FEATURES OF THE INFLUENCE OF EXTERNAL FACTORS ON THE LINEAR DIMENSIONS OF POLYVINYL CHLORIDE LINOLEUM

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Abstract: *the article studies the changes observed under the influence of external factors on samples of polyvinyl chloride linoleums produced using various technologies. In particular, the influence of such factors as natural storage in a heated warehouse mode at a temperature of 293±3K, dry-air thermostating at a temperature of 343K, and liquid thermostating in distilled water at a temperature of 353K are investigated.*

The combined PVC linoleum on a heat and sound insulating base, three-layer roll-calender PVC linoleum without a base, and foamed PVC linoleum with a printed pattern were tested. When using dry-air thermostating, a standard method was used, when using liquid thermostating, a non-standard method was used. The change in the linear dimensions of PVC linoleums was determined by comparing the distances between the marks on the linoleum sample before and after exposure to it for a given time.

The change in the linear dimensions of different types of PVC linoleums during storage was not the same for different types of linoleum. The greatest changes in both longitudinal and transverse directions during the first twelve months of storage were observed in roll-calender linoleum, which can be explained by the occurrence of large residual stresses during the production process. Foamed PVC linoleum had a fairly high stability of linear dimensions, and this feature took place during all three types of impact on the material. At the same time, the greatest changes in linear dimensions could be observed precisely during liquid thermostating, which is associated, first of all, with an increased heat and energy effect on the test samples.

Keywords*: PVC linoleum, linear dimensions, storage, thermostating control.*

ОСОБЕННОСТИ ВЛИЯНИЯ ВНЕШНИХ ФАКТОРОВ НА ЛИНЕЙНЫЕ РАЗМЕРЫ ПОЛИВИНХЛОРИДНОГО ЛИНОЛЕУМА

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Аннотация: *в статье исследованы изменения, наблюдаемые под воздействием внешних факторов на образцах поливинилхлоридных линолеумов, изготовленных по различным технологиям. В частности, исследовано влияние таких факторов, как естественное хранение в режиме отапливаемого склада при температуре 293±3K, термостатирование сухим воздухом при температуре 343K и термостатирование жидкости в дистиллированной воде при температуре 353K. Испытывались комбинированный ПВХ-линолеум на тепло- и звукоизоляционной основе, трехслойный рулонно-каландровый ПВХ-линолеум без основы и вспененный ПВХ-линолеум с напечатанным рисунком. При суховоздушном термостатировании применяли стандартный метод, при жидкостном термостатировании – нестандартный. Изменение линейных размеров ПВХ-линолеумов определяли путем сравнения расстояний между метками на образце линолеума до и после воздействия на него в течение заданного времени. Изменение линейных размеров разных видов ПВХ-линолеумов при хранении было неодинаково для разных видов линолеума. Наибольшие изменения как в продольном, так и в поперечном направлении в течение первых двенадцати месяцев хранения наблюдались у рулонно-каландрового линолеума, что можно объяснить возникновением больших остаточных напряжений в процессе производства. Вспененный ПВХ-линолеум обладал достаточно высокой стабильностью линейных размеров, причем эта особенность имела место при всех трех видах воздействия на материал. При этом наибольшие изменения линейных размеров наблюдались именно при термостатировании жидкости, что связано, прежде всего, с повышенным теплоэнергетическим воздействием на испытуемые образцы.*

Ключевые слова: *ПВХ-линолеум, линейные размеры, хранение, термостатирование.*

Introduction. Polymer composite materials are used in a variety of industries, due to a set of consumer properties that provide this type of material with certain advantages over other materials. They are distinguished by lightness, good resistance to various kinds of chemical and physical influences, ease of installation, sufficient

durability and a number of other positive properties. One of the areas where this type of material is used particularly widely is building materials and products, in particular flooring materials. Flooring materials, for example, linoleums, are very often produced on the basis of polyvinyl chloride. In this case, both suspension and latex polyvinyl chloride of various grades are used. In addition to the polymer itself, fillers, DEHP plasticizers, stabilizers, and other additives are added to the composition of the polymer composition for the production of linoleums, which can significantly change the properties of the material in one direction or another [1]. At the same time, the strength characteristics of materials change, for example, tensile strength (σ), absolute and relative elongation at break (ε), their linear dimensions can fluctuate greatly over time during storage and operation of PVC linoleums, there are noticeable differences in density (ρ) and porosity of materials, etc. [2,3] Many of the above changes can ultimately lead to a decrease in the service life and, accordingly, to a decrease in the quality of the finished product [4]. Therefore, the analysis of the change in the linear dimensions of PVC linoleums under the influence of certain factors is important in terms of determining the service life of PVC flooring materials.

Objects and methods of research. The basis of the modern range of PVC materials for floors today is linoleum, linoleum carpets and PVC tiles. The materials supplied to the consumer market by modern manufacturers differ in length, width, thickness, the presence of a substrate, the number of layers and a number of other parameters. As a result of the analysis of the modern consumer market of polyvinyl chloride flooring materials, in order to conduct comprehensive studies, a combined PVC linoleum on a heat and sound insulatingsubstrate, a three-layer roll-calender linoleum without a substrate, and foamed PVC linoleum with a printed pattern and a fiberglass frame from various manufacturers were selected (Table 1).

Table 1. Characteristics of PVC linoleums.

№	Variety of linoleum	Color and condition of the surface of the sheet	Number of polymer layers	Type of subbase or frame	Thickness of the front film (mm)	Thickness of the polymer layer (mm)
1	Combined on a heat and sound-insulating substrate	With a transparent front layer	1	Needle-punched from bast fibers	0,2	1,2
2	Roll-calender multilayer without asubstrate	Light brown, smooth	3	No	0,2	1,3
3	Foamed linoleum with a printed pattern	Light brown parquet pattern, matt surface	1	Fiberglass	0,2	1,8

When conducting research, samples of PVC linoleums were selected from the part of the rolls that met the requirements. The method for determining the change in the linear dimensions of PVC linoleums was based on a comparison of the distances between the marks applied to the linoleum sample before and after storage, as well as before and after exposure to elevated temperatures for a given time. Marks are applied with a marking pattern. The tests were carried out in a dry-air thermostat XT-3/70 maintaining a temperature of 70±0.1°C and a liquid thermostat T-2 at a temperature of 80±0.5°C. The distances between the marks were measured using an optical meter providing a tenfold increase and equipped with a measuring scale with a division value of 0.1 mm. On the surface of the control template, made of steel for grading the marking template, there is a point and an arc, the distance between which is 100 ± 0.5 mm. The marking template consists of a metal rod 130 mm long, in which two parallel-mounted needles made of U8 steel are fixed at a distance of 15 mm from the edges. Sample measurements are performed on a polished steel plate with a flat and smooth surface. In parallel, markings were applied in a non-destructive way through a stencil made of polymethyl methacrylate. Three samples were cut from sections of PVC linoleum not close to the edges 130×130 mm in size, which were laid on the surface of a polished steel plate and covered with a marking steel plate with a flat surface, having a section of 150×150 mm. After marking three samples of linoleum, they were laid on horizontally placed shelves of a dry-air thermostat or immersed in a liquid thermostat tank and kept at a temperature of 70±0.1°C for 18,000 seconds or at a temperature of 80±0.5°C for 900 seconds respectively. Then the samples were removed from the appropriate thermostat, laid on horizontal surfaces, cooled to a temperature of 20±2°C and kept for 1800 seconds. On the cooled samples in the sequence described above, the marks were repeatedly applied. The distance between the marks was measured using an optical device with an accuracy equal to half the division value (0.05 mm).

The change in linear dimensions, X (%) was determined by:

$X = \Delta l/l \times 100,$

where Δl is the distance fixed between the marks, mm;

l is the distance between the needles of the marking template, mm.

The studied indicator was calculated both for the direction coinciding with the direction axis of the sheet (longitudinal) and for the direction perpendicular to the forming axis (transverse). Repeated measurements with a polymethyl methacrylate stencil were carried out using an optical meter. The final result of measuring the change in the linear dimensions of linoleum samples was considered the arithmetic mean of the test results of three samples.

Research results and their justification. The results of the study of the stability of the linear dimensions of PVC flooring materials depending on the storage time at 293±3K, as well as the results of the standard test method in the XT-3/70 dry-air thermostat (343K) and the non-standard method of liquid thermostat control in the T-2 thermostat (353K) are presented in Table 2 and in Figures 1, 2 and 3.

Table 2. The dependence of the change in the linear dimensions of PVC-linoleum samples in the longitudinal (a) and transverse (b) directions on the duration of storage in the heated warehouse mode (293 ± 3K) and the results of dry-air (XT-3/70; 343K) and liquid (T-2; 353K) thermostating control.*

№ №	Type of linoleum	Duration of storage (months; %)				Dry-air thermostating control, 343K (%)	Liquid temperature control, 353K (%)	Standart requirements, no more (%)
		1	3	6	12			
11	Combined on a heat and sound insulating base, A	a +0,3** b-0,2***	0,5 0,3	0,63 0,4	0,65 0,4	0,5	0,9	0,5
22	Roll calender three-layer without substrate, B	a +0,45 b-0,1	0,6 0,2	0,73 0,3	0,75 0,3	0,65	1,0	1,0
33	Foamed linoleum with a printed pattern, C	a 0 b 0	+0,05 0	0,05 0	0,1 0	0	0,15	0,2

* the number of samples tested in parallel is nine; **elongation; ***shrinkage

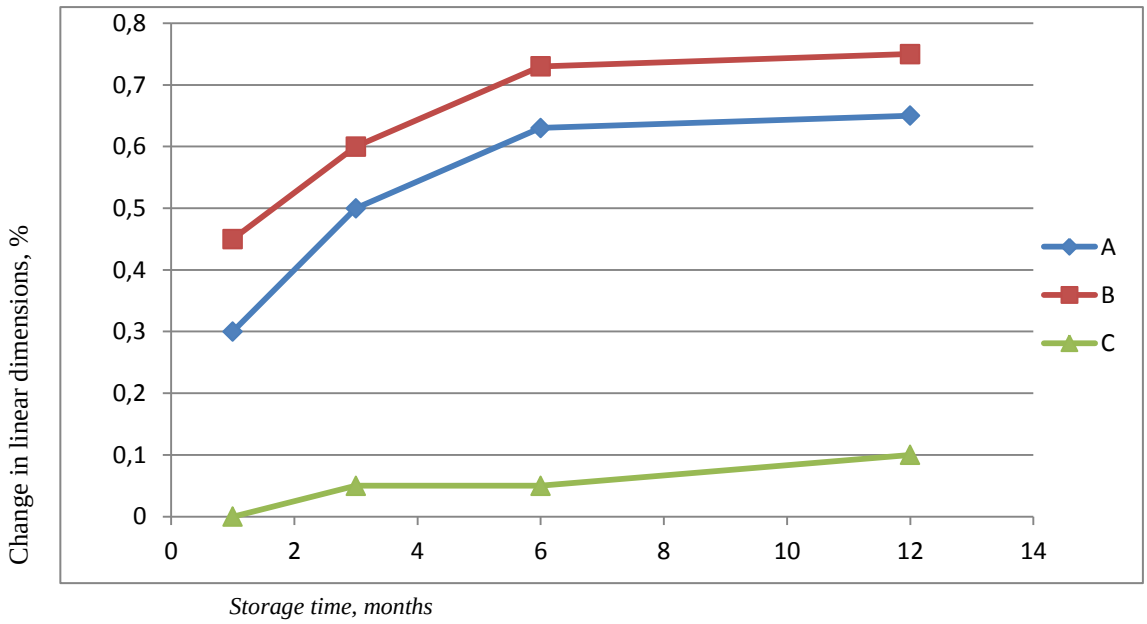

Fig. 1. Dependence of the change in the linear dimensions of PVC linoleum samples in the longitudinal direction on the duration of storage at 293±3K. Designations as in table 2.

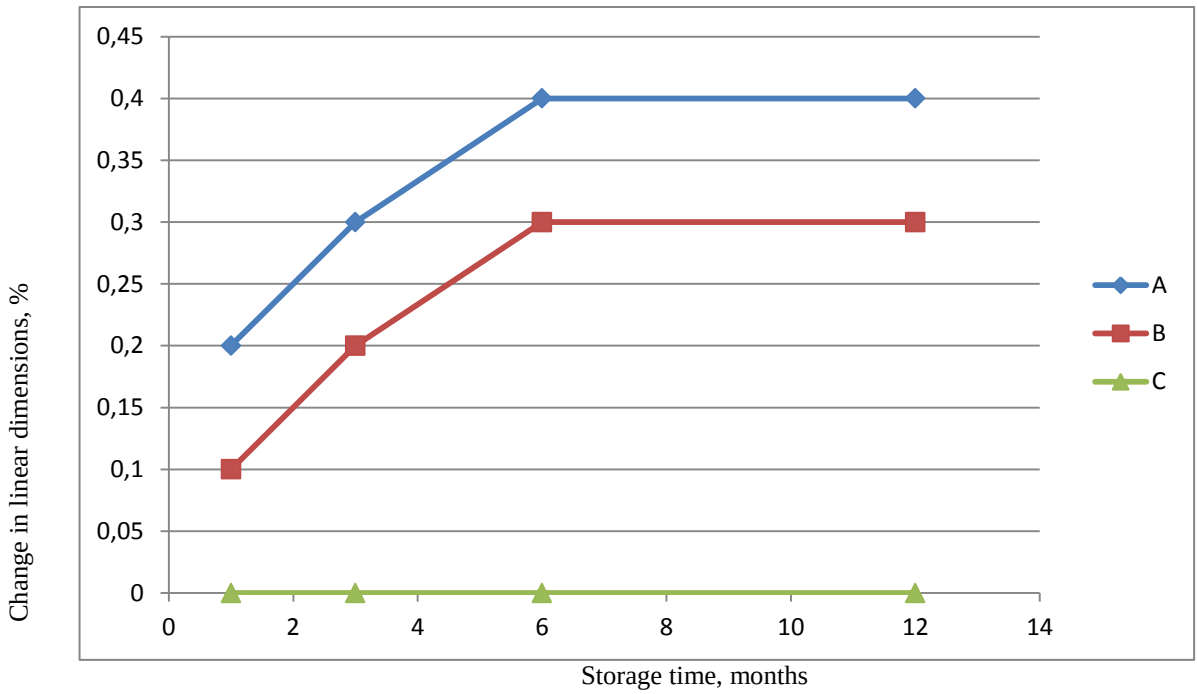

Fig. 2. Dependence of the change in the linear dimensions of PVC linoleum samples in the transverse direction on the duration of storage at 293±3K. Designations as in table 2.

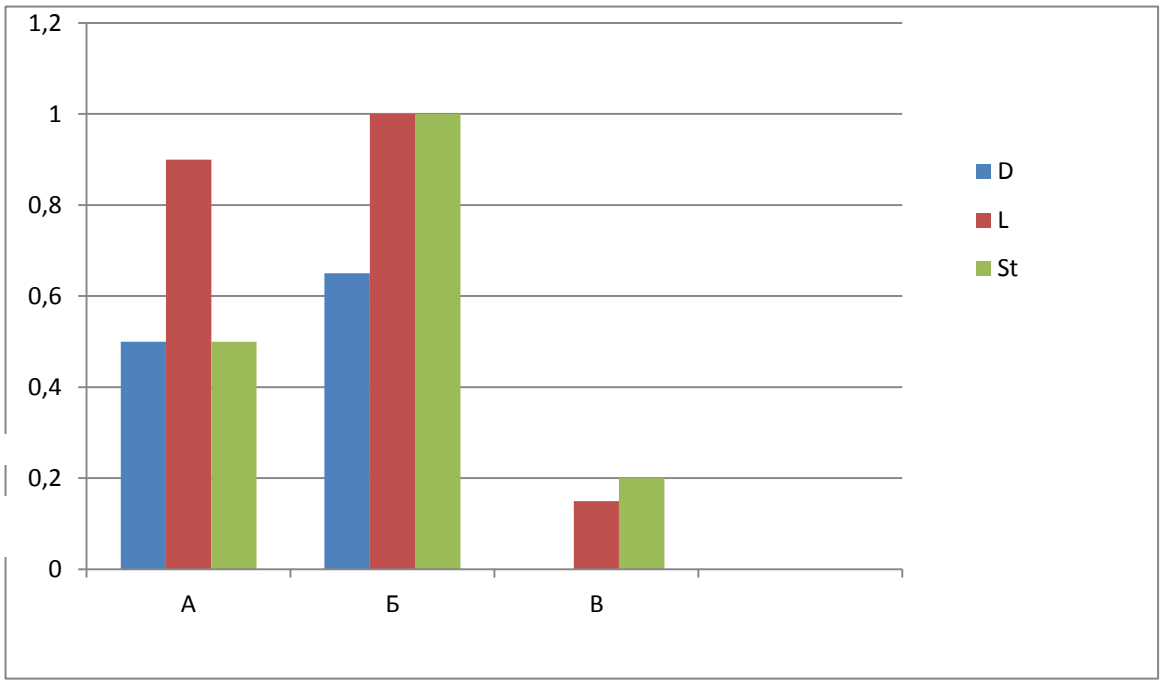

Fig. 3. Changes in the linear dimensions of PVC linoleums in the longitudinal direction during dry-air (343K - D) and liquid (353K - L) thermostating control. Designations as in table 2.

As can be seen from Table 2 and Figures 1 and 2, the change in the linear dimensions of various types of PVC linoleums during storage occurs differently for different types of linoleum. The largest change in linear dimensions (up to +0.75% in the longitudinal and up to -0.3% in the transverse direction) in the first twelve months of storage is observed in roll-calender linoleum, the production technology of which (rolling and calendering) contributes to the occurrence of large residual stresses. The rapid relaxation of such stresses leads to increased shrinkage already at the beginning of storage. The change in linear dimensions of the combined linoleum on a heat and sound insulating substrate during 12 months of storage amounted to +0.65% in the longitudinal and -0.4% in the transverse direction. The high stability of linear dimensions in foamed PVC linoleum (up to -0.1% only in the longitudinal direction), associated with the peculiarities of the technological

process, is explained by the presence of a reinforcing frame made of fiberglass in this type of linoleum. At the same time, it should be noted that the intensity of the relaxation process (changes in linear dimensions) is uneven and the instability of the dimensions of PVC linoleum samples manifests itself especially strongly at the first stages of storage, which does not contradict fundamental research [4]. It should be added that in the study of polyvinyl chloride linoleums, a special place is given to their bactericidal properties [5], the emission of phthalate-containing compounds from the composition of linoleums, etc. [6]. The choice of raw materials for the production of PVC linoleums also has a great influence on the stability of linear dimensions [7].

The results of testing samples (table 2 and figure 3) according to the standard method of dry-air thermostating in a thermostat XT-3/70 at 343K for 5 hours (0.5% for combined, 0.65% for roll calender and 0% for foamed PVC linoleums), although they reflect the specifics of dimensional instability for these types of linoleum [8], they do not provide an objective assessment of the true change in linear dimensions, which can be seen from the results of studying this indicator already in the first 12 months of storage.

At the same time, a non-standard method of liquid thermostating in distilled water (T-2 thermostat) at 353K for 15 minutes (0.9% for combined, 1.0% for roll-calender and 0.15% for foamed PVC linoleums) reveals a much greater instability of the linear dimensions of the tested samples, which is associated, first of all, with an increased heat and energy effect on the samples.

Conclusions. It was found that a change in linear dimensions over time of storage is observed in all types of PVC linoleums selected for testing, and these changes manifests themselves more in the first months of storage, which is explained by the high rate of relaxation of stresses that have arisen in materials during production during this period. At the same time, changes in the linear dimensions of PVC linoleum samples as a result of dry-air and liquid thermostating for a short period of time indicate stress relaxation at a much higher rate than during conventional storage. However, this speed in dry-air and liquid thermostating differs significantly. Thus, analyzing the results of the studies of the stability of the linear dimensions of PVC linoleums during storage for 12 months and according to the results of standard and non-standard tests, it can be assumed that the above method of liquid thermostating provides the most objective assessment of the true change in linear dimensions during storage and operation.

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