TECHNICAL BULLETIN

COTTON INCORPORATED

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TRI 1012

SELECTED QUALITY CONTROL RECOMMENDATIONS FOR PREPARING MID-RANGE COTTON YARNS

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INTRODUCTION

Effective quality control is a definite prerequisite to cost efficient processing of cotton. This technical bulletin provides an overview of a reasonable quality control program for a medium count, combed yarn mill.

Throughout this report, examples of test results/values and ranges are shown for this typical mill. These values should not be interpreted as standards since our intent is to provide a format to be used as a guideline in establishing an effective yarn mill quality control program. Each mill will likely find the characteristics of their yarn to vary; standards and tolerances, therefore, should be established to suit each particular yarn mill.

RECOMMENDATIONS FOR PHYSICAL TESTING LABORATORY FOR FIBER AND YARN

Equipment

Evenness Tester

Yarn Fault Classification Tester

Winder (6 place)

Single End Yarn Tester

Skein Reel

Roving Reel

Yarn Numbering Processor, multi-scale w/RS232 output

Yarn Appearance Winder, multi-board

Twist Tester

Precision Balance, 10 mg

Digital Fibrograph

Instron Tensile Tester

Fibronaire

Skein Reel

HVI Line (High Volume Instrument Testing)

... PLEASE SEE NEXT PAGE FOR SOURCES ...

LABORATORY EQUIPMENT SOURCES

Evenness Fault Classification Single End Yarn Tester	Zellweger Uster Corporation P.O. Box 51270 456 Troy Circle Knoxville, TN 37950-1270 Telephone: (615) 588-9716 and Lawson Hemphill Sales, Inc. P.O. Drawer 6388 Road 57 at I-85 Spartanburg, SC 29304 Telephone: (803) 579-0644
Winder	T.C.I. Machinery Incorporated 920 N. Highland Street Gastonia, NC 28052 Telephone: (704) 867-8331
Skein Reel Yarn Numbering Processor	Industrial Laboratory Equipment Co., Inc. P.O. Box 220245 Charlotte, NC 28222 Telephone: (704) 847-9160/847-9169
Yarn Numbering Processor Balances	J.A. King & Co. P.O. Box 24225 2620 High Point Road Greensboro, NC 27420 Telephone: (919) 292-0511
Roving Reel Yarn Appearance Winder Precision Twist Tester	Alfred Suter Company Prel Plaza Orangeburg, NY 10962 Telephone: (914) 359-8010
Digital Fibrograph High Volume Instrument Test Line	Zellweger Uster Corporation (see above)
High Volume Instrument Test Line	Peyer Corporation P.O. Box 6446 117-B Belton Drive Spartanburg, SC 29304-6446 Telephone: (803) 574-0310
Instron Tensile Tester	Instron Corporation 100 Royall Street Canton, MA 02021 Telephone: (617) 828-2500

QUALITY CONTROL TESTING PROGRAM

				Typical Testing Results	
Process	**Test**	**Frequency of Testing**	**Sampling Plan**	**Standard**	**Tolerance**
OPENING	Opening Hoppers - Percentage Operating Time	Quarterly	30-Minute Check	85%	±5%
	Cleaning Efficiency	Quarterly	Samples From All Opening/Cleaning Machinery Prior To Carding	35%	±3%
PICKING	Lap Yd/Yd Weight CV	All Pickers Weekly	Sample Lap From Each Picker	1.0 CV	1.0-1.2
	Total Lap Weight	Weekly	Weigh 5-10 Laps Previously Weighed On Each Shift	70 lbs.	±0.5 lbs.
CARDING (Revolving Flat Top Cards)	Sliver Weight Grains/Yd	All Cards Daily	One 100 Yd. Length	72 gr.	±2.0 gr.
	Grains/Yd Weight CV	Weekly	Calculate From Daily Card Weights	2.0 CV	2.0-3.0
	Sliver Uster CV/Periodic Defects	All Cards Weekly	Test 2.5 min. @ 25 ypm	3.5 CV	3.5-5.0
	Nep Count	All Cards Weekly	Three Web Samples/Card	**Neps Per 100 Sq. In.** 15	10-20
	Percent Undercard Waste	Quarterly and After Maintenance Is Performed On a Card	2-Hour Waste Test	2.5%	2.0%-3.0%
	Percent Flat Strip Waste	Quarterly and After Maintenance Is Performed On a Card	2-Hour Waste Test	1.25%	1.0%-1.5%

(cont'd)				Typical Testing Results	
Process	**Test**	**Frequency of Testing**	**Sampling Plan**	**Standard**	**Tolerance**
PREP DRAWING	Sliver Weight Grains/Yd	All Frames Daily	Five 1-Yd Lengths or One 5-Yd Length/Delivery	42 gr.	±1.0
	Grains/Yd Weight/CV	Weekly	Calculate From Daily Weights	2.0 CV	2.0-2.5
	Sliver Uster CV/Periodic Defects	All Frames Twice/ Week	Test 2.5 min. @ 25 ypm	3.5 CV	3.5-4.5
LAP WINDING	Lap Weight Grains/Yd	Each Machine Quarterly	Four 1-Yd Lengths	900 gr.	±10
	Grains/Yd Weight CV	Weekly	Calculate From Daily Weights	0.8 CV	0.8-1.1
COMBING	Sliver Weight Grains/Yd	All Machines Twice/ Week	Five 1-Yd Lengths or One 5-Yd Length/Delivery	56.0 gr.	±1.0
	Grains/Yd Weight CV	Weekly	Calculate From Daily Weights	1.5 CV	1.5-2.0
	Sliver Uster CV/ Periodic Defects	Each Delivery Weekly	Test 2.5 min. @ 25 ypm	4.0 CV	4.0-5.5
	Percent Noil Removal	All Machines Weekly	One Sample From Each Delivery	16%	±0.5%
BREAKER DRAWING	Sliver Weight Grains/Yd	All Frames Daily	Five 1-Yd Lengths or One 5-Yd Length Delivery	66 gr.	±1.0
	Grains/Yd Weight CV	Weekly	Calculate From Daily Weights	2.0 CV	2.0-2.5
	Sliver Uster CV/ Periodic Defects	All Frames Twice/ Week	Test 2.5 min. @ 25 ypm	3.5 CV	3.5-4.5

(cont'd)				Typical Testing Results	
Process	**Test**	**Frequency of Testing**	**Sampling Plan**	**Standard**	**Tolerance**
FINISHER DRAWING	Sliver Weight Grains/Yd	All Frames Daily	Five 1-Yd Lengths or One 5-yd Length Delivery	60 gr.	±1.0
	Grains/Yd Weight CV	Weekly	Calculate From Daily Weights	1.5 CV	1.5-2.0
	Sliver Uster CV/ Periodic Defects	All Frames Daily	Test 2.5 min. @ 25 ypm	3.0 CV	3.0-4.5
	Micronaire of Sliver	Weekly	One Sample From Each Delivery	4.2	±0.3
	CV of Micronaire	Weekly	Calculate From Weekly Data	2.5 CV	2.5-4.0
ROVING	Hank Roving Count	Each Frame Twice/Week	Four Bobbins/Frame 12 Yds/Bobbin	0.80 H.R.	±0.01 H.R.
	Roving Count CV	Weekly	Calculate From Daily Weights	1.5 CV	1.5-2.2
	Roving Uster CV/ Periodic Defects	Each Frame Twice/Week	Four Bobbins/Frame Two From Front Line and Two From Back Line Test 2.5 min. @ 50 ypm	5.5 CV	5.5-7.4
SPINNING	Yarn Count	10% Of Frames/ Count Weekly	Ten Bobbins/Frame Five/Side 120 Yd/Bobbin	24.0	±0.3
	Count CV	Weekly	Calculate From Daily Weights	2.0 CV	2.0-2.6
	Skein Strength	10% Of Frames/ Count Weekly	Ten Bobbins/Frame Five/Side	96 lbs. min.	
	Strength CV	Weekly	Calculate From Daily Data	4.0 CV	4.0-5.0
	Skein Break Factor	Each Major Count Weekly	Calculate From Daily Data	**B. Factor** 2304	2304+

(cont'd)				Typical Testing Results	
Process	**Test**	**Frequency of Testing**	**Sampling Plan**	**Standard**	**Tolerance**
SPINNING (cont'd)	Yarn Uniformity CV/Periodic Defects	10% of Frames/ Count Weekly	Ten Bobbins/Frame Five/Side *Test 1000 Yds @ Maximum ypm	16.5	16.5-18.0
	Yarn Imperfections I.P.I.	10% Of Frames/ Count Weekly	Ten Bobbins/Frame Five/Side		
			Thin/1000 Yds	10	5-30
			Thick/1000 Yds	40	10-100
			Neps/1000 Yds	40	20-100
	Single-End Strength	10% Of Frames/ Count Weekly	Ten Bobbins/Frame Five/Side	450 gms. min.	
	Single-End Strength CV	10% Of Frames/ Count Weekly	Calculate From Break Data	8.0	8.0-9.0
	% Elongation	10% Of Frames/ Count Weekly	Calculate From Break Data	8.0	7.2-8.0
	Grams/Tex	10% Of Frames/ Count Weekly	Calculate From Single-End Break and Tex Count	15.5	±1.0
	Yarn Imperfections (Uncleared Yarn)	Each Count Monthly	Test 500,000 Yds 1 Count		
			Major Defects/100,000 Yds	10	5-20
			Minor Defects/100,000 Yds	300	200-800
	Yarn Appearance	Each Count Monthly	Five Bobbins/Count	A	A-B
*1000 yards per package or bobbin is a normal sampling.					

COEFFICIENT OF VARIATION

$$\bar{x} = \frac{\Sigma x}{N} (mean)$$

$$\text{Variance} = \frac{\Sigma (x - \bar{x})^2}{N - 1}$$

$$\text{Standard Deviation} = \sqrt{\text{Variance}}$$

$$\% \text{ CV} = \frac{\text{Standard Deviation}}{\bar{x} \text{ (mean)}} \times 100$$

Calculation of the Standard Deviation

1	2	3
Cloth strength (lb)	*Deviation from mean strength*	*(Deviation)²*
x	$x - \bar{x}$	$(x - \bar{x})^2$
42	+0.2	0.04
39	−2.8	7.84
45	+3.2	10.24
47	+5.2	27.04
38	−3.8	14.44
39	−2.8	7.84
46	+4.2	17.64
44	+2.2	4.84
41	−0.8	0.64
37	−4.8	23.04
418		113.60
$\bar{x} = 41.8$		

$$\Sigma (x - \bar{x})^2 = 113.60$$

$$n - 1 = 10 - 1 = 9$$

$$\text{Variance} = \frac{113.60}{9}$$

$$= 12.62$$

$$\sigma = \sqrt{\text{variance}}$$

$$= \sqrt{12.62}$$

Therefore,

$$\text{Standard deviation} = 3.55 \text{ lb}$$

$$\text{Coefficient of variation} = \frac{100\,\sigma}{\bar{x}} = \frac{3.55 \times 100}{41.8}$$

$$= 8.5 \text{ percent}$$

SINGLE END STRENGTH VARIATION

Single end testers measure and record the frequency distribution of the breaking strength of yarn in grams. From this distribution chart an *overall* variation (Vo) in breaking strength of all breaks performed can be determined (i.e., 20 bobbins tested × 20 breaks/ bobbin = 400 total breaks). The variation between the average breaking strengths of each bobbin is designated *between* bobbin variation (Vb). The variation between the twenty breaking strength values of each of the yarn bobbins is the *within* bobbin variation (Vw).

The relationship between Vo, Vb and Vw is as follows:

$$Vo^2 = Vw^2 + Vb^2$$

Example: If, from the distribution chart from the single end tester, overall variation (Vo) was determined to be 10.7%, and the variation between the average breaking strengths of the individual bobbins (Vb) was calculated using the standard formula for percent variation (% CV) and determined to be 4.3%, then the Vw would be calculated as follows:

$$Vw = \sqrt{Vo^2 - Vb^2}$$
$$Vw = \sqrt{(10.7)^2 - (4.3)^2}$$
$$Vw = \sqrt{114.49 - 18.49}$$
$$Vw = \sqrt{96}$$
$$Vw = 9.80$$

Data Significance

The overall variation (Vo) is a measure of the consistency of the stock being processed and the variation introduced by the various processing machinery. This variation is normally in the 8-10% range for average quality. The within (Vw) is a measure of the consistency of the individual deliveries on a spinning frame. This variation should be in the 7-8% range. If this percent Vw is greater than 8% and approaches the value for the overall variation (Vo), it is an indication that there are mechanical and/or setting problems at the spinning process. The between bobbin (Vb) variation is a measure of the consistency between the individual deliveries. This variation should be in the 3.0 to 5.0 percent range. A high percent variation between the means of the tested bobbins indicates excessive stock variation. This could occur because of lack of fiber control at opening (blending) or variation introduced by processes prior to spinning.

It must be emphasized that this statistical analysis is a tool that can be used to help isolate a quality problem. It must be used in conjunction with other analytical methods [i.e., evenness, IPI (Imperfections Indicator), yarn count, % CV, etc.] to fully benefit from this exercise.

QUALITY CONTROL CHART

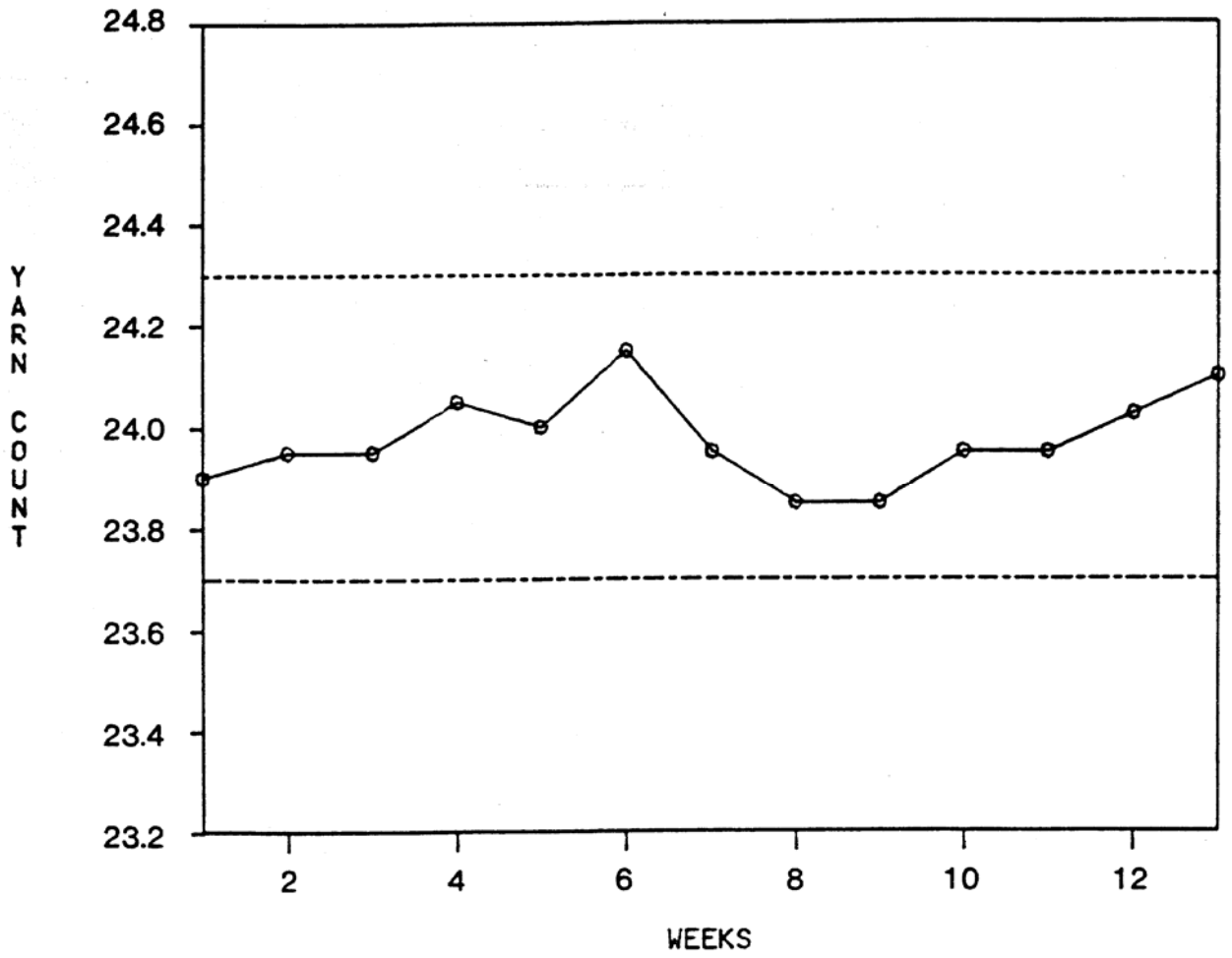
This chart is an example of a typical control chart, which is monitoring the average count of a 24/1 yarn. The standard is indicated as 24.0 with an upper control limit of 24.3 and a lower control limit of 23.7.

The week-to-week count average is quite stable and well within the control limits. This type of chart affords a very effective visual aid in tracking count trends.

The next chart is monitoring yarn count CV. The standard CV is 2.0 with an upper control limit of 2.6. The count CV in this example is excessive for several weeks. Although an improving trend is noted during the last several weeks, the CV level is still higher than should be expected. This is an indication to management that improved weight control at prior processes (beginning at cards) should be obtained to yield a subsequent improvement in yarn count CV.

EXAMPLE QUALITY CONTROL CHART

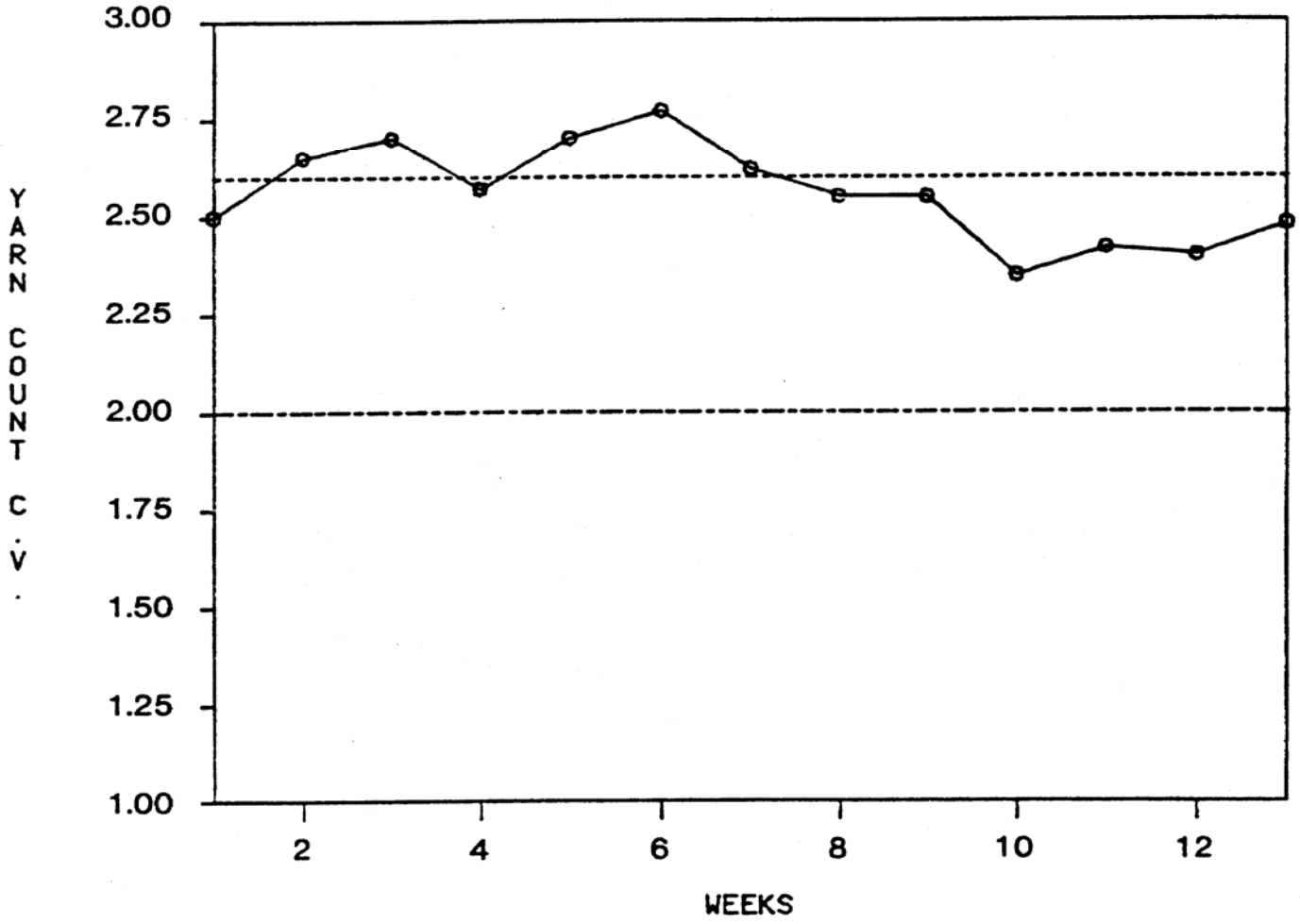
24/1 Ne 100% Cotton



QUALITY CONTROL CHART (cont'd)

EXAMPLE QUALITY CONTROL CHART

24/1 Ne 100% Cotton



QUALITY CONTROL REPORT

This is an example of a trend report which is widely used to monitor long-term trends in quality levels. This particular report shows the average on all test data for the past two complete years and immediate prior three quarters. Data for all thirteen weeks of the current quarter will be shown throughout the quarter. This type of report is continually updated and always affords the same amount of historical data. This particular example covers skein and single-end data for a 24/1 yarn; however, this type of report can be used to cover all processes in yarn manufacturing. This type of quality control report is an excellent tool for management in that it permits rapid observation and analysis of a great amount of data covering a long period of time. Any abnormal or undesirable trends in quality levels are quickly noted, permitting management to make timely and proper adjustments to correct out-of-control conditions.

EXAMPLE: QUALITY CONTROL REPORT
24/1 Ne 100% Cotton

	Yarn Count	Count CV	Skein Break	Break CV	Break Factor	% CV	S.E. Break (Grams)	S.E. Break CV	S.E. Break Factor	% Elong.
Standard	24.0	2.0	96.0	4.0	2304	16.5	450	8.0	10,800	8.0
Year 1	24.1	2.2	93.7	3.8	2258	16.7	440	8.2	10,604	7.8
Year 2	23.8	2.4	93.6	4.2	2228	16.8	444	7.8	10,567	8.2
Year 3-1st Qtr	23.9	2.3	94.0	4.3	2247	16.1	439	8.0	10,492	7.6
Year 3-2nd Qtr	23.8	2.3	92.9	4.0	2211	16.0	449	8.0	10,686	7.7
Year 3-3rd Qtr	23.9	2.1	94.2	3.9	2251	15.9	453	8.3	10,827	7.7
Current Qtr w/e Week No										
1	24.1	2.4	95.1	3.9	2292	15.9	454	8.0	10,941	7.7
2	24.2	2.0	95.2	4.0	2304	16.4	456	8.7	11,035	7.8
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										

HELPFUL CALCULATIONS

$$\text{Yarn Count (Ne)} = \frac{8.33 \times \text{Yds}}{\text{Grains}}$$

$$\text{Lbs} = \frac{8.33 \times \text{Yds}}{\text{Ne} \times 7000}$$

$$\text{Yards/Lb} = \text{Ne} \times 840$$

$$\text{Twist Multiple} = \frac{\text{Turns/Inch}}{\sqrt{\text{Ne}}}$$

$$\text{Turns Inch} = \text{Twist Multiple} \times \sqrt{\text{Ne}}$$

$$\text{Pounds Per Spindle Hour (Ring)} = \frac{\text{FRRPM*} \times \pi \times \text{Dia. of Front Roll} \times \text{Min. Per Hour}}{\text{Hank Roving} \times 36 \text{ In. Per Yd} \times 840 \text{ Yd Per Hank}}$$

$$\text{Traveler Speed (Feet/Minute)} = \frac{\text{Spindle RPM} \times \text{Ring Dia. (inches)} \times \pi}{12}$$

$$\text{Draft} = \frac{\text{Ne Yarn}}{\text{Ne Roving}}$$

CONVERSIONS:

$$\text{(Tex)} \quad \text{Ne} = \frac{590.54}{\text{Tex}} \qquad \text{Tex} = \frac{\text{Denier}}{9}$$

$$\text{(Metric)} \quad \text{Ne} = \text{Nm} \times 0.59054 \qquad \text{Nm} = \frac{1000}{\text{Tex}}$$

$$\text{(Denier)} \quad \text{Ne} = \frac{0.5315}{\text{Denier}}$$

$$\text{Micronaire} = \frac{\text{Denier}}{0.354}$$

*FRRPM = Front Roll rpm

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.
- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.
- Computerized fiber management techniques result from in-depth fiber processing research.
- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.
- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.
- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.
- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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