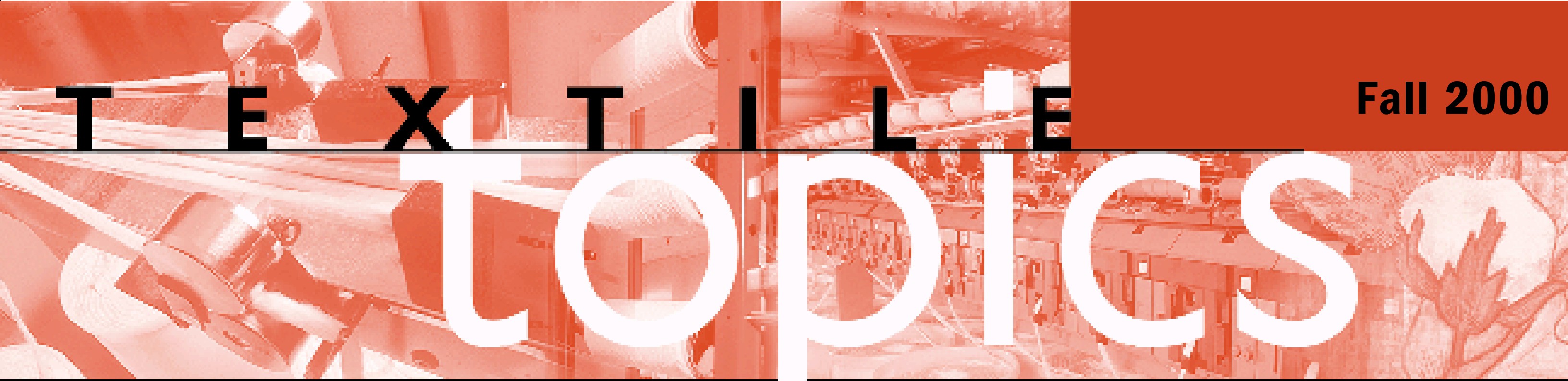

International Textile Center | Texas Tech University | Lubbock, Texas USA

Sharing current research information and trends in the cotton and textile industries.

NEW EQUIPMENT INSTALLATION COMPLETED

After months of moving, waiting, and a lot of hard work several new upgrades are completed. These include Suessen Fiomax 1000 and Suessen Elite compact ring spinning frames, a new Truetzschler HSR 1000 draw frame, and a Truetzschler DK903A card, and custom-made, small-sample, ring-spinning machinery. A large amount of machinery for drycleaning, wetcleaning, and fabric care has also been installed. Pictures of the new machinery may be seen on our web page.

SUMMER ISSUE OF TEXTILE TOPICS CANCELLED

The summer issue of Textile Topics was cancelled due to the massive equipment installations.

ITC CONDUCTS SPECIAL EDUCATION/TRAINING

- A class of 23 students, coming from seven countries, attended the Texas International Cotton School in May. The intensive two-week program covered all aspects of the global cotton/textile industry.
- A class of 24 people attended a two-day fiber properties seminar in July.
- A group of 20 international cotton seed marketing personnel of the Delta and Pine Land Company were provided a two-day short course on the measurement and meaning of cotton fiber properties in July.
- All employees of Southwest Textiles, Inc., Abernathy, TX, attended a five-day, customized training course in October. Emphasis was on quality control practices in manufacturing.

SOUTHWEST RESEARCH CENTER FOR LAUNDRY AND DRYCLEANING GRAND OPENING

The Southwest Drycleaners Association (SDA) held a grand opening for the new research center located at the ITC on Oct. 28 in conjunction with their board of directors meeting in Lubbock. The first training classes were held Oct. 16-20 in Stain Removal and Advanced Stain Removal and were taught by Jane Zellers.

STAFF TRAVEL

- Dean Ethridge to Austin, Texas for the annual meeting of the Texas Cotton Association and a meeting of the Fiber Advisory Committee for the Texas Commissioner of Agriculture.
- Dean Ethridge to San Angelo, Texas for a board meeting of the Texas Independent Ginners Association.
- Dean Ethridge to Bakersfield, California to speak at the Calcot Classing and Marketing School.
- Dean Ethridge and Khalil Rehman to south Texas and northern Mexico to evaluate textile manufacturing industry.
- Eric Hequet to Memphis, Tennessee for meeting of the U.S. Committee on Cotton Quality Measurements.
- Dean Ethridge and Khalil Rehman to Greenville, South Carolina to attend the American Textile Machinery Exposition.
- Dean Ethridge and Khalil Rehman to Los Angeles, California to evaluate textile manufacturing industry.

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MONITORING AND CONTROL OF THE AFIS® INSTRUMENT

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M. Dean Ethridge, Director

Cotton Incorporated and the Texas Food and Fibers Commission funded the research reported here.

INTRODUCTION

The AFIS® instrument has proven to be an indispensable tool for fiber research, testing and evaluation, and process control in textile manufacturing. To realize its potential, however, it must be carefully maintained and monitored to ensure that measurements are accurate and repeatable. For example, experience has shown that contamination caused by sticky cotton will cause drifting and level shifts in fiber property measurements.

All instruments for measuring cotton fiber properties—whether it be the manual Stelometer or the more sophisticated, computerized ones like the HVI and the AFIS—require calibration to achieve reliable, repeatable results. Calibration, in turn, requires standard cottons, or other suitable standard materials, selected and maintained for that purpose.

In a previous phase of this project, a set of seven standard cottons were selected and evaluated. A subset of three of these was then selected for use in controlling the short-term and long-term stability of the AFIS. This paper reports on results obtained in tracking the various sources of instrument variability and implications for controlling the quality of AFIS measurements.

PROCEDURES

For simplicity, denote the three standard cottons (SCs) used as SC1, SC2 and SC3. Each of these was run on the AFIS twice daily (morning and afternoon) for 70 consecutive workdays. All measurements provided by the AFIS Multidata were collected in a database. These measurements are defined in Table 1.

Statistical analyses were done to determine if there were level shifts, repetitive outliers and drifting of the measurements. Also, an appropriate moving average technique was used to detect instrument-related patterns and trends in the data.

A summary of basic statistics on properties measured by the AFIS is given in Table 2. The data show that the three standard cottons selected provide useful ranges in all of the properties measured using the AFIS Multidata.

DISTRIBUTION OF AFIS MEASUREMENTS

If observed variations in the AFIS measurements during the 70-day testing period follow a normal distribution, then it can be concluded that there was no drift or level shifts in the instrument and there were no repetitive outlier values. In order to evaluate this, the measurement distributions were evaluated for skewness and kurtosis. Also, the Shapiro-Wilks' W test for non-normality was done on each variable measured.

Skewness is a measure of the extent that the distribution of a variable is skewed to the left (negative value) or right (positive value), relative to the standard normal distribution (for which skewness = 0). It is defined as follows:

$$\text{Skewness} = \frac{nM_3}{(n-1)(n-2)\sigma^3}$$

where: M_3 = 3rd moment of distribution = $\sum_i (x_i - \bar{x})^3$,

n = number of observations, and

σ = standard deviation.

The Kurtosis is a measure of "wide" versus "narrow" (or "flat" versus "peaked") in the shape of the distribution of a variable, relative to the standard normal distribution (for which kurtosis = 0). It is defined as follows:

$$\text{Kurtosis} = \frac{[n(n-1)M_4] - [3M_2^2(n-2)(n-3)]}{(n-1)(n-2)(n-3)\sigma^4},$$

where: M_j = jth moment of distribution = $\sum_i (x_i - \bar{x})^j$

and the other variables are defined above.

The results on skewness and kurtosis are summarized in Table 3. They indicate that (1) a positive skew may exist in the distributions of ML, IFC, and VFM, and (2) a negative skew may exist in the distributions of UQL, F, and MR. They further indicate that a positive kurtosis may exist in the distribution of VFM.

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Table 1. Measurements from AFIS Multidata

Fiber Properties	Abbreviations	Units
Mean Length (by weight)	ML	in.
Upper Quartile Length (by weight)	UQL	in.
Short Fiber Content (by weight)	SFC	%
Fineness	F	mtex
Maturity Ratio	MR	ratio
Immature Fiber Content	IFC	%
Neps	N	cnt/g
Seed Coat Neps	SCN	cnt/g
Visible Foreign Matter	VFM	%

Table 2. Basic Statistical Data from AFIS on Standard Cottons

	Mean Value	Mean Confidence Interval (95%)	Minimum Value	Maximum Value	Standard Deviation
SC1					
ML	0.983	0.980 – 0.987	0.960	1.010	0.014
UQL	1.255	1.252 – 1.258	1.230	1.280	0.012
SFC	11.6	11.4 – 11.8	9.6	13.3	0.9
F	161.6	161.3 – 162.0	162.0	156.0	164.0
MR	0.851	0.848 – 0.853	0.820	0.870	0.009
IFC	8.7	8.6 – 8.8	7.8	10.2	0.5
N	252.3	248.2 – 256.4	216.0	285.0	17.3
SCN	14.3	13.7 –15.0	8.8	21.2	2.8
VFM	0.117	0.106 – 0.128	0.050	0.300	0.047
SC2					
ML	0.910	0.907 – 0.912	0.890	0.950	0.010
UQL	1.101	1.100 – 1.103	1.090	1.130	0.008
SFC	9.9	9.7 – 10.1	7.3	11.4	0.8
F	183.9	183.5 – 184.3	180.0	186.8	1.5
MR	0.942	0.940 – 0.944	0.920	0.960	0.008
IFC	5.7	5.6 – 5.8	4.8	6.7	0.4
N	122.9	120.6 – 125.2	102.0	150.0	9.6
SCN	13.9	13.3 – 14.5	8.8	18.8	2.2
VFM	0.163	0.154 – 0.171	0.060	0.280	0.036
SC3					
ML	0.920	0.918 – 0.923	0.900	0.950	0.010
UQL	1.115	0.113 – 1.117	1.100	1.140	0.008
SFC	9.7	9.5 – 9.8	7.9	11.2	0.7
F	181.6	181.2 – 182.0	176.4	184.8	1.8
MR	0.913	0.911 – 0.915	0.890	0.930	0.008
IFC	6.4	6.3 – 6.5	5.7	7.9	0.4
N	109.4	107.1 – 111.6	83.0	131.0	9.4
SCN	19.3	18.7 – 20.0	13.6	26.0	2.6
VFM	0.265	0.256 – 0.275	0.150	0.400	0.040

Table 3. Skewness and Kurtosis of AFIS Measurements on Standard Cottons

	Skewness			Kurtosis		
	SC1	SC2	SC3	SC1	SC2	SC3
ML	0.090	0.977	0.687	-0.805	2.101	0.191
UQL	-0.326	0.682	-0.046	-0.531	1.030	0.197
SFC	-0.302	-0.613	-0.485	-0.481	0.849	-0.073
F	-1.024	-0.502	-0.727	1.120	-0.260	0.091
MR	-0.797	-0.644	-0.377	0.789	0.357	-0.485
IFC	0.869	0.467	1.139	0.385	0.260	1.921
N	-0.073	0.363	-0.211	-0.629	0.019	-0.044
SCN	0.440	0.034	0.337	-0.262	-0.173	0.106
VFM	1.864	0.309	0.154	4.086	1.442	1.485

The Shapiro-Wilks' W test is the preferred test for non-normality because of its good power properties (see Shapiro, Wilks, & Chen, 1968). The STATISTICA™ software package was used to make this test; it employs a computational technique that allows the test to be applied to samples with up to 2000 observations. If the W statistic is significant, then the hypothesis that the respective distribution is normal should be rejected.

Results of the Shapiro-Wilks' W Test are summarized in Table 4. They require rejection of the hypothesis of normality for ML, UQL, F, MR, and IFC. Only two of the three standard cottons pass the test of normality for SFC and VFM; therefore, uncertainty exists about these variables. The two properties that consistently pass the test for normality are N and SCN; therefore, at least the measurements of neps and seed coat neps appear to be free of repetitive outliers, level shifts and drift.

Table 4. Shapiro-Wilks' W Test Results

	Values			Statistical Significance[a/]		
	SC1	SC2	SC3	SC1	SC2	SC3
ML	0.926	0.873	0.878	***	***	***
UQL	0.918	0.846	0.858	***	***	***
SFC	0.975	0.970	0.960	NS	NS	*
F	0.927	0.970	0.953	***	NS	*
MR	0.864	0.846	0.858	***	***	***
IFC	0.943	0.964	0.927	**	*	***
N	0.982	0.982	0.987	NS	NS	NS
SCN	0.970	0.985	0.982	NS	NS	NS
VFM	0.821	0.974	0.979	***	NS	NS

[a/] NS not significant; * significant at a = 0.05; ** significant at a = 0.01; *** significant at a = 0.001

MONITORING TO CONTROL QUALITY

In addition to daily time-series plots of measurement results on the standard cottons, moving averages provide valuable information for controlling instrument errors; e.g., drift, repetitive outliers, cycling, etc. These may be structured to monitor either long-term or short-term performance of the instrument.

The data showed that the behavior of measurements on the three standard cottons was very similar. Therefore, it was concluded that the best way to monitor instrument changes was by taking the average over all three standard cottons. All subsequent results are based on this average.

Long-Term Tracking

For monitoring the long-term accuracy of the AFIS, an appropriate method is provided by an exponentially weighted moving average. This is a generalization of a simple moving average, which computes each data point as follows:

$$Z_t = \lambda \bar{x}_t + (1-\lambda)Z_{t-1} ,$$

where: Z_t = computed value at time t,

$\bar{x}_t$ = mean value of observations through time t, and

λ = weighting factor ($0 < \lambda < 1$).

This is a common exponential smoothing formula (see Montgomery, 1985, p. 239), which specifies that the weight for historically "old" sample means decreases geometrically as one continues to add observations. It also smoothes the pattern of means across samples, which makes it easier to detect unwanted trends or level shifts. In this analysis, it was decided to set $\lambda = 0.1$, which means that the influence of past observations would disappear slowly.

Three AFIS measurements are used to illustrate the results: SFC, MR, and N. Each of these is measured using different "modules" within the AFIS; therefore, these three properties exercise all of the techniques within the AFIS Multidata.

The exponentially weighted moving averages are shown for SFC in Chart 1, for MR in Chart 2, and for N in Chart 3. In all cases, even small "trends," "drifts" or "level shifts" in the data are clearly revealed. The boundary lines drawn above and below the mean value line in each chart encompass three standard deviations for the exponential moving average series. The interval encompassing three standard deviations is quite narrow, due to the highly smoothed behavior of such a data series.

The data reveal a drift toward lower values for SFC (Chart 1) and toward higher values for N (Chart 3). It also shows slight level shifts for MR, but these are so small that they are clearly not significant (Chart 2). As a tool to detect non-normality and trends, this one is quite sensitive. Because of its lagging behavior, however, it is not appropriate for deciding exactly when there should be an operator intervention to check and clean the instrument for the purpose of determining whether it is necessary to recalibrate it. A short-term protocol is needed for this purpose.

Chart 1. Exponentially Weighted Moving Averages for Short Fiber Content Measurements

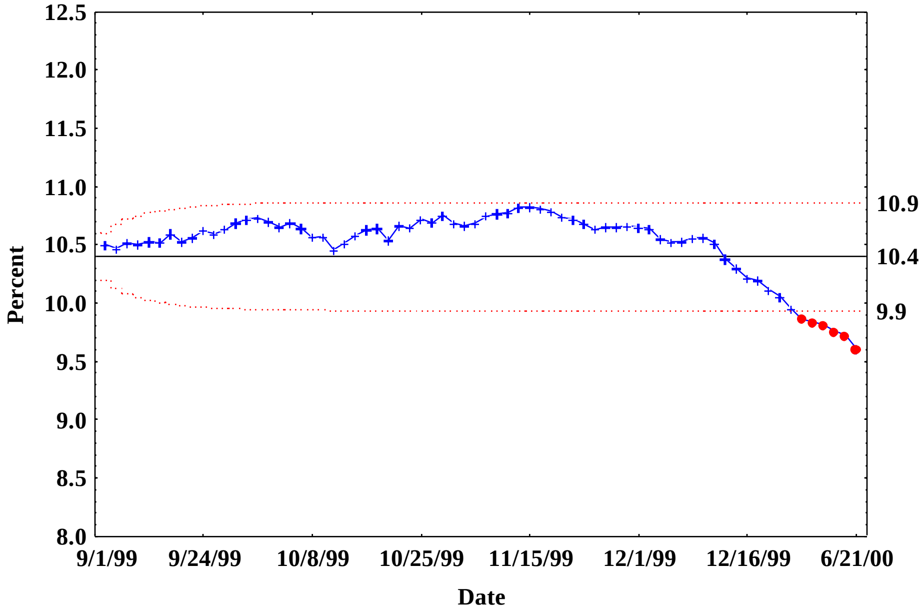


Chart 2. Exponentially Weighted Moving Averages for Maturity Ratio Measurements

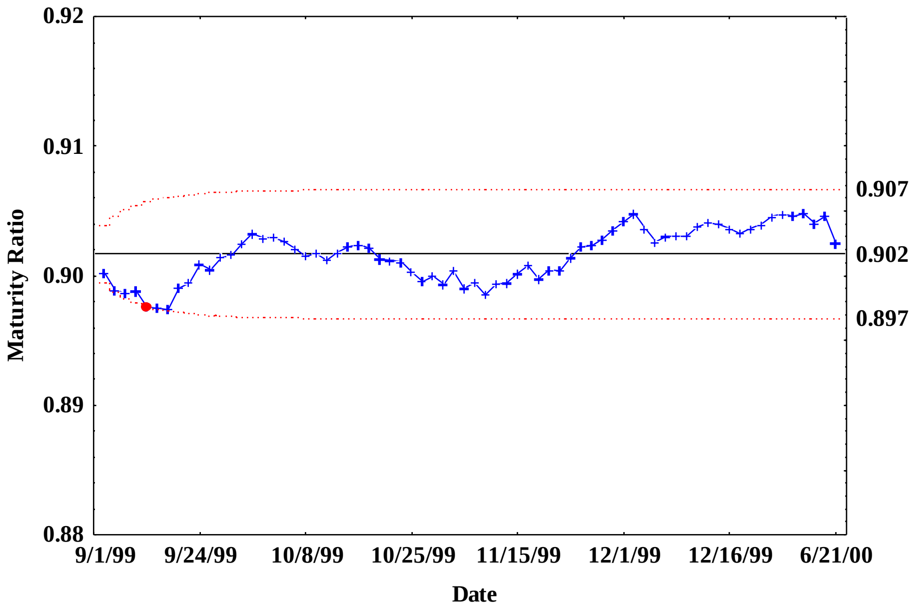
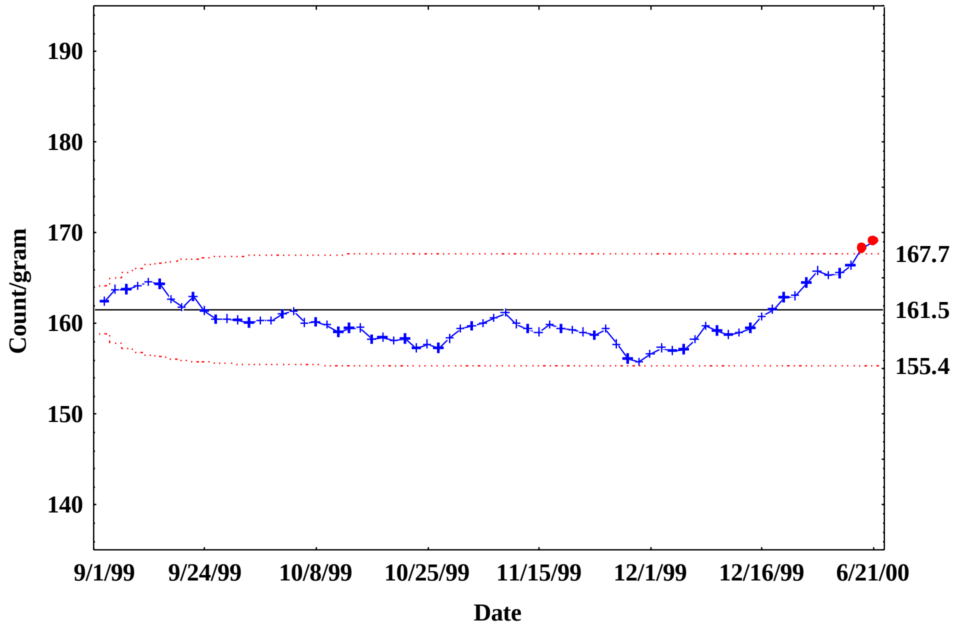


Chart 3. Exponentially Weighted Moving Averages for Nep Measurements



Short-term Tracking

To monitor non-random patterns and shifts that indicate the instrument may have gone "out of calibration," a simple moving average using two periods (i.e., two observations) is quite sensitive. This is computed according to the following formula:

$$Z_t = \frac{x_t + x_{t-1}}{2} ,$$

where: Z_t = computed value at time t, and
x_t = observation at time t.

These simple moving averages are shown for SFC in Chart 4, for MR in Chart 5, and for N in Chart 6. Like in the previous charts, the boundary lines drawn above and below the mean value lines encompass three standard deviations for the simple moving average series. Because this moving average uses only the two most recent observations, the data are much more volatile than were the exponentially weighted moving average data; therefore, the interval encompassing three standard deviations is correspondingly wider.

Chart 4. Simple Moving Averages for Short Fiber Content Measurements

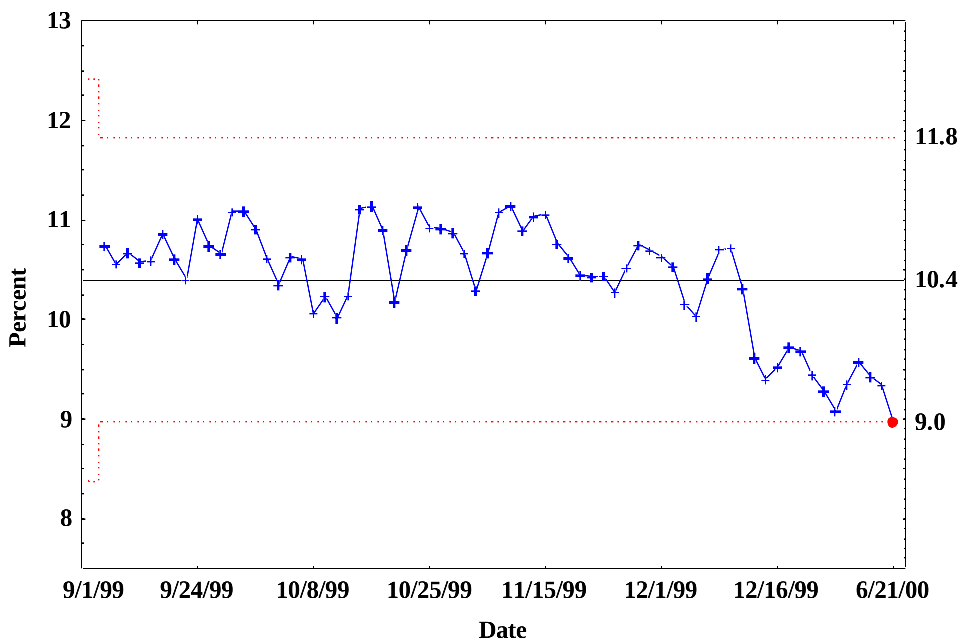


Chart 5. Simple Moving Averages for Maturity Ratio Measurements

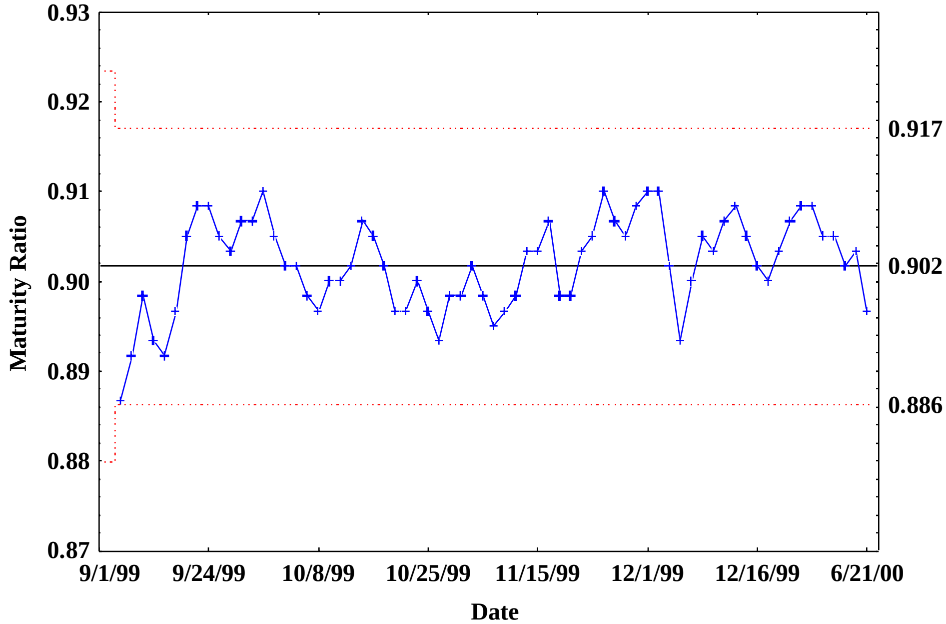
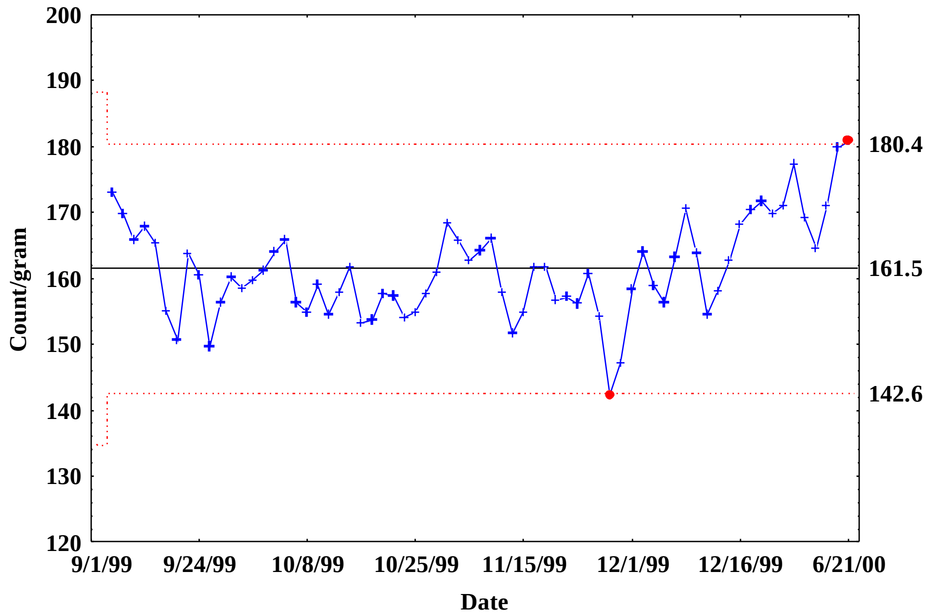


Chart 6. Simple Moving Averages for Nep Measurements



The quality control procedure used in the ITC laboratory requires that whenever the simple, two-period moving average approaches the boundary lines, two additional measurements are made on the standard cottons. If these measurements confirm that the instrument is close to or outside of the three-standard-deviation boundaries, then the AFIS is thoroughly cleaned, checked, and three more measurements are taken on the standard cottons. If these measurements indicate that the instrument is taking satisfactory measurements, standard operation is resumed. However, if they indicate that the measurements are still erroneous, the AFIS is recalibrated to produce the proper measurements of the standard cottons.

Accumulated Experience

During the 70-day experiment related here and for the approximately five months of operation since completion of the experiment, the ITC's AFIS has needed recalibration only one time. That occurred when a check of the instrument revealed a failed sensor, requiring replacement and then recalibration. In all other instances, the AFIS was brought back into compliance either by remedying a problem revealed in the check-up or by thoroughly cleaning the instrument.

It should be noted that previous experience has shown that, with daily use of the AFIS, a daily cleaning regimen is necessary for the instrument to be accurate and reliable. Even with this regimen, it is quite possible that contamination can occur within a day's operation that interferes with accurate measurements. The instrument should always be carefully cleaned and then tested before a decision is made to recalibrate it.

EFFECTS OF STICKINESS CONTAMINATION

Contamination of the AFIS from sticky cotton is a particularly insidious problem. To evaluate the extent of the problem, a known sticky cotton bale was used to repeatedly put sticky cotton through the AFIS during a 9-day period. The sticky samples were put through 13 times throughout each day, with 5 replications each time. Therefore, measurements were made 117 times (9 x 13 = 117), and the sticky fibers were fed through the AFIS 585 times (117 x 5 = 585). The established cleaning regimen for the AFIS was done throughout the experiment. We did not detect and any drifts or level shifts in the data; therefore, the cleaning regimen for the AFIS appears to be generally adequate.

Table 5 summarizes, for each of the AFIS measurements, the minimum values, maximum values, ranges, and coefficients of variation among days. The data look normal for all properties measured except two: seed coat neps (SCN) and visible foreign matter (VFM). For these two properties, there is clearly a higher-than-normal variability. We think that the high variability of the SCN could be due to the incorrect identification of some sticky neps as seed coat neps. We hypothesize that the high variability of VFM is due to the tendency for the trash in sticky cotton to adhere to the sticky spots, resulting in a non-random distribution of trash.

Table 5. Summary of Daily Variation Indicators for AFIS Measurements on Sticky Cotton

	Minimum	Maximum	Range	CV%
ML	0.880	0.892	0.012	0.5
UQL	1.074	1.085	0.011	0.3
SFC	10.2	11.2	1.0	3.6
F	179.1	181.8	2.7	0.5
MR	0.885	0.893	0.008	0.3
IFC	5.1	5.5	0.5	2.6
N	272.0	298.0	26.0	3.3
SCN	22.1	36.4	14.3	16.6
VFM	0.918	1.271	0.353	10.4

CONCLUSION

By combining a daily cleaning regimen with standard cottons, statistical monitoring and rigorous calibration procedures, the AFIS has become a reliable, repeatable instrument for the International Textile Center. It is appropriate to close with the emphasis that these factors are necessary for any sophisticated fiber instrument to produce reliable, repeatable results. These requirements do add significantly to the time and expense of operating such instruments. But it is a cost that must be incurred, because the alternative (of unreliable data) is not acceptable.

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