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STUDY OF THE PROPERTIES OF THE ELASTIC WOVEN FRAME OF RESCUE HOSES

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Abstract
The shrinkage of an elastic woven frame under the influence of moisture and the change in its residual deformation with a change in the number of deformation cycles have been studied. The results are presented in the form of tables and histograms.

Keywords: Elastic rescue sleeve, fabric, modulus of elasticity, deformation, elongation at break, elastic deformation.

Introduction
The dimensions of fabrics can change during moisture-heat treatment, washing, ironing, finishing, storage in an air environment with high humidity, such a change in the size of the fabric is called fabric shrinkage. Usually, the size of the tissues decreases. This shrinkage is called positive shrinkage. Fabric shrinkage occurs for the following reasons:
- in all transitions of the technological process of weaving, the threads are under the influence of tension. When the fabric gets wet, the fibers and fabric fibers try to return to their original position;
- in a humid environment, fibers and threads absorb moisture, swell and collapse in length.

The elastic fabric of the new structure is weaved from cotton yarn along the warp, and the weft thread is obtained by warping rubber and polyester threads. As mentioned above, threads made from natural fibers shrink more than threads made from artificial fibers. In the process of laying the weft, the rubber threads of the warp are significantly stretched, but the warp threads do not allow them to fully return to their original position. It is necessary to study the process of shrinkage under the influence of moisture of a new fabric structure, consisting of threads of such a heterogeneous structure.
To determine the amount of shrinkage of the new structure of the elastic tissue, tissue samples were prepared according to GOST R 30157.1-95 [1] with a size of 250x250 mm. Marks were placed on the samples in the direction of the warp and weft and the distance between them was measured. After washing. Drying and ironing the samples again measured the distance between the marks. Based on the results obtained, we calculated:
1. Linear shrinkage of the fabric

$$K_a = \frac{(L_1 - L_2)}{L_1} \cdot 100 = 1 - \frac{L_2}{L_1},\ \% \qquad (1)$$

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2. Surface shrinkage of the fabric

$$K_S = \frac{S_1 - S_2}{S_1} \cdot 100\,,\ \% \quad (2)$$

3. Bulk shrinkage of the fabric

$$K_V = \frac{V_1 - V_2}{V_1} \cdot 100 \quad (3)$$

Here: L_1, S_1, V_1 – respectively, the initial length, area and volume of the tissue sample;
L_2, S_2, V_2 – respectively, the length, area and volume of the fabric after shrinkage.
The results of measurements and calculations are shown in Table 1.

Table 1 Numerical indicators of shrinkage of samples of elastic tissue

№	Tissue samples	Thread density, n/dm		thread direction	Sample length, mm		Shrinkage amount, %
		Warp	Weft		Before soaking -L_1	After soaking -L_2	
1.	1-образец	120	180	By warp	250	242,3	3,1
				By weft	250	241,3	3,5
2.	2-образец	120	140	By warp	250	240,0	4,0
				By weft	250	234,3	4,3
3.	3-образец	120	100	By warp	250	239,0	5,2
				By weft	250	232,5	5,4

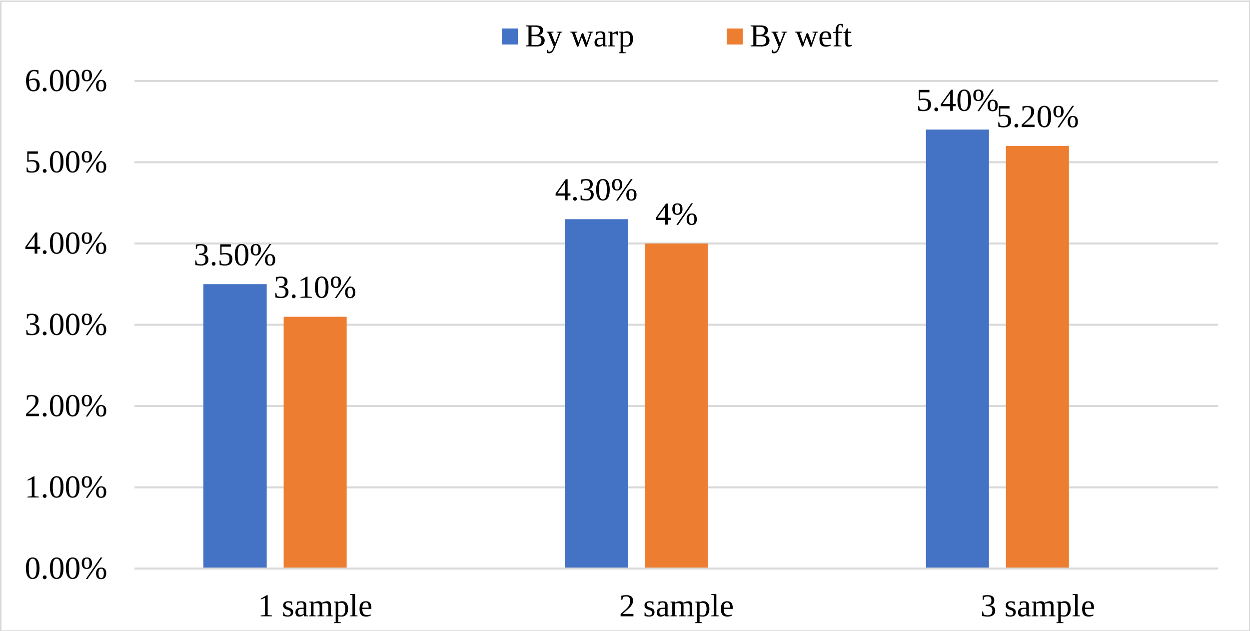

Figure 1. Histogram of shrinkage of elastic tissues.

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The results of the experiment show that under the influence of moisture, the fibers become elastic, swell, shorten, as a result of which the fabric shrinks, that is, the warp and weft threads are aligned. In fabrics made from the same structure of warp and weft threads, shrinkage is greater in the direction of the warp. In our fabric, the weft thread has high elastic properties, so the shrinkage of the fabric in the weft direction is higher. According to GOST R 53271-2009, shrinkage should not exceed 5%. As can be seen from the histogram, the first and second tissue samples meet these requirements.

During operation, the elastic sleeve is subjected to tensile forces that cause deformation of the sleeve. Therefore, it is advisable to study the nature and magnitude of the complete and residual deformation of the new structure of the elastic sleeve under the action of a tensile load.

To determine the complete and residual deformation of the elastic tissue, tests were carried out by stretching the tissue sample under the action of a load. To determine the deformation, tissue samples were prepared in accordance with GOST R 8847-85 [2]:

1. Dimensions of fabric samples 25x200mm;
2. Number of samples-10;
3. Fabric loading time-60 min;
4. Rest time - 120 min;
5. The value of the current load according to GOST R 53271-2009 is 10±0.1 kg [3].

The values of residual deformation of tissue samples are determined by the following formula [4]:

$$\varepsilon = \frac{\Delta l}{l_o} \cdot 100\% \qquad (4)$$

Here: l_o- length of the deformable piece of tissue; l- warped tissue length; Δl- length increment due to stretching ($l-l_o$), mm. The values of residual deformation calculated by formula (4) are given in table 2 [5].

Table 2. Tissue permanent deformation index

№	Tissue samples	Thread density N/dm		The magnitude of the applied load	The amount of fabric elongation in the weft direction ε			Surface density, g/m
		Warp	Weft	By weft Pa, H	Under load %	After unloading %	After rest %	
1.	I	120	180	10±0,1	194,0	11,9	6,1	436
2.	II	120	140		195,2	12,6	6,3	340
3.	III	120	100		196,1	12,8	6,4	242

As mentioned above, the elastic rescue sleeve is under the influence of deforming forces during operation. Also, during operation, the residual deformation of the elastic sleeve gradually increases to a certain value. In accordance with the requirements of the state standard, residual deformation should not exceed the established limit. To determine the conformity of the residual deformation in the weft

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with the requirements of the standard, experimental studies of the dependence of elongation under loading and residual deformation of tissue samples depending on loading cycles were carried out. The tests were carried out by the above method. The test results are shown in table 3.

Table 3 Changes in the residual deformation of new tissue structures in weft depending on the cycles of deformation

№	The number of cycles	Samples	The value of the applied load, kg	Weft elongation		
				When loaded %	After unloading %	After rest %
1.	25	I	10±0,1	194,0	11,9	6,1
		II		195,2	12,6	6,3
		III		196,1	12,8	6,4
2.	50	I		195,1	12,4	6,6
		II		196,3	13,2	6,9
		III		197,6	13,6	7,1
3.	75	I		196,0	12,9	7,2
		II		197,3	13,9	7,6
		III		199,0	14,5	7,9
4.	100	I		196,8	13,4	7,7
		II		198,4	14,4	8,2
		III		200,5	15,4	8,6
5.	125	I		197,7	13,9	8,3
		II		199,6	15,0	8,9
		III		202,1	16,3	9,3
6.	150	I		198,6	14,4	8,9
		II		201,0	15,7	9,7
		III		203,8	17,4	10,2

Figure 2 shows a histogram of changes in the residual deformation of the fabric in the weft, depending on the cycles of deformation, obtained on the basis of processing experimental data.

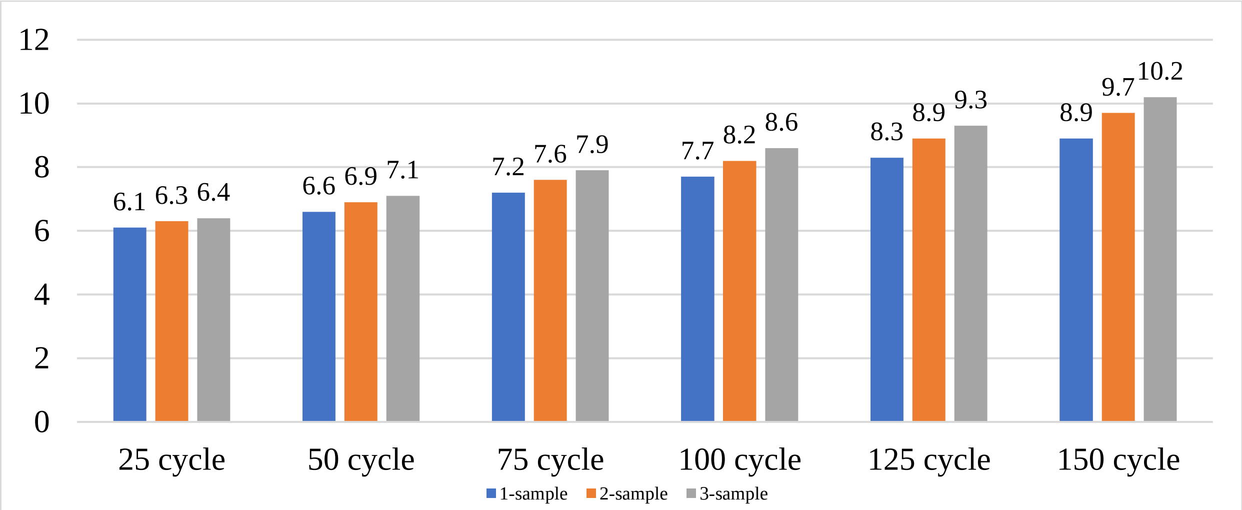

Figure 2. The histogram of the change in the residual deformation of the weft, and the dependence on the cycles of deformation, %.

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According to the requirements of GOST R 53271-2009, the value of residual deformation on the weft should not exceed 15%. Therefore, all presented samples meet the requirements of the standard. However, taking into account the fact that in the process of long-term operation one of the main indicators is the value of residual deformation along the weft, it is advisable to take sample No. 1 as the elastic frame of the rescue hose, which, after 150 deformation cycles, stretches under load by 198.6% and has a residual deformation of 8 ,9%.

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