Wydział Inżynierii Lądowej

POLITECHNIKA WARSZAWSKA

BUILDING MATERIALS

LABORATORY PRACTICAL TASK

Plastics as building materials

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Table of contents

1. Aim of the task

The aim of the task is to learn basic information about the selected types of plastics, their properties and test methods.

Tests to perform:

Test:	**Material:**
• volumetric density	styrofoam (a specimen with a regular shape of a rectangular prism)
• flexibility	PVC lining (polyvinyl chloride)
• viscosity - flow time (Ford cup) • ability to cover the substrate layer	paint (eg. silicone paint) in a liquid state
• scratch resistance of paint coatings (Clemen apparatus) • impact resistance of paint coatings (Du Pont apparatus)	paint (eg. epoxy paint) in a solid state

2. Theoretical background

2.1. Definitions

Plastics – materials containing macromolecular organic substances as the basic component – polymers and additives (fillers, plasticizers, fixers, dyes);

Polymers (gr. *polymeres* – multi-part) macromolecular compounds that are formed as a result of the polyreaction of monomers (low-molecular substances);

Natural polymers (biopolymers) – polymers that occur naturally in living organisms (are produced by them), eg. natural rubber, polysaccharides (cellulose, starch), nucleic acids (polynucleotides - DNA and RNA), polypeptides and proteins, including enzyme proteins (casein).

Synthetic polymers – they do not occur naturally, they are entirely a product of chemical synthesis (starting with simple monomers), eg. polyethylene, polystyrene, poly(vinyl chloride).

Modified polymers – natural polymers, chemically artificially modified, usually to improve their performance, eg. poly(vinyl alcohol).

Polymerization – a reaction as a result of which monomers or a mixture of monomers react with each other and form of molecules with a molecular mass many times greater than the substrates mass, forming polymers.

Polyaddition – repeated monomer attachment process without by-product separation (this is how polyethylene polymerizes, for example).

Polycondensaction – the repeated process of combining monomers with the release of a low molecular weight by-product - e.g. H_2O, HCl (this is how, for example, melamine resin polymerizes).

Thermoplastics – will melt when heated and solidify when cooled

Processing: extrusion, injection (e.g. polyethylene).

Thermosetting and chemosetting plastics – they cure under the influence of heating, UV or chemicals; they do not melt when heated, decompose irreversibly at a sufficiently high temperature (e.g. epoxy resins).

3. Laboratory task

3.1. Volumetric density

3.1.1. Materials and equipment

- styrofoam specimen with a regular shape,
- automatic scale,
- caliper.

3.1.2. Measurement

Check the dimensions of the test polystyrene specimen (of regular shape) and the specimen mass (m) with an accuracy of 0.1 grams. Then calculate the volume of the sample (V) in cm^3 and the apparent density with the accuracy of 0.001 g/cm^3 using the formula:

$$\rho_p = \frac{m}{V}$$

Where:

ρ_p – volumetric density [g/cm^3],

m – specimen mass[g],

V – specimen volume (with pores) [cm^3].

3.2. Flexibility

3.2.1. Materials and equipment

- PVC lining (polyvinyl chloride),
- steel pin for elasticity testing,
- caliper.

3.2.2. Measurement

Test according to standard EN 435:2000.

Test procedure:

- Determine the external dimensions (using a caliper) and the thickness (using a micrometer screw) of the lining sample.
- Place the sample on a metal rod with a known diameter (top layer outside).
- Bend the carpet by wrapping it around the roller.
- Assess changes to sample, including the presence of scratches and cracks.
- Repeat the steps for the lining placed on the roller with the bottom layer on the outside.

Test result:

The test result is the smallest bending bar diameter in mm (from a set of metal bars), around which the sample shows no surface damage (Fig. 1). Scratches and cracks are unacceptable.

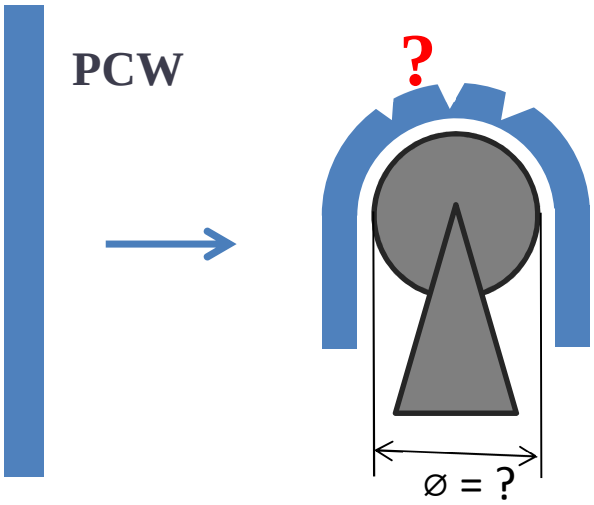

Fig. 1. Testing the flexibility of the PVC lining

3.3. Viscosity - flow time (Ford cup)

3.3.1. Materials and equipment

- paint (eg. silicone paint) in a liquid state,
- Ford cup,
- beaker with a capacity of 250 ml,
- baguette (glass rode),
- stopwatch (on the phone).

3.3.2. Measurement

Test according to standard EN ISO 2431.

Test procedure:

- Fill the Ford cup with the sample (filtered through a suitable sieve), first plugging the hole.
- Remove excess sample (together with any air bubbles) with a ruler or glass plate.
- Place a vessel under the flow cup so that the distance between the cup opening and the sample dripping surface is not more than 100 mm.
- Remove your finger from the hole while starting the timer.
- The outflow time should be measured with an accuracy of 0.5 s until the first interruption of the flowing sample.

Test result:

The result is the average of two measurements which do not differ by more than 5% from their mean.

3.4. Ability to cover the substrate layer

3.4.1. Materials end equipment

- paint (eg. silicone paint) in a liquid state,
- brush,
- glass plate,
- micrometer screw (optional);

- drier/oven.

3.4.2. Measurement

The test (determination of the quantitative coverage) consists in determining the smallest number of layers of the coating applied under the conditions established by the standard on a black and white substrate (checkerboard pattern), which ensures the invisibility of the substrate (pattern) in every place. (Additionally, the thickness of each applied coating layer can be measured with a micrometer screw.)

Test procedure:

- Apply a layer of paint to a sample of a surface with a black and white checkerboard pattern (apply with a brush in one direction), and then place the sample in the dryer.
- After the sample is dry, the test coating should be observed - check whether the checker pattern from the substrate is visible. If it is not visible, the test can be terminated. Otherwise:
- Another layer of paint should be applied to the sample (the paint should be applied perpendicular to the direction of the previous layer), and then the sample should be placed in the dryer.
- After the sample is dry, check whether the checker pattern on the substrate is visible. If it is not visible, the test can be terminated. If not, repeat the steps from the previous point.

Determination of thickness (Fig. 2):

- Before applying a layer of paint, use micrometric screws to measure the thickness of the sample. After the coating has dried, measure the thickness of the layer with the coating and determine the thickness of the applied coating. Repeat the operation in the case of applying further layers.

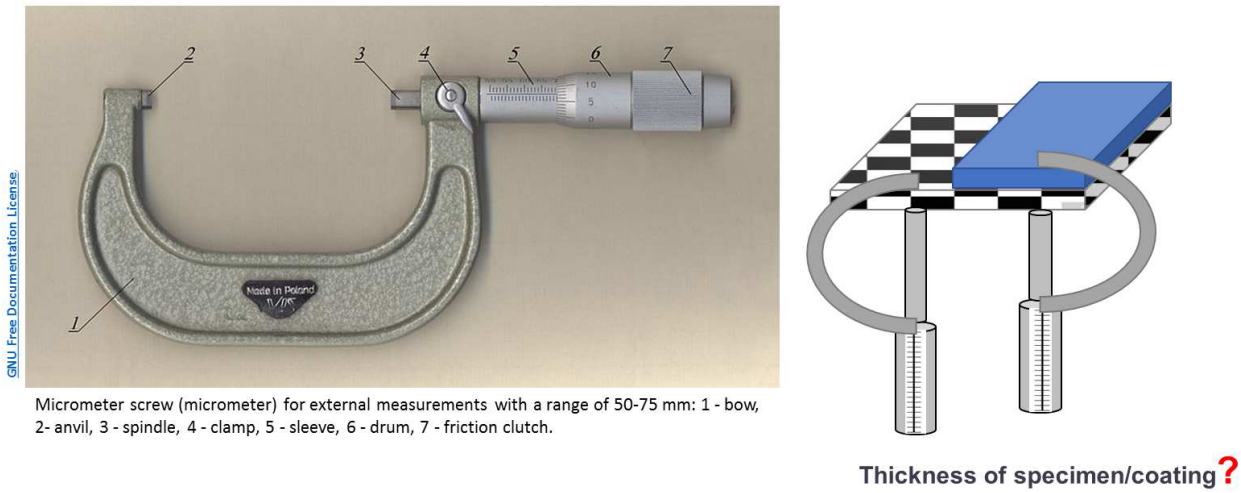

Fig. 2. Determination of thickness using micrometer screw

Test result:

The result is the number of coating layers needed to achieve complete coverage. In the event of measurement, the thickness of the individual coating layers should be analyzed.

3.5. Scratch resistance of paint coatings

3.5.1. Materials and equipment

- paint (eg. epoxy paint) in a solid state,
- Clemen apparatus.

3.5.2. Measurement

The test is performed according to EN ISO 1518. The principle of the method consists in checking whether the loaded stylus of the Clemen apparatus causes surface scratching without exposing the substrate (Fig. 3). Plates with dimensions of 100 mm x 80 mm x 1 mm (prepared acc. to PN-64 / C-81513) with a coating thickness of 30 ÷ 40 μm (mass of the weight according to the standard for the tested product) should be used.

Test procedure:

- The test sample is placed on a stage that moves at a length of at least 60 mm.
- Make 3 scratches at least 10 mm apart.
- Scratching should be observed with the bare eye.

- Repeat the test with the greater mass until the coating is broken.

Test result:

In the absence of the subject standard, the scratch resistance should be the highest load, which causes surface scratch, without exposing the substrate (i.e. at which the continuity of the paint coating has not been broken).

Fig. 3. Testing scratch resistance of paint coatings using Clemen apparatus (Anyicor) [photo source: https://anticorr.pl/clemen-test,p,354,863.html]

3.6. Impact resistance of paint coatings

3.6.1. Materials and equipment

- paint (eg. epoxy paint) in a solid state,
- Du Pont apparatus.

3.6.2. Measurement

The impact resistance of paint coatings is tested with the Du Pont apparatus in accordance with EN ISO 6272-1. The measurement consists in determining the maximum height from which the weight of 1 kg falls on the plate with the tested coating, without causing mechanical damage to the coating.

Test procedure:

- The plate is placed with the coating facing up on the anvil under the spike.
- After fixing the weight at the required height, release the clamp.

- Then the test coating must be observed. If there are no cracks or chipping of the coating from the plate, drop the weight from a greater height.

Test result:

The impact resistance of a coating is defined as the highest height at which no damage has occurred to the coating. Take 12 measurements on 3 tiles, 4 tests each. The arithmetic mean of the individual results (excluding the highest and the lowest) is taken as the final result, but the difference between the results should not exceed 1.5 cm in height.

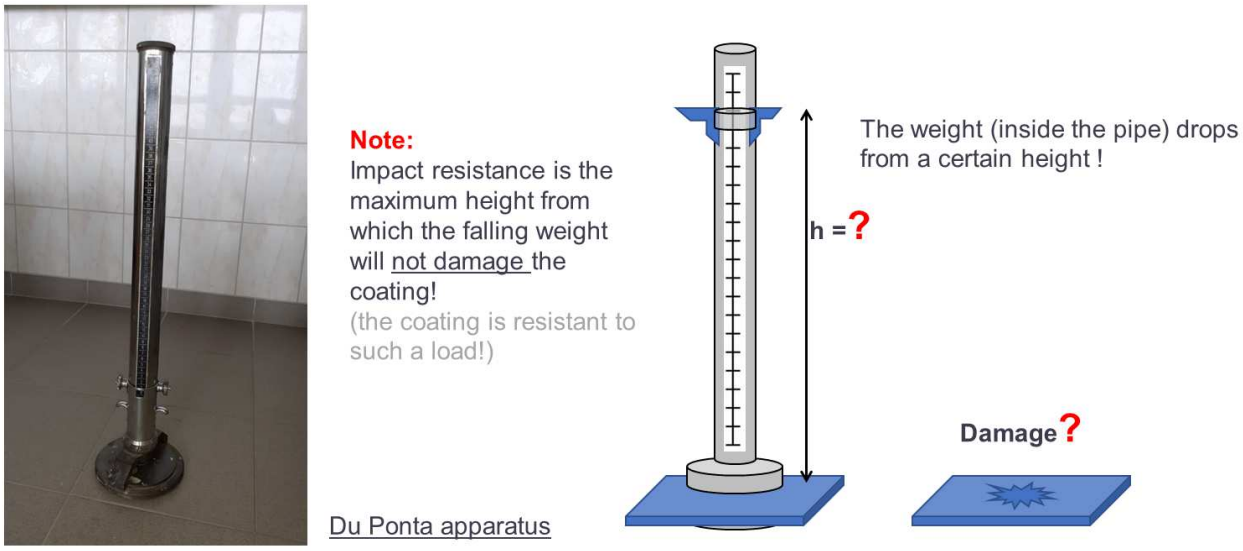

Fig. 4. Testing impact resistance of paint coatings using Du Pont apparatus

4. Summary of the measurements

Tab. 1. Results of testing – summary (example of table)

Test	Volumetric density, g/cm^3	Flexibility	Viscosity (flow time), s	3.4. Ability to cover	Scratch resistance, g	Impact resistance, cm
Styrofoam ……		x	x	x	x	x
Styrofoam ……		x	x	x	x	x
Styrofoam ……		x	x	x	x	x
Styrofoam ……		x	x	x	x	x
PVC lining …			x	x	x	x
PVC lining …			x	x	x	x
PVC lining …			x	x	x	x
PVC lining …			x	x	x	x
Silicone paint …	x	x		x	x	x
Silicone paint …	x	x		x	x	x
Silicone paint …	x	x		x	x	x
Silicone paint …	x	x		x	x	x
Silicone paint …white	x	x	x		x	x
Epoxy paint …	x	x	x	x		
Epoxy paint …	x	x	x	x		

5. The report

The report should include the following points:

- Subject of study (basic information about the tested materials)
- Findings (the results of determinations are presented in tables and compiled as indicated)
- Conclusions (bulleted statements formulated on the basis of the obtained results)

- References (list of references to the literature, e.g.books, papers, documents, internet websites, used to prepare the report).

6. Literature

- Mamlouk M., Zaniewski J.: Materials for Civil and Construction Engineers