International

ISO 18488

Polyethylene (PE) materials for piping systems — Determination of strain hardening modulus in relation to slow crack growth — Test method

Matériaux polyéthylène (PE) pour systèmes de canalisations — Détermination du module d'écrouissage en relation avec la propagation lente de fissures — Méthode d'essai

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This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories — Test methods and basic specifications*.

This second edition cancels and replaces the first edition (ISO 18488:2015), which has been technically revised.

The main changes are as follows:

— the definition for strain hardening modulus, $<G_p>$, has been improved;

— the definitions that are also in ISO 527-1 have been removed from this document;

— an improved depiction of L in Figure 1;

— the gripping distance in Table 1 has been clarified;

— the tolerance for the gauge length, $l_{0,}$ has been increased;

— regrind from PE products has been added in 6.2 to align with the product standards (e.g. ISO 4437-2 and ISO 4437-3);

— reference to ISO 293 for compression moulding has been added;

— the description of the measurement of the thickness, h, and width, b_1, have been clarified;

— the explanations of the data analysis (Clause 8) and the strain hardening behaviour and the Neo-Hookean constitutive model (Annex A) have been revised.

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Resistance to slow crack growth of polyethylene materials is related in general to the lifetime of the material and thus, the lifetime of polyethylene products, e.g. pipes and fittings. The slow crack growth behaviour of a polyethylene material can be regarded as a combination of resistance to deformation of the crystalline phase (manifested as yield stress) and the amorphous phase (entangled chains and tie molecules) as reported by Kramer and Brown.[2],[3],[5],[6] The resistance to disentanglement of polymer chains in the amorphous phase of a polymer structure upon application of constant load will determine its resistance against slow crack growth.

The strain hardening modulus of polyethylene material is a measure of the resistance to disentanglement of the entangled chains and tie molecules of this polymer and is an intrinsic property. The strain hardening modulus of polyethylene is obtained from a “true stress vs. draw ratio” curve above the natural draw ratio. The “true stress vs. draw ratio” curve of a compression moulded sheet is relatively easily obtained using a tensile test apparatus equipped with an appropriate extensometer. The test time for measuring the strain hardening modulus is a consequence of the speed of tensile testing and is therefore constant for all measurements and independent of the slow crack growth property of the tested material itself.

The strain hardening modulus value allows differentiation between polyethylene materials. It has been demonstrated that the strain hardening modulus is sensitive to structural parameters of polyethylene [9],[10] and corresponds very well with several environmental stress cracking test methods for polyethylene, such as environmental stress cracking resistance (ESCR),[7] Pennsylvania notch test (PENT),[8] full-notch creep test (FNCT),[4] cracked round bar test (CRB) and notched pipe test (NPT)[11].