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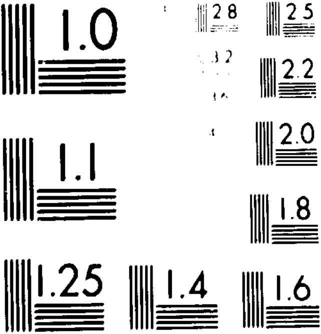
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PROCESSING OF SYNTHETIC FIBERS AND BLENDS

FIBER-BLENDS AND THEIR PROPERTIES

by

Prof. Dipl.Ing. Johann Hördler

Ladies and gentlemen!

I am very pleased to be given the opportunity to lecture on synthetic fibre processing. The short time available will not allow me to go into many details.

At first I will try to give you a survey about the properties, especially of fibre blends as well as the reasons for blending and how it is done.

Consumption of manmade fibres hit on all time high in the last year the increase came from gains in noncellulosic fibres. The increasing use of synthetic fibres is due to several facts, which you do know, I think. The most important ones are the new properties.

For a summary of physical and chemical data please look at the appendix. The tables are examples for certain types of fibres and we have to mention, that there are several types and modifications which have different properties. The conditions in manufacturing are determining special properties too.

For the use in clothings some of them are of general interest. The easy-care-effect is one of the most important I think. Minimum shrinkage, high tenacity and elasticity, resistance to abrasion, resistance to moth and mildew are further ones.

One strong argument against synthetic fibres is the low moisture regain.

The tables (appendix) also show examples for applications.

We all expect certain properties form our clothings but I am sorry to say that synthetic fibres don't possess the same qualities as natural fibres. However the wearer doesn't like to miss any comfort. Let me mention moisture absorption as an example. Therefore, blends have been introduced and in this way properties desired have been combined.

This explains the increase in the production of cloths, in which manmade and natural fibres or various types of manmade fibres have been blended. I think the most important reason is, that blends have properties which are different from those of their components and which result in new processing technologies and new end uses.
On the other hand some new difficulties arise, which must be overcome.

There are a lot of reasons which justify fibre blends. Now I shall ~~now~~ try to explain some of the most important ones.

1. PROPERTIES USEFUL TO THE WEARER

Each type of fibre has particular properties, as I mentioned above. We can easily recognize that natural fibres and synthetic fibres have opposite properties. Therefore, it is obvious that blends which combine the useful properties of their components should be produced. Of course the unfavourable properties should not impair the usefulness..

The percentages of components vary. The optimal composition may be interpreted in a mathematical way. (See appendix, fig. 1 as a two - component model).

If I take only one component into consideration, it must be possible to draw a function, the value of which gives the customers appriciation of the properties of this component.

It seems plausible that there will not be a linear coherence. Only a small percentage of one component brings distinct properties to the blend. In many cases there is one outstanding property which is needed for a particular use. The sum of the two functions will give a curve similar to that in figure 1. It is obvious that it must be possible to find the most suitable blend by means of the maximum value.

The usual fibre blends are of that kind, but actually they have been developed by experimenting and not by theoretic calculation.

Two examples may show you, how to determine the optimal percentages in a blend.

One comes from the research department of Lenzing. To find suitable blends of their fiber 333, a HWM-type viscose-fiber with others, they spun an wove blends with varying percentages of HWM fiber with cotton as well as with polyester. Those fabrics were tested, part of the results I am going to show to you.
(Figures see Appendix)

Tensile strength, abrasion resistance and the results of weaving-test are given as a function of percentages in fig. 2 and the same for absorptivity, crease resistance and loss in whiteness in fig. 3. The curves are drawn in such manner, that high values occur for positiv properties.

The diagrams contain both, blend with polyester - left hand - and blend with cotton - right hand, - with pure HWM-fiber in the middle.

With those results as a background, Lenzing recommended blends of HWM with about 50% to 70% cotton or with 20% to 40% polyester.

Another nice method to show properties of blends and to determine the optimum of percentages I found in a paper of Du Pont some years ago; the method is still suitable and of interest.

The properties like texture, bulk and so on (see fig. 4) are characterized with four levels, due to test results or by subjective estimation.

All these properties are measured or estimated for varying percentages of components and you get a survey about their levels.

For wool/PE blends you will get a figure like nr. 5
And you will find suitable blend percentages with no property of poor level.

Of course you might take additional properties into consideration or you can choose other levels.

The appendix shows additional examples for other blends.

Let's look at some examples for types of blended fabrics:

a) A high-quality cloth distinguished by evenness, strength and comfort is obtained by blending natural fibres and synthetic ones. It is possible to make woolen clothings more resistant to abrasion by putting in a small percentage of Polyamid staple fibres.
I should like to mention the international woolmark and the wool-blend mark which allows synthetic fibres up to a percentage of 40%.

Some examples are:

Underwear:	80/20	85/15	90/10	Virgin wool/Polyamid
	80/20			Cotton/Polyamid
Hosiery	70/30			Virgin wool/Polyamid
Home furnishings	80/20			" /Polyester
Blankets	90/10			" /Acrylic
Outerwear	60/40			" /Polyester
	70/30			" /Polyamid

b) Blends distinguished by better dimensional stability and crease resistance as well as all the advantageous properties of natural fibres are composed as follows:
Examples:

Outerwear	55/45	Polyester/Wool
	50/50	" /"
	55/45	Acrylic/Wool
	55/50	" /"
	65/35	Polyester/Cotton
	38/62	" /"

c) Variation of surface, handle and transparency can be achieved by using different types of textured yarns, high bulk yarns or blends containing highly shrinkable fibres.

For example:	40/60	30/70	highly shrinkable/normal type
	40/15/45		highly shrinkable/normal type/wool
	40/30/30		" " /" /Viscose staple

d) Better wearing qualities and lower weight can be obtained by means of synthetic components in blend. Wash and wear may be combined with absorption of moisture in wool/synthetic or cotton/synthetic blends.

e) Quite new properties may be held by cloths consisting of synthetic fibres of the same type only or blends of natural and synthetic fibres or blends of different types of synthetic fibres.

For example: Elasticity in wovens and additional elasticity in knitwear due to texturized yarns. New spinning technologies will bring new types of yarns (e.g. Bobtex) with new possibilities for end use.

f) Blends are used when the customer insists on a natural fibre component although the wearer could do without it. Often this psychological barrier is an argument against synthetic fibre indeed.

g) It also might be a physiological problem and often you would not be able to seperate them from each other. And both, psychological and physiological arguments hinder the introduction of man made fibers and blends too.

2. PRODUCTION PROCESSES ARE SIMPLIFIED AND FACILITATED

a) The synthetic component of blends shortens the spinning process. Converting tow to top eliminates a lot of work in spinning. You can get stronger and more even yarns.

The diagram nr. 9 shows the unevenness, measured by "Uster-Equipment" decreasing at higher percentage of man made fiber.

b) Cellulosic man made fibres could be used for replacing the natural fibre component. For example Polynosic fibres (HWM fibres) used instead of cotton facilitates the spinning process, but there is hardly any chang in the properties.

c) Downtime during spinning, weaving and knitting is reduced. That is one of the results of synthetic fibre admixture.

d) You can get multi-coloured fancy cloths in one dyeing process only by using blends of fibres with different dye-stuff affinity. Different shades are obtained in the case of fibres of the differential-dyeing type.

For example:	65/12/23	Polyester/Acrylic/Cotton
	92/8	Polyester/Flax

3. PRICE

There might be the opportunity to use blend-components which are produced in the home country in order to stabilize prices or to be independent of foreign fibre supply. The prices of manmade cellulosic fibres are still regarded to be competitive.

4. CUSTOMS

Sometimes you will come across quite unusual percentages of the components of a blend. That may be due to the endeavour to meet the most favourable custom regulations.

For example there are 52/48 Polyester/Cotton
51/49 Cotton/Viscose staple
if the tariff is based on the component with higher percentage.

5. SHORTAGE IN RAW MATERIALS,

Natural or man-made, should also induce technicians to search for new types of fibers or fiber blends.

HOW TO GET BLENDS

The previous look at the properties of blends was independent of the blending techniques. There are different ways. Blending could take place during the fibre production, in the spinning weaving and knitting process, in nonwovens or by means of special new technologies.

Now I am going to give you a survey of some of these techniques.

1) Joining different types of polymer in one filament (bi-component fibres)
2) Blending different types of staple fibres for yarn as well as for different types of non-wovens.
3) Joining different types of fibres in the shape of card web especially as a variant in the production of non-wovens.
4) Joining different types of sliver on the drawing frame. Blending at this stage of the spinning process allows to shorten the spinning process for the synthetic fibre component as I mentioned above. (tow to top or tow to sliver)

   This method becomes more and more important. Special drawing frames have been developed for this purpose.
5) Joining different types of filament or plying different types of yarns.
6) Twisting different types of yarns, for instance aiming at different colours in one thread.
7) Different types of threads in the finished cloth. Some wovens consist of different types of fibres in warp and weft. There also might be different types of ends and /or picks in the cloth. This method is well known in double-woven cloths and multi warp cloths as well as in pile fabrics. Knitted fabrics may consist of different types of threads in the feeds and the guide bars respectively.
8) Laminated fabrics consisting of two or more layers of cloth of different properties, sometimes combined with non-textile layers.
9) Certain types of new technologies in spinning and in non-wovens for instance Bobtex with its filament carrier, polymer core and staple fibre surface.

TEXTURING

An impulse for synthetic fibre production was texturing. Texturing brought the possibility to make synthetic fibres bulky and stretchable. [illegible]merous types can be produced by different methods (Fig 2)

The reason, why I enclose texturing in my lecture is, that textured yarn can be a component of a blend. You already got a lecture on texturing and therefore I only will give you a survey about textured yarns and similar types with examples for end uses.

Stretch Yarns

Yarns made from thermoplastic fibre, usually in the form of continuous filaments, which are capable of a pronounced degree of stretch and rapid recovery. This property is conferred on yarn (having one or more filaments) which has been subjected to an appropriate combination of deforming heat-setting, and developing treatment. The yarns so produced may also have a greater bulk in the unstretched form (see Bulked yarns)

It is desirable to be able to distinguish between two broad classes of stretch yarns. These are (a) those produced by crimping, and(b) those produced by twisting and heat-setting.

Bulked yarns

Yarns which have been treated physically or chemically so as to have a notably greater "apparent volume" or bulk sufficiently stable.

For example: Two components of staple fibres with different shrinkage (pre-shrunk and untreated) are blended. The yarn final is treated to shrink and the pre-shrunk fibres bring the bulk. As texturing is suitable for thermoplastic fibres only the described method is used especially for acrylics. The high-bulk-types are well known in knitting.

Bulky Yarns

(1) Yarn in which the apparent density of the filaments is much lower than the real density. Examples are man-made fibres which are hollow along part or all of their length and fibres which have cross-sectional shapes of such gross irregularity that close packing is impossible.

(2) Spun yarns made from staple fibres having a high degree of resiliency. Such fibres resist the twist imposed upon them during processing and so produce a voluminous yarn, e.g., acrylics.

The end uses of textured yarns are numerous. I will give some examples:

Stretch yarns: (torque) Stretch yarns are used extensively in a wide variety of "stretch-to-fit" knit fabrics and garments including: leotards, half-hose, gloves, ladies' hosiery, girdles, swimwear, briefs, tights, underwear, surgical stockings, etc. A vast poundage is also being used in a broad range of stretch woven fabrics for applications that include ski-pants and many other sportswear items.

Stretch yarns: (no torque) Knit fabrics for a wide range of end uses including ladies' hosiery and underwear.

Modified stretch yarns: All types of knitted outerwear (including sweaters, dresses, and swimwear), tricot garments, foundation garments, webbings and braids, and woven fabrics of many different types ranging from sheer crepes to sturdy industrial fabrics and including fabrics for lingerie, shirts, blouses, and dress goods.

Bulk Yarns (crimp type): These yarns are used extensively in halfhose and all types of knitted outerwear including sports shirts and sweaters. Other end uses include underwear, swimwear, gloves, foundation garments, lace, double-knit fabrics, tricot, warp knit fabric , upholstery fabrics, industrial fabrics, and woven fabrics of various types. In heavy deniers these yarns are being used in rugs, carpets, upholstery fabrics, industrial fabrics, webbings and braids.

Bulk yarns (loop type): Apparel items such as men's jackets, sport shirts, dress shirts, and ties; women's blouses, dresses, suits, coats, and sweaters; children's snowsuits; gloves and scarves; sewing threads; shoe fabrics and shoe laces.
Household furnishings such as carpets, draperies, lace tablecloths, sheets, and upholstery fabrics.

I hope you were interested in my lecture. I thank you for listening.

A P P E N D I X I

Properties of synthetic fibres

POLYAMIDE FIBRES (Nylon 6)

Chemical Base	Polyamide (Caprolactam)		
Properties	Regular	High tenacity	Staple
specific gravity		1.14	
moisture regain(%)		4.0-5.0	
tenacity (g/denier):			
conditioned	4.2-5.8	6.8-8.7	3.8-5.5
wet	4.0-5.3	5.4-7.6	3.4-5.0
breaking extension (%):			
conditioned	24-40	16-17.5	37-46
wet	28-43	18-24	42-50
elasticity recovery (%)	100 at 4% extension		
softening point	At 300°F (149°C) for 5 hr. Yellows		
melting point	420°F (216° C)		
flammability	Self-extinguishing		
resistance to acids:			
strong	Poor:dissolves in conc. formic acid		
weak	Fair		
resistance to alkalis:			
strong	Good		
weak	Good		
effect of oxidizing agents	Resistant		
effect of org. solvents	Similar to Nylon 6,6		
resistance to mildew	Resistant		
resistance to moth	Resistant		
effect of sunlight	Similar to Nylon 6,6		

End uses: Knitted and woven fabrics in a wide denier range with end uses for ~~for~~ stockings to carpets, standing alone or in blends. Fabrics for technical purposes.

POLYAMIDE FIBRES (Nylon 6,6)

Chemical Base	Polyamide (polyhexamethylene adipamide)		
Properties	Regular	High	Staple
specific gravity		1.14	
moisture regain (%)		4.5	
tenacity (g/denier):			
conditioned	4.5-5.8	6.0-9.5	4.0-7.2
wet	4.0-5.2	5.2-8.0	3.6-6.2
breaking extension (%):			
conditioned	26-32	16-26	18-40
wet	30-38	18-32	20-46
elastic recovery (%)	100 at 4% extension		
softening point	Sticks at 445° F (230° C)		
melting point	Melts at about 485° F (250° C)		
flammability	Melts slowly, does not support combustion		
resistance to acids:			
strong	Poor		
weak	Fair		
resistance to alkalis:			
strong	Good		
weak	Good		
effect of oxidizing agents	Generally resistant		
effect of org. solvents	Generally resistant dissolves in 90% formic acid		
resistance to mildew	Resistant		
resistance to moth	Resistant		
effect of sunlight	Loses strength after long exposure		

End uses: smiliar to Nylon 6.

POLYESTER FIBRES

Chemical Base	Polyethylene terephthalate		
Properties	Regular tenacity	High tenacity	Staple
specific gravity		1,38	
moisture regain (%)		0.4	
tenacity (g/denier):			
conditioned	4.5-5.5	6-7	3.5-4
wet	4.5-5.5	6-7	3.5-4
breaking extension (%):			
conditioned	20-30	8-16	25-40
wet	20-30	8-16	25-40
modulus of elasticity (g/denier):	110	130	52.5
thermal properties	Exposed 168 hr at 302° F (150° C) loses 15 to 30% of original strength		
softening point	Sticks at 453° F (235° C)		
melting point	About 485° F (250° C)		
flammability	Burns slowly with a sooty flame		
resistance to acids:			
strong	Resistant		
weak	Resistant		
resistance to alkalis:			
strong	Moderate resistance at room temperature: slowly dissolved in 10 % NaOH at 210° F (99° C)		
weak	Resistant		
effect of org. solvents	Resistant, but some phenols dissolve Terylene		
effect of oxidizing agents	Resistant		
resistance to mildew	Resistant		
effect of sunlight	Weakens but resistant behind glass		

End uses: Due to the properties several end uses in outer wear shirts, blouses and ~~won~~ so on; household fabrics, tents, nets, tilts, houses, technical fabrics.

ACRYLIC FIBRES

Chemical Base	Polyacrylonitrile
Properties	Staple (3 denier)
Specific gravity	1.17
moisture regain (%)	2.0
tenacity (g/denier)	
conditioned	3.0-3.3
wet	2.1-2.4
breaking extension (%):	
conditioned	40-45
wet	40-45
elastic recovery (%)	From 2% extension -93% From 10% extension -56%
melting point	Does not melt, sticks at 560° F (293° C)
flammability	Will burn but not dangerously inflammable
resistance to acids:	
strong	Resistant
weak	Resistant
resistance to alkalis:	
strong	Moderately resistant
weak	Resistant
effect of org. solvents	Not affected by dry-cleaning solvents or any common organic chemicals
resistance to mildew	Resistant
resistance to moth	Completely resistant
resistance to sunlight	Very resistant

End uses: Due to the good hand all kinds of outerwear, knitted and woven; technical and chemical use too.

POLYPROPYLENE FIBRES

Chemical Base	Polypropylene
Properties	Type 800 filament
specific gravity	0.90
moisture regain (%)	0
tenacity (g/denier):	
conditioned	5-7
wet	5-7
breaking extension (%):	
conditioned	15-25
wet	15-25
elastic recovery (%)	98 at 5% extension
softening point	280-300° F (138°-150° C)
melting point	325-335° F (162°-168° C)
flammability	Burns slowly
resistance to acids:	
strong	Resistant (except nitric acid)
weak	Resistant
resistance to alkalis:	
strong	Resistant
weak	Resistant
effect of org. solvents	Generally resistant (some cause swelling)
resistance to mildew	Resistant
resistance to moth	Resistant
effect of sunlight	Loses strength on prolonged exposure

End uses: Baggings, floor coverings, technical use.

APPENDIX II

Figure 1: Mathematical discussion of suitable blend

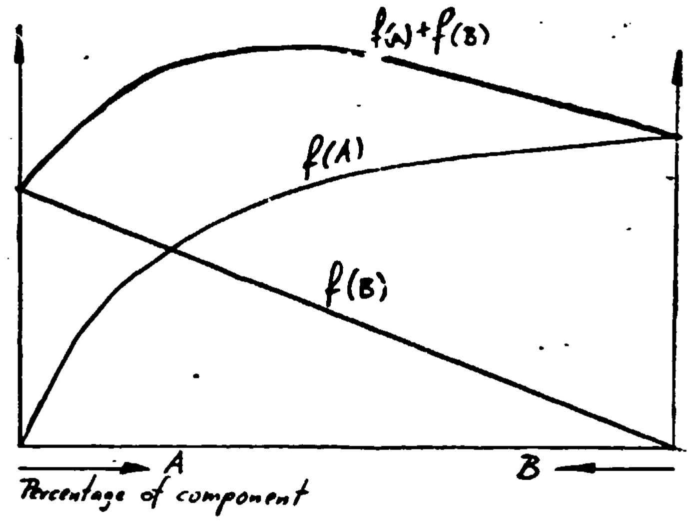
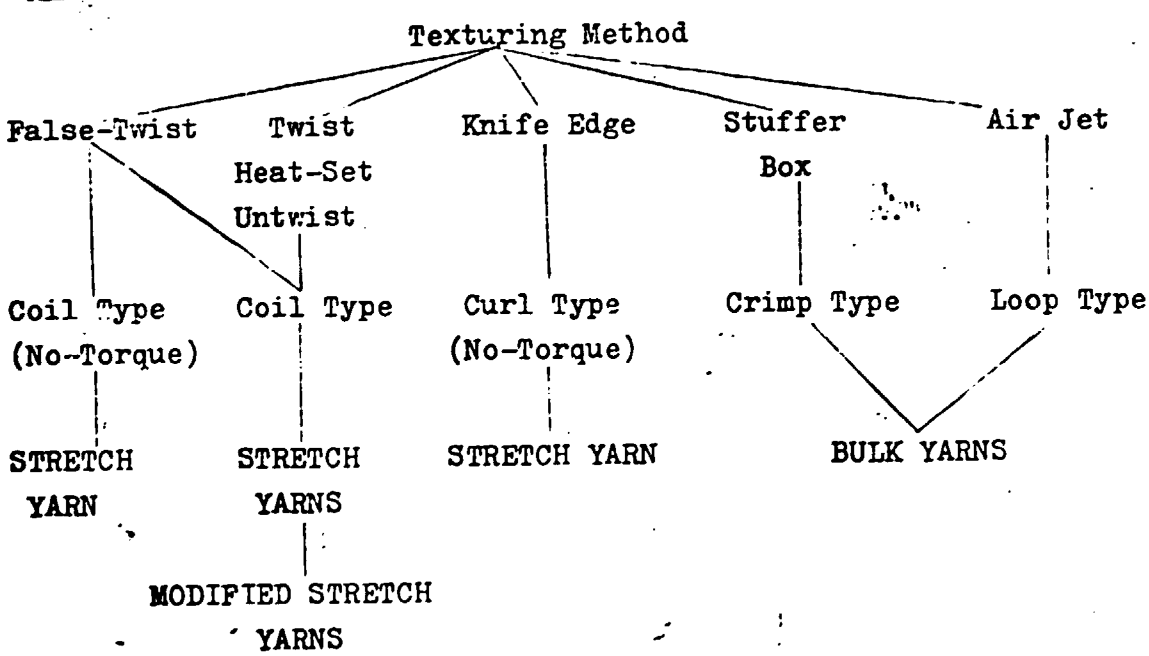


Figure 2: Texturing Methods



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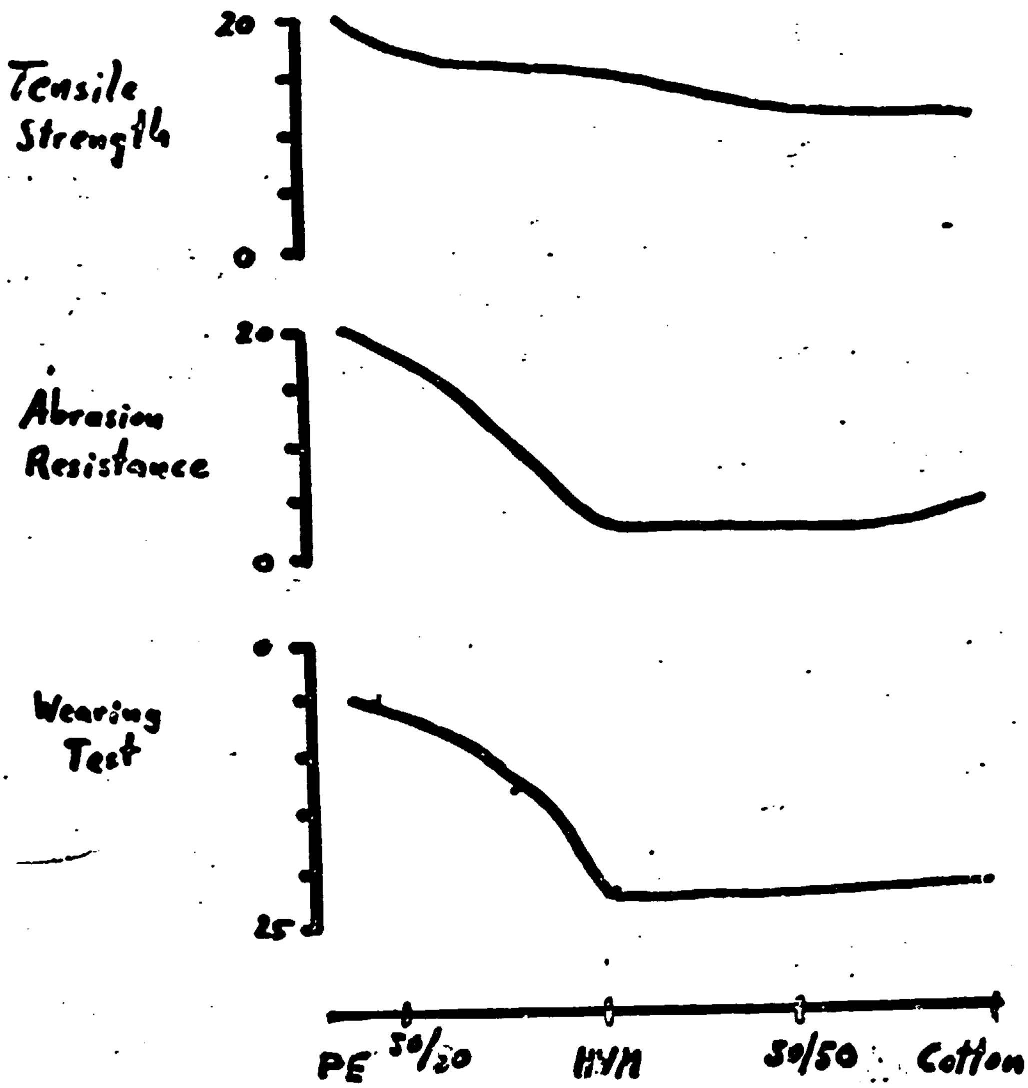
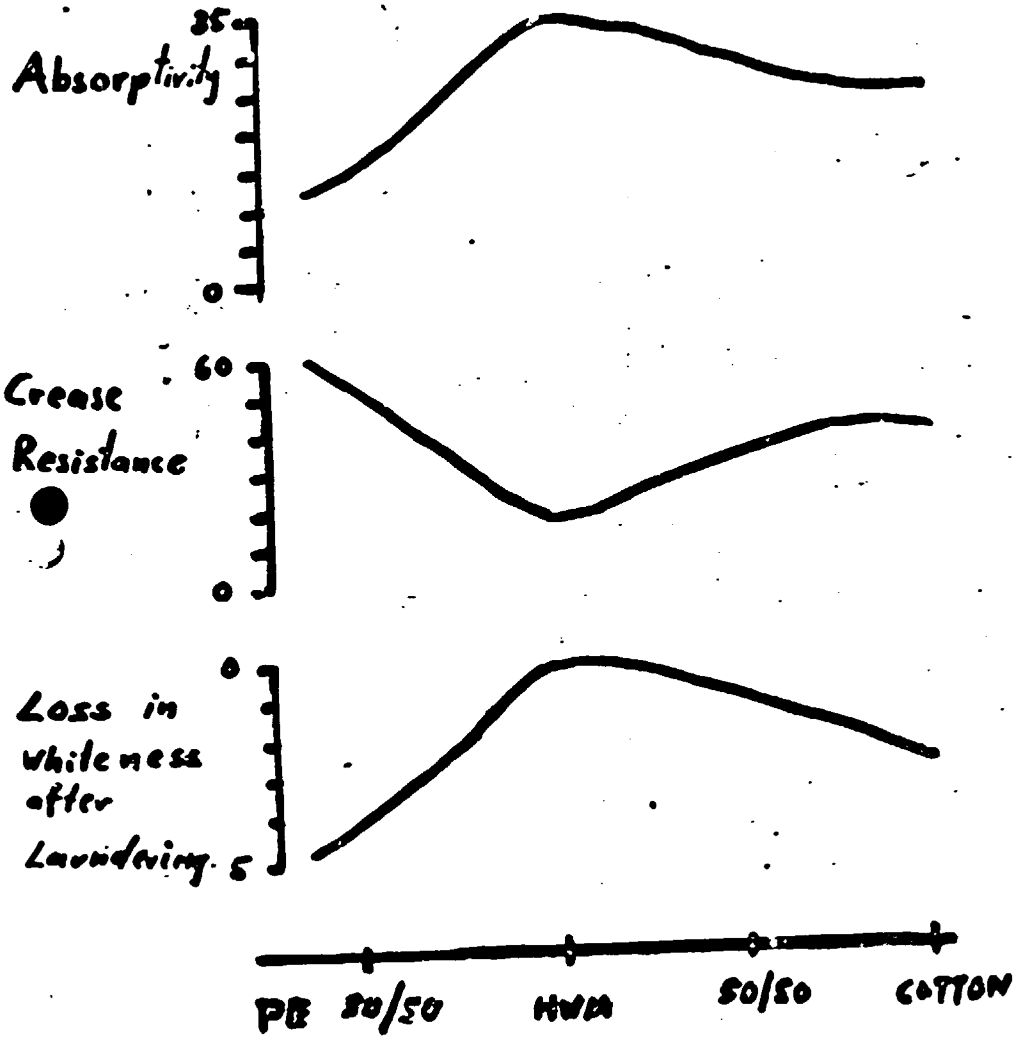

20
Tensile Strength
0
20
Abrasion Resistance
0
0
Wearing Test
25
PE
50/20
HYM
50/50
Cotton

3



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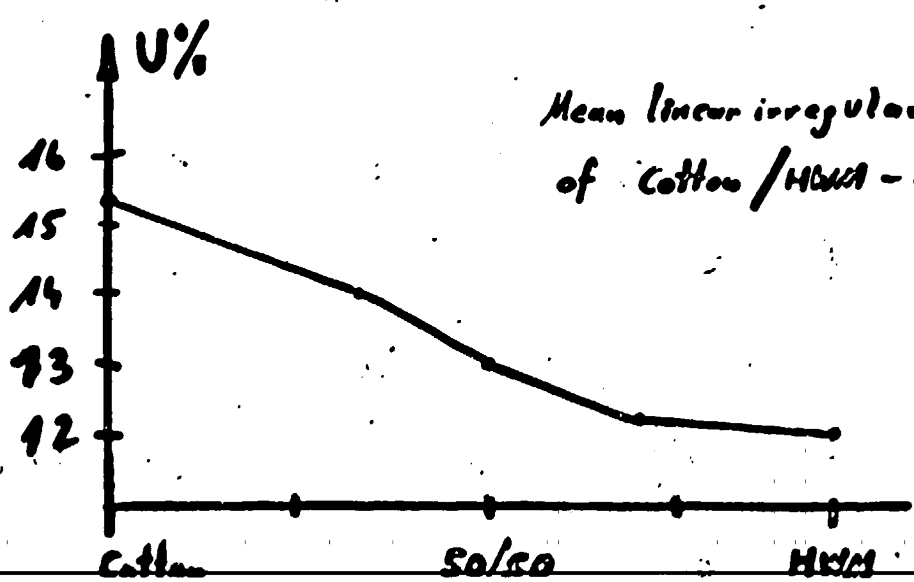
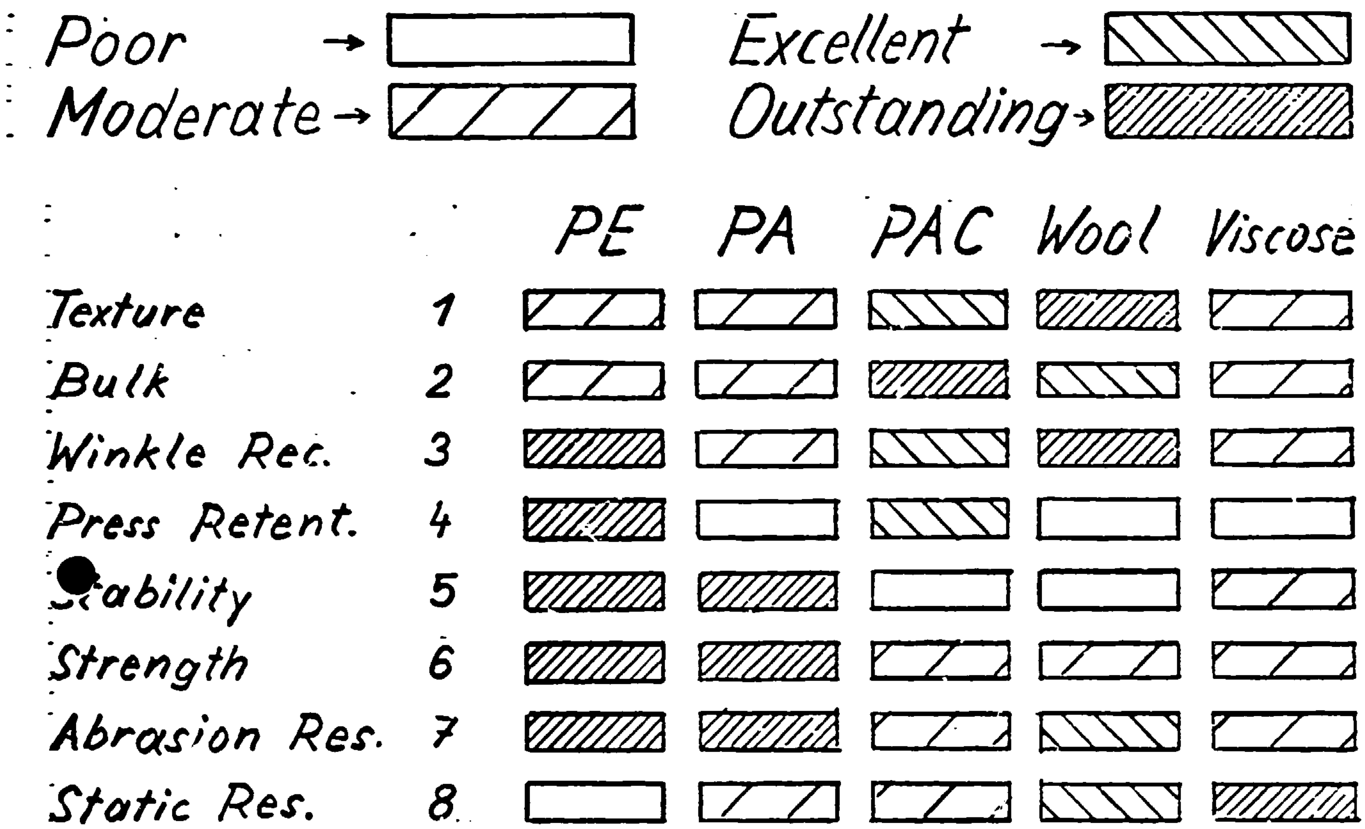


Mean linear irregularity of Cotton/HWM-yarn

Property Ratings

4



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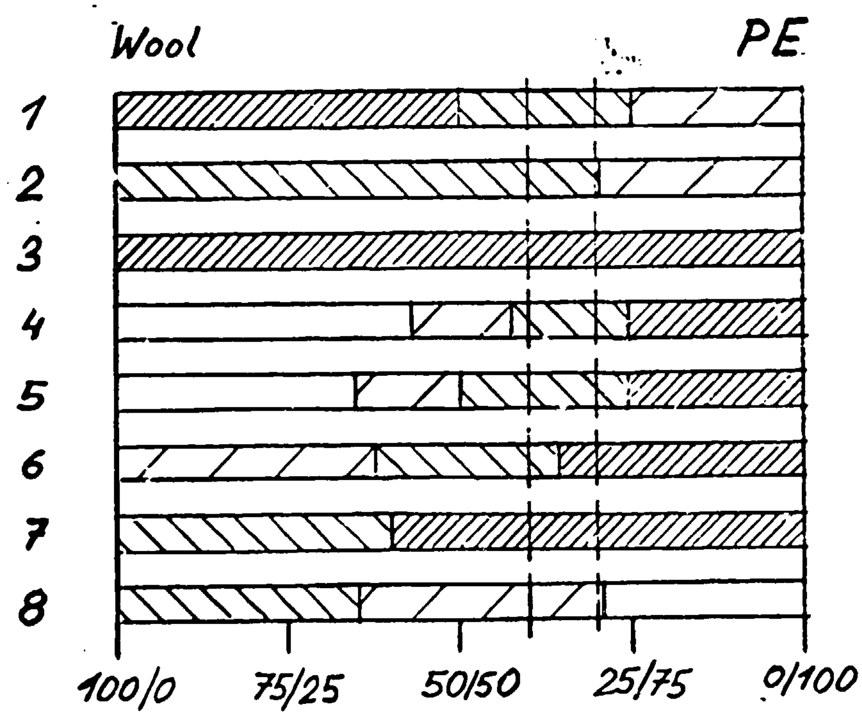

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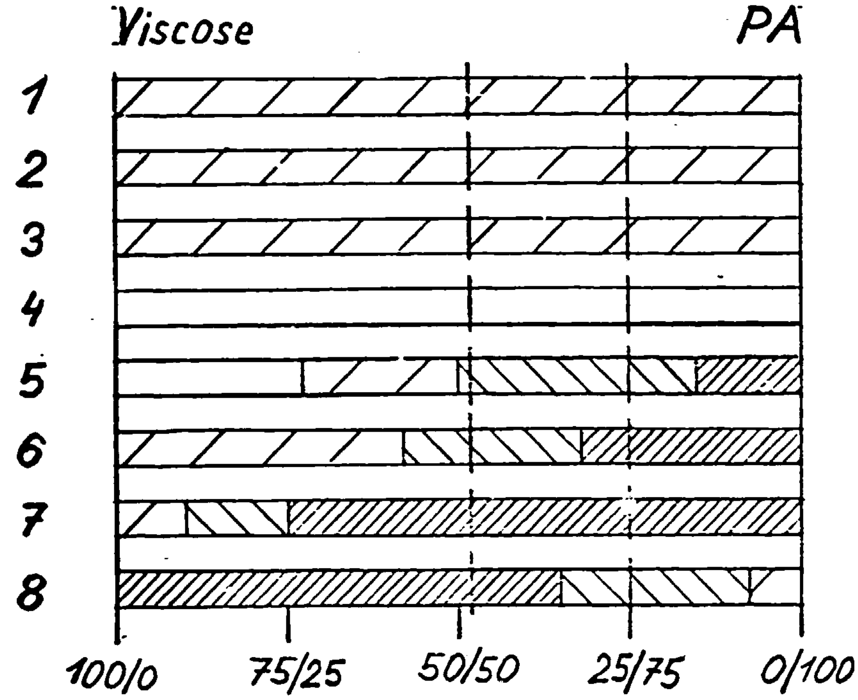
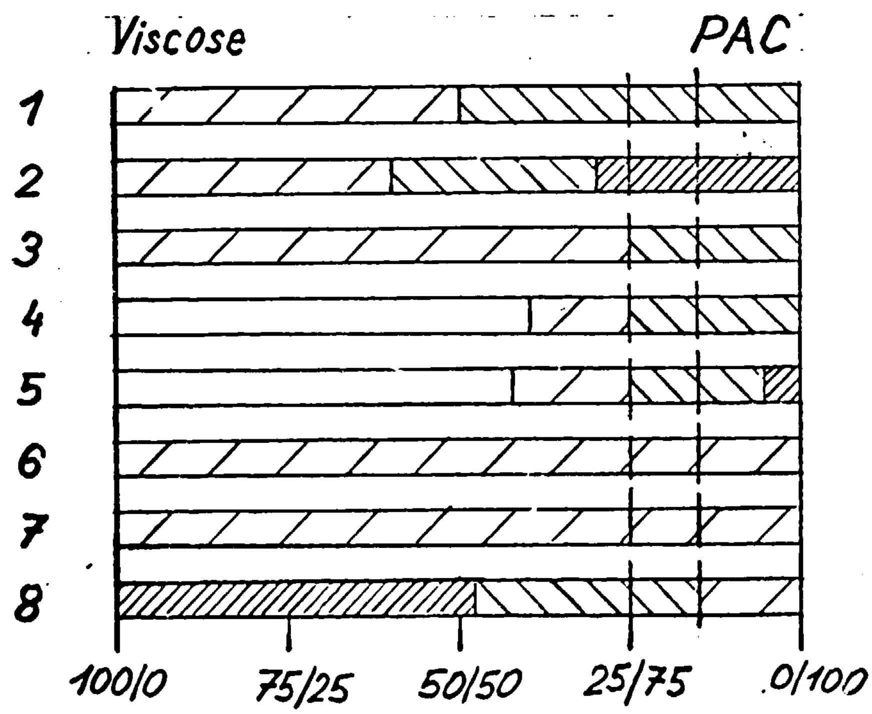

Viscose
PA
1
2
3
4
5
6
7
8
100/0
75/25
50/50
25/75
0/100


Viscose
PAC
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100/0
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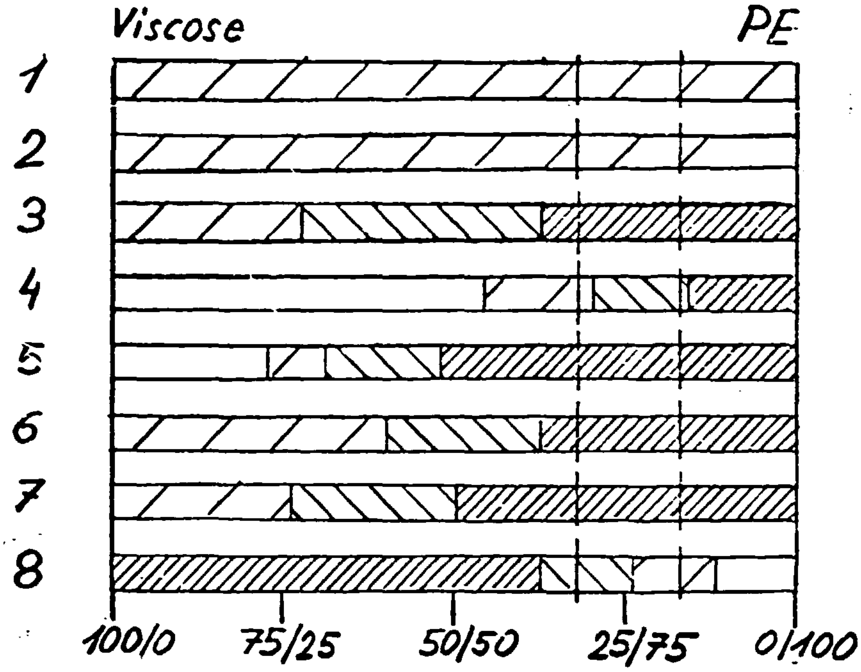
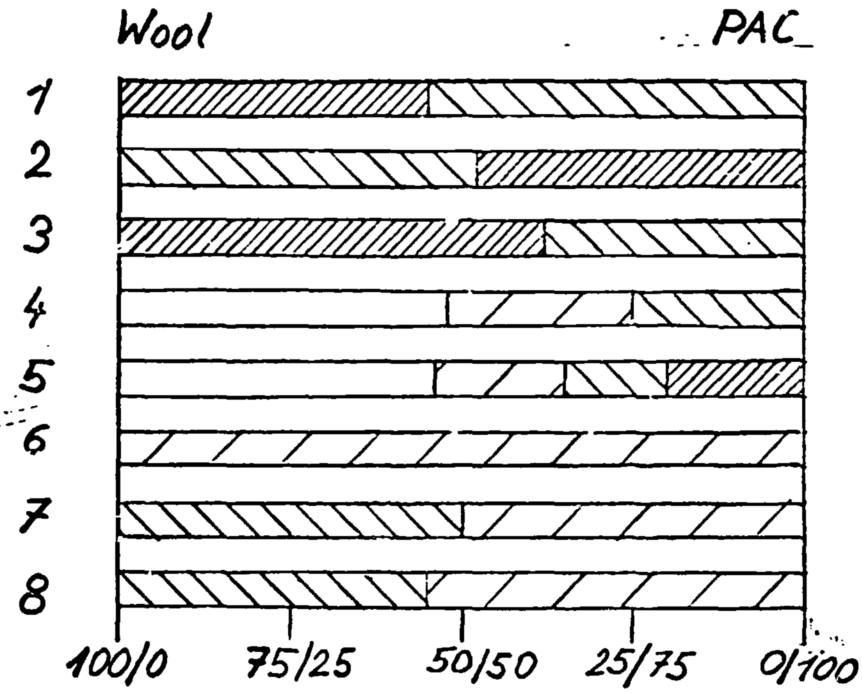
50/50
25/75
0/100

7

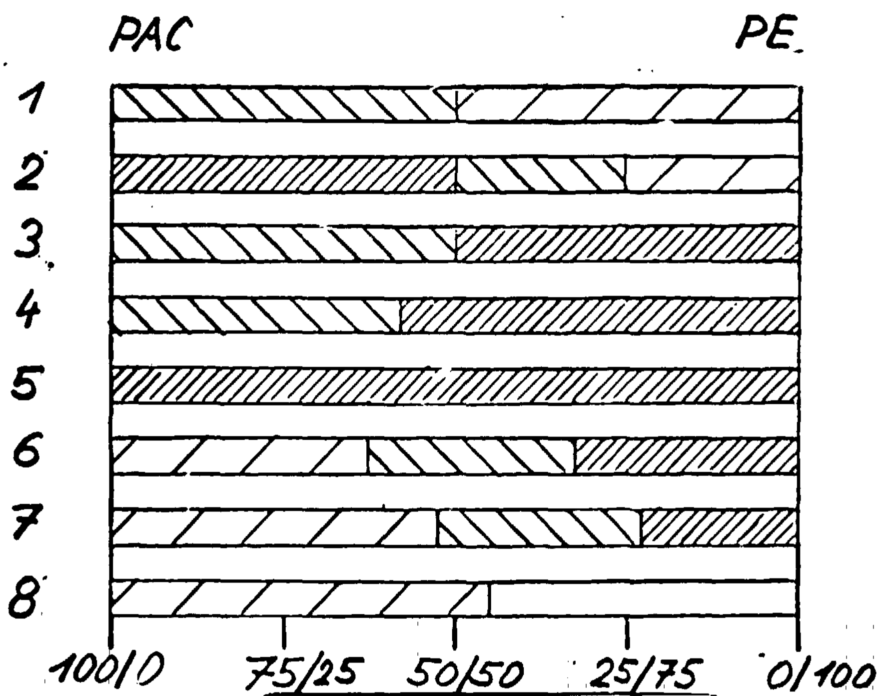


Viscose
PE
1
2
3
4
5
6
7
8
100/0
75/25
50/50
25/75
0/100



Wool
PAC
1
2
3
4
5
6
7
8
100/0
75/25
50/50
25/75
0/100

8



PAC
PE
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75/25
50/50
25/75
0/100