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StandardPractice for Polyurethane Raw Materials: Polyurethane Foam Cup Test[1]

This standard is issued under the fixed designation D7487; 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 covers the determination of cream time (initiation time), top of cup time, free rise time, free rise height, string gel time (pull time), tack free time, settle back, and free rise density of polyurethane foam formulations using a cup foam test.

1.2 Typical definitions, terms, and techniques are described; including procedures for mixing and transferring samples to the foaming container; and data gathering and evaluation. However, agreement between the customer and the testing laboratory for all these items must be obtained prior to use.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

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

3. Terminology

3.1 *Definitions*—Terminology used in this practice follows that defined in Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cream time (initiation time)*—the time between the start of mixing and the point at which fine bubbles begin to appear.

3.2.2 *top of cup time*—the time at which the crown of the rising foam reaches the plane of the top of the cup.

3.2.3 *free rise time (end of rise time)*—the time at which the foam stops expanding as observed visually.

3.2.4 *string gel time (pull time)*—time at which long "strings" of tacky material can be pulled away from the surface of the foam when the surface is touched by the edge of a tongue depressor or similar implement.

3.2.5 *tack free time*—the time at which the surface of the foam can be touched with a gloved finger or tongue depressor without sticking.

3.2.6 *free rise density*—the density in kg/m^3 of a polyurethane foam prepared in an open cup.

3.2.7 *free rise height*—height of the foam at free rise time

3.2.8 *final height*—height of foam after specified time

3.2.9 *% settle back (% recession, % sigh back, or % sink back)*—percentage decrease from free rise height to final height

3.2.10 *resin blend (formulated polyol)*—complete ingredient formulation without the isocyanate

4. Summary of Practice

4.1 Specific events (cream time, initiation time, top of cup time, free rise time, free rise height, string gel time, and tack free time) from a polyurethane foamed in a cup are measured to verify the resin blend composition or levels of ingredients in formulations used to make polyurethane foams.

4.2 An estimation of the method precision is given. An estimation of bias is not given because there is no suitable reference method.

5. Significance and Use

5.1 *General Utility:*

5.1.1 It is useful to verify catalyst levels in a resin blend or a polyurethane system.

5.1.2 This practice is suitable for research, quality control, specification testing, and process control.

5.2 *Limitations:*

5.2.1 Several of the measured parameters are subjective. Therefore, operator-to-operator variability and lab-to-lab variability can be much higher than that of a single operator.

5.2.2 The variability of this practice is dependent on the consistency of mixing of the reactants.

5.2.3 The estimation of precision in this practice is based on typical formulations for rigid and flexible foams. Formulations

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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.

with faster reaction times will likely have greater variability, particularly cream time (initiation time). Formulations with slower reaction times will likely have greater variability in the measurement of free rise time.

5.2.4 It is possible that low-level (ppm, ppb) ingredient contamination will not be detectable using this practice. Confirmation of such contamination will potentially require large-scale (~ 20 litres) tests and is out of the scope of this practice.

6. Apparatus

6.1 *Stirrer for Mixing:*

6.1.1 Stirring motor,

6.1.2 Propeller or other type of mixing apparatus, and

6.1.3 Stainless steel shaft.

6.2 *Cups*

6.3 *Knife*—Cutting length of the blade must be large enough to cleanly cut through the risen foam at the top of the cup.

6.4 *Thermometers*—accurate to ±0.5°C.

6.5 *Stopwatch*—capable of measuring to 0.1 s.

6.6 *Balance*—capacity of 100 g and capable of weighing to 0.1 g.

6.7 *Tachometer*—capable of measuring to the nearest rpm.

6.8 *Ruler*—capable of measuring to 1 mm.

7. Test Conditions

7.1 Since isocyanates react with moisture, keep laboratory humidity low, preferably around 50 % relative humidity.

7.2 Some of the parameters are influenced by atmospheric pressure. The quantitative influence is not known at this time. If results are to be compared between laboratories located at significantly different elevations above sea level, it is advisable to measure the barometric pressure and develop a suitable, empirical correction factor. (**Warning—**Many diisocyanates are known or suspected sensitizers. Over-exposure to diisocyanates can lead to adverse health effects which may include the development of occupational asthma and other respiratory, skin, and eye effects. Engineering controls, or personal protective equipment, or both, including respiratory, skin, and eye protection, are to be used when there is a potential for over-exposure to diisocyanates. The product suppliers' Material Data Safety Sheet (MSDS) provides more detailed information about potential adverse health effects and other important safety and handling information. Always follow the specific instructions provided on the MSDS.)

8. Procedure

8.1 Check the stirrer speed with a tachometer and rotation direction in air with no load and turn the stirrer off after checking.

8.2 Weigh an empty cup and record the weight.

8.3 Weigh reactants into the cup in accordance with previously established order of addition.

NOTE 2—Ensure that the temperature of the reactants is as specified prior to use.

NOTE 3—This cup is then nested into another cup to prevent spilling chemicals in case the propeller cuts the first cup. Some practitioners use plastic cups with thicker walls and omit the second cup.

NOTE 4—If users elect to mix in one cup and pour into a second cup, results may vary.

8.4 Immerse the stirrer blade completely to a starting position in contact with the bottom of the cup and retract it slightly.

8.5 Simultaneously, turn on the mixer switch, and start the stopwatch.

NOTE 5—In some cases, it is better to ramp up the mixer speed. Such modifications need to be established prior to testing.

8.6 Mix the materials for a specified time then, remove the cup from the spinning mixing blade.

NOTE 6—Care must be taken to remove the cup slowly so that splashing of the reaction mixture does not occur. If appropriate, stop the mixer at the end of the specified time and then remove the cup.

8.7 Place the cup in a fume hood and record the times as defined in Section 3.

8.8 Clean the stirrer blade thoroughly after each test.

8.9 After a specified time, cut off the crown of the foam as close to the top edge of the paper cup as possible.

8.10 Record the weight of the cup plus remaining foam to the nearest 0.1 g.

9. Calculation

9.1 Calculate the Free Rise Density and express as kg/m^3.

9.1.1 An example of how Free Rise Density can be determined is as follows:

9.1.1.1 Calculate the weight of the foam in the cup as follows:

$$W_{(foam)} = \left[W_{(cup+cut\ foam)} - W_{(empty\ cup)}\right]$$

where:

$W_{(foam)}$ = weight in grams of the remaining foam in the cup

$W_{(cup\ +\ cut\ foam)}$ = weight in grams of the cup plus remaining foam

$W_{(empty\ cup)}$ = weight in grams of the empty cup

9.1.1.2 Calculate the Free Rise Density as follows:

$$Free\ Rise\ Density\ (kg/m^3) = g/L = W_{(foam)}/V_{(cup)}$$

where:

$W_{(foam)}$ = weight in grams of the remaining foam in the cup

$V_{(cup)}$ = the volume of the cup in litres

9.1.2 An example of how to calculate % Settle Back as follows:

$$\%\ Settle\ Back = (H_{rise} - H_{final}) \times 100\,\%/H_{rise}$$

where:

H_{rise} = free rise height of foam in millimetres

H_{final} = final foam height in millimetres

10. Report

10.1 Report all time results as previously agreed, typically to the nearest whole second.