USTER® *STATISTICS*

Application Handbook

Edition 2013

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http://www.uster.com/fileadmin/customer/Services/USTER_Statistics/Application_Handbook_Uster_Statistics_pdf_for_internet.pdf

1 Introduction

We are pleased to announce the publication of three essential new documents supporting the release of USTER® *STATISTICS 2013*:

- USTER® *NEWS BULLETIN No. 49*
- Easy User Guide for USTER® *STATISTICS*
- Application Handbook for USTER® *STATISTICS*

Firstly, **USTER® *NEWS BULLETIN No. 49*** underlines the value of USTER® *STATISTICS* for users throughout the textile chain. It explains the key benefits of these unrivaled global benchmarks, looking at their historic development and pinpointing innovations in the latest edition of USTER® *STATISTICS.* All the highlights are covered in the bulletin, continuing the tradition of releasing USTER® *STATISTICS* in this form for more than 50 years.

Secondly, the **Easy User Guide** has been fully updated, taking users through the day-to-day processes for accessing and interacting with USTER® *STATISTICS* – whether online at the Uster Technologies website (www.uster.com), on CD-ROM, or integrated within USTER®instruments. The Easy User Guide sets out clearly the best methods for working with the interactive graphs and tables to reach key data. It points the way, quickly and efficiently, to tasks such as finding USTER® *STATISTICS* percentile values and the absolute values related to them.

Thirdly, the **Application Handbook** for USTER® *STATISTICS* provides the all-important fine detail behind the latest release of the benchmarks. It describes testing procedures, defines parameters, and sets out details of updates and changes in the current version of the statistics. The Handbook also spells out the restrictions for proper use of USTER® *STATISTICS,* and these should be read carefully before using and applying the benchmarks.

The latest edition of USTER® *STATISTICS* supports the textile industry even more fully than in previous years, with extra data now covering more yarns made from different raw material blends, along with some of the new yarn types in use worldwide. Data now also takes in the increasingly popular air-jet yarns, as well as the currently fashionable cotton and elastomer core yarns.

The new version of USTER® *STATISTICS* includes, for the first time, benchmarking values for USTER® *ZWEIGLE HL400* and USTER® *CLASSIMAT 5* instruments. For a full understanding of these parameters, please refer to the descriptions in chapter 4.5.2 and chapter 4.5.5.

USTER® *STATISTICS* fulfill many different needs throughout textiles – promoting understanding of the correlation between different parameters, improving or adjusting yarn quality, and facilitating objective yarn sourcing and trading. Whatever your specific goal, we would like to wish all users every success in applying the new USTER® *STATISTICS 2013* to your business.

For any questions, inputs or feedback, please feel free to make contact via the USTER® *STATISTICS* section of our website.

2 Content, changes and improvements

2.1 Distinction between Knitting and Weaving Yarns, Ring-spun

Also, in the USTER® *STATISTICS 2013* a distinction was made again between weaving and knitting yarns. The threshold between weaving and knitting yarn has been determined to be the following twist multipliers:

- Combed cotton yarn $\alpha_e = 3.7$ ($\alpha_m = 112$)
- Carded cotton yarn $\alpha_e = 3.9$ ($\alpha_m = 119$)

Yarns with twist multipliers below these values have been classified as knitting yarns.

2.2 Distinction between Knitting and Weaving Yarns for OE-rotor yarns

Many customers asked us to divide OE knitting yarns and OE weaving yarns into two separate chapters, similar to the distinction made for ring-spun yarns made of carded and combed cotton. The results of the USTER® *ZWEIGLE TWIST TESTER* could not be used for this distinction because OE-rotor spun yarns do not have a real twist. Instead, the customers, who provided the samples for the USTER® *STATISTICS*, were asked to declare the end-use of the OE-rotor spun yarn in the yarn identification. This made it possible to divide the former chapter about OE-rotor-spun yarns made out of 100% cotton into a chapter about OE knitting yarns and another chapter about OE weaving yarns.

2.3 New count distinction for the USTER® *CLASSIMAT*

Uster Technologies received a lot of feedback regarding the statistics for the USTER® *CLASSIMAT*, i.e. the wide count range for which the graphs were valid. This input was considered carefully, and it was decided to divide the USTER® *CLASSIMAT QUANTUM* and the USTER® *CLASSIMAT 5 STATISTICS* into three different count ranges (where applicable):

Description	Count range
Coarse	• 30.1 – 50 tex (Ne 12 - Ne 20)
Medium	• 15.1 – 30 tex (Ne 20.1 - Ne 40)
Fine	• ≤15 tex (> Ne 40)

Table 2-1

2.4 New Yarn Quality Characteristics

The following new parameters were introduced with the USTER® *STATISTICS 2013*

Instrument	Parameter
USTER® *TESTER 5*	• CV_m 1m: coefficient of variation of the mass for a cut length of 1m • CV_m 3m: coefficient of variation of the mass for a cut length of 3m • CV_m 10m: coefficient of variation of the mass for a cut length of 10m • CV FS: coefficient of variation for the fine structure of the yarn surface
USTER® *ZWEIGLE TWIST TESTER*	• Twist per inch
USTER® *ZWEIGLE HL400*	• S3 value per 100 m (sum of protruding fibers with a length of 3 mm and longer)
USTER® *CLASSIMAT 5*	Classification parameters: • NSLT for the standard classes • NSLT for the extended classes • Foreign matter Dark (FD) • Vegetable matter (VEG) Outliers statistics: • NSLT, FD, VEG, PP • Sum of affected share of CV_m, IP, H • Yarn body • Dense areas for FD and VEG

Table 2-2

2.5 New Yarn Measuring equipment

The results of the following instruments are included in the USTER® *STATISTICS 2013*:

- USTER® *ZWEIGLE HL400*
  This instrument was introduced in the market by Uster Technologies in 2010. It was developed to classify the protruding fibers of staple yarns into classes according to their length. The yarns that were received for the USTER® *STATISTICS 2013* were also measured on the USTER® *ZWEIGLE HL400* after the market launch of this instrument. This parameter is shown for the main yarn types for the time being due to the relatively short time period since 2010, but will be extended for all yarn types in the future.

- USTER® *CLASSIMAT 5*
  The USTER® *CLASSIMAT* has been providing results for the classification of the seldom-occurring yarn faults for many decades. New features have been added since 2003, when the USTER® *CLASSIMAT QUANTUM* was developed, and the USTER® *CLASSIMAT 5*, a new classification instrument, was introduced in the market in 2012. Provisional statistics for this instrument have been integrated into this first version of the USTER® *STATISTICS 2013* to give customers benchmarks right from the first hour of operation of the USTER® *CLASSIMAT 5*.

2.6 New Yarn Processing Chapter

This chapter serves as a guideline for evaluating possible changes of certain quality parameters from bobbins to cones. All the six quality parameters selected are shown one page in order to make the graphs as user-friendly as possible. We have focussed on the most important quality parameters that are measured in the laboratory. CV_m, Thin-40%, Thick+35%, Neps+200%, H and Tenacity. Although we are aware that the standard settings for thin places is -50%, we decided to calculate the deviation for thin places of -40% instead. This is due to mathematical reasons, as the number of thin places is often very small. Therefore, calculating the percentage difference of small numbers is not very helpful for the spinner, e.g. an increase from 2 to 4 thin places per 1000m. The percentage deviation is 100%, although the absolute difference is statistically insignificant.

Deviations are calculated based on the results of bobbins, which are considered as reference. The resulting value is given in percentage. The following two examples are given in order to make the calculation clearer:

1. Nep count in bobbins: 100 / 1000m ➔ nep count in cones: 120 / 1000m
   ➔ Resulting deviation is +20%

2. Tenacity in bobbins: 18 cN/tex ➔ Tenacity in cones: 17.5 cN/tex
   ➔ Resulting deviation is: - 2.7%

2.7 New Raw Material for Roving

The following raw materials are new for the roving chapter:

- 100% CO, compact, combed
- 100% PES, ring
- 100% CV, ring
- 65/35% PES/CO, ring

2.8 New Raw Materials and Yarn Types

We were able to add the following new chapters and raw materials to the USTER® *STATISTICS 2013* to provide the textile industry with a wider variety of raw materials and yarn types.

2.8.1 New spinning process for the Fiber Processing chapter

A new chapter has been introduced to the current version of the USTER® *STATISTICS* in addition to the existing fiber processing graphs for combed and carded ring-spun yarn as well as the OE-rotor-spun processing graphs. The fiber processing parameters for the compact spinning process are described in this chapter.

2.8.2 New yarn types

- Two-plied yarns made out of 100% cotton, ring-spun, carded as well as combed. Please note that the yarn count given in the x-axis is the resulting count of the two individual yarn counts.
- Core yarns made out of cotton and elastomer for bobbins and cones (confirmation of the provisional USTER® *STATISTICS 2007*).
- Airjet yarns for:
  - 50/50%, 65/35% PES/CO
  - 100% CO
  - 100% PES

2.8.3 New raw materials and yarn blends

- Linen yarns made of chemically treated yarns, i.e. boiled or bleached (as introduced in the USTER® *STATISTICS 2007* version 4)
- New blends:
  - 50/50%, 60/40%, 70/30%, CO/CV, ring, combed, bobbins & cones
  - 50/50% PES/CO, ring, combed, bobbins & cones
  - 40/60%, 45/55% PES/CO, ring, combed, bobbins & cones
  - 40/60%, 45/55% PES/CO, ring, carded, bobbins

3 Testing conditions and sample size

All tests in relation to the USTER® *STATISTICS 2013* were carried out under constant climatic conditions in the laboratories of Uster Technologies in Uster, Switzerland as well as in Suzhou, China. The temperature was according to ISO 139 20 °C ± 2°C and the relative humidity 65% ± 4%. The following table lists the testing conditions and the sample sizes.

The calibration cotton used for the HVI® calibration is according to USDA HVI-CC.

Fiber testing

Parameter	Abbreviation	Unit	Instrument	No of samples	Test within
Micronaire	Mic	---	USTER® *HVI*	1	10
Upper Half Mean Length	UHML	mm	USTER® *HVI*	1	10
Uniformity Index	UI	%	USTER® *HVI*	1	10
Short Fiber Index	SF	%	USTER® *HVI*	1	10
Bundle tenacity	Str	gf/tex	USTER® *HVI*	1	10
Color	Rd	%	USTER® *HVI*	1	10
	+b	---		1	10
Trash	Tr Cnt	---	USTER® *HVI*	1	10
	Tr Area	%		1	10
Spinning Consistency Index	SCI	---	USTER® *HVI*	1	10
Neps Count	Total Neps	1/g	USTER® *AFIS*	1	10
	SCN	1/g		1	10
Length	SFC(n)	%	USTER® *AFIS*	1	10
	SFC(w)	%		1	10
	UQL(w)	mm		1	10
Maturity	Fine	mtex	USTER® *AFIS*	1	10
	IFC	%		1	10
	Mat	---		1	10
Trash	Total Trash	1/g	USTER® *AFIS*	1	10
	Dust	1/g		1	10
	V.F.M.	%		1	10

Table 3-1

Yarn testing

Parameter	Abbreviation	Unit	Instrument	No of samples	Test within
Count variations	CV_{cb}	%	USTER® *TESTER 4/5* FA Sensor	10	1
Mass variations	CV_m CV_{mb} $CV_{m\,1m}$ $CV_{m\,3m}$ $CV_{m\,10m}$	% % % % %	USTER® *TESTER 4/5* CS Sensor	10 10 Testing speed: Duration of test:	1 1 400 m/min 2.5 min
Hairiness	H s_H CV_{HB}	--- --- %	USTER® *TESTER 4/5* OH Sensor	10 10 10 Testing speed: Duration of test:	1 1 1 400 m/min 2.5 min
Imperfections	Thin places Thick places Neps	1/1000 m 1/1000 m 1/1000 m	USTER® *TESTER 4/5* CS Sensor	10 10 10 Testing speed: Duration of test:	1 1 1 400 m/min 2.5 min
Trash	Dust Trash	1/1000 m 1/1000 m	USTER® *TESTER 4/5* OI Sensor	10 10 Testing speed: Duration of test:	1 1 400 m/min 2.5 min
Diameter variation	CV_d Shape Density CV FS	% --- g/cm^3 %	USTER® *TESTER 4/5* OM Sensor	10 10 10 Testing speed: Duration of test:	1 1 1 400 m/min 2.5 min
Tensile properties	F_H R_H CV_{RH} ε_H $CV\varepsilon_H$ W_H CV_{WH}	cN cN/tex % % % cNcm %	USTER® *TENSORAPID*	10 10 10 10 10 10 10 Testing speed:	20 20 20 20 20 20 20 5 m/min
HV tensile properties	F_H R_H CV_{RH} ε_H $CV\varepsilon_H$ W_H CV_{WH}	cN cN/tex % % % cNcm %	USTER® *TENSOJET*	10 10 10 10 10 10 10 Testing speed:	1000 1000 1000 1000 1000 1000 1000 400 m/min
Hairiness length classification	S3	1/100m	USTER® *ZWEIGLE HL400*	10 Testing speed: Duration of test:	1 400 m/min 1min
Twist	T/m or TPI CV T	1/m or 1/inch %	USTER® *ZWEIGLE TWIST TESTER*	10 Testing method 1	10

Parameter	Abbreviation	Unit	Instrument	No of samples	Test within
Yarn classification	NSLT FD	1/100 km 1/100 km	USTER® *CLASSIMAT QUANTUM*	Testing length: 100 km (ring spun) Testing length: 300 km (OE-rotor)	
Yarn classification	NSLT FD VEG PP Outliers	1/100 km 1/100 km	USTER® *CLASSIMAT 5*	Testing length: 200km (ring spun) Testing length: 200 km (OE-rotor)	

Table 3-2

Testing of rovings

Parameter	Abbreviation	Unit	Instrument	No of samples	Test within
Count variations	CV_{cb}	%	USTER® *TESTER 5* FA Sensor	10 Length 10 m	1
Mass variations	CV_m $CV_{m\ 1m}$ $CV_{m\ 3m}$	% % %	USTER® *TESTER 5* CS Sensor	10 10 10 Testing speed: Duration of test:	1 1 1 50 m/min 5 min

Table 3-3

Testing of slivers

Parameter	Abbreviation	Unit	Instrument	Reference length
Mass variation	CV_m $CV_{m\ 1m}$ $CV_{m\ 3m}$ $CV_{m\ 10m}$	% % % %	USTER® *SLIVERGUARD*	100 m 100 m 100 m 100 m

Table 3-4

Ambient Laboratory Conditions for Fiber and Yarn Testing

Some textile fibers are highly hygroscopic and their properties change notably as a function of the moisture content. Typical hygroscopic fibers are cotton, wool, rayon, silk, flax, etc. Moisture content is particularly critical in the case of dynamometric properties, i.e. yarn tenacity, elongation, and work-to-break, but yarn evenness, imperfections, and defect levels are also affected. As a result, conditioning and testing must be carried out under constant standard atmospheric conditions. The standard temperate atmosphere for textile testing according to ISO 139 involves a temperature of 20±2°C (68±4°F) and 65±4% relative humidity. The standard alternative atmospheres according to ISO 139 shall have a temperature of 23±2°C (73.4±4°F) of and a relative humidity of of 50±4%). The alternative atmosphere may be used only if the parties involved agree on its use. Prior to testing, the samples must be conditioned under constant standard atmospheric conditions until in moisture equilibrium with the surrounding air. To attain the moisture equilibrium, a conditioning time of at least 24 hours is required, 48 hours is preferred. For samples with a high moisture content (thermally conditioned yarns), conditioning time should be at least 48 hours.

The best practice is to precondition such samples in a dry atmosphere, so that the moisture equilibrium is later approached from the dry side. During conditioning, the samples must be removed from any boxes or containers used for transportation, cleared from all packing material, placed in an upright position to expose the entire bobbin or package surface to the conditioned air, and arranged in such a fashion that ample space is left between the samples to allow conditioned air to circulate freely. Laboratory conditions should be monitored by appropriate devices that record both short-term fluctuation and long-term drift.

Applicable standards for the 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, Standard atmosphere for conditioning and testing DIN 53 802.

4 Quality Characteristics of the USTER® *STATISTICS 2013*

The following paragraphs provide useful background information on the different measurements introduced in the USTER® *STATISTICS 2013*. It is not our intention to give detailed explanations of the instruments, measurement methods, or the technological significance of each measurement. Many instrument users are well familiar with these aspects to begin with and specialized literature which focuses on these topics is readily available. This Application Handbook primarily serves to clarify certain questions that may arise when studying the USTER® *STATISTICS* and it gives valuable, practical hints as to the origin, interpretation, and use of certain data. Needless to say that if you have any specific needs, please do not hesitate to contact us or your nearest Uster Technologies representative office.

4.1 Fiber Testing

The USTER® *STATISTICS* on raw cotton fiber properties have been established with USTER® *HVI* and USTER® *AFIS* instruments. The corresponding graphs have been developed from a representative selection of about 3000 different international cottons. All percentile curves are plotted over staple length. Staple length is the fundamental characteristic of cotton as a textile fiber. In the USTER® *STATISTICS* graphs, HVI® and AFIS® parameters or the percentiles indicating a certain share of the world cotton production can be determined for a given staple length. Staple length is usually specified in the contract as classer's or trade staple. Upper half mean length (UHML) describes the equivalent staple length of cottons classified by HVI®. An alternative is to use the 25% staple length by weight (UQL(w)) measured with AFIS®. This measurement also correlates to the classer's staple.

Please note that the data in the USTER® *STATISTICS* cover several crop years. The average fiber quality of cottons from a certain growing region changes from one year to another as a result of the prevalent environmental conditions during the growing season. With the consideration of more than one crop year, however, these differences are leveled out.

4.1.1 Bundle fiber measurement with 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) as well as the Chinese Fiber Inspection Bureau (CFIB). 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.

Length & Strength

Characteristics	Abbreviation	Unit	Description
Upper Half Mean Length	UHML	mm	Upper half mean length = mean length by weight of the longer 50% of fibers
Uniformity Index	UI	%	Uniformity Index = length uniformity of the fibers. $\frac{ML \cdot 100}{UHML} = \text{Uniformity Index}$ Classification of the length uniformity: Uniformity Index very low: below 76 low: 77 – 79 average: 80 – 82 high: 83 – 85 very high: above 86
Strength	Str	gf/tex	Breaking force of the fiber bundle divided by fiber fineness Assessment of the fiber strength (without long staple): below 21 = very low 22 to 24 = low 25 to 27 = average 28 to 30 = high over 30 = very high
Elongation	Elg	%	Breaking elongation of the fiber bundle
Short Fiber Index	SF	%	Short fiber index = percentage of fibers shorter than ½ inch or 12.7 mm
Spinning Consistency Index	SCI		Spinning consistency index. A coefficient is calculated by means of various quality characteristics by a multiple regression analysis. The SCI used is calculated with the original formula provided by USTER. 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.

Table 4-1

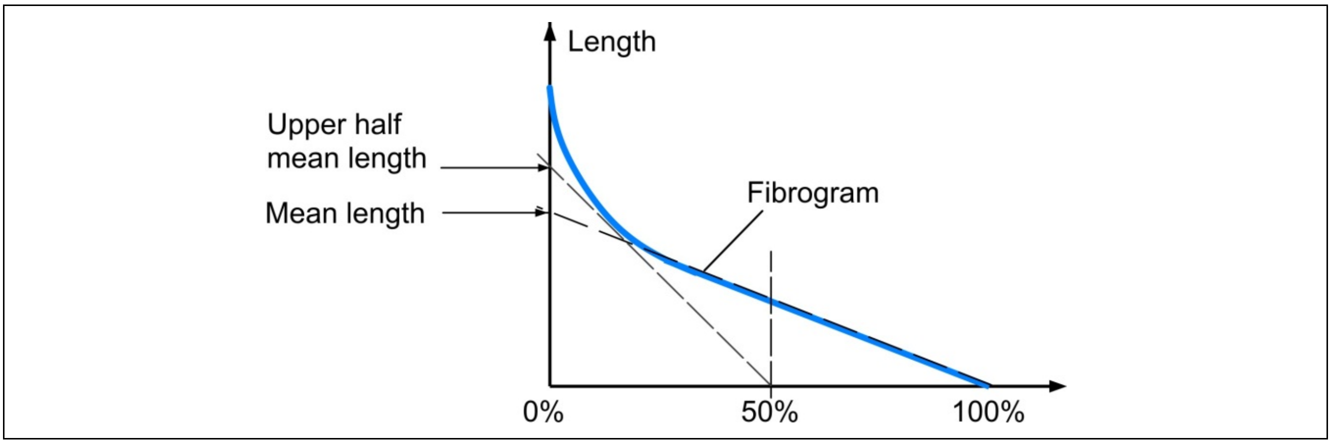


Fig. 4-1 USDA-mode / Fibrogram

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

Micronaire

Characteristics	Abbreviation	Unit	Description
Micronaire	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

Table 4-2

Color & Trash

Characteristics	Abbreviation	Unit	Description
Reflectance	Rd	%	Reflectance of the fibers, higher Rd values mean a higher color grade
Yellowness	+b		Yellowness of the fibers (Nickerson/Hunter scale)
Trash Area	Tr Area	%	Area of the sample covered with trash particles
Trash Cnt	Tr Cnt		Number of trash particles

Table 4-3

Applicable standards for 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

4.1.2 Single fiber measurement with 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.

Neps

Characteristics	Abbreviation	Unit	Description
Total Nep	Nep	1/g	Number of neps per gram
SCN	SCN	1/g	Number of seed-coat neps per gram

Table 4-4

Length & Maturity

Characteristics	Abbreviation	Unit	Description
Short Fiber Content	SFC (n,w)	%	Short fiber content by number or by weight, percentage of fibers shorter than ½ inch or 12.7 mm
Upper Quartile Length by weight	UQL (w)	mm	Upper quartile length = length exceeded by 25% of the fibers
Fineness	Fine	mtex	Fiber fineness (linear density)
Immature Fiber Content	IFC	%	Immature fiber content = percentage of immature fibers
Maturity Ratio	Mat Ratio		Maturity ratio

Table 4-5

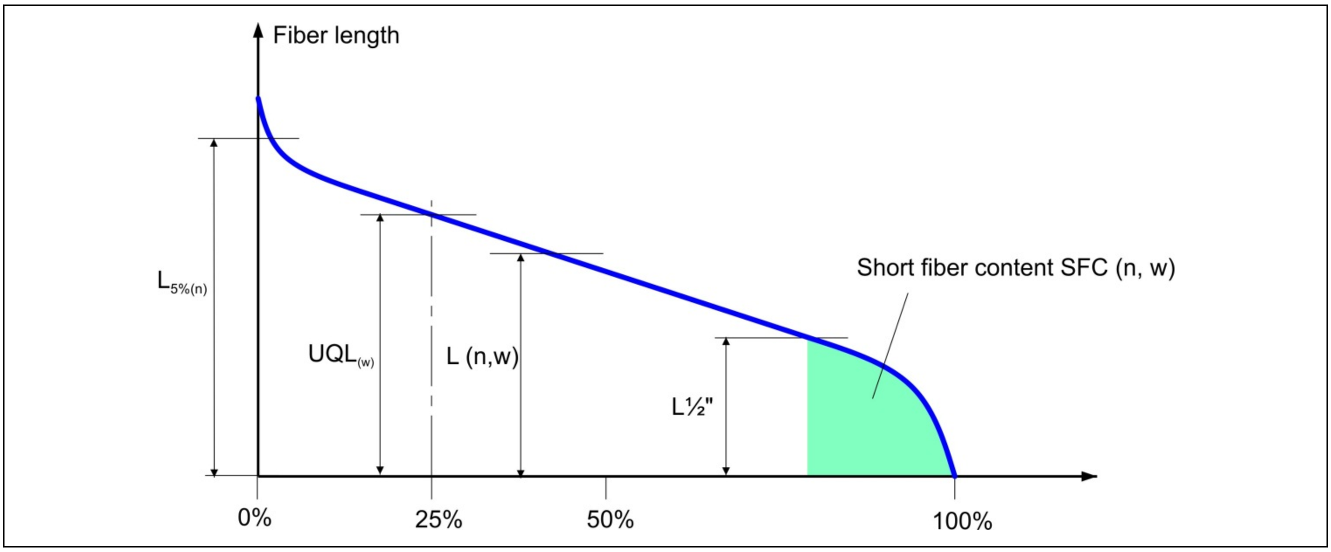


Fig. 4-2 Fiber staple diagram

Trash

Characteristics	Abbreviation	Unit	Description
Total Trash	Total Trash	1/g	Total number of particles per gram
Dust	Dust	1/g	Dust particles per gram (<500 μm)
V.F.M.	V.F.M.	%	Visible foreign matter

Table 4-6

Applicable standards for USTER® *AFIS*

ASTM D-5866 AFIS® nep testing

4.2 Fiber Processing

In yarn manufacturing of cotton and cotton-based blends, the AFIS® length, nep, and trash modules have been successfully employed to determine raw material properties, to monitor and optimize production machinery, and to replace static, periodic overhaul schedules by flexible, targeted maintenance. The performance of the opening and cleaning line, of cards, and combers can be substantially enhanced by analyzing the input/output relationship of fiber length and short fiber content, neps, and trash. This is accomplished by a modification of the corresponding machine configurations, settings, and speeds. Statistical process control techniques provide an opportunity for the proper timing of maintenance interventions when the parameters monitored by the AFIS® exceed the established control limits. The effects of these measures include a substantial improvement of the yarn and fabric quality and a concurrent reduction of operating cost and waste. By identifying and selecting the most suitable cottons for the processing into yarns with the desired quality levels, further savings in the field of raw materials can be generated.

The cotton fiber processing section of the USTER® *STATISTICS* represents a statistical analysis of in-process AFIS® measurements which have been performed on a large number of samples drawn at important intermediate processing stages: Bale, card mat, card sliver, comber sliver, finisher drawing, and roving.

The following is of utmost importance when making a comparison between the results obtained in actual mill processing and the USTER® *STATISTICS*: The percentile curves in the fiber processing graphs connect independent data points. Each data point represents one of the five percentiles (5th, 25th, 50th, 75th, and 95th percentile) which have been calculated from all samples from the same processing stage. Therefore, the 50% curve, for instance, does not represent the typical behavior of an average spinning process; rather, it indicates the theoretical process curve that would be obtained if the parameters measured at each processing stage would always correspond to the 50th percentile. In practice, we will rarely encounter a spinning process that will exactly track one of the percentile curves. In addition, the confidence intervals must be taken into consideration. An example relating to AFIS® neps for a combed ring-spun yarn: A mill processes a raw material with an average of 225±Δx neps/g. This would correspond to the 50th percentile. After opening and cleaning, we find 300±Δx neps/g in the card mat, which represents a point between the 25th and 50th percentile curve. Carding removes 75% of the neps and leaves 70±Δx neps/g in the card sliver. Again, this nep count is positioned in close vicinity to the 50th percentile curve. Our mill ends up with 23±Δx neps/g in the combed sliver and is back on the 50% curve. The USTER® *STATISTICS* on through-the-mill nep levels can also be used in conjunction with a USTER® *MN 100* stand-alone nep tester.
When making an assessment of the manufacturing process, it is equally important to consider the overriding influence of the raw material. Machine performance is not independent of the raw material. Experience proves that in the majority of all cases, poor processing results are to some extent related to the fibrous material processed. Textile machines are meticulously engineered products. If they are well maintained, operated at moderate speeds and with appropriate settings, they will deliver excellent quality provided sufficient know-how has also been put into the selection of adequate raw materials. The effect of raw materials is also indirectly represented in the USTER® *STATISTICS* graphs on fiber processing. It is a well-known fact, for example, that some cottons or cotton mixes are more prone to nep formation in opening and cleaning than others. The tendency towards nep formation is particularly critical with very fine or immature fibers, i.e. fibers with lower bending rigidity. Likewise, there are cottons which have a tendency to more strongly resist nep removal in carding. Less mature cottons will also suffer more pronounced fiber damage during mechanical processing and exhibit a higher short fiber content. The absolute breaking strength of such fibers is much lower due to the lack of cellulose in the fiber cell wall. The actual reduction of the short fiber content in combing is clearly dependent on the percentage of short fibers present in the raw material and thus in the lap prior to combing.

Furthermore, trash removal efficiency in mill processing is not only a function of the absolute amount of trash in the raw material but also of the general cleanability of a cotton mix, which is related to both the fiber properties and the post-harvest processing history of the cottons. These factors should be thoroughly investigated before making adjustments in the process or at individual machines.

Proper calibration of the instrument is a necessary prerequisite to make correct comparisons between the actual AFIS® measurements and the USTER® *STATISTICS* on fiber processing. The calibration of an AFIS® should be left to authorized Uster Technologies service personnel. We recommend that reference samples, e.g. round test samples, be used to monitor the consistency of the measurements and to contact the nearest Uster Technologies service station if unexpected changes or long-term drift should occur. The ICA Bremen, Germany, conducts USTER® *AFIS* & USTER® *HVI* round tests on an international basis. CSITC is also conducting international round tests for USTER® *HVI* instruments. Participation in such programs is highly recommended for closely monitoring the performance of the instrument, i.e. the consistency of the measurements and the compatibility with other laboratories. This, of course, includes compatibility with the USTER® *STATISTICS* as well.

Nep testing with the USTER® *AFIS* system is a standardized procedure and is described in detail in ASTM D-5866. Further explanations of the individual functional elements of the system, the significance of the measurements, and the proper calibration and operation of the instrument are given in the operating instructions. Adequate sample conditioning and maintaining constant standard atmospheric conditions in the laboratory during testing is important.

4.3 Sliver Testing

The USTER® *STATISTICS* for slivers are based on measurements determined on-line. The data shown in the USTER® *STATISTICS 2013* were completed in 2008.
The sliver measurement data provided in these USTER® *STATISTICS* have been determined with USTER® *SLIVERGUARD*, which is comparable to the USTER® *TESTER* with regard to measuring accuracy. The quick response USTER® *FP-SENSOR* permits sliver measurements that are equivalent to those carried out offline with the USTER® *TESTER* in the laboratory. In practice, and provided the above-mentioned sliver delivery aspects are kept in mind, the results of the USTER® *SLIVERGUARD* can therefore be compared with the measurements of the USTER® *TESTER*. The USTER® *STATISTICS* on sliver mass variation include graphs on the coefficient of variation of sliver mass (CV_m, CV_m (1m), CV_m (3m), CV_m (10m)).

Proper maintenance of the USTER® *SLIVERGUARD* is a necessary prerequisite to make correct comparisons between the actual measurements and the USTER® *STATISTICS* on sliver mass variation. If the customer is in possession of the "USTER® *FP-MT* test set", he can carry out the calibration of the USTER® *SLIVERGUARD* himself. Otherwise, it should be left to authorized Uster Technologies service personnel. Further explanations of the individual functional elements of USTER® online systems for the measurement of sliver mass variation, the significance of the measurements, and the proper calibration and operation of the systems are given in the respective operation instructions and Application Handbooks.

Characteristics	Abbreviation	Unit	Description
Coefficient of variation of mass	CV_m	%	Coefficient of variation of the yarn mass (Fig. 4-4)
Coefficient of variation of mass at different cut lengths	CV_m (L)	%	Coefficient of variation of the yarn mass at cut lengths of 1 m, 3 m, 10 m

Table 4-7

4.4 Roving Testing

Mass variation of the roving has a decisive influence on the yarn quality later on. Therefore, it is important to monitor the evenness of the roving regularly. The capacitive measuring system of the USTER® *TESTER* permits fast and reproducible measurements. Based on spectrograms and diagrams, it is easy to eliminate the sources of defects in the same or previous processes.

Characteristics	Abbreviation	Unit	Description
Coefficient of variation of mass	CV_m	%	Coefficient of variation of the yarn mass (Fig. 4-4)
Coefficient of variation of mass at different cut lengths	CV_m (L)	%	Coefficient of variation of the yarn mass at cut lengths of 1 m, 3 m , 10 m

Table 4-8

4.5 Yarn Testing

Practical experience has proven time and time again that winding alters the yarn surface structure. The impact on yarn evenness (CV_m) is very limited but changes in imperfection counts (thin places, thick places, and neps), hairiness (H), and standard deviation of hairiness (s_H) are much more pronounced. Under normal circumstances, the tensile properties, i.e. tenacity, elongation, and work-to-break are not affected unless yarns are subjected to excessive winding tension or winding speeds, which is very rarely the case and certainly not a prudent practice. A clear statement must be made concerning the role of the winding machine: Changes in the yarn surface structure due to winding cannot be avoided. Nobody would honestly expect a yarn to become better after it has been accelerated from zero to 1500 m/min or more in a few milliseconds while being pulled off the bobbin, dragged across several deflection bars and eyelets, forced into a traverse motion at speeds that make it invisible, and finally rolled up into a firm construction called package or cone. The factors that affect the yarn structure during winding include the frictional properties of the yarn itself, the friction of the drum, the bobbin geometry and the bobbin unwinding behavior, winding speed, winding geometry as well as the number and design of the yarn/machine contact points. However, much as the bobbin unwinding behavior today is the limiting factor for winding speed, it is also the main reason for these changes in yarn structure. Most of the damage occurs at the moment when the end is detached and removed from the tight assembly of yarn layers on the bobbin and dragged along the tube at very high speeds.

When testing 100% cotton yarns in cone form for evenness, imperfections, and hairiness with the USTER® *TESTER*, some very fine and delicate yarns will again respond with marginal structural changes. This is not a result of mechanical stress like in winding but a natural reaction caused by the reversal of the yarn running direction. Directional influences are omnipresent; they become apparent in all subsequent processing stages. The evidence of changes in the yarn surface structure due to the winding process or as a result of reversing the yarn running direction is confined to a few very delicate 100% man-made fiber yarns, core yarns, and 100% cotton yarns finer than Ne 60 (Nm 100, 10 tex). We recommend, however, that the USTER® *STATISTICS* on 100% carded and combed cotton ring-spun yarns on cross-wound packages be referred to whenever mass variation, hairiness, and imperfections of cotton yarns in cones form are of interest.

Since the tensile properties are not affected by the phenomena described above, the USTER® *STATISTICS* on ring-spun bobbins could be used for packages as well. The STATISTICS on count variation and the between-sample coefficients of variation of evenness and hairiness are only useful when testing bobbins.

Testing packages of ring-spun yarns always involves the risk of catching the top end of one bobbin and the bottom end of another (plus the splice in between), which may distort the measurements.
Incorrect comparisons with the USTER® *STATISTICS* may also result from testing actively conditioned yarns. Active thermal conditioning is performed at the very end of the manufacturing process to suppress the twist liveliness or the yarn torque. This is normally accomplished by treating bobbins or packages with high-temperature water vapor in a conditioning chamber or in a vacuum environment with low-temperature saturated steam in the gaseous phase. In any case, the moisture regain of the fibers may alter their physical properties and affect capacitive yarn testing. In addition, the moisture is not always homogeneously distributed within a thermally conditioned bobbin or package. Therefore, changes in tenacity, elongation, and work-to-break as well as evenness, imperfections, and defect levels must be expected. The bobbin and package samples tested within the framework of the USTER® *STATISTICS* have been cleared of all packing material upon receipt, preconditioned in a dry atmosphere for several days or weeks, and conditioned to moisture equilibrium under constant standard atmospheric conditions. By doing so, any adverse effects on testing caused by thermal conditioning are completely eliminated.

It is a true fact of life that nobody can spin a world-class yarn from coarse wool or short and weak cotton fibers even if the latest and best machinery is employed. The quality status achieved by a spinner always represents the compound effect of the skills of the work force and the management, the performance of the machines, the quality of the raw material, and the know-how in processing technology.

4.5.1 Yarn testing with the 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 addition, the hairiness measurement is very 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).

Mass variations

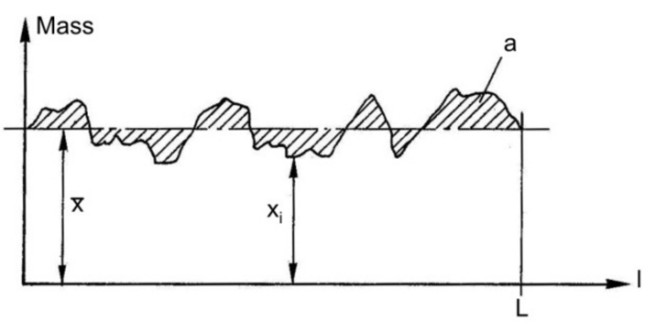


Fig. 4-3 Mass variations / Irregularity U

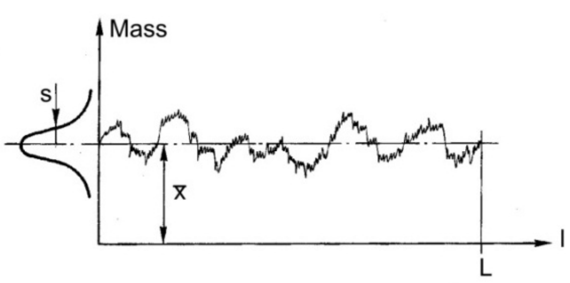


Fig. 4-4 Mass variations / Coefficient of variation CV

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

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

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

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

Characteristics	Abbreviation	Unit	Description
Coefficient of variation of mass	CV_m	%	Coefficient of variation of the yarn mass (Fig. 4-4)
Coefficient of variation of mass at different cut lengths	CV_m (L)	%	Coefficient of variation of the yarn mass at cut lengths of 1 m, 3 m, 10 m
Imperfections	IP	1/1000m	Number of thin places, thick places and neps at selected sensitivity settings Thin places: -40% , -50% Thick places: +35% , +50% Neps: +140% , +200% , +280%
Absolute Count	Cnt	Ne, Nm, tex	Linear density of the yarn unit length (yarn count)
Count variation	CVcb	%	Coefficient of variation of the linear density of the yarn

Table 4-9

Hairiness

The receiver detects only the light transmitted by the protruding fibers (Fig. 4-5). 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.

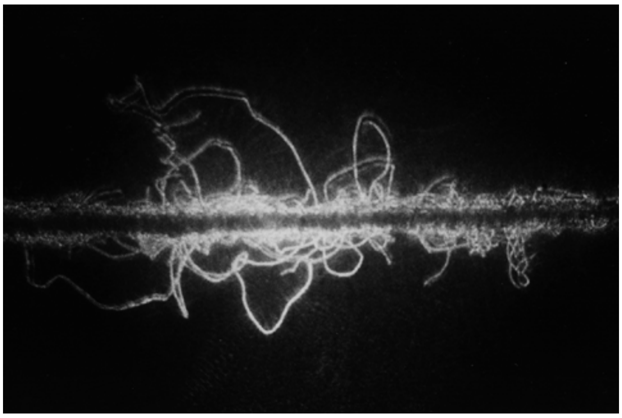


Fig. 4-5

Characteristics	Abbreviation	Unit	Description
Hairiness	H		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.
Standard deviation of hairiness	sH		Standard deviation of hairiness
Coefficient of variation of hairiness	CV Hb	%	Coefficient of variation of the yarn hairiness

Table 4-10

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°.

Characteristics	Abbreviation	Unit	Description
CV2D0.3mm	CV2D0.3mm	%	Coefficient of variation of the diameter over the reference length of 0.3 mm
CV Fine Structure	CV FS	%	Coefficient of variation of the fine structure, assessment of short term variations
Shape	Shape		Non-dimensional value between 0 and 1, which describes the roundness of a yarn (1 = circular, 0.5 = elliptical)
Density	D	g/cm^3	Mean yarn density related to the nominal count

Table 4-11

Dust and trash

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

Characteristics	Abbreviation	Unit	Description
Trash count	Trash count	1/1000m	Trash particles per km or yard > 500 µm
Dust count	Dust count	1/1000m	Dust particles per km or yard > 100 - 500 µm

Table 4-12

Applicable standards for USTER® *TESTER*

ISO 2060, DIN 53 830 Determination of yarn count
ISO 2649, DIN 53 817, Determination of yarn evenness
ASTM 1423

4.5.2 Hairiness length classification with USTER® *ZWEIGLE HL400*

Besides the traditional yarn parameters like evenness, imperfections, strength and elongation, the hairiness plays also an important role in the evaluation of a yarn. The hairiness influences the performance of subsequent processes like weaving, knitting or dyeing as well as the appearance and end use of the final fabric or garment. The factors influencing hairiness can be sub-divided into 3 major groups:

- Fiber properties
- Yarn parameters
- Process parameters

The hairiness length classification gives detailed hairiness information for various applications in the spinning process and also its subsequent processes. This information is especially interesting for:

- Compact spinning
- Machine maintenance
- Knitting
- Weaving

Characteristics	Abbreviation	Unit	Description
S3 value	S3	1/100m	The S3 value is the sum of all fiber classes 3 mm and longer (cumulative). This value describes the long protruding fibers of a yarn.

Table 4-13

4.5.3 Strength and elongation of yarns with USTER® *TENSORAPID* and USTER® *TENSOJET*

Conventional strength and elongation with 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 principle 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 test up to 40 samples automatically.

Characteristics	Abbreviation	Unit	Description
B-Force	B-Force	cN	Breaking force = maximum tensile force measured (Fig. 4-6)
Tenacity	Tenacity	cN/tex	Breaking force divided by the linear density of the specimen
CV Tenacity	CV_{RH}	%	Coefficient of variation of the tenacity
Elongation	Elong.	%	Breaking elongation = elongation at maximum force (Fig. 4-6)
CV Elongation	$CV_{\varepsilon H}$	%	Coefficient of variation of the elongation
B-Work	B-Work	cNcm	Work to break = work at maximum force (area below the force/elongation curve drawn to the point of maximum force, (Fig. 4-6)
CV Work	CV_W	%	Coefficient of variation of the work

Table 4-14

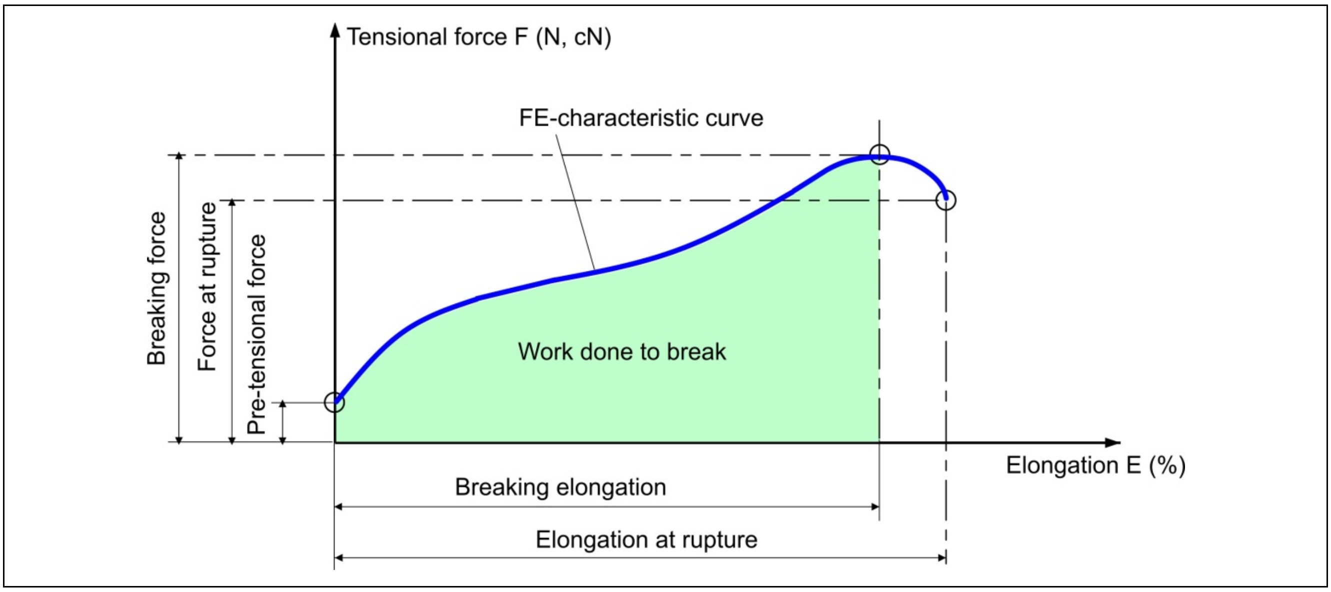


Fig. 4-6 Force-Elongation Curve

Applicable standards for USTER® *TENSORAPID*

ISO 2062, DIN 53 834, ASTM D-1578, JIS — Single-end tensile testing

Ultra-high speed strength tests with USTER® *TENSOJET*

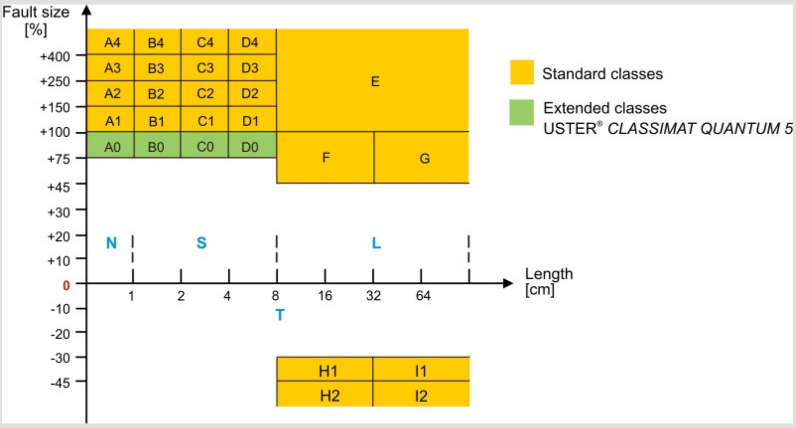
The USTER® *TENSOJET* is the first tensile testing instrument which is capable of measuring at speeds of 400 m/min. In one hour, the testing unit can carry out up to 30,000 tensile tests. The mechanism to load, elongate and finally break the test sample consists of two pairs of counter-rotating rollers, 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	Abbreviation	Unit	Description
B-Force	B-Force	cN	Breaking force = maximum tensile force measured (Fig. 4-6)
Tenacity	Tenacity	cN/tex	Breaking force divided by the linear density of the specimen
CV Tenacity	CV_{RH}	%	Coefficient of variation of the tenacity
Elongation	Elong.	%	Breaking elongation = elongation at maximum force (Fig. 4-6)
CV Elongation	$CV_{\varepsilon H}$	%	Coefficient of variation of the elongation
B-Work	B-Work	cNcm	Work to break = work at maximum force (area below the force/elongation curve drawn to the point of maximum force, (Fig. 4-6)
CV Work	CV_W	%	Coefficient of variation of the work

Table 4-15

4.5.4 Classification of yarn faults with USTER® *CLASSIMAT QUANTUM*

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	
Fault lengths	A: shorter than 1 cm B: 1 to 2 cm C: 2 to 4 cm D: 4 to 8 cm E: longer than 8 cm F+H: 8 to 32 cm G+I: longer than 32 cm

Characteristics	Description		
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%	
	H1/I1:	-30 to -45%	
	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		
		Sensitivity	Reference length
	N channel:	+100% to +500%	0.1 to 1 cm
	S channel:	+50% to +300%	1 to 10 cm
	L channel:	+10% to +200%	1 to 200 cm
	T channel:	-10% to -80%	10 to 200 cm
	C channel:	±5% to ±80%	12.8 m

Table 4-16 Classing matrix of the CLASSIMAT®

4.5.5 Classification of yarn faults with the USTER® *CLASSIMAT 5*

Like its predecessor, the USTER® *CLASSIMAT* 5 detects and analyzes the seldom occurring remaining defects in cones, and state-of-the-art clearing technology was used for the USTER® *CLASSIMAT* 5 in order to achieve this. The USTER® *CLASSIMAT 5* controls the tension and the yarn path, thus guaranteeing high reproducibility of the results.

Some of the new features added to the USTER® *CLASSIMAT* 5 are:

- Yarn body for Thick and Thin places (NSLT)
- Dense area for Foreign Matter (FD and VEG)
- Scatter plot for polypropylene defects (PP)
- Extended classification
- Quality outliers (OL)
- Periodic defects detection and classification (PF)

Structure of the classification matrix for Thick and Thin Places (NSLT)

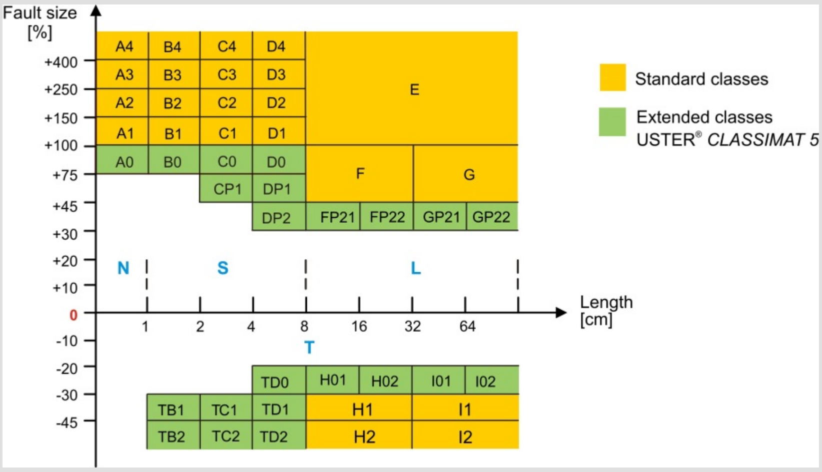
<table>
<tr><th>Characteristics</th><th>Description</th></tr>
<tr><td>Fault classification</td><td>
</td></tr>
<tr><td>Fault lengths</td><td>A: shorter than 1 cm
B+TB: 1 to 2 cm
C+TC: 2 to 4 cm
D+TD: 4 to 8 cm
E: longer than 8 cm
F+H: 8 to 32 cm
G+I: longer than 32 cm</td></tr>
<tr><td>Fault sizes</td><td>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%
DP2/FP21/FP22/GP21/GP22: +30 to +45%
CP1/DP1: +45 to +75%
TB1/TC1/TD1/H1/I1: -30 to -45%
TB2/TC2/TD2/H2/I2: -45 to -75%</td></tr>
<tr><td>Fault channels of the clearers</td><td>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
<table>
<tr><th></th><th>Sensitivity</th><th>Reference length</th></tr>
<tr><td>N channel:</td><td>+100% to +500%</td><td>0.1 to 1 cm</td></tr>
<tr><td>S channel:</td><td>+50% to +300%</td><td>1 to 10 cm</td></tr>
<tr><td>L channel:</td><td>+10% to +200%</td><td>1 to 200 cm</td></tr>
<tr><td>T channel:</td><td>-10% to -80%</td><td>10 to 200 cm</td></tr>
<tr><td>C channel:</td><td>±5% to ±80%</td><td>12.8 m</td></tr>
</table></td></tr>
</table>

Table 4-17 Classing matrix of the USTER® CLASSIMAT 5 for Thin and Thick Places (NSLT)

Structure of the classification matrix for Foreign Matter (FD, VEG)

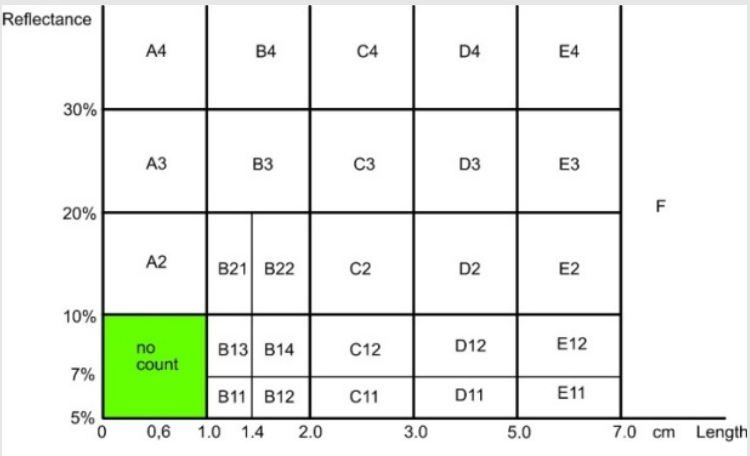
Characteristics	Description	
Definition for USTER® *CLASSIMAT QUANTUM*		
Fault lengths	Definition	Length range
	AA (only for CMT5)	shorter than 0,6 cm
	A (only for CMT5)	shorter than 0.6 to 1 cm (0 to 1 cm for USTER® *CLASSIMAT QUANTUM*)
	B	1 to 2 cm
	B11	1 to 1.4 cm
	B13	1 to 1.4 cm
	B12	1.4 to 2 cm
	B14	1.4 to 2 cm
	B21	1 to 1.4 cm
	B22	1.4 to 2 cm
	C	2 to 3 cm
	D	3 to 5 cm
	E	5 to 7 cm
	F	longer than 7 cm
Fault sizes	Definition	Range of mass increase
	1	+5 to +10%
	11	+5 to +7%
	12	+5 to +7%
	13	+7 to +10%
	14	+7 to +10%
	2	+10 to +20%
	3	+20 to +30%
	4	over +30%
	F	over +5%
Fault channels of the clearers	FD Dark foreign fibers in light yarns VEG Vegetable matter	

Table 4-18 Classing matrix of the USTER® CLASSIMAT 5 and USTER® CLASSIMAT QUANTUM for Foreign Matter (FD, VEG)

Outlier types and their definitions

Outlier Type	Abbreviation	Limits	Description
NSLT Outliers	NSL (100%) T (65%)	NSL outlier limit is set at 100% above the yarn body T Outlier limit is set at -65% of the yarn body.	Outliers for neps, short thick, long thick and thin places (NSLT). The outlier limit depends on the yarn body shape and may differ for various yarn types.
FD Outliers	FD (8%, 2cm)	FD outlier curve passes through the point of intersection at 8%, 2 cm.	Outliers for colored foreign fibers (FD). The FD outlier limit is fixed and applies to all types of yarns.
VEG Outliers	VEG (10%, 2.6 cm)	VEG outlier curve is fixed and applies to all yarn types. The curve passes the point of intersection at 10%, 2.6 cm.	Outliers for vegetable matter (VEG). The VEG outlier limit is fixed and applies to all yarn types.
PP Outliers	PP (65%)	PP Outlier limit is set at 65% of the scatter plot.	Outliers for polypropylene fibers (PP). The outlier limit depends on the scatter plot shape and may differ for various types of yarns.

Quality Outlier Type	Abbreviation	Limits	Description
Yarn evenness	(CV_m) (-16%, +20%)	Mean Value (MV) – 0.16x MV Mean Value (MV) + 0.20x MV	Outliers for yarn evenness. The range is indicative for the CV_m variation of the entire lot and the CV_m values (100 m yarn samples) ranged between these limits.
Imperfection outliers for standard classes: Thick places: +50 / Thin places: -50 / Neps: +200	Imperfection (Standard) (3σ)	Mean value (MV) of the standard imperfection classes ± 3 x standard deviation (s).	Outliers for imperfections (standard classes). The range is indicative for the variation of the standard imperfection classes of the entire lot. An affected share value is shown where at least one of the standard imperfection classes exceeded the -3σ or the +3σ border limits within the distribution.
Imperfection outliers for sensitive classes: Thick places: +35 / Thin places: -40 / Neps: +140	Imperfection (Sensitive) (3σ)	Mean value (MV) of the sensitive imperfection classes ± 3 x standard deviation (s).	Outliers for imperfections (sensitive classes). The range is indicative for the variation of the sensitive imperfection classes of the entire lot. An affected share value is shown where at least one of the sensitive imperfection classes exceeded the -3σ or the +3σ border limits within the distribution.
Hairiness outliers	Hairiness (H) (-1.0, +1.0)	(Mean Value ± 1)	Outliers for hairiness. The range is indicative for the Hairiness variation of the entire lot and the H values (100 m yarn samples) ranged between these limits.
Affected Share	Affected Share (%)		The affected share gives the percentage (%) value of the length of the respective outliers out of the entire sample test length. This value is an indicative of the share of defective yarn in the lot.

Table 4-19

4.5.6 Yarn twist with USTER® *ZWEIGLE TWIST TESTER*

The amount of twist placed in a staple spun yarn is important from a technical viewpoint because of its effect on physical properties and performance, and on finished product appearance. It has an effect on fabric luster, hand, weight and strength. It is also important from a production standpoint because with every turn of twist there is an accompanying reduction in productivity and an increase in cost.

There are two possible twist directions, Z and S. Yarns twisted clockwise have S-twist, yarns twisted counter-clockwise have Z-twist. Most yarns worldwide have Z-twist.

Usually, the twist of a yarn is given in turns per meter or turns per inch, respectively. The amount of twist is determined mostly by the end use, and by the type and length of the fibers used.

The twist of a yarn can be described by the twist per unit length (per meter or per inch), and by the twist multiplier. Another decisive parameter for the twist characteristic of a yarn is the variation of the twist, which should be kept within narrow limits.

Absolute twist

The absolute twist is the amount of twist per meter or twist per inch, respectively. In general, one can say that within certain limits a yarn with a higher twist is stronger than the same yarn with a lower twist. Also, the yarn with the lower twist has a larger diameter.

The conversion of turns per meter into turns per inch can be done according to the following formula:

Turns per inch	=	Turns per meter / 39.37	=	Turns per meter x 0.0254
Turns per meter	=	Turns per inch x 39.37		

Twist multiplier

The most common term used to express a twist level is the twist multiplier as it is independent of the yarn count. It is used for the comparison of certain yarn characteristics of yarns with different counts. A finer yarn, e.g. needs more twist in order to reach the same character as a coarse one.

The following formula shows the calculation for the twist multiplier:

English twist multiplier:	α_e = turns per inch / $\sqrt{Ne}$
Metric twist multiplier:	α_m = turns per meter / $\sqrt{Nm}$

Characteristics	Abbreviation	Unit	Description
Twist	T/m or TPI	1/m or 1/inch	Twist of the yarn per meter or twist of the yarn per inch
Coefficient of variation	CV_T	%	Coefficient of variation of the twist value

Table 4-20

Applicable standards for USTER® *ZWEIGLE TWIST TESTER*

ISO 2061	Determination of twist in yarn – direct counting method
ASTM 1423	Twist in yarns by direct counting

5 Restrictions

This section addresses the restrictions that apply to the use of the USTER® *STATISTICS* and we would like to repeat our advice that this be read carefully and adhered to. Both deliberate and unintentional misuse of the STATISTICS have in some instances in the past resulted in lengthy and costly disputes – all of which could have been avoided if all parties involved would have had the same clear understanding of the concept underlying the STATISTICS. The reading of this section is a must for those who are not familiar with that concept, with the STATISTICS as such, or with the proper interpretation of the data.

5.1 Restrictions Imposed by the Raw Material

Four primary variables have a decisive impact on corporate success in our textile environment as well as in any other industrial venture: man, machine, material, and know-how or information in general. Among these four key elements, the raw material is the crucial component which largely dictates quality but also productivity and cost in yarn manufacturing. By virtue of their design, the USTER® *STATISTICS* for spun yarns do not provide direct access to information about the raw material used for spinning. However, those differences in raw material usage are indirectly reflected in the data. A high-quality yarn can only be spun from high-quality raw materials and since the raw material frequently accounts for more than 50% of the total manufacturing costs in the medium to fine count range, the utilization of high-quality, high-priced raw materials will be proportionally reflected in the yarn price. Any measures taken in the field of raw materials will not only have a considerable impact on quality but also on a mill's competitiveness and bottom-line performance.

In those rare cases where the STATISTICS have been corrupted, the motives have always been related to what evidently is the single most important driving force in the global textile scenario: price. The USTER® *STATISTICS*, however, provide a dependable indication of quality, exclusively. Although quality is a somewhat elusive term, it is nevertheless a result of tangible assets and thus to a certain degree interrelated with the sales price of a product (more details and examples are available in USTER® *NEWS BULLETIN No. 49*).

The USTER® *STATISTICS* should not be interpreted as saying 5% is "good". In contrary, the 5% line might be indicative of high cost, high price, luxuriousness – even a tendency to price oneself out of the market. By the same token, 95% should not imply "poor" – it might be indicative of a very attractive price and just the right quality for the target markets. A "good" spinner is actually one who is in a position to achieve an acceptable quality level from a less expensive fiber – the genuine mastery of spinning. The trouble starts when the USTER® *STATISTICS* are referred to in order to corroborate complaints about a low rating in certain quality categories. This complaint may be directed at the "good" spinner who produces a reasonably priced yarn from a reasonably priced fiber. Yarn price, however, is directly proportional to fiber quality and fiber quality in turn dictates yarn quality to a great extent. Consequently, pushing yarn quality towards better values would simply cannibalize the price advantage. The USTER® *STATISTICS* should be employed as what they really are: a global survey of yarn quality as produced in every part of the world. Whether or not these qualities are produced economically from adequate raw materials and offered at a legitimate price is certainly beyond the scope of the STATISTICS.

5.2 Restrictions Imposed by the Final Product

It lies in the nature of the matter that end uses remain somewhat vague when yarns are marketed via merchants or importers. It is rare for any merchant to have firm orders before entering into a contract. Consequently, the focus is on obtaining qualities that are likely to meet the requirements of any potential customer and which can be successfully marketed in many places and at any given point in time. In the current buyer's market, merchants have a large number of alternative sources to choose from. Yet, to minimize risk, commodity type yarns with high volume of trade are preferred. Under these circumstances, specified and actual quality requirements seem to have very little in common.

5.3 Restrictions Imposed by the Yarn Design

When properly tailored to the anticipated end use, yarns will exhibit inherent strengths and weaknesses: As opposed to weaving yarns, for instance, knitting yarns produced from cotton, man-made fibers, or blends thereof are spun at low twist multipliers. They will rarely display a high breaking tenacity. If they did, they would probably result in stiff, harsh fabrics. A somewhat lower breaking tenacity must also be expected from knitting yarns spun from low-tenacity or pill-resistant man-made fibers which are specifically designed for that purpose. Such low-tenacity fibers, however, usually result in excellent yarn elongation. Knitting yarns also possess a higher hairiness. While this would be detrimental to weaving yarns, the knitted fabric enjoys a greater cover and a softer hand. To make it clear: It is technically impossible and fatal with respect to the end use to demand that a yarn be perfect in all categories, say above the 25% line of the USTER® *STATISTICS*. The proper way out of this dilemma is for the yarn producer and the yarn processor to jointly develop detailed specifications or requirement profiles for specific end uses. Many good examples of this partnership approach have become known and the USTER® *STATISTICS* can be of tremendous help in realizing such projects.

5.4 Missing Correlation between Different Quality Characteristics

Unfortunately, the USTER® *STATISTICS* still mislead some people into thinking in causal relationships that do not exist in reality. Several quality parameters displayed in the STATISTICS are believed to be highly correlated but the fact is that they are not. High breaking tenacity, for instance, is not necessarily linked to high breaking elongation; rather, yarn elongation is determined by spinning speed, spinning geometry, and the resultant specific spinning tension. Likewise, a very even yarn may well have a high nep count. End uses calling for a relative freedom of neps cannot be satisfied by using yarns with a good USTER® CV_m. The opposite is sometimes the case: Few neps in a very uniform yarn tend to visually stick out like a black sheep. Yarns with a little higher CV_m or greater hairiness tend to conceal neps in the overall irregularity, much like the often quoted needle in a haystack. If there is a problem with neppy appearance and no way to reduce nep counts, try to go a little higher with the CV_m.

5.5 Outliers and Frequent Defects in a Spinning Mill

It is a popular illusion that yarns with a high rating according to the USTER® *STATISTICS* are always above and beyond suspicion. A good overall quality does not only encompass excellent mean values but also low variability of the quality attributes as well as unconditional consistency. Only one bad package in the creel of a knitting machine or in warping is bound to ruin several hundred meters of greige fabric. We have come a long way in gaining control over sporadic yarn defects by on-line quality monitoring and over scattered weak places by applying the USTER® *TENSOJET*. Every now and then, however, various off-quality situations tend to recur with malicious persistence in spite of the blind faith often put in the USTER® *STATISTICS* ratings. These include outliers, mix-ups, overlength/underlength or damaged packages, problems with package unwinding behavior, missing transfer tails, improper waxing, shedding and fly, dye streaks (barré), white specks – just to name a few. Quality in a broader sense has many dimensions: A truckload of 5% USTER® *STATISTICS* yarn that arrives too late at the weaver's loading ramp will not be considered a quality product. Timing is vital due to the seasonal characteristic of the textile business with its frequent peak demands and, of course, due to the increasing popularity of just-in-time and quick response production.

5.6 Restrictions in Guarantee Agreements

The issue of performance guarantees negotiated between yarn producers and machinery manufacturers has already been briefly touched upon. Such performance guarantees based on the USTER® *STATISTICS* must be considered a dubious practice when the effect of raw material, machine settings, maintenance, ambient conditions, and operator proficiency is neglected. A legitimate performance guarantee should include references to in-depth technological trials conducted prior to preparing such a document. It should also embrace technically sound prohibitive clauses that serve to preclude misunderstandings – or even worse – litigation between machinery manufacturers and yarn producers. In the majority of all cases, it is not the machine that produces poor quality. If it would not have to process a capricious material like textile fibers, the average textile machine would probably run uninterruptedly for ten, fifteen years or more without any major problems at all. Before making claims against machinery manufacturers, the potential source of the quality problem as well as its true nature and extent should be investigated thoroughly and objectively.

5.7 Reproducibility and Variability of Measurements

Last but not least, a few comments on reproducibility and variability of measurements. No matter what measuring instrument is used – from yardstick to atomic clock – there will always be a certain measurement error. This is also true for textile testing. There are three types of measurement errors: avoidable error, systematic error (bias), and random error. Avoidable error encompasses the failure to choose an appropriate measurement method or to properly operate a measuring instrument. In the textile laboratory, this is of little significance but selecting instrument settings and sample conditioning present a potential source of avoidable error. Systematic error includes calibration error, instrument tolerances, and the fluctuation of ambient conditions. This type of error can be quantified fairly accurately. Random error is the most critical component in textile testing. It is predominantly caused by the variability of the tested material itself. Its magnitude can be approximated by statistical calculations – the confidence interval of the mean. The absolute error of a measurement is the total of all three types of errors. A measurement should therefore always be reported as $x \pm \Delta x$, i.e. the mean value plus/minus the total error to indicate that the true measurement value is located somewhere within that interval.

All USTER® instruments calculate the confidence intervals automatically and they are part of the test report. The confidence interval covers the random error component; information on the systematic error, i.e. instrument tolerances, is provided in our application handbooks.

When comparing actual measurements with the data illustrated in the USTER® *STATISTICS*, it is of utmost importance that the total measurement error is kept to an absolute minimum to warrant compatibility. If this is not the case, false conclusions may be drawn from such a comparison.

There are four things that can be done to minimize the measurement error:

- proper conditioning under constant standard atmospheric conditions
- exact calibration of the instrument
- correct settings of the instrument
- adequate sample size

When actual measurements are then compared with the USTER® *STATISTICS*, they would appear in the graph as a short vertical line – not as a dot. The top and bottom ends of that line represent the upper and lower limits of the confidence interval with the mean exactly in the middle. We cannot eliminate the random error; however, the confidence interval quickly becomes smaller when the sample size is increased. For detailed information on recommended sample sizes and testing conditions, please refer to chapter 3.

In the context of commercial agreements via yarn contracts and product specifications, it frequently transpires that disputes result from discrepancies between measurements performed by the purchaser and by the supplier and from the subsequent comparison of disparate measurements with the USTER® *STATISTICS*. When such incidents are examined more closely, the result often is that the basic conditions listed above have been ignored or have simply not been identical in both testing locations. In other cases, the problem could be quickly resolved by applying the t-test procedure. It proved that the differences were not statistically significant but strictly random due to a pronounced sample variability. The t-test procedure along with further detailed explanations is outlined in our application handbooks. A simplified t-test can be performed by comparing the confidence intervals: If the confidence intervals of two mean overlap, then the observed difference between the two means is random or statistically insignificant; if they are separated, the difference is considered statistically significant. Applying the concept of the confidence interval can be both very helpful and revealing. It pinpoints the highly variable characteristic of textile materials which should always be taken into consideration.

6 Validity

The information provided with this edition supersedes all the descriptions pertaining to textile material quality published in previous editions of the USTER® *STATISTICS*. The quality of industrially manufactured goods is a moving target. It depends on a multitude of factors, most of which are an intrinsic function of time. The dependence on time is predominantly related to the state of technology of the productive assets and the technological know-how prevalent in the industry. Time is also a factor in determining the overall economic environment, the supply and demand situation, as well as general consumer attitudes and behavior. All of the above, acting jointly or separately, may have an effect on the quality of raw materials, semi-processed, or finished textile goods. Consequently, the validity of the information provided in the USTER® *STATISTICS 2013* is confined to the period of time actually covered by the data. The data are essentially of historical nature by the time this document is published. Naturally, such information will not sustain its initial significance as time progresses and eventually become obsolete unless it is updated at some point in the future. Therefore, the information presented in this document in either a verbal, numerical, or graphical form is subject to change at any time without prior or public notice. Conventional wisdom proves, however, that the USTER® *STATISTICS* maintain their significance over an extended period of five years or more.

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