



The standard from fiber to fabric

Application Report

***Description of all quality parameters
measured by Uster Technologies
fiber and yarn testing equipment***

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1 Introduction

It was 50 years ago that Uster Technologies put their first testing unit, the evenness tester GGP, on to the market. Since that time, a vast number of other testing instruments such as tensile testing installations and yarn clearers, for example, have been developed by Uster Technologies. Today, the USTER® *TESTER 4*, which was introduced in 1997, already represents the fifth generation of the "old" GGP. Aside from the measuring principle, however, the USTER® *TESTER 4* has very little in common with the first GGP tester. A good 10 years ago, Uster Technologies entered the last field of textile testing in the spinning mill by extending their activities to fiber testing.

Thanks to the wide range of testing instruments and computer-aided systems, today's quality assurance can count on a large number of quality parameters. It is hard to believe, but there are well over 150 characteristics to describe the quality of a fiber or a yarn. In some cases, this great variety has resulted in confusion and communication problems, because some quality parameters are only distinguished by minor changes such as different prefixes.

We hope that this paper, which describes and explains the test parameters of all laboratory tests carried out with Uster Technologies instruments, will provide the necessary information. It is intended as a reference that should make your daily work with test parameters a little easier. The individual chapters contain a brief description of the respective testing unit and its quality parameters. On the left hand side you will find the abbreviations, which you know from the test reports, and on the right the corresponding explanations of these abbreviations.

2 USTER® *HVI*

The USTER® *HVI* testing system (High-Volume Instrument) uses the latest measurement technology for the testing of large quantities of cotton samples within a minimum amount of time. It is a high-performance system that permits the annual classification of entire cotton crops. Particularly worth mentioning is the exclusive use of this system at the US Department of Agriculture (USDA). HVI systems are also used for the classification of entire inventories or complete lots at the cotton producer, at the merchant or in the spinning mill.

The following information is, of course, also applicable if you use a product from our LVI family instead of a HVI installation.

2.1 Length & Strength

Characteristics	Unit	Description												
• Len 1	[mm or in]	Mean length (HVI mode) = mean fiber length												
• Len 2	[mm or in]	Upper half mean length (HVI mode) = mean length by weight of the longer 50% of fibers (Fig. 1)												
• Unf	[%]	<p>Uniformity Index = length uniformity of the fibers. The Uniformity Index is only valid for the HVI mode.</p> <p>$\frac{\text{Len 1} \cdot 100}{\text{Len 2}} = \text{Uniformity Index}$</p> <p>Classification of the length uniformity:</p> <table><tr><td></td><td>Uniformity Index</td></tr><tr><td>very low</td><td>below 76</td></tr><tr><td>low</td><td>77 – 79</td></tr><tr><td>average</td><td>80 – 82</td></tr><tr><td>high</td><td>83 – 85</td></tr><tr><td>very high</td><td>above 86</td></tr></table>		Uniformity Index	very low	below 76	low	77 – 79	average	80 – 82	high	83 – 85	very high	above 86
	Uniformity Index													
very low	below 76													
low	77 – 79													
average	80 – 82													
high	83 – 85													
very high	above 86													
• Strength	[g/tex]	<p>Breaking force of the fiber bundle divided by fiber fineness</p> <p>Assessment of the fiber strength (without long staple):</p> <table><tr><td></td><td>HVI 1/8 (HVICC)</td></tr><tr><td>below 21</td><td>= very low</td></tr><tr><td>22 to 24</td><td>= low</td></tr><tr><td>25 to 27</td><td>= average</td></tr><tr><td>28 to 30</td><td>= high</td></tr><tr><td>over 30</td><td>= very high</td></tr></table>		HVI 1/8 (HVICC)	below 21	= very low	22 to 24	= low	25 to 27	= average	28 to 30	= high	over 30	= very high
	HVI 1/8 (HVICC)													
below 21	= very low													
22 to 24	= low													
25 to 27	= average													
28 to 30	= high													
over 30	= very high													
• Elg	[%]	Breaking elongation of the fiber bundle												
• Amt		Amount, Parameter describing the optically measured number of fibers in the bundle at the time of break												
• SFI	[%]	Short fiber index = percentage of fibers shorter than ½ inch or 12.7 mm												
• SCI		Spinning consistency index. A coefficient is calculated by means of various quality characteristics by a multiple regression analysis. The main benefit of the SCI is a simplified selection of bales for a predetermined blend of fibers as well as the long-term check of the raw material blend.												

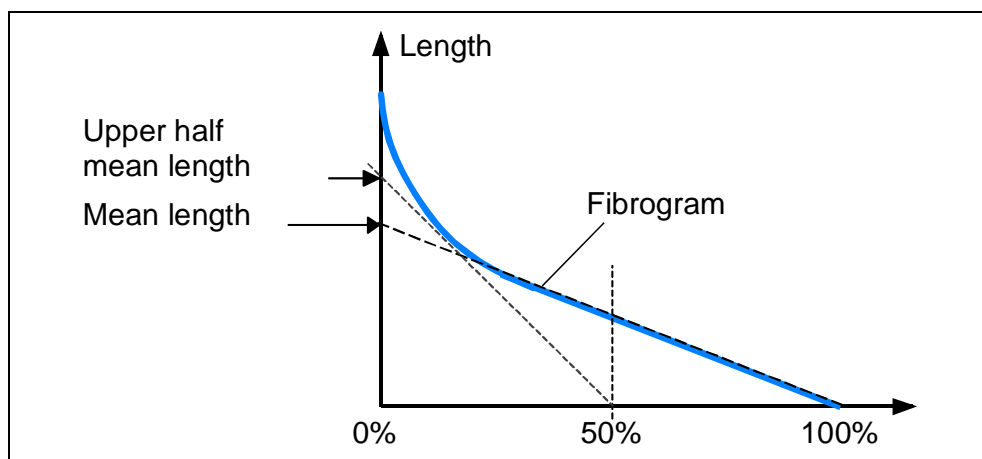


Fig. 1
USDA-mode / Fibrogram

The fibrogram is a non-endaligned staple diagram and is calculated from a randomly taken fiber bundle which is fixed in a measuring grip.

2.2 Micronaire

Characteristics	Unit	Description
• Mic		Parameter describing cotton fiber fineness Micronaire Ratings: below 3.0 = very fine 3.1 - 3.9 = fine 4.0 - 4.9 = average 5.0 - 5.9 = coarse over 6.0 = very coarse
• Mat		Parameter describing cotton maturity Maturity Index Ratings: below 0.70 = uncommon 0.71 – 0.85 = immature 0.86 – 1.00 = mature above 1.01 = very mature

2.3 Color & Trash

Characteristics	Unit	Description
• Rd		Reflectance of the fibers, higher Rd values mean a higher color grade
• +b		Yellowness of the fibers (Nickerson/Hunter scale)
• C-Grade		Color grade = Color classing parameter according to the American Grade Standards (USDA) for Upland and Pima cottons or according to a user-specific classification
• Tr Area		Area of the sample covered with trash particles
• Tr Cnt		Number of trash particles
• Tr Trash		Trash code = trash classing according to USDA

3 USTER® AFIS

The USTER® AFIS (Advanced Fiber Information System) is used for the measurement of individual fibers. The fibers are opened and individualized with a pair of spiked rollers surrounded by carding segments. The fiber opening unit works by aero-mechanical separation to separate trash particles and large seed-coat fragments from the fibers. These trash particles are extracted through the trash channel, while individual fibers and neps pass through the fiber channel. Both channels are equipped with opto-electrical sensors. The modular design of the USTER® AFIS provides extensive information on important quality parameters and the respective frequency distribution.

3.1 Neps (USTER® AFIS-M)

Characteristics	Unit	Description
• Weight	[g]	Sample weight
• Nep	[µm]	Mean nep size
• Nep	[Cnt/g]	Number of neps per gram
• SCN	[µm]	Mean seed-coat nep size
• SCN	[Cnt/g]	Number of seed-coat neps per gram

3.2 Length & Maturity (USTER® AFIS-L&M)

Characteristics	Unit	Description
• n		by number of fibers
• w		by fiber weight
• L (n,w)	[mm or in]	Mean fiber length
• L (n,w) CV	[%]	Coefficient of variation of the fiber length
• SFC (n,w)	[%]	Short fiber content, percentage of fibers shorter than ½ inch or 12.7 mm (Fig. 2)
• UQL (w)	[mm or in]	Upper quartile length = length exceeded by 25% of the fibers (Fig. 2)
• 5% (n)	[mm]	Length exceeded by 5% of the fibers (Fig. 2)
• 2.5% (n)	[mm]	Length exceeded by 2.5% of the fibers (Fig. 2)
• Fine	[mtex]	Fiber fineness (linear density)
• IFC [%]		Immature fiber content = percentage of immature fibers
• Mat Ratio		Maturity ratio

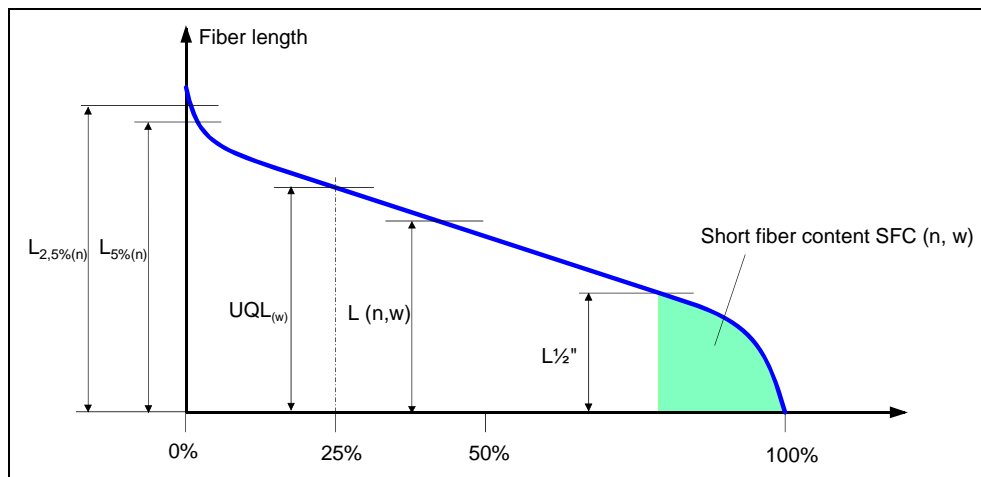


Fig. 2
Staple diagram

Fig. 3 and Fig. 4 show the definition of the measured values in relation to the maturity characteristics. The respective parameters can be explained using Fig. 3. Fig. 3 shows the cross-section of a cotton fiber.

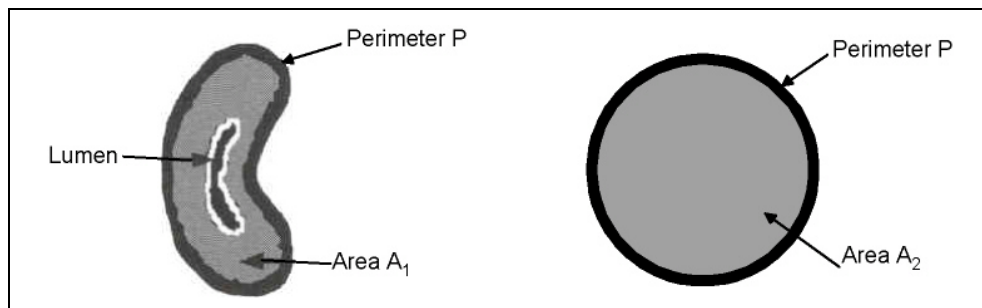


Fig. 3
Degree of thickening

To compute the mean degree of thickening theta, a circular cross-section of the measured fiber having a perimeter P is calculated, and subsequently area A1 is divided by area A2.

Fig. 4 shows a maturity measurement using the USTER® AFIS as well as the values computed for theta.

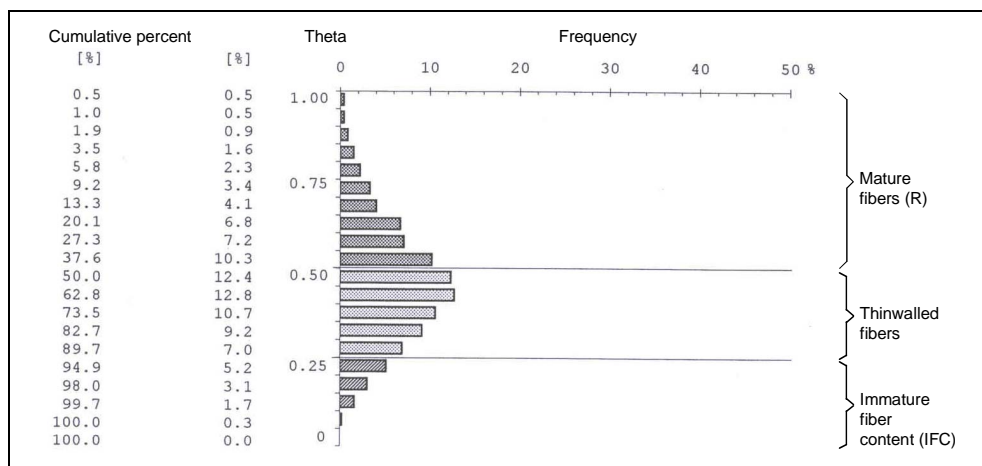


Fig. 4
Histogram of AFIS maturity

For this example, the following apply:

Mature fiber content R = 37.6%

Immature fiber content IFC = 10.3%

$$\text{Maturity (according to Lord): } M = \frac{R - \text{IFC}}{200} + 0.7 = \frac{37.6 - 10.3}{200} + 0.7 = 0.83$$

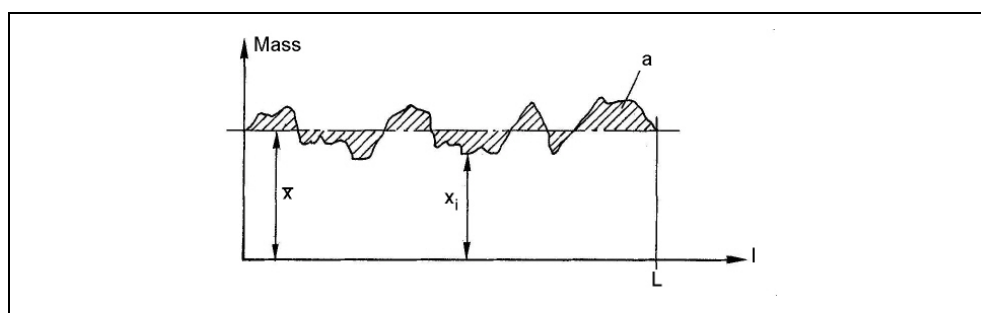
3.3 Trash (USTER® AFIS-T)

Characteristics	Unit	Description
• Total	[Cnt/g]	Total number of particles per gram
• Mean size	[µm]	Mean particle size
• Dust	[Cnt/g]	Dust particles per gram (<500 µm)
• Trash	[Cnt/g]	Trash particles per gram (>500 µm)
• V.F.M.	[%]	Visible foreign matter

4 USTER® TESTER

Mass variations, count variations and imperfections have a decisive influence on the utility and market value of a yarn. The USTER® TESTER determines these quality parameters on yarns, rovings and slivers very quickly. The capacitive measuring system permits fast and reproducible measurements. Based on spectrograms and diagrams, it is easy to eliminate the sources of defects. In recent years, the hairiness measurement has become more and more important, because hairiness can also affect the quality a woven or knitted fabric. The modular design of the USTER® TESTER permits simultaneous testing of all parameters. With the USTER® TESTER 4 additional optical sensors have been introduced (sensors OM and OI).

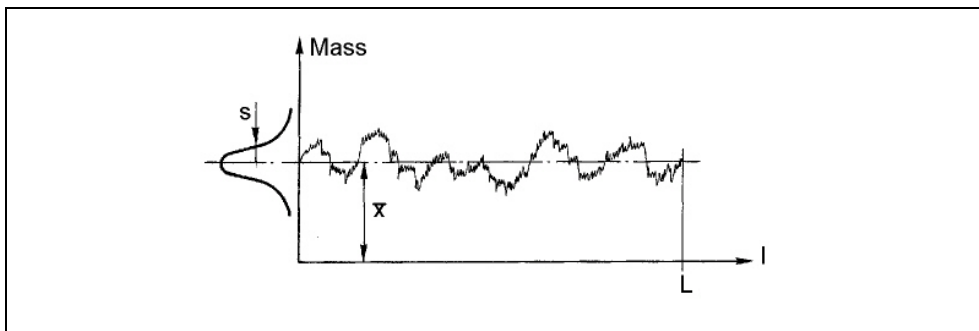
4.1 Mass variations



*Fig. 5
Mass variations /
Irregularity U*

Definition: $U = \frac{a}{\bar{x} \cdot L}$

- a = shaded area
- \bar{x} = mean value
- x_i = mass value at a given point in time
- L = test length



*Fig. 6
Mass variations /
Coefficient of variation CV*

Definition: $CV = \frac{s}{\bar{x}}$

s = standard deviation
 \bar{x} = mean value
L = test length

Characteristics	Unit	Description
• Um	[%]	Mean linear irregularity (now obsolete, CVm is more common today, Fig. 5)
• CVm	[%]	Coefficient of variation of the yarn mass (Fig. 6)
• CVm (L)	[%]	Coefficient of variation of the yarn mass at cut lengths of 1, 3, 10, 50, 100 m and in the Inert and Half Inert modes
• Mass deviation		m(max)= maximum mass m(min)= minimum mass cut lengths for the calculation are 1, 3, 10 m or Half Inert
• Index		Ratio between the ideal and actual evenness of staple fiber strands
• Imperfections		Number of thin places, thick places and neps at selected sensitivity settings (staple fiber yarns only) thin places: -30% , -40% , -50% , -60% thick places: +35% , +50% , +70% , +100% neps: +140% , +200% , +280% , +400%
• Rel. count	[%]	Count deviation relating to the length of yarn tested, the mean corresponds to 100%
• Abs. count	[e.g. tex, Ne]	Linear density of the yarn unit length (yarn count)

4.2 Hairiness

The receiver detects only the light transmitted by the protruding fibers (Fig. 7). The yarn body remains black and does not transmit light. The light intensity, at the receiver, therefore, measures the light intensity which is proportional to the hairiness of the yarn.

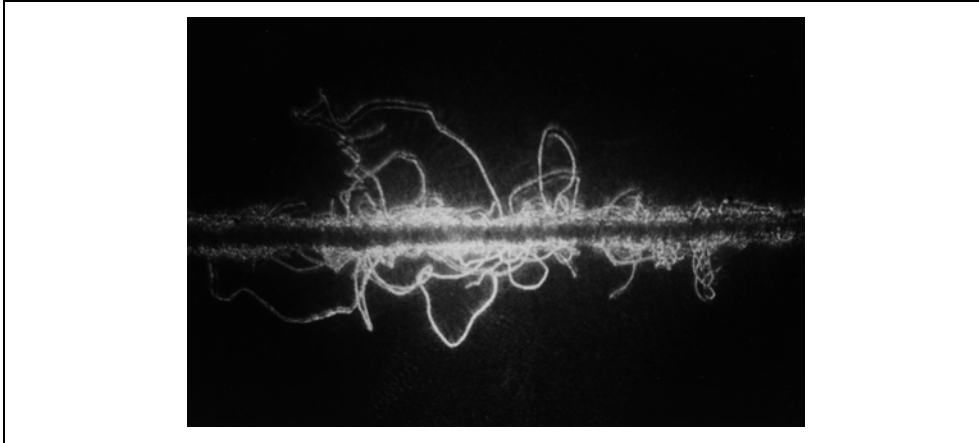


Fig. 7

Characteristics	Unit	Description
• Hairiness		The hairiness H corresponds to the total length of protruding fibers divided by the length of the sensor of 1 cm. The hairiness is, therefore, a figure without a unit.
• sh		Standard deviation of hairiness
• sh (L)		Standard deviation of hairiness at cut lengths of 1, 3, 10, 50, 100 m
• Hairiness deviation		h(max)= maximum hairiness h(min)= minimum hairiness cut lengths for the calculation are 1, 3, 10 m

4.3 Optical evaluation of yarns

The following characteristics are evaluated by an optical sensor which illuminates the yarn from 2 different directions and with an angle of 90° degrees.

Characteristics	Unit	Description
• 2DØ	[mm]	Mean value of the two-dimensional diameter over the measured yarn length
• s2D8mm	[mm]	Standard deviation of the diameter over the reference length of 8 mm
• CV2D8mm	[%]	Coefficient of variation of the diameter over the reference length of 8 mm
• CV2D0.3mm	[%]	Coefficient of variation of the diameter over the reference length of 0.3 mm
• CV FS	[%]	Coefficient of variation of the fine structure, assessment of short-wave variations
• CV1D0.3mm	[%]	Coefficient of variation of the one-dimensional yarn diameter, related to 0.3 mm
• Shape		Non-dimensional value between 0 and 1, which describes the roundness of a yarn (1 = circular, 0.5 = elliptical)
• D	[g/cm ³]	Mean yarn density related to the nominal count

4.4 Dust and trash

The following characteristics are determined by a sensor which determines dust and trash in yarns.

Characteristics	Unit	Description
• Trash count	[Cnt/km or yd]	Trash particles per km or yard > 500 µm
• Trash count spec.	[Cnt/g]	Trash particles per gram > 500 µm
• Dust count	[Cnt/km or yd]	Dust particles per km or yard > 100 - 500 µm
• Dust count spec.	[Cnt/g]	Dust particles per gram > 100 - 500 µm
• Trash size	[µm]	Mean trash particles size
• Dust size	[µm]	Mean dust particles size

5 Strength and elongation of yarns

5.1 Conventional strength and elongation (USTER® TENSORAPID)

In quality assurance, tensile testing of textile and technical yarns is one of the most important tests. The USTER® TENSORAPID operates in accordance with the CRE measuring principle. The abbreviation CRE stands for "Constant Rate of Extension". This means that the active clamp is moving at constant speed. The measuring unit is suitable for the testing of textile yarns (staple and filament yarns), technical yarns, woven fabrics and skeins. With the USTER® TENSORAPID, it is possible to process up to 40 samples automatically.

Characteristics	Unit	Description
• Pretension		Force applied to the yarn at the beginning of the strength test to guarantee reproducible initial conditions. Standard pretension is 0.5 cN/tex.
• Time to Br.	[sec]	Time elapsed between the start of the measurement and the breakage of the specimen (Fig. 8)
• B-Force	[cN]	Breaking force = maximum tensile force measured (Fig. 8)
• Elongation	[%]	Breaking elongation = elongation at maximum force (Fig. 8)
• Tenacity	[cN/tex]	Breaking force divided by the linear density of the specimen
• B-Work	[cNcm]	Work to break = work at maximum force (area below the force/elongation curve drawn to the point of maximum force, (Fig. 8)
• Work	[cNcm]	Partial work (area below the force/elongation curve drawn between two specified elongation values)
• Ref. val.		Reference values (maximum of 8 values)
• F ...%	[cN]	Force at a specified elongation
• E ...N	[%]	Elongation at a specified force
• E (F-)	[%]	Elongation at a specified force drop
• F (1.br.)	[cN]	Breaking force of the first filament at a defined force drop
• M1 ...%	[N/tex]	Modulus (maximum of 8 values), either secant
• M2 ...%	[N/tex]	Modulus or Young's modulus = slope of the force/elongation curve measured at a specified elongation

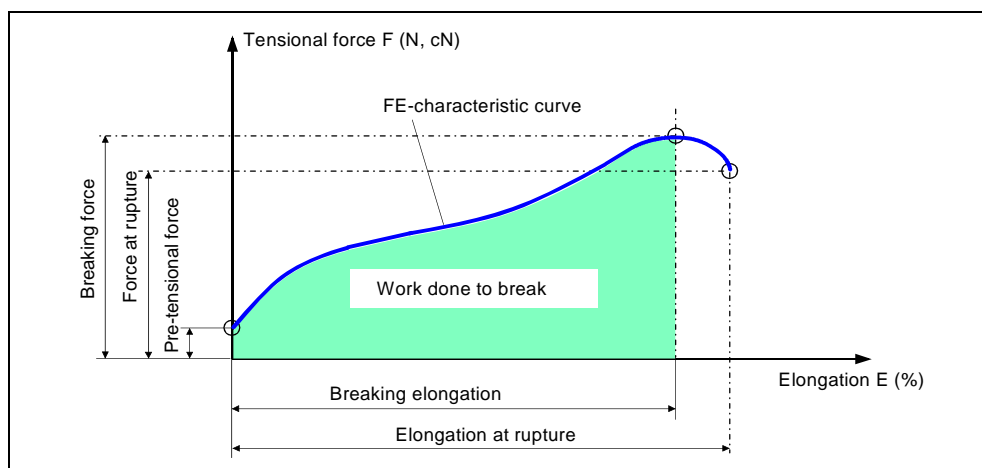


Fig. 8
Force-Elongation Curve

The software for filament testing provides the following additional parameters:

Characteristics	Unit	Description
• Y-Point		Point at the end of the elastic range of filament yarn
• Y-Point Load.	[N]	Force value at the end of the elastic range of filament yarn
• Y-Point Stress	[cN/tex]	Tenacity referred to the fineness or diameter at the end of the elastic range of filament yarn
• Y-Point Strain	[%]	Elongation at which the elastic range of a filament yarn ends
• Natural Draw Ratio (NDR)		Point at the end of the flow range
• NDR Load	[N]	Force at the end of the flow range
• NDR Stress	[cN/tex]	Tenacity referred to the fineness or diameter at the end of the flow range
• NDR Extension	[%]	Elongation at the end of the flow range
• NDR Ratio		Ratio between NDR extension and Yield strain

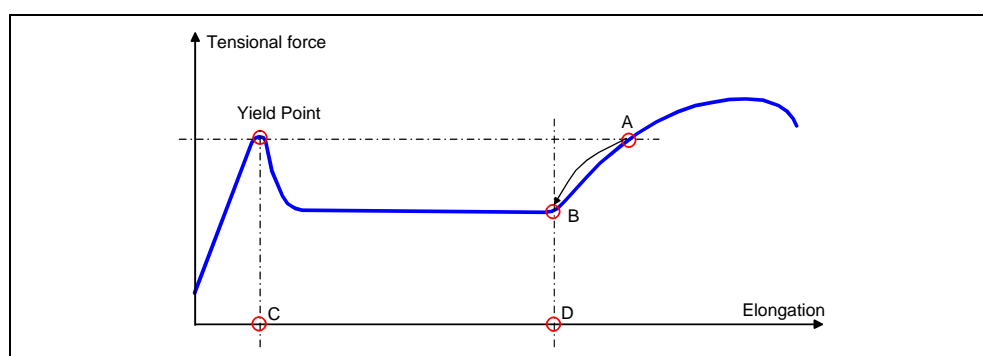


Fig. 9
Determination of the Yield Point

5.2 Ultra-high speed strength tests (USTER® *TENSOJET*)

The USTER® *TENSOJET* is the first tensile testing installation which is capable of measuring at speeds of 400 m/min. In one hour, the testing unit can carry out up to 30,000 tensile tests. The mechanism to load, elongate and finally break the test sample consists of two pairs of counter-rotating rollers, which are arranged at a distance of 500 mm. The measuring cycle is divided into four phases: continuous drawing-off of the yarn and intermediate storage, insertion of the thread by an air jet, clamping and elongation until it is broken by the rollers and, finally, removal of the remaining pieces of thread into a waste container by compressed air. The USTER® *TENSOJET*, like the USTER® *TENSORAPID*, operates in accordance with the CRE measuring principle.

Characteristics	Unit	Description
• B-Force	[cN]	Breaking force = maximum tensile force measured (Fig. 8)
• Elongation	[%]	Breaking elongation = elongation at maximum force (Fig. 8)
• Tenacity	[cN/tex]	Breaking force divided by the linear density of the (Fig. 8)
• B-Work	[cN*cm]	Work done to break = work at breaking force (area below the force/elongation curve drawn to the point of maximum force, Fig. 8)
• Max values		Maximum value of force, elongation, tenacity or work within one test series
• Min values		Minimum value of force, elongation, tenacity or work within one test series
• Percentile values e.g. P. 0.01		0.01%, 0.05%, 0.1%, 0.5%, 1.0% of all measurements are below the reported value

6 Classification of yarn faults (USTER® *CLASSIMAT*)

There are basically two types of yarn faults. Firstly, there are the frequent yarn faults, better known as imperfections which are detected with an evenness tester. Secondly, there are rare yarn faults, which occur at such irregular intervals that at least 100 km of yarn has to be tested to ensure reliable detection. For open end yarns a test length of 1000 km is recommended. As a yarn fault classifying installation, the USTER® *CLASSIMAT* detects all seldom-occurring yarn faults and classifies these into the respective classes of the *CLASSIMAT* system.

Using the CLASSIMAT matrix, it is possible to define or control the most suitable yarn clearer settings.

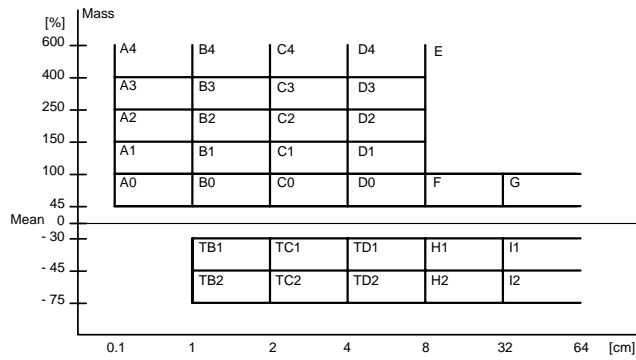
Characteristics	Description
• Fault classification	<div></div>
• Fault lengths	A: shorter than 1 cm B+TB: 1 to 2 cm C+TC: 2 to 4 cm D+TD: 4 to 8 cm E: longer than 8 cm F+H: 8 to 32 cm G+I: longer than 32 cm
• Fault sizes	0: +45 to +100% 1: +100 to +150% 2: +150 to +250% 3: +250 to +400% 4: over +400% E: over +100% F+G: +45 to 100% TB1/TC1/TD1/H1/I1: -30 to -45% TB2/TC2/TD2/H2/I2: -45 to -75%
• Fault channels of the clearers	N channel for very short thick places S channel for short thick places L channel for long thick places T channel for long thin places C channel for count deviations

Fig. 10
Classing matrix of the
Classimat

7 Applicable standards

Most fiber and yarn testing methods are covered by national or international standards. Since fiber testing instruments are mainly developed in the United States, ASTM standards apply in most cases. Yarn testing is covered by DIN, EN or ISO standards and Japan Industrial Standards.

The following standards apply to USTER® *PRODUCTS*:

1. USTER® *HVI*

ASTM D-1448, ISO 2403	Micronaire reading of cotton fibers
ASTM D-1447	Fibrograph measurement of length and length uniformity
ASTM D-1445	Breaking strength and elongation (flat bundle method)
ASTM D-2253	Nickerson/Hunter colorimeter
ASTM D-2812	Non-lint content of cotton
ASTM D-5867	High-volume instrument testing

2. USTER® *AFIS*

ASTM D-5866	AFIS nep testing
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3. USTER® *TESTER*

ISO 2060, DIN 53 830	Determination of yarn count
ISO 2649, DIN 53 817	Determination of yarn evenness

4. USTER® *TENSORAPID*

ISO 2062, DIN 53 834, ASTM D-1578 JIS	Single-end tensile testing
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5. Environmental conditions

Since most measurements on textile products are affected by both the temperature and the relative humidity, textile testing should be performed under constant standard atmospheric conditions.

ISO 139, EN 20 139, DIN 53 802	Standard atmosphere for conditioning and testing
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