخدام، والمستخدمة في الزراعة والبستنة (الملش)

Plastics — Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture(mulch)

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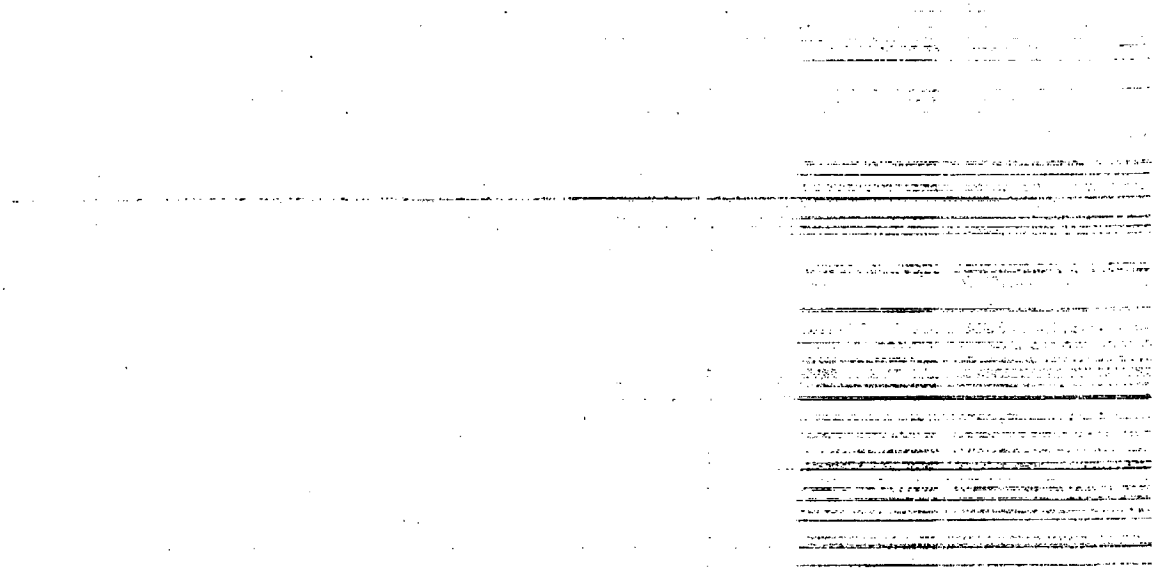

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This Jordanian Standard cancels and replaces the same Jordanian standard issued in 2004.

Foreword

The Jordan Institution for Standards and Metrology is the national standardization body in Jordan. The work of preparing Jordanian Standards is normally carried out by technical committees composed of the interested parties, which are involved in the scope of standard. All the interested parties have the right to vote on the draft Jordanian Standard during the enquiry stage, taking into consideration the importance of harmonizing Jordanian Standards with the International, regional or national standards (as much as possible) for the purpose of eliminating technical barriers to trade and facilitating the International trade.

Jordanian Standards are drafted in accordance with the rules given in the Jordanian Directive 1-2:2005, part 2: Rules for the structure and drafting of Jordanian Standards*.

The permanent technical committee for Plastics 22 has studied the Jordanian Standard 588:2004 EN 13655:2002 related to **"Plastics – Thermoplastic films for use in agriculture and horticulture (mulch)"**, and the prepared project 588:2023 related to **"Plastics – Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture (mulch)"** and has recommended to approve the amended project as a Jordanian Standard 588:2023, according to article (12) of Standards and Metrology Law No. (22) for the year 2000 and it's amendments.

This Jordanian Standard 588:2023 is an modified adoption of the European Standard 13655:2018 **"Plastics – Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture"** using reprint method, single vertical bars (|) in the margins are used to indicate the applicable technical modifications which have been changed and shown in annex NA, and single vertical dotted bars (⋮) in the margins are used to indicate the applicable editorial modifications which have been changed and listed below.

For the purposes of this Jordanian Standard, the following editorial changes have been made:
– Substitution of "this document" by "this Jordanian Standard".
– Addition of word "clause" for each clause number.
– Deletion of word "Europe" form scope.
– Arrange normative references in ascending order.
– Adding of "or to another technically equivalent standard" to clauses 10 b), 11-1, 11-2.
– Inclusion of bibliography in an informative Annex F.

* under amendment.

Plastics – Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture (mulch)

1- Scope

This Jordanian Standard specifies the requirements related to dimensional, mechanical, optical and thermal characteristics of thermoplastic films for mulching applications in agriculture and horticulture.
These mulch films are intended to be removed after use and not incorporated in the soil.
These mulch films are not intended to be used for soil disinfection by fumigation. Films for this application are in the scope of EN 17098-1[1].
This Jordanian Standard specifies a classification for durability of mulching films and the test methods referred to in Jordanian Standard.
This Jordanian Standard is applicable to thermoplastic mulch films, used for agriculture and horticulture, based on polyethylene and/or ethylene copolymers, of the following types:
- transparent films;
- black films;
- reflective films (e.g. white films, black/white films and black/silver films);
- films of other colour(s) for weed control (e.g. green, brown).

This Jordanian Standard also defines installation, use and removal conditions of mulch films.
Note: mulch films are considered as highly contaminated by soil and vegetal residues: the observed rates (or levels) of contamination of mulch films can vary from 70 % to 90 %. Therefore the film thickness is a key factor on the rate of contamination, the thinnest films (e.g. less than 25 µm) will be the mostly contaminated, difficult, expensive to remove, recover and recycle.

2- Normative references

The following referenced documents are indispensable for the application 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 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 4592, Plastics - Film and sheeting - Determination of length and width.
- ISO 4593, Plastics - Film and sheeting - Determination of thickness by mechanical scanning.
- ISO 9845-1, Solar energy - Reference solar spectral irradiance at the ground at different receiving conditions, Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5.
- EN ISO 527-1, Plastics - Determination of tensile properties, Part 1: General principles (ISO 527-1).
- EN ISO 527-3:1995, Plastics - Determination of tensile properties, Part 3: Test conditions for films and sheets (ISO 527-3:1995).
- EN ISO 4892-2:2013, Plastics - Methods of exposure to laboratory light sources, Part 2: Xenon-arc lamps (ISO 4892-2:2013).
- EN ISO 7765-1:2004, Plastics film and sheeting - Determination of impact resistance by the free-falling dart method, Part 1: Staircase methods (ISO 7765-1:1988).
- ASTM D 1003:2013, Standard test method for haze and luminous transmittance of transparent plastics.

3- Terms and definitions

For the purposes of this Jordanian Standard, the following terms and definitions apply:
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

• IEC Electropedia: available at http://www.electropedia.org/.
• ISO Online browsing platform: available at http://www.iso.org/obp.

3-1
width
total width of a film when laid flat
Note: It is expressed in millimetres (mm).

3-2
nominal width
width of a film, as declared by the manufacturer/supplier
Note: It is expressed in millimetres (mm).

3-3
nominal thickness
thickness of a film, as declared by the manufacturer/supplier
Note: It is expressed in micrometres (μm).

3-4
roll length
largest dimension of the film corresponding to the length of the unwinded roll
Note: It is expressed in metres (m).

3-5
longitudinal direction of the film
MD
direction parallel to the roll length corresponding to the extrusion direction

3-6
transverse direction of the film
TD
direction parallel to the width (at right angles to the length)

3-7
radiant exposure
H
time integral of irradiance
Note: It is measured in joules per square metre ($J \cdot m^{-2}$).
[Source: ISO 9370:2017, definition 3.27[2]].

4- Types and use

The different types of mulch films, their optical characteristics and use are given in Table 1.

Table 1 – Types and use of mulching films

Type	Optical characteristic	Use
Transparent film	Transparent to sunlight radiation	To warm up the soil Not used for weed growth control
Black film	Very low sunlight transmission	When prevention of weeds growth is requested in order to limit warming effect of the soil
Reflective film [a)]	Very low sunlight transmission	When prevention of weeds growth is requested and sunlight reflection prevent young leaves burning and improves photosynthesis by light reflection

Table 1 – Types and use of mulching films (continue)

Type	Optical characteristic	Use
Film of other colour(s) for weed control [b)]	Selective sunlight transmission in PAR (photosynthesis active radiation) and in near IR	When prevention of weeds growth and warming up of soil are needed

[a)] E.g. white, black/white and black/silver.
[b)] E.g. green, brown, etc.

5- Material

Mulch films according to this Jordanian Standard are usually manufactured from polyolefins.

6- Durability

The durability of mulch films is characterized by the class N, A, B, C and D. This classification, given in Table 2, is depending on the duration of exposure of the film to an artificial weathering using xenon-arc lamps according to clause 8-10, which induces a decrease of the value of tensile strain at break equal or less than 50 % of the initial value.
The class of durability shall be declared by the manufacturer/supplier.

Table 2 – Classification according to artificial weathering

Class	Minimum duration of exposure h
	At irradiance (narrowband 340 nm) 0,51 W/(m^2.nm)
N	280
A	1 400
B	2 450
C	4 070
D	5 600

Other light sources may be used provided that a correlation between the test results obtained with these light sources and these obtained after a natural exposure can be demonstrated. This can be useful when the durations of the exposure to xenon-arc lamps as defined in Table 2 are too long. Details of these methods are given in Annex A (Informative).
In case of dispute, the exposure to xenon-arc lamps according to clause 8-10 and the classification according to Table 2 shall be used.
Note: a numerical correlation between durability of mulch films exposed to artificial weathering and natural exposure is given in Annex B (Informative).

7- Requirements

7-1 General requirements

Transparent films, black films, reflective films and films of other colour(s) for weed control shall fulfil the requirements of Tables 3, 4, 5 and 6, respectively.

Table 3 – Requirements for transparent films

Characteristics	Unit	Nominal thickness		Test method Subclause
	µm	≥ 20 [a)]	≥ 35	
Appearance	-	Shall conform to clause 7-2		7-2
Dimensional characteristics				
Tolerance of average thickness/nominal thickness	%	±5		8-1
Tolerance of single point thickness/nominal thickness	%	from − 20 to 25	from −15 to 25	8-1
Width tolerance/ nominal width	%	±2		8-2
Tolerances of the roll length/nominal length	%	−1		8-3
Mechanical characteristics of unexposed film				
Tensile stress at yield (MD, TD)	MPa	≥ 9		8-4
Tensile stress at break (MD, TD)	MPa	≥ 20		
Tensile strain at break MD TD	 % %	 ≥ 250 ≥ 350		
Impact resistance Flat area Fold area	 g g	 ≥ 75 ≥ 50	 ≥ 80 ≥ 60	8-5
Optical characteristic of unexposed film				
Total luminous transmittance	%	≥ 90		8-6

[a)] 20 µm ≤ nominal thickness < 35 µm.

Table 4 – Requirements for black films

Characteristics	Unit	Nominal thickness			Test method Subclause
	µm	≥ 20 [a)]	≥ 50 [b)]	≥ 100	
Appearance	-	Shall conform to clause 7-2			7-2
Dimensional characteristics					
Tolerance of average thickness/nominal thickness	%	±5			8-1
Tolerance of single point thickness/nominal thickness	%	from − 20 to 25	±15	±15	8-1
Width tolerance/ nominal width	%	±2			8-2
Tolerances of the roll length/nominal length	%	−1			8-3
Mechanical characteristics of unexposed film					
Tensile stress at yield (MD, TD)	MPa	≥ 9			8-4
Tensile stress at break (MD, TD)	MPa	≥ 20			
Tensile strain at break MD TD	 % %	 ≥ 250 ≥ 350			
Impact resistance Flat area Fold area	 g g	 ≥ 75 ≥ 50	 ≥ 120 ≥ 60	 ≥ 250 ≥ 120	8-5
Optical characteristic of unexposed film					
Relative light transmission	%	$\leq 10^{-2}$	$\leq 10^{-2}$	$\leq 10^{-3}$	8-9

[a)] 20 µm ≤ nominal thickness < 50 µm.

[b)] 50 µm ≤ nominal thickness < 100 µm.

Table 5 – Requirements for reflective films (white, black/white, black/silver)

Characteristics	Unit	Nominal thickness		Test method Subclause
	µm	≥ 25 [a)]	≥ 60	
Appearance	-	Shall conform to clause 7-2		7-2
Dimensional characteristics				
Tolerance of average thickness/nominal thickness	%	±5		8-1
Tolerance of single point thickness/nominal thickness	%	from − 20 to 25	±15	8-1
Width tolerance/ nominal width	%	±2		8-2
Tolerances of the roll length/nominal length	%	−1		8-3
Mechanical characteristics of unexposed film				
Tensile stress at yield (MD, TD)	MPa	≥ 9		8-4
Tensile stress at break (MD, TD)	MPa	≥ 20		
Tensile strain at break MD TD	 % %	 ≥ 250 ≥ 350		
Impact resistance Flat area Fold area	 g g	 ≥ 80 ≥ 40	 ≥ 150 ≥ 80	8-5
Optical characteristic of unexposed film				
Relative light transmission (for film with at least one black layer)	%	≤ 1	≤ 0,1	8-9
Relative light transmission (for film without black layers)	%	≥ 60	≥ 50	8-9
Solar reflectance (for film with at least one white layer)	%	≥ 55	≥ 60	8-8
Solar reflectance (for film without white layers)	%	To be declared by the manufacturer	To be declared by the manufacturer	8-8

[a)] 25 µm ≤ nominal thickness < 60 µm.

Table 6 – Requirements for films of other colour(s) for weed control

Characteristics	Unit µm	Nominal thickness ≥ 25	Test method Subclause
Appearance	-	Shall conform to clause 7-2	7-2
Dimensional characteristics			
Tolerance of average thickness/nominal thickness	%	±5	8-1
Tolerance of single point thickness/nominal thickness	%	from −20 to 25	8-1
Width tolerance/ nominal width	%	±2	8-2
Tolerances of the roll length/nominal length	%	−1 −1	8-3
Mechanical characteristics of unexposed film			
Tensile stress at yield (MD, TD)	MPa	≥ 9	8-4
Tensile stress at break (MD, TD)	MPa	≥ 20	
Tensile strain at break MD TD	 % %	 ≥ 250 ≥ 350	
Impact resistance on flat area	g	≥ 80	8-5
Optical characteristic of unexposed film			
Transmission of solar radiation in the photosynthesis active radiation (PAR) Range 400 nm to 500 nm Range 600 nm to 700 nm	 % %	 < 25 < 20	8-7
Transmission of solar radiation in the near-infrared region (NIR) Range 850 nm to 1 100 nm	%	> 55	8-7

7-2 Requirement for appearance

The free edges of the roll shall be sealed with adhesive tape or by some other similar means, in order to prevent its unwinding.

The edges shall be properly in line and there shall be sufficient tension to prevent the layers of the roll from transversal slipping when it is handled.

The film shall be homogeneous for the purpose of the application and check it by unrolling at least 2 m of the film and examining it against the light, holding it tight at arm length.

8- Test methods

8-1 Determination of thickness

The thickness of the single points of the film shall be determined in accordance with ISO 4593. The average thickness of the film shall be determined in accordance with ISO 4591 or ISO 4593. Testing is performed using one strip of film cut in transverse direction of the roll (TD).

8-2 Determination of width

The width of the film shall be determined in accordance with ISO 4592.

8-3 Determination of film length

The length of the film shall be determined by unwinding the roll by means of a calibrated reel in contact continuously with its outside surface (see Figure 1). The calibrated reel is connected to a revolution counter. The diameter of the calibrated reel shall be measured with a accuracy of ± 0,2 %. The roll shall be totally unwound at a speed of 100 m/min ± 10 m/min.

The value of the length of the film is calculated by using Formula (1):

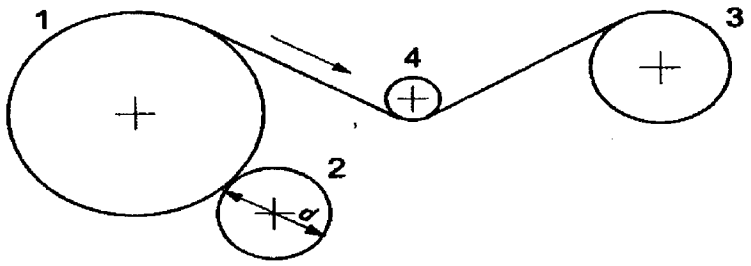
$$l = n \times \pi \times d \quad \text{.....(1)}$$

Where

l: is the value of the length of the film, expressed in metres (m);

n: is the number of revolutions of the calibrated reel during the total unwinding of the roll;

d: is the diameter of the calibrated reel, expressed in metres (m).



Key

1: film roll

2: calibrated reel with a revolution counter

3: collection reel

4: deflection reel

d: diameter of the calibrated reel

Figure 1 – Apparatus for the determination of the film length

8-4 Determination of tensile characteristics

The tensile characteristics shall be determined according to EN ISO 527-1 and EN ISO 527-3 using five test pieces type 2 (see Figure 1 of EN ISO 527-3:1995) with a width of 10 mm, cut in each direction of the film [longitudinal direction (MD) and transverse direction (TD)], at a testing speed of 500 mm/min.

Calculate the arithmetic average value of the five measurements.

8-5 Determination of impact resistance

8-5-1 General

In case of a folded film, a distinction shall be made between the test pieces taken from the folds (fold area) and test pieces taken from areas which have not been folded (flat area).

Note: films which are wider than 2 000 mm are usually folded lengthwise at least once before winding on a reel. These folds are retained even when the film is laid out flat, and this can affect test results.

8-5-2 Flat area

The impact resistance (Dart drop test) in flat area shall be determined in accordance with EN ISO 7765-1:2004, method A.

Calculate the impact failure mass m_f, in grams, in accordance with EN ISO 7765-1.

8-5-3 Fold area

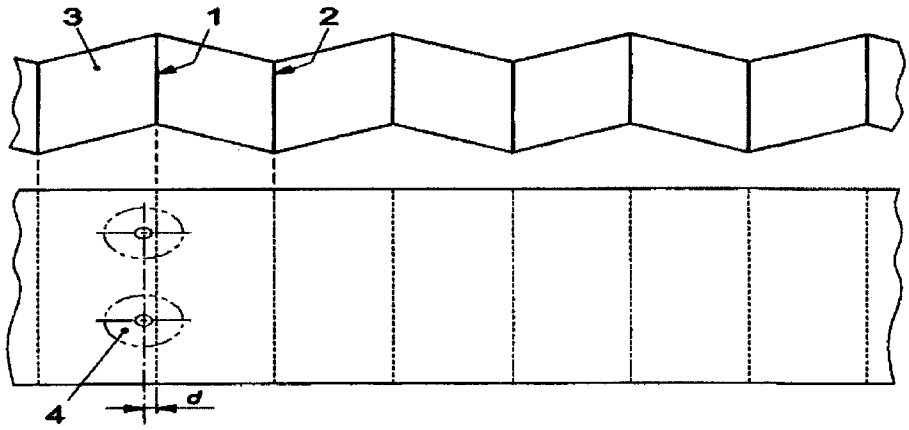
The impact resistance (Dart drop test) in fold area shall be determined using the apparatus specified in EN ISO 7765-1:2004, method A.

Spread out the film with the marked face onto the apparatus and test every folds tangentially twice, alternately internal and external folds, with a mass as specified in Table 3 to Table 6, as applicable. The tangential test is obtained by shifting forward the fold of 13 mm from the vertical axle of the specimen clamp (see Figure 2).

If no failure occurs, the result is declared "pass".

If one failure occurs, carry out two additional tests on the fold which failed in the same position (internal or external fold). Then, if no failure occurs, the result is declared "pass" and if one or two failure(s) occur(s), the result is declared "fail".

If two failures occur, the result is declared "fail".



Key
1: external fold
2: internal fold
3: film
4: vertical axle of the specimen clamps
d: 13 mm

Figure 2 – Position of impact on folds

8-6 Determination of the total luminous transmittance (transparent films)

The total luminous transmittance shall be determined in accordance with ASTM D 1003:2013 on five test pieces cut from the film.

Calculate the arithmetic average value of the five measurements.

8-7 Determination of solar radiation in PAR and NIR region

8-7-1 Principle

The Visible-NIR transmission spectrum within the wavelength range 400 nm to 1 100 nm of a film is measured by means of spectrophotometer.

8-7-2 Apparatus

8-7-2-1 UV-Visible-Near-IR spectrophotometer equipped with an integrating sphere, capable to measure and record continuously the transmittance at least between 300 nm and 1 200 nm.

8-7-2-2 Software, capable to integrate the transmittance.

8-7-3 Procedure

Carried out the measurement on five test pieces cut from the film.

Set up a test piece on the specimen holder of the integrating sphere and record the transmittance at least between 300 nm and 1 200 nm.

Determine for each range of wavelength (i.e. 400 nm to 500 nm, 600 nm to 700 nm and 850 nm to 1 100 nm), by using the software, the following ratio:

$$R_{i-j} = \frac{S_1}{S_2}$$

Where

s_1: is the area between the line corresponding to a transmittance of 0 % and the curve of the spectrum;

s_2: is the area between the line corresponding to a transmittance of 0 % and the line corresponding to a transmittance of 100 %.

These three different ratios correspond to different ranges of wavelengths (λ) on the recorded spectrum:

- $R_{400\text{-}500}$ and $R_{600\text{-}700}$ in the visible region of the spectrum:
- for $R_{400\text{-}500}$ the limits of the spectrum are: λ = 400 nm and λ = 500 nm;
- for $R_{600\text{-}700}$ the limits of the spectrum are: λ = 600 nm and λ = 700 nm.
- $R_{850\text{-}1100}$ in the Near-IR region of the spectrum:
- for $R_{850\text{-}1100}$ the limits of the spectrum are: λ = 850 nm and λ = 1 100 nm.

8-7-4 Expression of results

For each ratio calculate the arithmetic average value of the five measurements.

8-8 Solar reflectance

The solar reflectance shall be determined according to Annex C on five test pieces cut from the film.

8-9 Determination of the relative light transmission

The relative light transmission is determined in accordance with Annex D on five test pieces cut from the film.

Calculate the arithmetic average value of the five measurements.

8-10 Resistance to artificial weathering

8-10-1 Principle

The variation of the tensile strain at break of specimens is determined before and after an exposure to xenon-arc lamps.

8-10-2 Exposure to xenon-arc lamps

Carry out the artificial weathering according to EN ISO 4892-2:2013, Method A, Cycle n°1, using the test conditions given in Table 7.

Table 7 – Exposure cycle and test conditions

Exposure period	Irradiance		Black-standard Temperature °C	Chamber Temperature °C	Relative humidity %
	Broadband (300 nm to 400 nm) W/m^2	Narrowband (340 nm) W/(m^2·nm)			
102 min dry	60 ± 2	0,51 ± 0,02	65 ± 3	38 ± 3	50 ± 5
18 min water spray	60 ± 2	0,51 ± 0,02	—	—	—

8-10-3 Procedure

Expose the specimens with a backing made of matt aluminium plate according to clause 8-10-2 during the minimum duration of exposure specified in Table 2, corresponding to the class of durability of the film.

After the exposure, determine the tensile strain at break according to EN ISO 527-1 and EN ISO 527-3, using five type 2 test pieces, (see Figure 1 of EN ISO 527-3:1995), 10 mm wide, 150 mm long, taken longitudinally in the film (MD), at a test speed of 500 mm/min.

8-10-4 Calculation and expression of results

Calculate the arithmetic mean value of the five measurements performed on the test pieces cut from the exposed specimens and the arithmetic mean value of the five measurements performed on the test pieces cut from the unexposed specimens in longitudinal direction (MD) (see clause 8-4). Compare these two values.

The test is considered successful when the value calculated for specimens exposed to artificial weathering is equal or greater than 50 % of the value calculated for unexposed specimens.

9- Roll acceptance, storage and handling

9-1 Delivery checking

Carefully examine the rolls upon delivery in order to find any apparent damage or anomalies.

If a defect is found, take the necessary actions for the case.

Whenever possible, it is recommended to take a photograph of the damage.

9-2 Storage and handling of rolls

The rolls shall be carried, not dragged over the ground or any other surface.

Keep the films in their original packaging and store them in a location protected from the elements (sunlight, heat, rain).

It is recommended that the films be used within six months of delivery.

It is recommended that rolls delivered with a cardboard core be stored in a dry location.

Handling of rolls should be performed horizontally.

10- Designation

The designation of the film shall include the following information:

a) use of the film: MULCHING FILM with the type according to Table 1;

b) reference to this Jordanian Standard, i.e. JS 588, or to another technically equivalent standard;

c) nominal width of the film in millimetres (mm);

d) nominal roll length in metres (m);

e) nominal thickness of the film in micrometres (µm) ;

f) class of durability according to Table 2.

All these information have to be put on the accompanying label.

Where the labels accompanying the films indicate instructions for installation and use, these instructions are mandatory.
IMPORTANT: In order to ensure traceability, the end-user shall keep the labels accompanying the films or their packaging up to end-of-use. Keeping only the pallet label for homogeneous pallet deliveries is acceptable.
Example: TRANSPARENT MULCH-FILM EN 13655 5000 1000 50 A
Designation of a transparent mulch film, 5 000 mm wide, in roll of length 1 000 m, 50 µm thickness, and with a duration of exposure to an artificial weathering, conforming to clause 8-10 of 1 700 h.

11- Marking

11-1 Marking of the film

Marking along the edges of the film shall include at least the following information:
a) reference to Jordanian Standard, i.e. JS 588, or to another technically equivalent standard;
b) nominal width (mm), nominal length (m), nominal thickness (mm).
c) class of durability according to Table 2;
d) manufacturing code, including traceability to define manufacturing date (optional);
e) manufacturer's trademark (optional);
f) recovery logo (optional).

11-2 Marking on the packaging or label

Marking on the packaging or label shall include at least the following information:
a) type of film see Table 1;
b) reference to Jordanian Standard, i.e. JS 588, or to another technically equivalent standard;
c) nominal width, in millimetres (mm);
d) nominal length in metres (m);
e) nominal thickness in micrometres (µm);
f) class of durability according to Table 2;
g) manufacturer's trade mark (optional);
h) manufacturing code, including traceability to define manufacturing date;
i) recovery logo (optional).
j) country of origin
Example: BLACK FILM EN 13655 PE-LD 5000 50 A AnyCo 2014–06 Germany.

12- Functions and factors of degradability of mulch films

Information related to the main functions and factors of degradability of mulch films are given in clause E-1 and clause E-2.

13- Conditions for installation and use of mulch films

The instructions of the film manufacturer for the conditions of installation and use of the mulch film shall be followed. In the absence of such instructions, guidance is given in clause E-3.

14- Removal instructions and end of life

For the removal instructions, the recommendations given by local authorities in charge of waste management of post-used agricultural films shall be followed.
The minimum technical requirements issued by the companies/organizations that collect films are available on their websites.
In the absence of such recommendations, see clause E-4, as guidance.

Thermoplastic films can be re-processed through a waste recovery process to save resources while minimizing harmful emissions into the air, water and soil, as well as their impacts on human health. EN 15347 [3] provides a framework for characterizing plastic waste. EN 15343 [4] provides the procedures necessary for ensuring the traceability of recycled plastics. EN 15344 [5] provide data for characterizing polyethylene recyclates respectively.
ISO 15270 [6] provides guidelines for terminology and material recovery, through mechanical recycling in particular.

Annex A
(Informative)
Exposure to other light sources

A-1 Medium pressure mercury vapour lamps

A-1-1 Durability classification

In the case of an exposure to medium pressure mercury vapour lamps, the class of durability of mulching films is given in Table A-1, depending on the duration of exposure of the film according to clause A-1-2, which induces a decrease of the values of tensile strain at break equal or less than 50 % of the initial values.

The class of durability shall be declared by the manufacturer.

Table A – 1 – Durability classification

Class	Minimum duration of exposure h
N	100
A	500
B	800
C	1 350
D	1 950

A-1-2 Exposure to medium pressure mercury vapour lamps

A-1-2-1 Exposure method

Carry out the exposure according to EN 16472 using the test conditions given in clause A-1-2-2 and clause A-1-2-3.

The exposure may be carried out in the presence of moisture in the form of water spray, condensation or by immersion cycles with or without light. In this case, test parameters shall be agreed between parties and recorded in the test report.

Note: Information on the influence of water and additive migration can be found in ISO 10640 [7].

A-1-2-2 Irradiance

The irradiance at the surface of the test specimens shall be (95 ± 15) W/m^2 in the spectral passband 290 nm to 420 nm.

A-1-2-3 Temperature

The apparatus can be designed according to different technologies (type of temperature sensor, layout of the test chamber, ventilation mode, etc.). The set points of the temperature of the different parts of the temperature controller (with an accuracy of ± 0,5 °C) shall ensure an accurate and reproducible control of the actual temperature of the exposed specimens.

The set points of the temperature for different apparatus available on the market at the date of the publication of this standard shall be as follows:

a) for apparatus including a platinum sensor in contact with a specimen attached to the specimen holder, the set point of the temperature shall be (60 ± 0,5) °C.

b) for apparatus the specimen compartment of which is separated from the compartment of the light source, and the sensor of which is a black-standard thermometer (BST) according to EN ISO 4892-1, the set point shall be (65 ± 0,5) °C and the temperature of the specimen compartment shall be (55 ± 0,5) °C.

c) for apparatus including a platinum sensor inserted in a white thermally-controlled component, the set point of the temperature shall be (58 ± 0,5) °C.

As a given temperature set point can lead to different results since the actual temperature of the exposed specimens is depending on the design of the apparatus, it is necessary to calibrate them. See clause A-1-2-4.

Note: The actual temperature of exposed specimens is critical since the thermal activation energy of photochemical processes leads to exponential variation of the degradation rate according to a type-Arrhenius law.

A-1-2-4 Apparatus calibration

The calibration of the apparatus shall be carried out relatively to the photochemistry be means of an actinometer made from a polyethylene reference specimens (PERS), as defined in ISO/TR 19032:2006 [7].

The calibration by means of a PERS allows controlling accurately the photochemical attack from both irradiance and temperature.

PERS shall be exposed during 72 h using test conditions specified in clause A-1-2-2 and clause A-1-2-3. The oxidation level shall be measured by using an infrared spectrometer in the transmission mode. The absorbance ratio (carbonyl index); Ar, shall satisfy the following condition:

$$1{,}8 \leq A_r = \frac{A_{1\,715}}{A_{2\,020}} \leq 2{,}4$$

Where

A_r: is the absorbance ratio (carbonyl index);

A_{1715}: is the maximum absorbance at near 1 715 cm^{-1};

A_{2020}: is the maximum absorbance at near 2 020 cm^{-1}.

If the calculated absorbance ratio is out of the range as defined above, adjust the temperature set point and recalibrate until this condition is satisfied (the temperature set point will be increased if $A_r < 1{,}8$ or will be decreased if $A_r > 2{,}4$).

Note: For detailed information on the method to determine the absorbance ratio see ISO/TR 19032:2006 [8], clause 4-1

A-1-3 Procedure

The specimen shall be exposed according to clause A-1-2, for the duration corresponding to the relevant class given in Table A-1.

After the exposure, the tensile strain at break shall be determined according to EN ISO 527-1 and EN ISO 527-3, using five type 2 test pieces (see Figure 1 of EN ISO 527-3:1995), 10 mm wide, taken longitudinally in the film (MD), at a test speed of 500 mm/min.

A-1-4 Calculation and expression of results

Calculate the arithmetic mean value of the five measurements performed on the test pieces cut from the exposed specimens and the arithmetic mean value of the five measurements performed on the test pieces cut from the unexposed specimens in longitudinal direction (MD) (see clause 8-4). Compare these two values.

The test is considered successful when the value calculated for specimens exposed to artificial weathering is equal or greater than 50 % of the value calculated for unexposed specimens.

A-2 Exposure to fluorescent UV lamps

A-2-1 Durability classification

In the case of an exposure to fluorescent UV lamps, the class of durability of mulching films is given in Table A-2, depending on the duration of exposure of the film according to clause A-2-2, which induces a decrease of the values of tensile strain at break equal or less than 50 % of the initial values.

The class of durability shall be declared by the manufacturer.

Table A – 2 – Durability classification

Class	Minimum duration of exposure h
N	275
A	1 385
B	2 425
C	4 030
D	5 550

A-2-2 Exposure to fluorescent UV lamps

Carry out the exposure according to EN ISO 4892-3, Method A, cycle 1, for the duration corresponding to the relevant class of durability given in Table A-2. The test method consists of an irradiance step (dry, with irradiance) and a condensation step (high humidity, without irradiation), with the following test conditions:

a) irradiance shall be (0,76 ± 0,06) W/m^2, measured at 340 nm at the surface of the test specimen.

b) the temperature of the test specimen shall be (60 ± 3) °C during irradiance and (50 ± 3) °C during condensation step. The temperature shall be measured with an uninsulated black-panel thermometer (BPT).

An accurate control of the effective temperature of the test specimen is of main importance. The thermal activation energy of photochemical processes leads to an exponential variation of the rate of degradation according to an Arrhenius type law.

A-2-3 Procedure

The sample shall be exposed according to clause A-2-2 for the duration corresponding to the relevant class of durability given in Table A-2.

After the exposure, the tensile strain at break shall be determined according to EN ISO 527-1 and EN ISO 527-3, using five type 2 test pieces (see Figure 1 of EN ISO 527-3:1995), 10 mm wide, 150 mm long, taken longitudinally in the film (MD), at a test speed of 500 mm/min.

A-2-4 Calculation and expression of results

Calculate the arithmetic mean value of the five measurements performed on the test pieces cut from the exposed samples and the arithmetic mean value of the five measurements performed on the test pieces cut from the unexposed samples in longitudinal direction (MD) (see clause 8-4). Compare these 2 values.

The test is considered successful when the value calculated for samples exposed to artificial weathering is equal or greater than 50 % of the value calculated for unexposed samples.

Annex B
(Informative)
Numerical correlation between durations of mulching films exposed to artificial weathering and a natural exposure

B-1 Exposure to xenon-arc lamps

The method specified in EN ISO 4892-2:2013, Method A, consists to expose films to radiations in the ultraviolet (UV) and visible regions of the spectrum that are very similar to the solar spectrum. For this reason it is reasonable to presume that a correlation exists between the artificial exposure and the natural exposure of a film to daylight.
This has been confirmed by tests carried out in laboratories that have compared the durations of UV stabilized polyethylene and ethylene vinyl acetate copolymers films in the two conditions of exposure.
Since the duration of a mulching film depends on the climatic characteristics of the zone of installation, it is useful to define three climatic zones, having different levels of global solar radiant exposure, as given in Table B-1.
A numerical correlation between durations of exposure to artificial weathering according to clause 8-10-2 and durations of natural exposure, measured in terms of average yearly global solar radiant exposure, of mulching films is given in Table B-1.

Table B – 1 – Correlation between the exposure to artificial weathering using xenon-arc lamps and natural weathering

Climatic zone	Global solar radiant exposure GJ/m^2/year (kLy/year) [a]	Duration of exposures for an expected lifetime of				
		3 months h	8 months h	12 months h	24 months h	36 months h
CZ1	up to 4,2 (up to 100)	280	770	1 160	2 300	3 480
CZ2	4,2 to 5,4 (101 to 130)	370	1 000	1 510	3 000	4 500
CZ3	5,4 to 6,7 (131 to 160)	460	1 240	1 860	3 700	5 580

[a] 1 kLy = 0,041 84 GJ/m^2

Example: Film classified A according to Table 2.
When exposed to artificial weathering, the duration of the films according to clause 8-10 is 1 400 h.
For a natural exposure in a mulch application, the approximate expected lifetime is:
- 1,5 years in the climatic zone CZ1;
- 10 months in the climatic zone CZ2;
- 8 months in the climatic zone CZ3.
- for exposures less than 1 year, the expected lifetime is affected by the actual period of the year when the exposure takes place; such a period has an increasing influence with decreasing the exposure time, thus the correlation has to be handled with great care.

In practice many factors reduce the correlation between the duration of a mulch film in outdoor real conditions and the duration of the same film exposed to artificial weathering. Among these it is

appropriate to mention the type of crop (the growth might influence the durability of the film by shading effect of the canopy) and the use of agrochemicals that may contain or develop substances inhibiting to some extent the protective action of the UV stabilizers.

B-2 Exposure to medium pressure mercury vapour lamps

A numerical correlation between the exposure to artificial weathering according to clause A-1 and natural weathering of mulching films is given in Table B-2.

Table B – 2 – Correlation between the exposure using medium pressure mercury vapour lamps and natural weathering

Climatic zone	Global solar radiant exposure GJ/m²/year (kLy/year) [a]	Duration of exposures for an expected lifetime of				
		3 months h	8 months h	12 months h	24 months h	36 months h
CZ1	up to 4,2 (up to 100)	100	275	400	800	1 200
CZ2	4,2 to 5,4 (101 to 130)	130	350	520	1 050	1 550
CZ3	5,4 to 6,7 (130 to 160)	165	450	650	1 300	1 950

[a] 1 kLy = 0,0418 4 GJ/m²

B-3 Exposure to fluorescent UV lamps

A numerical correlation between the exposure to artificial weathering according to clause A-2 and natural weathering is given in Table B-3.

Table B – 3 – Correlation between the exposure using fluorescent UV lamps and natural weathering

Climatic zone	Global solar radiant exposure GJ/m²/year (kLy/year) [a]	Duration of exposures for an expected lifetime of				
		3 months h	8 months h	12 months h	24 months h	36 months h
CZ1	up to 4,2 (up to 100)	275	765	1 150	2 280	3 450
CZ2	4,2 to 5,4 (101 to 130)	365	990	1 500	2 970	4 460
CZ3	5,4 to 6,7 (130 to 160)	455	1 230	1 850	3 670	5 540

[a] 1 kLy = 0,0418 4 GJ/m²

Annex C
(Normative)
Determination of solar reflectance

C-1 Principle

The reflectance spectra of a film are acquired by using a UV-VIS-NIR spectrophotometer equipped with an integrating sphere. The solar reflectance, *Rs*, is calculated according to the method described in ISO 9845-1.

C-2 Terms and definitions

For the purposes of this annex, the terms and definitions given in ISO 9845-1:1992 and the following apply.

specular

indicates that the flux leaves a surface or medium at an angle that is numerically equal to the angle of incidence, lies in the same plane as the incident ray and the perpendicular, but is on the opposite side of the perpendicular to the surface

[Source: ISO 16378:2013, definition clause 3-16] [9].

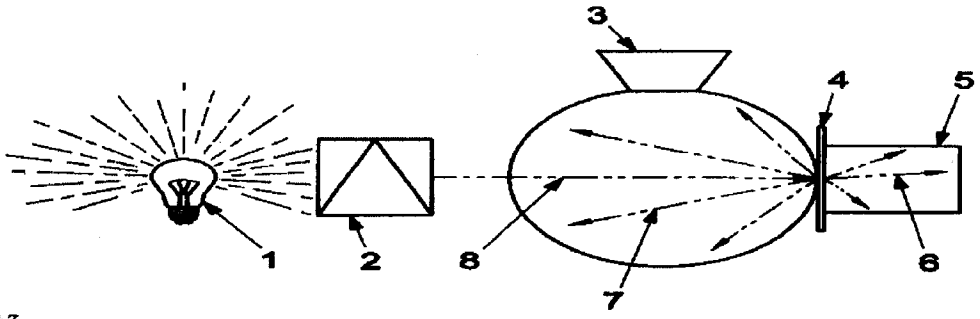
C-3 Apparatus

C-3-1 General

UV-VIS-NIR spectrophotometer equipped with an integrating sphere, collecting both the specular and the diffusively reflected part of the light, as shown in Figure C-1.

The internal side of the integrating sphere is covered with a highly reflecting material. The integrating sphere collects the diffusively reflected light from a surface. Specular part of the light could also be collected but often it can be ignored.

Behind the specimen a radiation trap (a cavity having a black internal surface) is placed in order to absorb the light, which is not absorbed or reflected by the specimen.



Key

1: source
2: monochromator
3: photodetector
4: specimen
5: radiant trap
6: transmitted radiation
7: reflected radiation
8: incident radiation

Figure C – 1 – Integrating sphere

C-3-2 Test specimens

Three specimens shall be cut from the film.

C-3-3 Procedure

The measurements are performed using the UV-VIS-NIR-spectrophotometer equipped with the integrating sphere, collecting both the specular and the diffusively reflected part of the light. The test specimen shall be placed at the exit port of the sphere, i.e. at the rear of the integrating sphere. The inside of the film as seen from the reel shall be directed towards the sphere. See Figure C-1.

A reflectance spectrum, $R_{spec}(\lambda)$, is acquired by the UV-VIS-NIR-spectrophotometer for each specimen between 300 nm and 2 500 nm on one layer of the film. The contribution from wavelengths greater than 2 500 mm can be neglected.

C-3-4 Calculation of the solar reflectance *Rs*

The solar reflectance, *Rs*, defined as the fraction of the total direct solar irradiation which is reflected by a body, shall be calculated according to ISO 9845-1:1992, Formula (1), i.e.:

$$R_s = \frac{\int_0^\infty R(\lambda)E_\lambda(\lambda)d\lambda}{\int_0^\infty E(\lambda)_\lambda d\lambda}$$

Where

$E_\lambda(\lambda)$: is the solar spectral irradiance;

$R(\lambda)$: is the absolute reflectance.

Reflectance spectra, $R_{spec}(\lambda)$, the UV-VIS-NIR-spectrophotometer are measured relatively to a reflectance standard with a known absolute reflectance value, $R_{ref}(\lambda)$.

$R(\lambda)$ is calculated from the reflectance spectrum from the following Formula:

$$R(\lambda) = R_{spec}(\lambda)R_{ref}(\lambda)$$

Where

$R_{spec}(\lambda)$: is the reflectance of the specimen;

$R_{ref}(\lambda)$: is the reflectance of a reflectance standard.

An example of a reflectance reference[1)] is pressed barium sulphate (BaSO4). $R_{ref}(\lambda)$ for BaSO4 can be obtained from National Physical Laboratory. Other reflectance references exist. The manufacturers provide the absolute reflectance values.

Calculate the arithmetic average value of the three measurements.

[1)] Pressed Eastman barium sulphate (BaSO4) is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by CEN of this product. Equivalent products may be used if they can be shown to lead to the same results.

Annex D
(Normative)
Determination of the relative light transmission

D-1 Principle

The opacity of a film is determined by measuring the relative light transmission, I_R, when the film is exposed to a light source of specified illuminance, I_0.

D-2 Apparatus

D-2-1 Light source consisting of a lamp for camera of 1 000 W power, fitted with a switch in order to turn on and off the light rapidly.
D-2-2 Luxmeter with a screen 1/10 and screen 1/100 which allows to measure from 1 up to 200 000 lx minimum.
D-2-3 Compressed air device to cool the film subjected to radiations.

D-3 Procedure

Position the light source perpendicularly to the photoelectric cell at an height of about 20 cm up to 30 cm to set on an illuminance of the initial light I_0 of 100 000 lx for film with at least one black layer and 1 000 lx for film without black layer.
Put the test piece on the cell to cover it totally.
Place the pressure air device over the photoelectric cell in order to cool the test piece placed on the cell during the measurement as it is subjected to strong calorific radiation of the source of light.
Record the illuminance of the transmitted light I.
Note: With this device a black film subjected to an initial light of illuminance 100 000 lx transmits an illuminance about 0,1 lx up to 0,001 lx.
As the luxmeter cannot measure values less than 1 lx, and it is preferable to use an amplifier which can increase 1 000 times the signal.

D-4 Expression of results

Calculate the relative light transmission I_R, as a percentage, using Formula (D-1).

$$I_R = \frac{I}{I_0} \times 100 \quad \text{(D-1)}$$

Where
I: is the illuminance of the transmitted light measured for the test piece, in lux (lx);
I_0: is the illuminance of the initial light, in lux (lx);

Annex E
(Informative)
Guidance for conditions for installation, use and removal of mulch films

E-1 Main functions of mulch films

Soil mulch improves growing conditions and thereby helps increase yields and improve crop quality by:
- inhibiting the development of weeds if the mulching film used is opaque to PAR;
- limiting water evaporation as it maintains soil moisture;
- limiting the leaching of mineral elements;
- protecting leaves and fruits against soil-borne diseases;
- protecting the products from dirt (earth);
- protecting the soil structure from the phenomenon of slaking;
- warming the soil, particularly with films which are non-opaque to near-infrared light.

E-2 Factors for degradability

The service life of mulch films is depending on external factors, such as:
- the sunlight which can induce a photodegradation of the films;
- the ambient temperature;
- the direction and strength of the wind or any other mechanical stresses, such as flapping, hail impact;
- the use of some fumigants;
- the soil type, which can affect the physical-chemical properties of the films.

These factors can react differently on the thermoplastic materials depending on their composition.
Consequently, mulch films are subjected to degradation more or less slowly depending on the geographic location (latitude, direction of the exposure), the season(s) of use and the cropping system.

E-3 Conditions for installation, use and removal

E-3-1 Installation instructions

Prepare the soil in order to avoid any risk of perforating or tearing the film.
For installation, use a machine with the speed and installation characteristics that are adapted to the film in order to avoid exceeding the mechanical characteristics of the film.
Adjust film tightness according to the ambient temperature: less tight for installation in hot weather and tighter for installation in cold weather.
For use conditions, follow any instructions that the manufacturer/supplier may have provided.
Check the condition of the film on a regular basis and implement the necessary protective measures if there is a fault.
The film installation date shall be recorded in writing, preferably in the growth record/farm register.

E-3-2 Durability of mulching films

Annex B provides information on the numerical correlation between durations of mulching films exposed to artificial ageing and a natural exposure.
The conventional expected service life of mulching films shall correspond to the value specified by the manufacturer/supplier, expressed in months.
The conventional expected service life is 3 months, 8 months, 12 months, 24 months, 36 months depending on the film.

E-4 Removal instructions

For the recovery of used plastic films, whatever the means [material recovery through mechanical recycling, energy recovery, contaminants inherent to the use of films in agriculture and horticulture (primarily water, plant material, soil particles that cling to the films) should be reduced to a minimum. For that purpose, care shall be taken when the plastic films are removed.

The presence of other contaminants, such as metals, wood, stones, paper, cardboard, adhesives, tyres, textiles, grease or paint found around farms shall also be proscribed.

To optimize recovery, do not:

a) mix films made from differing plastic materials, as these materials are not always compatible for material recovery;

b) mix of coloured films with transparent films;

c) mix thin films with thick films where they are both present at the same farming site or at a pooling area; films shall be stored in application family groups, i.e. silage films, covering films, mulching films, etc.;

d) drag the films over the ground.

Wherever possible, films should be removed during dry weather.

Films that have been removed shall be stored at the farming site on pallets or in very large crates (pallet boxes) in a location protected from adverse weather conditions.

Films that have been removed shall be stored at pooling sites on cement surfaces or in coated and fenced-in areas to prevent films from being dispersed in the environment.

Roll the films without core.

For mechanical removal, it is preferable to use a machine with a brushing system and form rolls without cores.

Annex F
(Informative)
Bibliography

[1] EN 17098-1, Plastics - Barrier films for agricultural and horticultural soil disinfection by fumigation, Part 1: Specifications for barrier films.
[2] ISO 9370:2017, Plastics - Instrumental determination of radiant exposure in weathering tests - General guidance and basic test method.
[3] EN 15347, Plastics - Recycled Plastics - Characterisation of plastics wastes.
[4] EN 15343, Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content.
[5] EN 15344, Plastics - Recycled Plastics - Characterisation of Polyethylene (PE) recyclates.
[6] ISO 15270, Plastics - Guidelines for the recovery and recycling of plastics waste.
[7] ISO 10640:2011, Plastics - Methodology for assessing polymer photoageing by FTIR and UV/visible spectroscopy.
[8] ISO/TR 19032, Plastics - Use of polyethylene reference specimens (PERS) for monitoring laboratory and outdoor weathering conditions.
[9] ISO 16378:2013, Space systems - Measurements of thermo-optical properties of thermal control materials.
[10] EN 16472, Plastics - Method for artificial accelerated photoageing using medium pressure mercury vapour lamps.
[11] EN ISO 4892-1, Plastics - Methods of exposure to laboratory light sources, Part 1: General guidance (ISO 4892-1).
[12] EN ISO 4892-3, Plastics - Methods of exposure to laboratory light sources, Part 3: Fluorescent UV lamps (ISO 4892-3).

Annex NA
(Normative)
National technical modifications

Table NA – 1 in this annex illustrates the technical national deviations from European standard 13655:2018 **"Plastics - Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture".**
Single vertical bars (|) in the margins are used to indicate these technical national modifications of the European standard which have been changed.
Technical deviations are cross-referenced to the clause of the European standard together with reasons for these deviations.

Table NA – 1 – List of national editorial modifications

No.	Clause	Modification	Explanation
1	10, 11-2	Deletion of "if required" from clause e)	Technical Committee decision, because it is important to declare the nominal thickness by manufacturer
2	11-1	Add nominal length (m), nominal thickness (mm) to clause b)	Technical Committee decision, because it is important that manufacturer to mark nominal length, nominal thickness on the edge of the film.
3	11-2	Add country of origin Clause j)	Applying the Jordanian Technical Regulation 119:2022 "Labeling – Labeling of industrial products"
4	11-2	Add "Germany" to the Example	As an example to the country of origin