



SOP for measuring Linear Shrinkage.

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Title: Measurement of Linear Shrinkage Using an Identification-Tab Tensile Slab Mold

Target Application: Synthetic Sealing Elastomers (NBR, HNBR, FKM, ACM, AEM)

1. Purpose

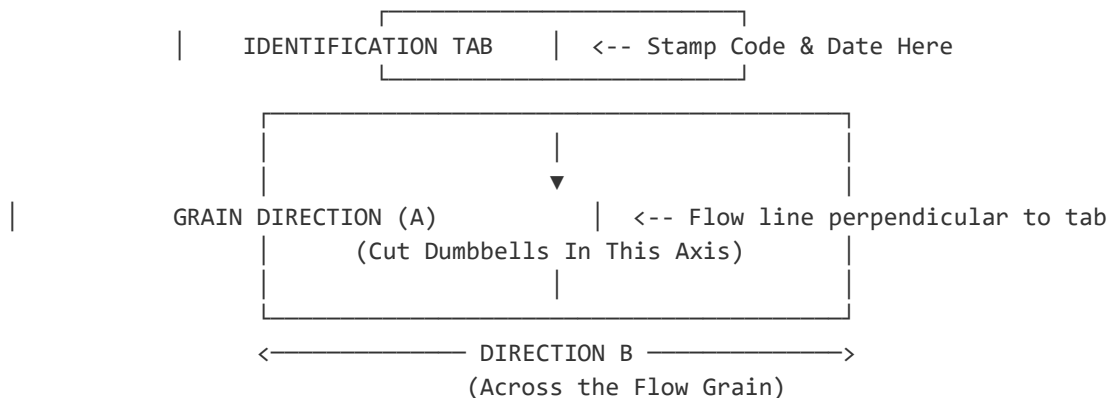
This procedure defines the standardized laboratory method to determine the linear shrinkage percentage of synthetic sealing elastomers (e.g., NBR, HNBR, FKM, ACM, AEM). It details how to properly utilize a standard 150 mm × 150 mm × 2 mm tensile slab mold equipped with a built-in identification tab. This testing simultaneously establishes the baseline tool-scaling factor required for rotary oil seal manufacturing and configures the slab optimally for grain-parallel tensile dumbbell die-cutting.

2. Equipment & Materials

- **Test Mold:** High-precision, single-cavity flash-type compression mold with a cavity measuring 150.0 mm × 150.0 mm × 2.0 mm, featuring a distinct built-in identification tab at one end.
- **Compression Press:** Hydraulic laboratory vulcanization press capable of maintaining specified platen temperatures ($\pm 2^{\circ}\text{C}$) and standard industrial molding pressures.
- **Measuring Instrument:** Digital calipers or a Coordinate Measuring Machine (CMM) calibrated to an accuracy of ± 0.01 mm.
- **Conditioning Substrate:** A flat, low-friction, thermally insulated surface (e.g., dry wood or thick cardboard sheet) kept at standard ambient conditions.
- **Die-Cutter:** Mechanical clicker press equipped with a standard ASTM D412 or ISO 37 Type 1/2 dumbbell specimen die.

3. Specialized Mold Orientation Topology

Synthetic compounds display tighter, more isotropic structures than natural rubber, but grain orientation must still be strictly managed for precise scaling and high-performance testing. The layout below rules the orientation:



4. Step-by-Step Procedure

Step 4.1: Cold Mold Baseline Calibration

1. Verify that the mold cavity and identification tab recess are completely clean.
2. Ensure the tool has stabilized to standard room temperature ($23 \pm 2^{\circ}\text{C}$).
3. Using precision calipers or a CMM, measure and record the exact dimensions of the cold steel cavity to the nearest 0.01 mm:
 - Dimension MA: Length measured perpendicular to the identification tab (along the future grain path).
 - Dimension MB: Width measured parallel to the identification tab (across the future grain path).

Step 4.2: Material Orientation & Loading

1. Sheet out the synthetic compound on the laboratory mixing mill. Explicitly track the mill grain/flow line direction.
2. Cut a square blank from the sheet, ensuring it is slightly smaller than the tool pocket footprint (e.g., 140 mm $\times$ 140 mm).
3. Load the raw rubber sheet into the pre-heated mold cavity such that the grain/flow direction runs perfectly perpendicular to the identification tab.

Step 4.3: Vulcanization & Indentation

1. Clamp the compression press and cure the slab according to the compound's validated time/temperature specification.
2. Utilize the mold's structural tab feature to deboss or permanently mark the unique compound batch code and processing date into the designated rubber tab extension.
3. Open the press platen, carefully eject the hot slab to prevent physical stretching, and immediately shear away edge flash.

Step 4.4: Environmental Stabilization & Relaxation

1. Transfer the hot, flash-free slab immediately onto the flat, insulated conditioning surface.
2. Allow the sheet to condition completely undisturbed for a minimum of 24 hours in a climate-controlled room maintained at $23 \pm 2^{\circ}\text{C}$. This ensures thorough dissipation of internal stresses and thermal equilibrium.

Step 4.5: Precision Linear Shrinkage Measurement

1. Place the relaxed slab face-up on a level benchtop after the 24-hour interval.
2. Apply the precision calipers gently to the slab midpoints (avoiding edge radiuses or localized anomalies):
 - Measure perpendicular to the identification tab (with the grain) to determine RA.
 - Measure parallel to the identification tab (across the grain) to determine RB.

Step 4.6: Tensile Specimen Production Handoff

1. Following successful dimension capture, transfer the relaxed slab directly to the mechanical clicker press.
2. Align the dumbbell specimen die perfectly parallel to the grain axis (running perpendicular to the stamped ID tab) and punch out the specimens for physical evaluation.

5. Mathematical Derivations & Calculations

Calculate the percentage shrinkage for both independent directional axes using the formulas below:

$$\text{With-Grain Shrinkage (\%)} = [(M_A - R_A) / M_A] \times 100$$



$$\text{Across-Grain Shrinkage (\%)} = [(M_B - R_B) / M_B] \times 100$$

For rotary oil seal application design: Given the highly controlled, isotropic nature of synthetic polymer chains like FKM, NBR, or HNBR, compute the Average Linear Shrinkage (S_{avg}) to serve as fundamental isotropic engineering scaling multiplier:

$$S_{avg} = (\text{With-Grain Shrinkage} + \text{Across-Grain Shrinkage}) / 2$$