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ABSTRACT

A 100% goosedown sample, treated with a hydrophobic silica pigment water-repellent finish was compared to an untreated 100% goosedown sample to determine the effect of the treatment on the amount of water absorbed by the down, and the properties of the down when wet.

The silica pigment markedly reduces the amount of water absorbed by the down, thus reducing its heat loss when wet. The finish remains effective after laundering, and there appear to be no changes in the mechanical properties of the down due to the finish.

The effectiveness of the finish was further assessed when treated and untreated wool/nylon socks were tested for amount of water absorbed. The untreated socks absorbed appreciably more water than did the treated socks.

RÉSUMÉ

On a comparé un échantillon constitué de 100 % de duvet d'oie, traité avec un apprêt hydrofuge contenant un pigment de silice hydrophobe, avec un autre échantillon non traité, en vue de déterminer l'effet du traitement sur la quantité d'eau absorbée par le duvet, et les propriétés du duvet mouillé.

Le pigment de silice diminue considérablement la quantité d'eau absorbée par le duvet, réduisant ainsi les pertes de chaleur lorsque le duvet est mouillé. Le produit conserve son efficacité après lavage; de plus, l'apprêt ne semble pas modifier les propriétés mécaniques du duvet.

On a évalué l'apprêt de façon plus approfondi en déterminant la quantité d'eau absorbée par des chaussettes traitées et non traitées, constituées d'un mélange de laine et de nylon. On a constaté que les chaussettes non-traités ont absorbées une plus grande quantité d'eau que les chausettes traitées.

INTRODUCTION

Two 100% goosedown samples were obtained from Polyset Inc., Manchester, Mass., for evaluation, one sample water repellent treated, and the other untreated. The water repellent down consists of two parts by weight of goosedown coated with one part of a hydrophobic silica pigment having a particle size less than one micron in diameter. Two wool socks were also obtained for testing, one treated as the down, and one untreated.

The thermal and mechanical properties of an insulant when wet are very important when the cold weather clothing or sleeping bag is intended for use in wet-cold conditions. The samples were tested to determine the effect of the treatment on the amount of water absorbed by the down, and on the properties of the down when wet. To further assess the effectiveness of the water-repellent treatment, the socks were tested for water absorption.

WATER ABSORPTION

To simulate the use of down in garments or sleepings bags, experiments were performed on the down samples sewn between two layers of shell fabric.

Approximately 3.75 g of treated and untreated down were sewn into circular bags of 0.07 kg/m^2 rip-stop nylon with a diameter of 16 cm. The dry weight was measured and the thickness, dry, was measured at minimal compression (0.16 kPa). The samples were submerged for 60 s in distilled water, during which time they were squeezed by hand 10 times. The samples were removed and drained for one minute, then run through 5 cm diameter rollers under a force of 100 N (25 lbs) repeatedly until no further water was removed (typically 5 times). The samples were reweighed and the thickness, wet, was recorded.

The dry and wet weights and thicknesses are shown in Table 1. Included, for comparison, are results from a previous paper (1) for an untreated 100% goosedown, a water repellent treated (Zepel-B) Polarguard sample, and the 0.07 kg/m^2 rip-stop nylon used as shell fabric, which were

TABLE 1

Wet and Dry Properties of Samples Sewn in 16 cm Diameter Discs Between 2 Layers of Rip-Stop Nylon Shell Fabric

Sample	Dry Thickness (mm)	Wet Thickness (mm)	Dry Mass (kg/m^2)**	Mass of Water Absorbed (kg/m^2)
Treated Down	13	4.2	0.34	0.18
Untreated Down	18	6.0*	0.36	0.38
Previous Untreated Down	13	2.5	0.34	0.26
Treated Polarguard	14	11	0.43	0.22
Shell Fabric	-	-	0.14	-

* Thickness poorly defined due to clumping of wet down.

** Mass of shell fabric included.

tested in a similar manner, to show the effectiveness of the silica pigment.

The water repellent treatment has a marked effect on the amount of water absorbed by the down, the treated sample absorbing the least amount of water of all four samples. The untreated sample of down absorbed much more water by weight (approximately 100%) than did the treated sample (50%). The previous down sample absorbed 75%, and the untreated Polarguard absorbed approximately 50% by weight.

A comparison of both types of down, alone, not enclosed in a shell fabric, was made in order to observe the physical reaction of the down in water. Samples of treated and untreated down were immersed in distilled water and held down manually for 1 min, during which time the down was squeezed, attempting to force water into it. When immersed, the treated sample did not wet out. After a week in contact with the water, the treated sample remained dry, and floated on the surface of the water. The untreated sample wetted slightly on first immersion and after 24 hours in contact with the water, the down was wetted and fully submerged.

HEAT LOSS

Wetted samples of down encased in the shell fabric, were placed on a sweating hot plate, as described in a previous paper (2) to determine heat loss during drying. The results are shown in Figure 1.

The initial high heat loss, when the samples were placed on the plate at time 0 s, was due to the heating of the sample from room temperature to close to 35°C, the temperature of the hot plate. The untreated down curve remains on a plateau which is presumed to be due to the evaporation of water that is concentrated near the plate. Its magnitude depends on the thickness of the sample, a small thickness results in a higher water vapour pressure gradient, and therefore a greater heat loss rate, its duration depends on the quantity of water absorbed. This plateau was not observed in the treated down sample, so it is presumed that the small quantity of water absorbed was evenly distributed throughout the sample. Once any concentration of water close to the plate has evaporated, the curve drops gradually to the dry heat loss. During this period, two factors are causing the heat loss to drop. One is that the evaporation is taking place from points progressively further from the plate which reduces the heat loss rate as discussed in a previous paper (2); and the other is that, as the down dries it regains its loft and the sample thickness increases, which increases both thermal and water vapour resistances.

The dry heat loss value for both the treated and untreated down samples was observed to be the same (20 W/m^2). The drying time for the

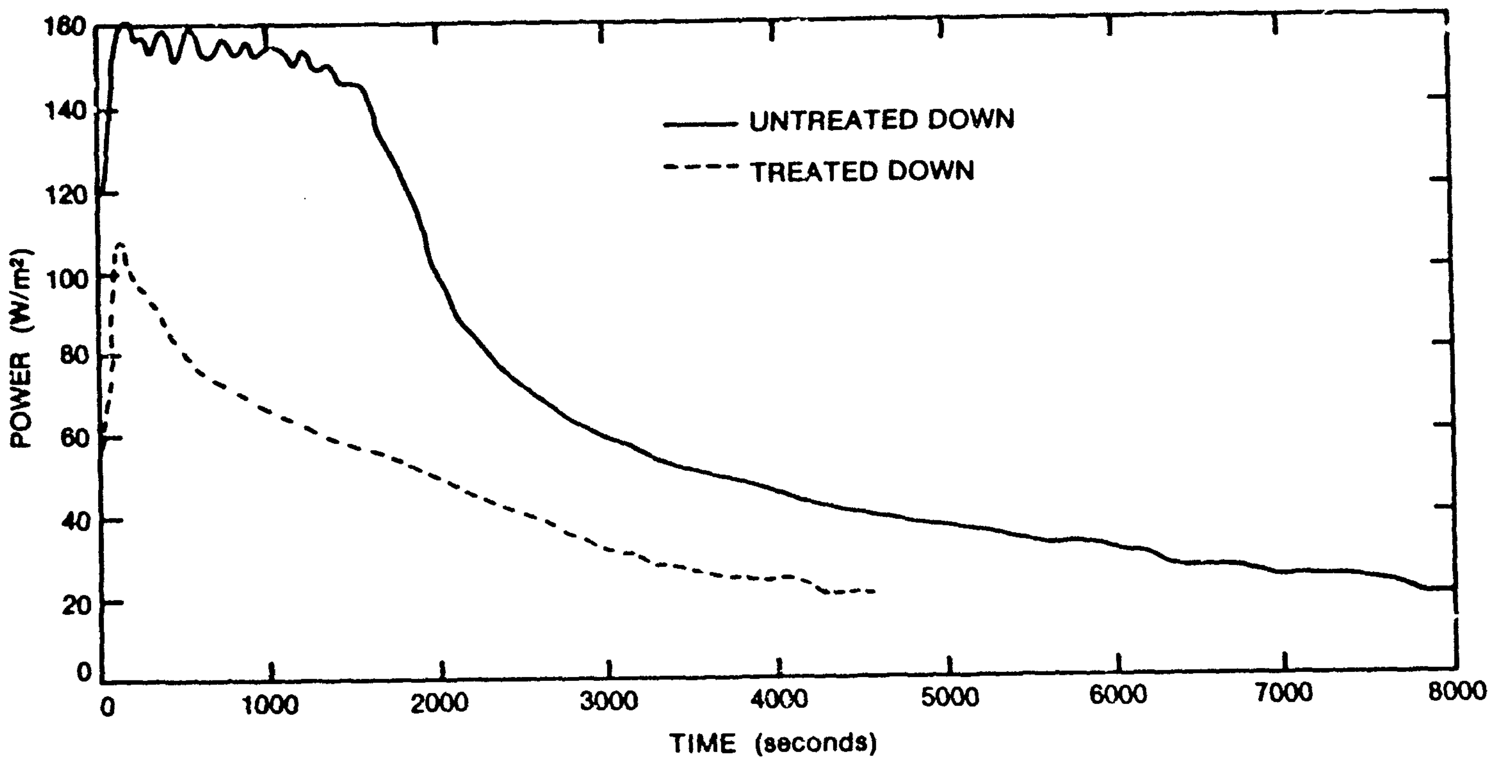

Figure 1: Heat loss during drying for both down samples sewn between layers of rip-stop nylon.

treated down is shorter (approximately 1 hour) than the untreated down (approximately 2 hours) due to the lower mass of water that needs to be evaporated.

A crude figure of merit for the wet insulation is the quantity of heat in excess of the dry heat loss that is lost over the drying period. These data can be seen in Table 2. These figures are again compared to a previous down sample, and a Polarguard sample treated with Zepel-B.

TABLE 2

Excess Heat Loss of Samples Sewn in 16 cm Diameter Discs Between 2 Layers of Rip-Stop Nylon Shell Fabric

Sample	Heat Loss (MJ/m^2)
Treated Down	0.19
Untreated Down	0.53
Previous Untreated Down	0.46
Treated Polarguard	0.14

LAUNDERING

To determine if there are any changes in the properties of the treated and untreated down samples, due to laundering, the samples within the rip-stop nylon shell fabric were retested for thickness, dry weight and water absorption as described earlier, after one, five and ten launderings, drying after each laundering. The washing was done in a Maytag washer, Model A308, and the drying in a Maytag dryer, Model DE 18CA, Series 02. The results are shown in Table 3 and Figure 2.

After one wash and dry cycle, the dry thickness of the treated sample increased, this is probably due to fluffing of the sample. After one wash, the amount of water absorbed by the untreated down increased by about a third. This is probably due to the initial removal of the natural water-repellent oil on the down and feathers.

TABLE 3

Wet and Dry Properties of Samples
After Laundering

	0 Wash	1 Wash	5 Washes	10 Washes
Thickness (cm)				
Treated Down				
Dry	1.3	1.9	2.1	2.0
Wet	0.42	0.70	0.62	0.61
Thickness (cm)				
Untreated Down				
Dry	1.8	1.8	2.0	2.1
Wet	0.60	0.54	0.26*	0.43
Dry Weight (kg/m^2)				
Treated Down	0.34	0.34	0.32	0.32
Untreated Down	0.36	0.36	0.35	0.35
Water Absorption				
% (dry weight)				
Treated Down	51	51	59	52
Untreated Down	105	138	145	128
(kg/m^2)				
Treated Down	0.18	0.17	0.19	0.16
Untreated Down	0.38	0.50	0.50	0.45

* Thickness poorly defined due to clumping of wet down.

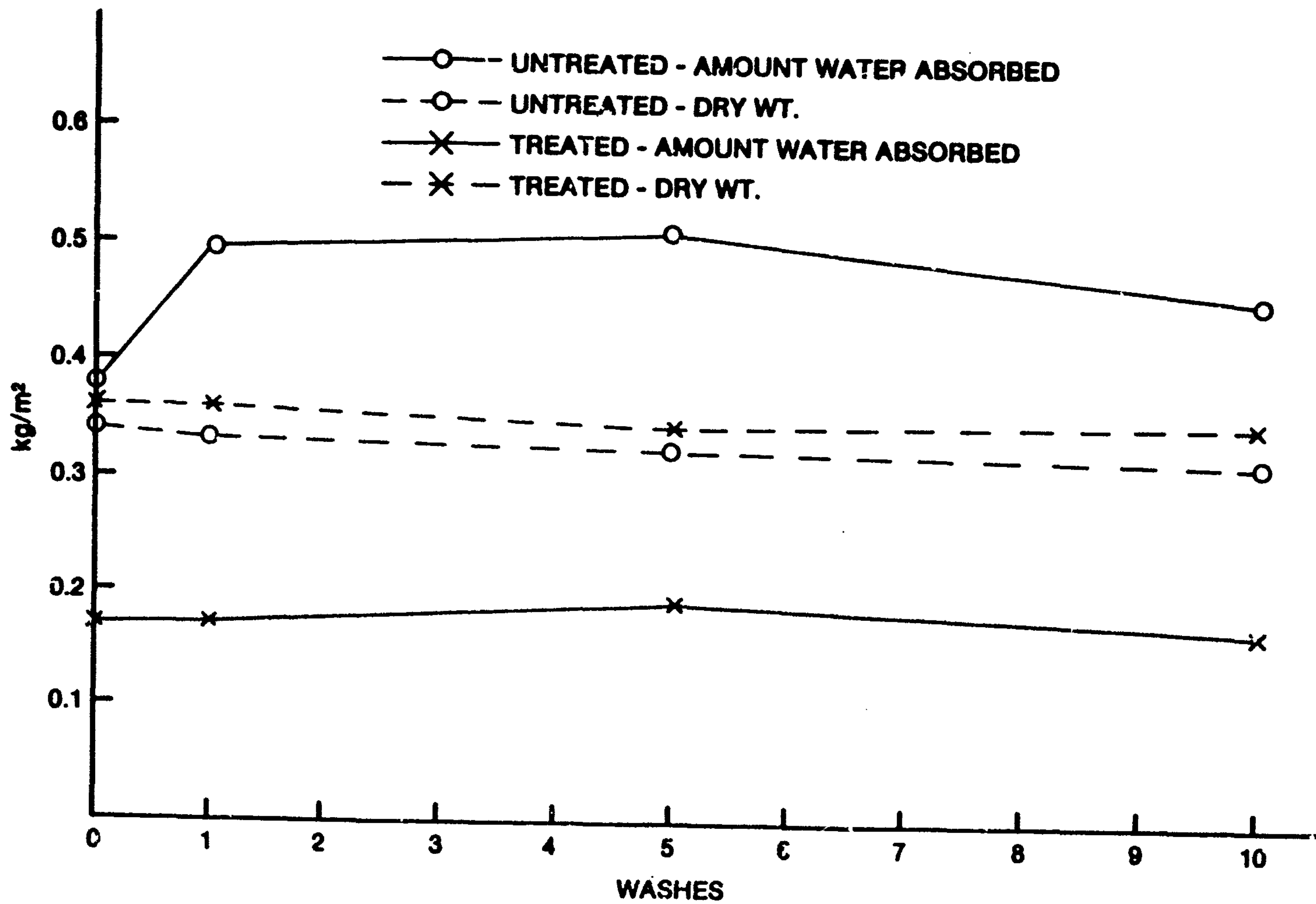

Figure 2: Change in dry weight and amount of water absorbed by treated and untreated down samples after laundering and drying.

Laundering up to ten times seems to have little effect on the properties of the treated down. It can be assumed that the hydrophobic silica pigment has quite a strong bond to the down fibres.

COMPRESSION

Samples of both types of down were compressed to determine if the finish had any effect on the mechanical properties of the down. Approximately 1.7 g of down were placed on a balance under a 9.2 cm diameter foot within a cardboard tube of the same diameter. The foot was lowered to various thicknesses, the force recorded, and the density and pressure calculated at each point. As can be seen in Figure 3, the finish appears to have no effect on the mechanical property of compression.

SOCKS

To further assess the effectiveness of the silica pigment water repellent treatment, samples of the treated and untreated socks were tested for water absorption by the method described in a previous paper (3).

Samples from each sock, two from the foot (plain knit) and one from the leg (rib knit) were tested after conditioning at 65% RH and 21°C. Each sample (7.5 × 7.5 cm) was weighed dry, immersed in distilled water for 1 min, allowed to drain for 1 min, then reweighed. This was repeated with immersion times of 5 min and 15 min, draining for 1 min. The percent (dry weight) water absorbed was then calculated.

To represent the friction subjected to the sock during wear, the samples were submerged in distilled water, removed, squeezed by hand then reimmersed for 1 min. After allowing to drain for 1 min, the samples were reweighed.

To determine the effect of pressure that is exerted upon a sock during wear, the samples were immersed for 5 min in distilled water and a metal screen was placed on top of the sample to disperse the weight of a 500 g weight.

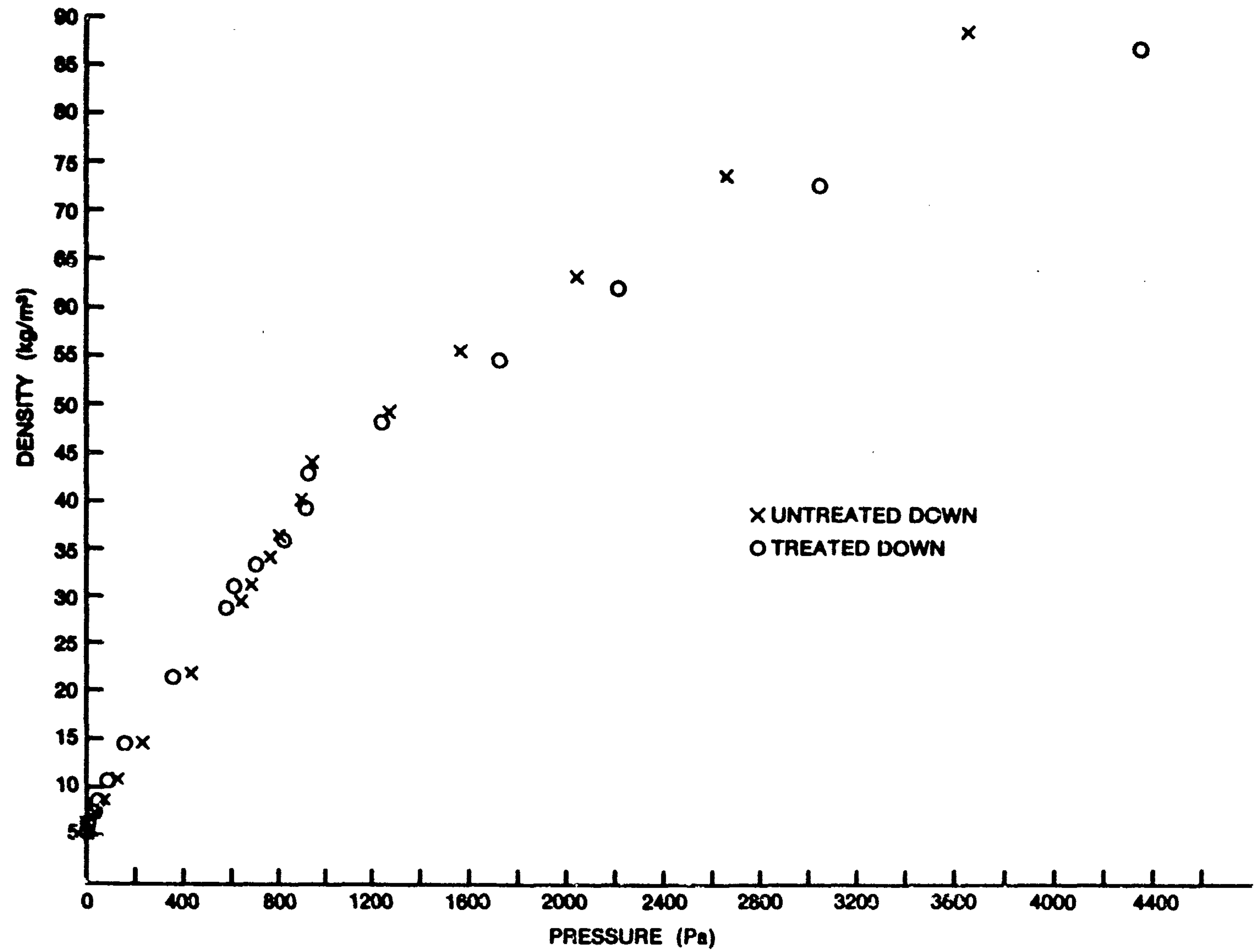

Figure 3: Mechanical property of compression of treated and untreated down samples.

The silica pigment water-repellent treatment had a marked effect on the amount of water absorbed by the sock, in all cases as can be seen in Table 4. The untreated sock samples absorbed at least 40% more water than the treated samples. Individual values for foot and leg samples are given when gross differences between the two occurred. The difference in water absorbed by the foot samples and leg samples is due to the difference in the knits. The rib knit has more exposed fibres and is therefore able to absorb more water. The silica pigment water-repellent, while reducing the amount of water absorbed, gives the socks a hand that would be unpleasant next to the skin.

CONCLUSIONS

The silica pigment markedly reduces the amount of water absorbed by the down, thus reducing its heat loss when wet. The finish remains effective after laundering and there appear to be no changes in the mechanical properties of the down due to the finish. As a result, the treated down would find widespread use in wet-cold climatic conditions.

The water-repellent finish greatly reduces the water absorbed by the socks. This would lead to a possible use as an outer sock for wet-cold conditions.

REFERENCES

1. B. Farnworth and B. Nordli, Defence Research Establishment Ottawa Technical Note No. 82-13.

2. P. Dolhan, Defence Research Establishment Ottawa Technical Note No. 82-12.

3. B. Farnworth and P. Dolhan, Defence Research Establishment Ottawa Technical Note No. 82-28.

TABLE 4

Summary of Results of Water Absorption by Treated and Untreated Sock Samples

	Treated % (dry wt) Water Absorbed	Untreated % (dry wt) Water Absorbed
1 min	0	12.6 ± 2.0
5 min	1.0 ± 0.1	15.6 ± 3.8
15 min	2.3 ± 0.2	foot 11.9 ± 1.0 leg 120
Squeezed 1 min	1.1 ± 0.3	foot 162 ± 11 leg 219
Weighted 5 min	4.8 ± 0.4	352 ± 4

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