Designation: D7310 – 21

Standard Practice for Defect Detection and Rating of Plastic Films Using Optical Sensors[1]

This standard is issued under the fixed designation D7310; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice intends to provide standardized approaches and criteria for the observation and reporting of defects in various types of plastic film, by means of an optical scanning system. Scope includes the in situ inspection of defects in films fabricated for specific applications after preparation of a suitable film from plastic resin.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

E456 Terminology Relating to Quality and Statistics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E2587 Practice for Use of Control Charts in Statistical Process Control

3. Terminology

3.1 *Definitions*—For definitions of terms that appear in this practice relating to plastics, refer to Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *defect*—for the purpose of this practice any entity in the film that is large enough to be detected by an optical sensor and is either polymeric in nature or caused by degradation, external contamination, undispersed additives or pigments, or similar sources.

3.2.1.1 *Discussion*—In Appendix X1, some types of defects are shown (cross-linked material, un-molten polymer, pinholes). The defects can be classified in three groups:

3.2.1.1 *gel*—particle of plastic material in the film matrix not blended with the matrix and often acting as a miniature lens. Several types of gels exist.

3.2.1.2 *contamination*—any particle in or on the film matrix affecting irradiated light differently than the matrix (dirt, insects, oxidized additives or material, catalyst residues, solid particles, metallic particles, undispersed pigments or additives, etc.).

3.2.1.3 *structural defect*—visual deviation not caused by gels or contaminations, for example, air bubbles, wrinkles, die lines, film holes, sharkskin, arrowheads.

3.2.2 *pixel*

3.2.2.1 *in a picture*—smallest element of an image that can be individually processed by a video display system or a physical point in a raster image.

3.2.2.1 *Discussion*—The greater the number of pixels per area, the higher the resolution.

3.2.2.2 *in a camera*—smallest single photo-electrical detector element of the camera sensor.

3.2.3 *effective pixel size*—actual size of the individual pixels in the analyzed image.

3.2.3.1 *Discussion*—The effective pixel size of the optical system is determined by the physical pixel size of the sensor and a magnification factor caused by the lens of the camera.

3.2.4 *resolution*

3.2.4.1 *image*—the detail an image holds, also called pixel density.

3.2.4.1 *Discussion*—Higher resolution means more image detail, often expressed in pixels per inch or dots per inch.

3.2.4.2 *camera*—resolution of the sensor: the sheer number of pixels on the sensor; the amount of detail that a camera can capture, measured in pixels (for example, 4k-camera).

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.5 *optical resolution*—describes the ability of an imaging system to resolve detail in the object that is being imaged.

3.2.5.1 *Discussion*—It is the sum of all system effects, such as lateral resolution, lens resolution, etc.

3.2.6 *minimum detectable object size*—smallest number of pixels of a defect such that the defect can be reliably detected, typically pixel size × 3.

3.2.7 *defect size*—a length derived from the area of the defect.

3.2.7.1 *Discussion*—Commonly equivalent circular diameter, longest elongation or longest axis through center of mass are used and may not yield a same value.

Pixel size depicted in Appendix X6 is effective pixel as defined in 3.2.3.

3.2.7.2 *equivalent circle diameter*—this is the diameter of a circle having the same area as the digitized image of the defect as depicted in Appendix X6.

3.2.7.3 *maximum extension*—the diagonal of a box circumscribing the defect as depicted in Appendix X6.

3.2.8 *sensitivity levels*—a threshold value (for example, % of grey value, brightness) to distinguish the pixels associated with the defect from the film matrix.

3.2.8.1 *Discussion*—It is the threshold limit where the software detects/reports defects in the film. This may be defined by the vendor (factory setting) but this value can be optimized for your test material. If the value is too low it will not properly detect the defects in the film. If the value is too high it will lead to false detection.

3.2.9 *grey level*—value associated with a pixel representing the lightness from black to white. Usually defined as a value from 0 to 255, with 0 being black and 255 being white.

3.2.9.1 *Discussion*—Other ranges are possible (vendor dependent).

3.2.10 *parcel*—a user-defined smallest area of inspected film for statistical analysis to which a detected defect can be attributed.

3.2.10.1 *Discussion*—The statistical evaluation is based on number of parcels.

3.2.11 *total defect area*—sum of areas of defects (vendor dependent).

3.2.12 *inspected area*—total area of the film, inspected for evaluation.

3.2.13 *light source*—consistent source of light that shines through or on the film to provide a clear image for defect detection and measurement.

3.2.13.1 *Discussion*—Different type of light sources can be used, for example, halogen, LED, fluorescent, laser.

3.2.14 *mean filter*—the mean filter is a sliding window value based on a defined number of film parcel areas inspected

3.2.14.1 *Discussion*—During continuous measurement scenarios, the test is not usually stopped; therefore, a mean filter value should be used for reporting. A mean filter value is reported every time a new parcel area is inspected.

3.2.15 *neck-in*—difference between the width of the film compared to the width of the die.

4. Significance and Use

4.1 Defects in film are not acceptable to the end-user as there is a reduction in the fitness-for-use in many applications. This document is intended to be a practice to assist users in the inspection, quantification and observation of defects.

4.2 This practice is applicable in a laboratory environment, continuous inspection as a quality control or as a research tool. It is also appropriate for use in any commercial process used to produce film including extrusion, calendaring, etc.

4.3 This practice is also suitable for use as an evaluation or screening tool for materials intended to be used in other processes where defects of this nature are critical, such as fiber spinning non-woven, etc.

4.4 Results achieved by different equipment, even from the same vendor in the same laboratory, are often not directly comparable as a bias exists that cannot be fully addressed through consistent operating conditions. Results frequently shift when analyzer components are upgraded. Additionally, results are often not directly comparable between different product types. All results are to be considered as relative values rather than absolute.

4.4.1 Therefore, it is not recommended to provide absolute results as part of a sales contract between the buyer and seller. For sales contracts, it is recommended to establish product grade designations based on the historical relationship of the absolute results reported, and fitness-for-use or based on a reference material agreed by both parties. This is attained by the collection of data over a time-period to establish acceptable control limits.

4.4.2 The defect size range of interest is usually different between resin supplier and converters. Total defect counts are not one to one comparable between small laboratory extrusion lines and commercial extrusion lines. Therefore, an individual correlation is the aim to get accepted results for fitness-for-use.

NOTE 2—This was tested on Brabender, Collin, Goettfert, and OCS systems.

4.5 For support in a basic interpretation of the different results the following points may be helpful for comparison.

4.5.1 Size classes (number and definition)

4.5.2 Reported defect types

4.5.3 Comparable units (gels/kg, gels/m^2, class system, index...)

4.5.4 Vendor (type of equipment, for example, cast or blown film...)

4.5.5 Camera settings (sensitivity, grey level, resolution...)

4.5.6 Extrusion parameters

NOTE 3—For attribute data such as defect counts, C-type control charts are most appropriate per recommendations within Practice E2587, Section 9.

5. Apparatus

5.1 *Extruder*—A device for melting polymer that produces a cast or blown (tubular) filmwith sizes varying from lab-scale to production-scale.

5.1.1 *Cast Film Extrusion*—An extrusion system that produces a flat film that is quenched immediately after extrusion by means of one or more cooling devices such as an air knife, chill roll or water bath.