Mansoura Engineering Journal

Volume 14 | Issue 1 Article 24

5-25-2021

Optimization of Blend Ratio and Twist Multiplier for Polyester /Cotton Shirt Fabrics Part ii: Tensile Properties of Produced Fabrics.

Hemdan Abou- Taleb
Assistant Professor of Textile Engineering Department, Faculty of Engineering, Mansoura University, Mansoura, Egypt., haboutaleb@mans.edu.eg

Recommended Citation
Abou- Taleb, Hemdan (2021) "Optimization of Blend Ratio and Twist Multiplier for Polyester /Cotton Shirt Fabrics Part ii: Tensile Properties of Produced Fabrics.," *Mansoura Engineering Journal*: Vol. 14 : Iss. 1 , Article 24.
Available at: https://doi.org/10.21608/bfemu.2021.172167

OPTIMIZATION OF BLEND RATIO AND TWIST MULTIPLIER FOR POLYESTER/COTTON SHIRT FABRICS

Part II: Tensile properties of produced fabrics.

المثالية فى نسب خلط وأس برم (قطن/بولى استر) فى أقمشة القمصان. الجزء الثانى : خواص الشد للأقمشة المنتجة

BY

HEMDAN A. ABO-TALEB

Textile Engineering Dept., Faculty of Engineering,
Mansoura University, Mansoura, EGYPT.

خلاصة ـ الدراسة فى هذه المقاله تهتم بتأثير كل من نسبة البولى استر وأس البرم لخيوط اللحمه على خواص الشد فى الاقمشة ، بصفة خاصة ، الشغل المبذول النوعى وامتطالية القطع ومتانة التمزق. الموديلات الرياضيه التى تصف هذه الخواص فى كلا من اتجاهى السداء واللحمه امكن الحصول عليها للتنبؤ بخواص الشد فى الاقمشة. ولقد وجد أن القيم المثاليه لنسبة البولى استر وأس البرم لخيط اللحمه من أجل الحصول على أعلى متانة فى اتجاه السداء هى ٦٧٪ بولى استر ، ٣٫٤٥ (α_e) وفى اتجاه اللحمه هى ٦٧٪ بولى استر ، ٣٫٨ (α_e).

ABSTRACT - The study reported in this paper concerns the influence of both polyester ratio and twist multiplier of weft yarns on the fabric tensile properties, specially, specific work of rupture, extensibility and tear strength. Mathematical models describing these parameters in both the warp and weft directions are presented in a form that can be easily predicted. It was found that the optimum values of polyester percent and twist multiplier of the weft yarns for obtaining the highest possible fabric strength in warp direction were 67% and 3.45 α_e while in the weft direction were 67% and 3.8 α_e.

1. INTRODUCTION

Blending of polyester/cotton fires to produce yarns and then fabrics is an interesting subject to be searched in Egypt; because polyester fibres have been produced in Egypt since 1980. Therefore, the textile industry started an experimental study to determine the optimum blending level for a specific end-use.

The study reported in this paper is a continuation of that described in part I [1] and deals with another subject on which nothing has been found in the literature. As well known, the twist multiplier influences the cotton yarn strength [2] and it has a slight influence on the strength of polyester/cotton yarn when twist multiplier is ranging from 3.2 α_e to 4.2 α_e [3] and the weft yarn strength is one of the parameters that determine fabric strength. Hence it is to be expected that the twist multiplier and polyester ratio in the blended weft yarn will affect tensile properties of fabrics. Therefore, the purpose of the study reported in this paper was to determine the validity of this hypothesis and to find the optimum values of these variables. The tensile properties taken into account were specific work of rupture, extensibility and tear strength in both warp and weft directions. These characteristics were established as responses in suitable experimental designs.

2. EXPERIMENTAL PLAN

The studied fabrics being the same as those used previously in part I [1].

The experimental plan that was used was an orthogonal [4] of two variables:

X_1 = polyester percent in the blend;
X_2 = twist multiplier.

For the case of two variables, the experimental plan is given in Table I and the actual levels of the variables are given in Table II.

Table I: Experimental Plan For Two Variables.

Experimental Combination	Levels of Variables X_1	X_2
1	-	-
2	+	-
3	-	+
4	+	+
5	-	0
6	+	0
7	0	-
8	0	+
9	0	0

Table II: Variable Levels.

Variable \ Level	-1	0	+1	Interval
X_1 = polyester percent (%)	33	50	67	17
X_2 = Twist multiplier (α_e)	3.2	3.7	4.2	0.5

Fabrics were tested in accordance with ASTM procedures [5]. All woven fabrics tests were made in both warp and weft directions. Breaking strength using cut strip method, extensibility and Elmendorf tearing strength were determined.

3. EXPERIMENTAL RESULTS

As shown in the experimental plan in Table I, the results obtained for fabric specific work of rupture during tension, extensibility and tear strength are detailed in Table III. The fabric specific work of rupture was calculated [2] from the following expression:

$$\text{Fabric specific work of rupture in g-wt/tex} = \frac{\text{energy to break fabric specimen in g-wt cm}}{\text{area density of fabric in g/m}^2 \times \text{specimen width in mm} \times \text{specimen length in cm}}$$

The results were fed to an UK 101 computer and regression coefficients were determined. The coefficients were tested for significance at the 95% significance level. Only significant terms were taken into consideration for a further analysis of the results. The response-surface equations for the various yarn characteristics are given in Table IV.

Table III: Experimental Results.

Property / Expr. Comb.	Specific work of rupture (g/tex)				Extensibility (%)				Tear strength (grams)			
	Warp		Weft		Warp		Weft		Warp		Weft	
	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.
1	1.127	1.055	0.168	0.448	13.40	14.491	13.13	13.717	1958	2008.88	3408	3228.89
2	1.091	1.055	0.413	0.448	13.10	12.941	13.60	12.979	2984	2923.54	4362	4323.23
3	1.007	0.847	0.228	0.202	12.90	12.941	11.50	11.371	2384	2332.22	3752	3687.89
4	1.202	0.847	0.394	0.202	15.70	14.491	13.45	12.100	2990	2826.80	3788	3864.23
5	1.040	0.951	0.753	0.602	13.80	13.716	15.75	15.192	2280	2242.48	3674	3852.33
6	0.696	0.951	0.551	0.602	12.70	13.716	14.10	15.192	2762	2947.14	4590	4487.67
7	1.091	0.8646	1.084	0.767	13.70	13.716	13.70	13.348	2306	2277.14	3668	3776.06
8	0.477	0.6566	0.306	0.522	11.60	13.716	10.65	11.740	2214	2390.48	3802	3776.06
9	0.900	0.7606	0.797	0.921	14.50	13.716	15.50	15.192	2480	2405.74	4132	4170.00

Table IV: Response-surface Equations.

Response	Response-surface Equation
Y_1= Specific work of rupture (g/tex) (in warp direction)	$Y_1 = 0.7606 - 0.1040\ X_2 + 0.1902\ X_1^2$
Y_2= Specific work of rupture (g/tex) (in weft direction)	$Y_2 = 0.9207 - 0.1227\ X_2 - 0.3192\ X_1^2 - 0.2765\ X_2^2$
Y_3= Extensibility (%) (in warp direction)	$Y_3 = 13.7155 + 0.775\ X_1X_2$
Y_4= Extensibility (%) (in weft direction)	$Y_4 = 15.1922 - 0.8042\ X_2 + 0.3688\ X_1X_2 - 2.6483\ X_2^2$
Y_5= Tear strength (grams) (in warp direction)	$Y_5 = 2405.738 + 352.33\ X_1 + 56.667\ X_2 + 189.07\ X_1^2 - 105\ X_1X_2 - 71.93\ X_2^2$
Y_6= Tear strength (grams) (in weft direction)	$Y_6 = 4170 + 317.667\ X_1 - 229.5\ X_1X_2 - 393.94\ X_2^2$

From table III, it was found that the experimental error in the centre of the scheme is low for all parameters except specific work of rupture because it is mainly a product of multiplying the values of breaking load by breaking elongation(energy to break fabric specimen). It therefore seems to be useful to obtain the plot of the response surfaces. Contour maps were constructed by using the response-surface equation.

4. DISCUSSION

4.1 Specific Work of Rupture:

Figures 1 and 2 show the effect of polyester percent and twist multiplier on fabric specific work of rupture for the warp and weft directions respectively. The contour lines are ellipses with a minimum, falling inside the experimental field. The contour lines in Fig. 1 clearly show that the specific work of rupture increases with a decrease in twist multiplier. This is probably be due to the fact that the fabric produced from blended yarns of higher twist tend to have lower strength because of increased fibre obliquity to the yarn axis.

However, for the polyester percent, the highest fabric specific work of rupture is noticed at the +1, -1 levels of polyester percent and twist multiplier 3.2. It is interesting to show that at the zero level of polyester ratio occurs minimum fabric specific work of rupture. This can be explained by the basic theory of blending [2] , where the extension of blended yarn follows the extension of the lower extensible fibre until a critical blending ratio. Beyond this ratio, the extension of the blended yarn is affected by the higher extensible component. Generally the critical blending ratio in the case of cotton-polyester is about 50/50. Thus the specific work of rupture of blended fabric is highly influenced by polyester ratio in the blend.

Figure 2 shows the effect of polyester ratio and twist multiplier on fabric specific work of rupture in weft direction. The contours of the response surface are ellipses showing a maximum value (0.7 g/tex) in the experimental field. When the twist multiplier

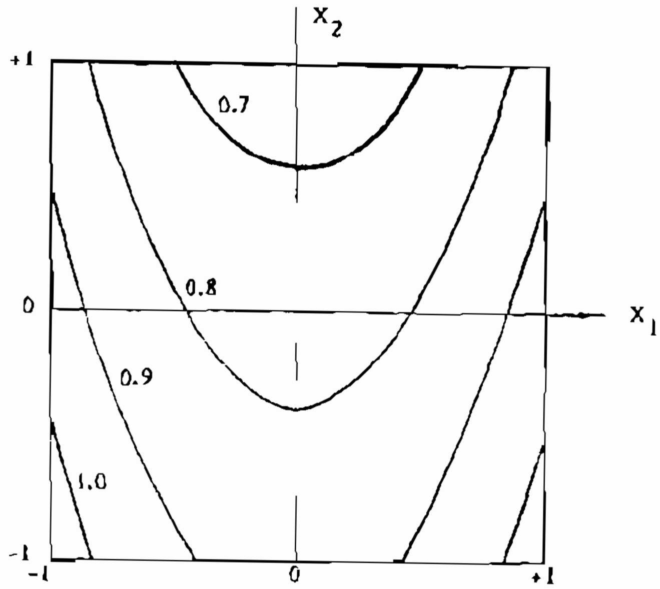

Fig. 1. Contours of constant response for work of rupture (in warp direction)

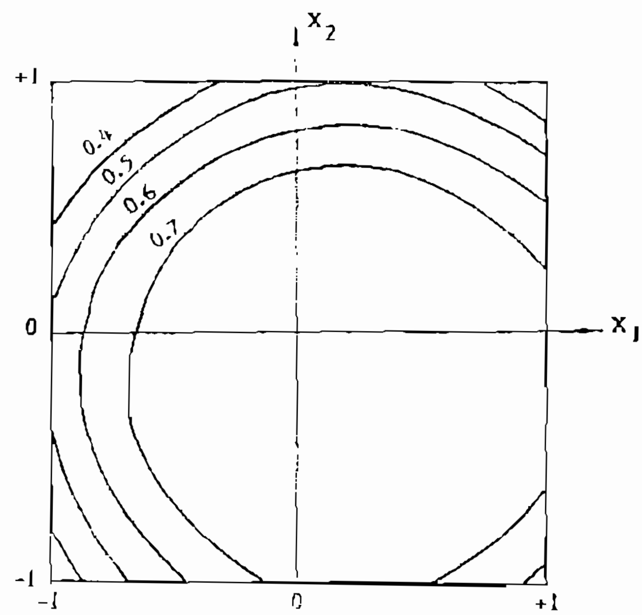

Fig. 2. Contours of constant response for work of rupture (in weft direction)

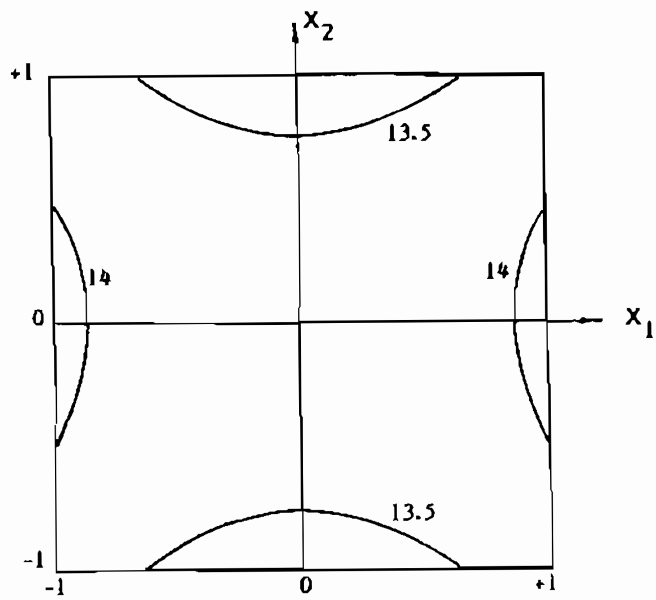

Fig. 3. Contours of constant response for extensibility (in warp direction)

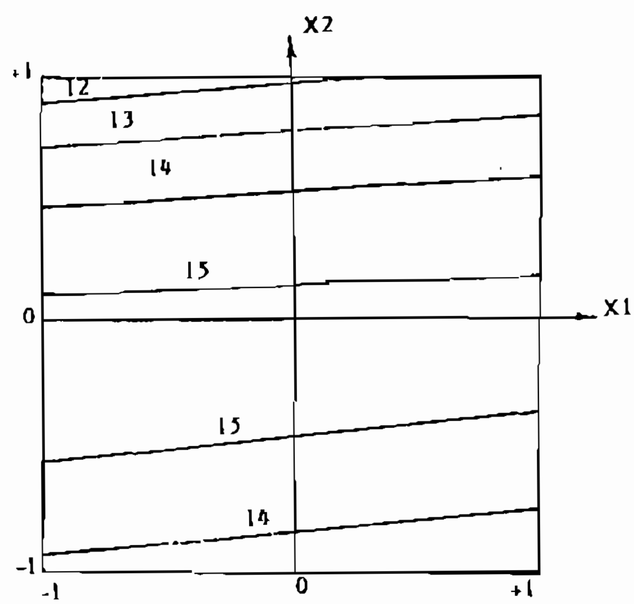

Fig. 4. Contours of constant response for extensibility (in weft direction)

increases, the specific work of rupture decreases independently of the polyester ratio. The decrease in specific work of rupture with increasing twist multiplier beyond 3.4 α_e can be noticed. This behaviour can be explained by the fibre obliquity which occurs as a result of increasing the twist.

4.2 Extensibility

The contours of the response surface are hyperbolas. The response surface is a mini-max with values swinging between 13.5 and 14%. The polyester percent and twist multiplier has no influence on the extensibility in the warp direction (Fig. 3).

An increase in the twist multiplier decreases the fabric extensibility in weft direction (Fig. 4). This is due to the crimp being much higher in the weft yarns than in the warp yarns, which are usually tensioned during the weaving process and are consequently more straight than the weft yarns. As the percentage of polyester was increased (from 33% to 67%) as shown in Fig. 4, the fabrics showed slight increase in breaking elongation because the polyester became the major contributor to fabric strength at the higher blend levels.

4.3 Tear Strength

Figure 5 shows the effect of polyester ratio and twist multiplier on the tear strength in the warp direction (when the weft yarns were being broken). The contour lines are hyperbolas with a minimum, falling outside the experimental field. The contours show that the tear strength increases with an increase in polyester ratio. This is clearly related to the increase of yarn strength by increasing the percent of polyester fibres which are stronger than cotton fibres. Therefore, the addition of polyester fibres in the blend with cotton improves the serviceability of the fabric which is directly related to the tear strength. But twist multiplier had a small opposite effect. Thus the polyester ratio alone is the most important factor.

The influence of polyester ratio and twist multiplier on tear strength in the weft direction (tearing in the weft direction normally causes the warp to be broken) is shown in Fig. 6. An increase in the polyester percent or twist multiplier within the experimental field leads to a higher tear strength. This is may be due to the high extensibility and low mobility of the warp yarns.

4.4 Determination of Optimum Values

Optimization of the studied factors to obtain the highest values of the specific work of rupture, extensibility and tear strength in both the warp and weft directions could be achieved by doublicating the graphs (figures 1, 3, 5) of the response surfaces together as shown in Fig. 7 for the characteristics in the warp direction. Also Fig. 8 could be drawn from doublication the graphs (Figures 2, 4, 6) of the response surfaees together for the parameters in the weft cirection.

In Fig. 7, if the value of specific work of rupture was equal to 1.0 g/tex and extensibility was larger than 14% and tear strength was equal to 2800 grams and upward, then the optimum factors would be found in the optimum zone specially in point A, which (X_1 = 67% polyester and X_2 = 3.45 α_e) will achieve the highest

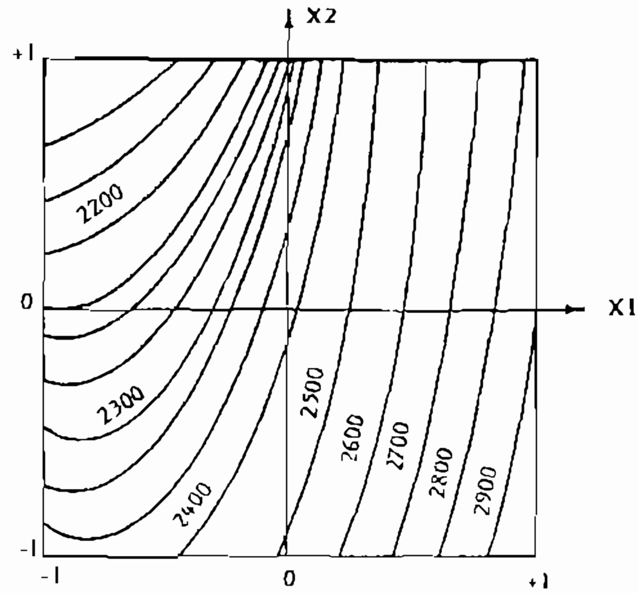

Fig. 5. Contours of constant response for tear strength (in warp direction)

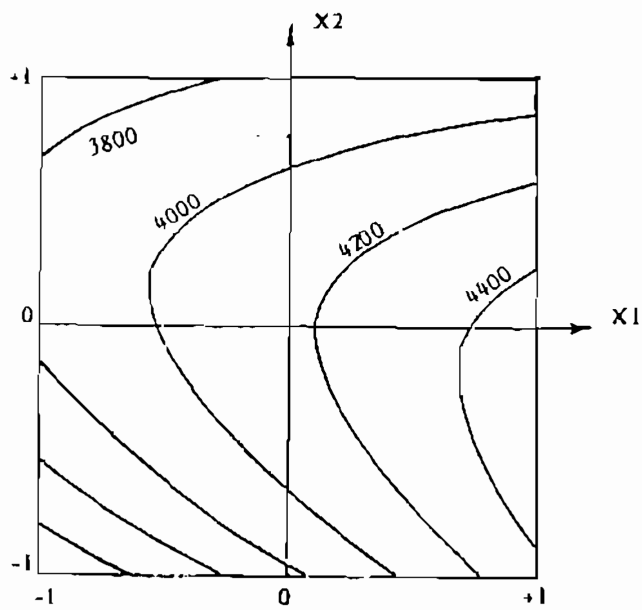

Fig. 6. Contours of constant response for tear strength (in weft direction)

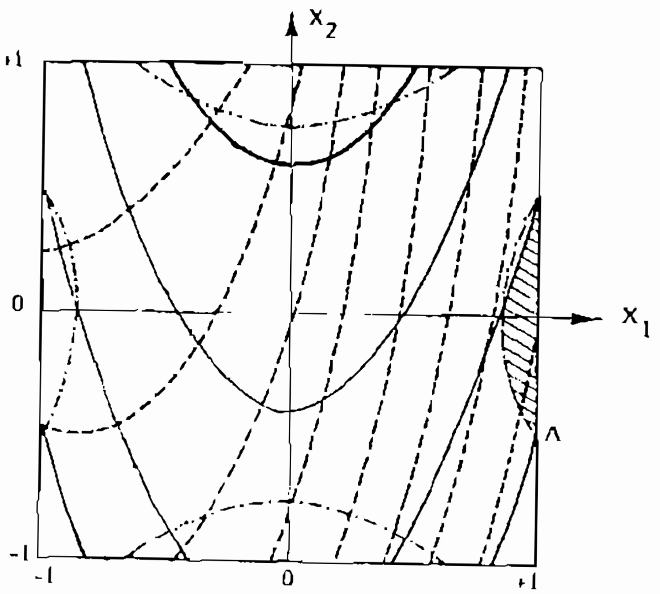

Fig. 7. The duplex cross section of the response surfaces (in warp direction)

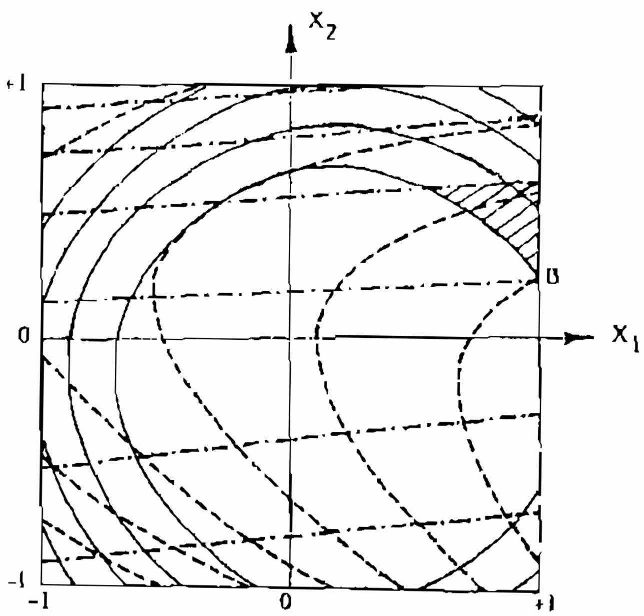

Fig. 8. The duplex cross section of the response surfaces (in welt direction)

——— Specific Work of rupture (g/tex)

–·–·–· Extensibility (%)

----- Tear strength (grams)

tensile properties in the warp direction.

But in Fig. 8, when the value of specific work of rupture was equal to 0.7 g/tex and extensibility was equal to 15% and tear strength was equal to 4400 grams and upward then the optimum factors would be found in the optimum zone specially in point B which (X_1 = 67% polyester and $X_2 = 3.8\,\alpha_e$) will achieve the best tensile properties in the weft direction.

5. CONCLUSIONS

From the studies reported above to investigate the influence of polyester ratio and twist multiplier of ring spun weft yarns on fabric tensile properties the following conclusions can be established:

1- Mathematical models describing the tensile properties (specific work of rupture, extensibility and tear strength) in both the warp and weft directions are presented in a form that can be easily predicted.

2- In both the warp and weft directions the polyester ratio influences fabric specific work of rupture and extensibility weakly but it affects the fabric tear strength more strongly. Whereas twist multiplier influences, to a small extent, on the investigated properties.

3- The optimum values of polyester percent in the blend and twist multiplier for obtaining the highest fabric tensile properties in both the warp and weft directions seem to be around (67% polyester γ $3.45\,\alpha_e$) and (67% polyester γ $3.8\,\alpha_e$) respectively.

REFERENCES

1. Abo-Taleb H.; El-Gaiar H.; El-Hadidy A. and Shahin A., Optimization of Blend Ratio and Twist Multiplier for Polyester/Cotton Shirt Fabrics. Part 1: Physical properties of produced Fabrics. The Bulletin of Faculty of Engineering, El-Mansoura University, Vol. 11, No. 2, T(56-64), 1986.

2. Hearle J.; Grosberg P. and Backer S., Structural Mechanics of Fibres, Yarns and Fabrics, Wiley-interscience, Ch. 1 and 8, page 16 and 312, 1969.

3. Abo-Taleb H.; El-Gaiar H.; El-Hadidy A. and Shahin A., Optimization of Blend Ratio and Twist Multiplier For Ring Spun Polyester/Cotton Yarns. Part I: Tensile Properties. The Bulletin of Faculty of Engineering, El-Mansoura University, Vol. 11, No. 2, T(21-33), 1986.

4. Кирюхин С.М., Соловьев А.Н. "Контроль и управление качеством текстильных материалов" - М. - Легкая индустрия, С. 284. 1977.

5. ASTM Standards, Part 32, D 1682, D 1424 (1975).