DEVELOPMENTS IN SHORT FIBER MEASUREMENTS

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Abstract

Efforts to develop a short fiber measurement suitable for use in commercial cotton classification are continuing. Recent results from USDA studies and the International Cotton Advisory Committee (ICAC) Commercial Standardization of Instrument Testing of Cotton (CSITC) Round Trial show low between instrument reproducibility for the Short Fiber Index (SFI) measurement. SFI cotton calibration is slowly being implemented into late model instruments, in hopes of reducing the wide range in short fiber measurement levels. Within and between instrument SFI Coefficients of Variation (CV) were found to be in the 5-6% range and 15-23% range, respectively, in two 2009 CSITC Round Trials. A short fiber prediction equation developed in 2003, by USDA utilizing length and uniformity index measurements was found to have strong agreement with the SFI measurement (R-squared = 98.3%), but with lower variability and higher reproducibility.

Introduction

The HVI SFI measurement has been under evaluation by the USDA, AMS, Cotton Division since 1997 (Knowlton, 2004). Although some improvements have occurred over time, high measurement variability and low between instrument reproducibility continue to be the major drawbacks. The measurements of HVI Length (L) and Uniformity Index (UI) provide a good indicator of short fiber content. Given the availability and high degree of reproducibility of these measurements, their usefulness for predicting short fiber should be recognized.

In this report, both the SFI measurement and the L/UI based short fiber prediction are evaluated. Data for the analyses were derived from recent USDA standard bale value setting tests, CSITC Round Trial results, USDA in-house check cotton results and USDA office to office check results.

USDA Standard Bale Value Setting Test

A set of 27 U.S. cotton bales was selected to represent a wide range of U.S. growing regions, lengths and short fiber contents. Approximately 200 tests were made on each bale by 10 Uster HVI 1000's in early 2009. Given the high number of tests conducted on these bales, the values established and shown on the following figures are very precise. Figure 1 gives the SFI plotted against length for each of the 27 bales. Each point on the graph represents the overall average of all tests per bale. The graph shows the range in short fiber contents and lengths for the set. The graph also shows the strong relationship between SFI and length with R^2=0.87. Figure 2 gives the SFI plotted against the Uniformity Index. The relationship between SFI and Uniformity Index is stronger than the SFI to length relationship as evidenced by R^2=0.97.

Figure 3 gives the SFI plotted against the L/UI predicted short fiber content as given by the following equation:

$$\text{L/UI Short Fiber} = a + bX + cY + dX^2 + eY^2 + fXY$$

Where:

X = Length (inches)
Y = Uniformity Index

a =	643.3879
b =	-166.099
c =	-12.3394
d =	-15.7353
e =	0.05493
f =	2.32838

The L/UI predicted short fiber equation was first developed by USDA around 1999 and last revised in 2002 (Knowlton, 2004). Results shown in Figure 3 indicate that there is very little difference between the information provided by the SFI measurement and the information provided by the length and uniformity index measurements (R^2=0.98).

Figure 4 shows the relationship between the SFI measurement and within instrument SFI standard deviation over a wide range of SFI measurement levels. As expected, SFI standard deviations increase as the SFI level increases. This data indicates a threefold increase in standard deviations over the SFI measurement range illustrating why the variability is so much higher in high short fiber cottons compared to cottons with low short fiber contents. Figure 5 shows the CV of SFI over the 27 bale range. For the most part, within instrument CV's are found in the 4.25% to 5.75% percent range.

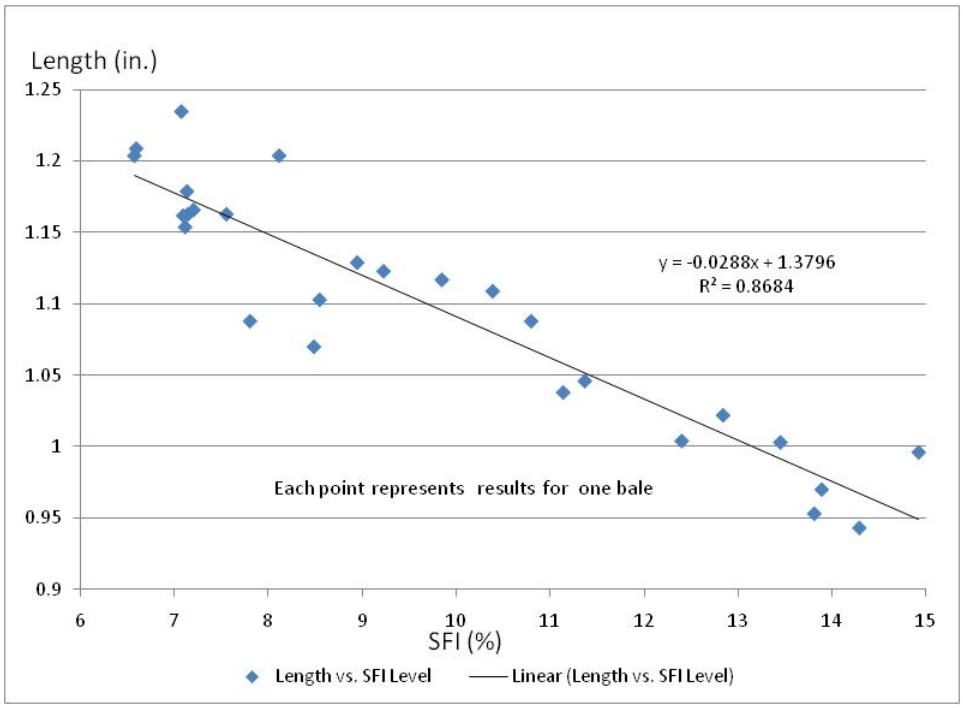

Figure 1. Relationship between SFI & Length on 27 bale set.

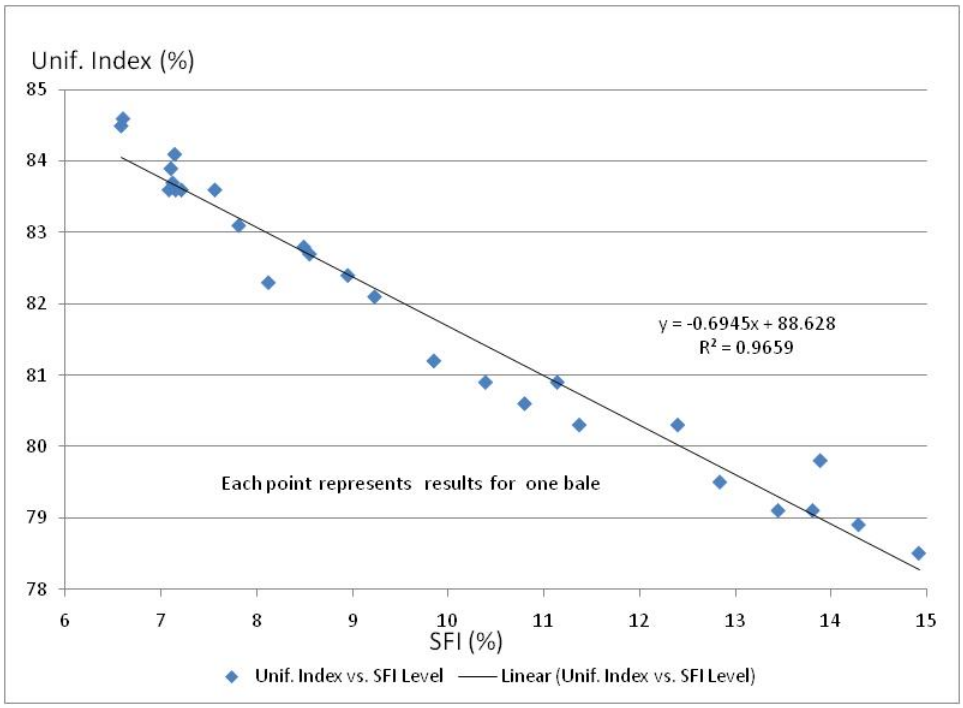

Figure 2. Relationship between SFI & Uniformity Index on 27 bale set.

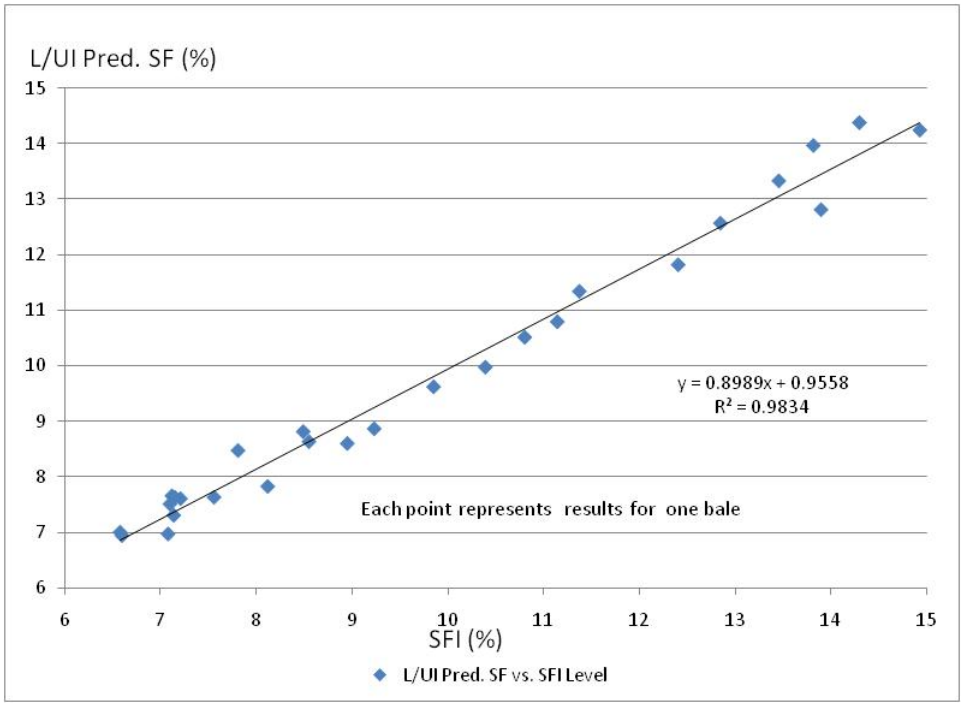

Figure 3. Relationship between SFI & Length/Uniformity Index Predicted Short Fiber on 27 bale set.

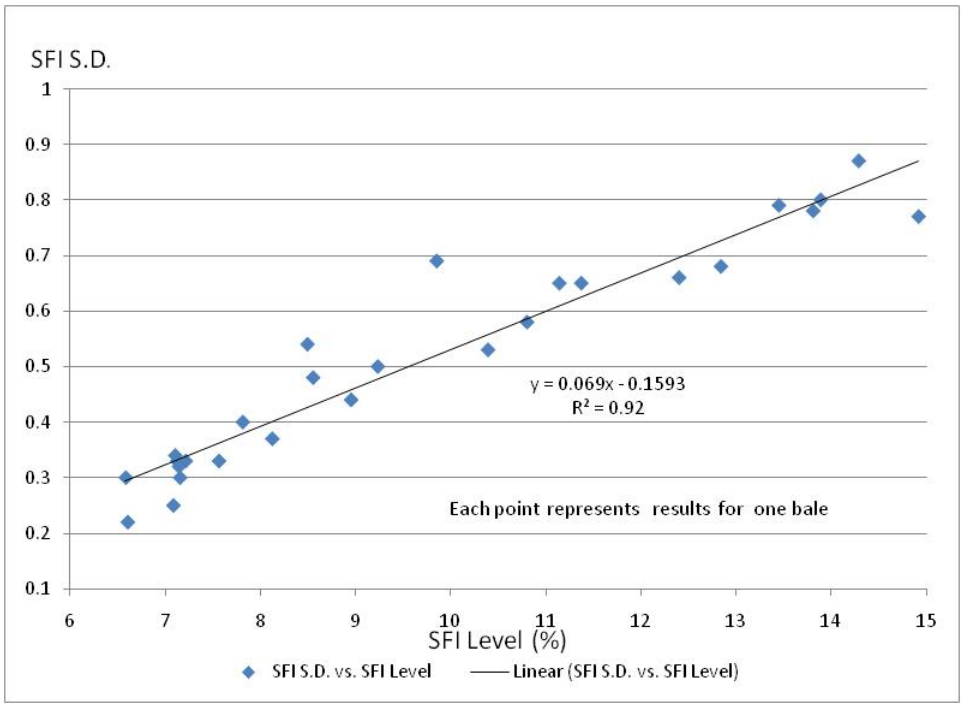

Figure 4. Within bale / within instrument SFI Standard deviations on 27 bale set.

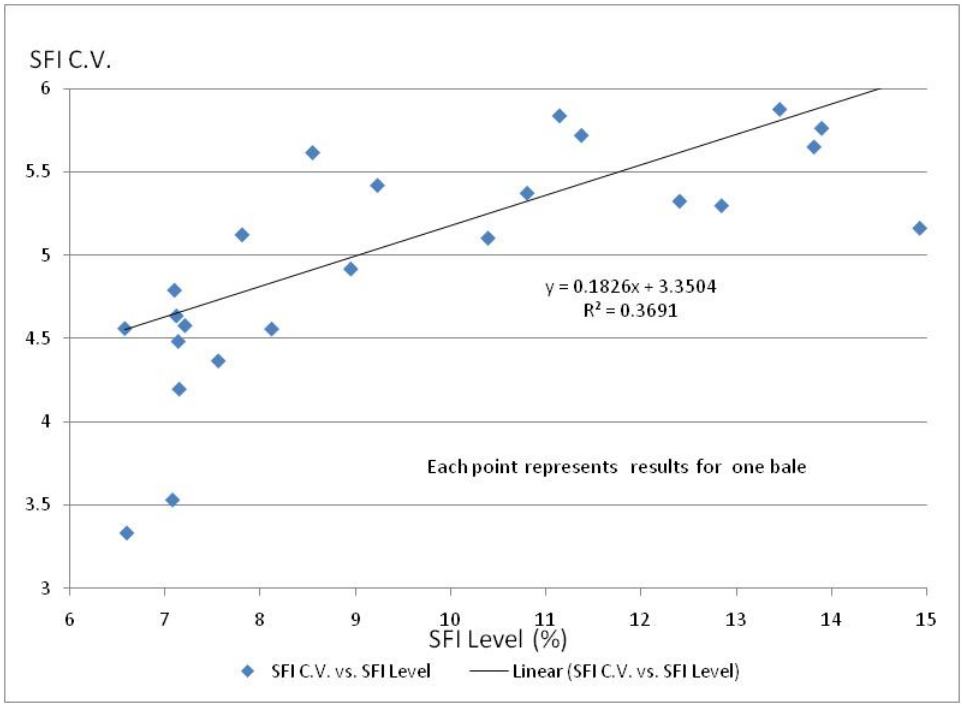

Figure 5. Within bale / within instrument SFI Coefficients of Variation on 27 bale set.

CSITC Round Trial SFI Results

The ICAC CSITC Round Trial is conducted on a quarterly basis and is designed to assess participant performance on the commercially accepted classification measurements of micronaire, strength, length, uniformity index, color Rd and color +b. Five different samples are prepared for each round trial and tested by the participants over a five day period. As an unofficial part of the CSITC Round Trial, during the 2009-3 and 2009-4 round trials, the

measurements of SFI and maturity were requested on a voluntary basis from participants. The purpose was to evaluate the commercial readiness of SFI and maturity. Tables I and II provide a summary of the SFI results for round trials 2009-3 and 2009-4, respectively. Within instrument standard deviations and CV's were similar to those found in the USDA 27 bale study (Figures 4 & 5). Between instrument standard deviations and CV's were calculated for the CSITC Round Trial results. Between instrument standard deviations ranged from 1.3% to 3.8%, while between instrument CV's ranged from 15.8% to 22.8%. For comparison, the measurements of color +b and strength, which have the highest between-lab CV's in the CSITC Round Trial, have between-lab CV's of just under 5.0%. Therefore, the SFI measurement results here indicate three to four times the variability of +b and strength.

Table I. CSITC Round Trial 2009-3 SFI Results

	Cotton 1	Cotton 2	Cotton 3	Cotton 4	Cotton 5
Overall Average	16.8	10.8	8.5	7.6	8.2
Between Instrument S.D.	3.8	1.8	1.7	1.5	1.6
Between Instrument C.V.	22.8	16.9	19.8	20.3	19.2
Within Instrument S.D.	0.88	0.56	0.51	0.42	0.51
Within Instrument C.V.	5.3	5.2	6.0	5.5	6.2
No. of Instruments: 35 No. of tests per cotton per instrument: 30					

Table II. CSITC Round Trial 2009-4 SFI Results

	Cotton 1	Cotton 2	Cotton 3	Cotton 4	Cotton 5
Overall Average	13.7	7.6	7.2	7.3	16.0
Between Instrument S.D.	2.2	1.3	1.3	1.4	2.5
Between Instrument C.V.	16.2	16.9	18.4	19.9	15.8
Within Instrument S.D.	0.81	0.46	0.39	0.36	0.87
Within Instrument C.V.	5.9	6.1	5.4	5.0	5.5
No. of Instruments: 39 No. of tests per cotton per instrument: 30					

Memphis SFI In-House Cotton Results

USDA classing offices utilize an "in-house" check cotton to monitor calibration levels throughout the testing day. Calibration is checked with the in-house cotton once every two hours of instrument operation to ensure instruments are maintaining the proper calibration levels. Table III gives a summary of the results for approximately 60 days of the 2009 classing season in the Memphis classing office. Over the 2009 classing season, the in-house cotton was tested approximately 875 times on each of 40 HVI 1000 instruments used in the Memphis classing office. All of the cotton tests are based on the same in-house check cotton. Table III gives the results for length, uniformity index, SFI and L/UI predicted short fiber. The CV's in this table represent the total variability of all 35,574 tests, from all 40 instruments, combined. With a CV of 9.42%, SFI is the most variable measurement in the table. The L/UI short fiber measurement provides a significantly less variable short fiber measurement option with a CV of 6.18%. The overall level of the L/UI short fiber (10.0%) compares closely to the SFI level (10.2%). For comparison, the much more stable measurements of length and uniformity index are shown with CV's of 1.21% and 0.77%, respectively.

All 40 Memphis instruments were calibrated for SFI at least once per week. The SFI CV for the Memphis in-house study is much lower at 9.42%, compared to the CSITC round trial SFI CV's which range from 15.8% to 20.8% (Tables I & II). The large CV's in the CSITC round trial are largely attributed to large between instrument differences as a result of not having SFI cotton calibration implemented industry wide.

Figure 6 shows the within instrument CV's of the USDA instruments for the in-house cotton. On average, the within instrument CV's were close to 9%. This is higher than the within instrument CV's found for the 27 bale set or the CSITC round trial. The primary reason for the higher within instrument CV's is due to the longer 60 day period of time in which the instrument measurements were made compared to 5 days for the CSITC round trial.

Table III. Memphis Classing Office In-House Check Cotton for 2009.

Measurement	Count	Mean	Std. Dev.	C.V.
SFI	35574	10.2	0.964	9.42
L/UI SF	35574	10.0	0.578	6.18
Length (in.)	35574	1.112	0.0134	1.21
Unif. Index	35574	81.7	0.627	0.77
No. of instruments (HVI 1000's): 40 Approximate no. of tests per HVI: 875				

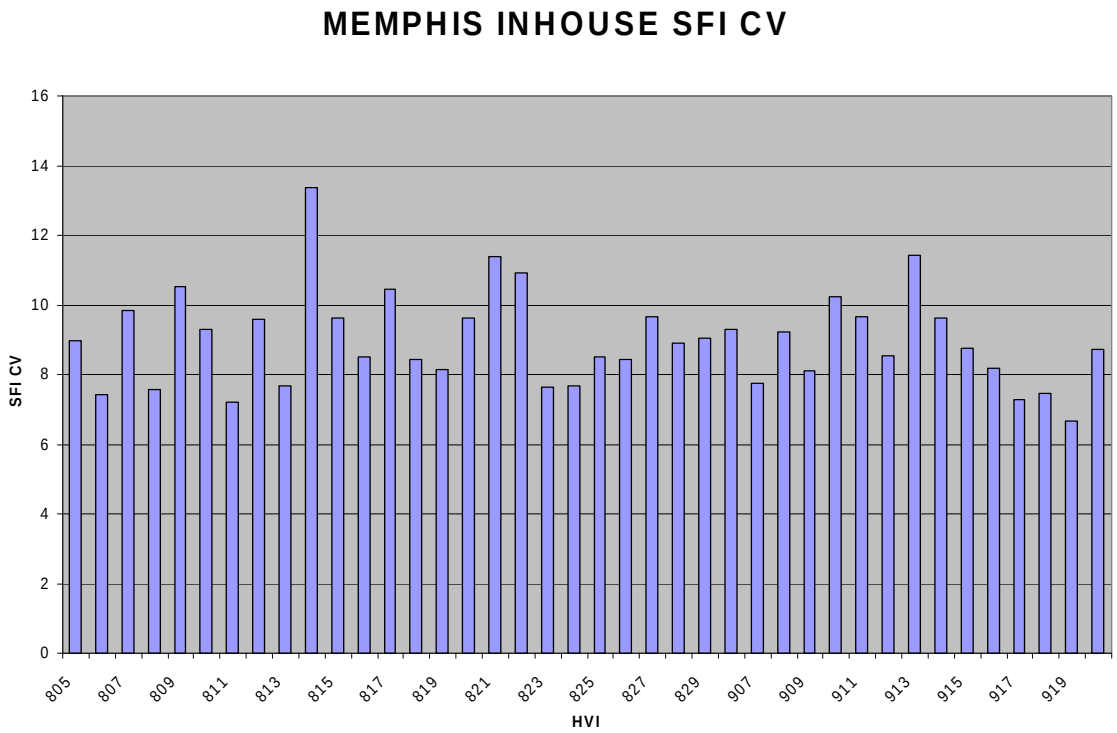

Figure 6. SFI CV by HVI 1000 instrument on Memphis Classing Office In-House Check Cotton over the 2009 cotton classing season. Approximately 875 tests per instrument.

SFI Between Lab Reproducibility

Table IV gives a summary of the SFI reproducibility between USDA classing offices and the USDA Quality Assurance (QA) lab in Memphis. Approximately 1 % of all samples classed in the USDA's classing offices are randomly selected and sent to Memphis for retesting in QA. Samples are tested on two different HVI's in QA and the two results are averaged. The averaged QA result is then compared to the classing office result. For SFI, if the classing office result is within +/- 1.0 of the QA result, the measurement is considered reproducible. Table IV shows the average reproducibility results for the nine classing offices that participated in the 2009 SFI evaluation. Reproducibility results ranged from 46.4% to 65.9% with an overall average of 56.2%. As expected, classing offices with the longest cottons had the best SFI reproducibility. For comparison, the L/UI predicted short fiber (based on the equation given previously) was calculated. The reproducibility of the L/UI predicted short fiber ranged from 61.5% to 78.8% with an overall average of 69.2%. Measurement biases between the classing offices and QA are also given.

Table IV. 2009 Between USDA Lab Reproducibility (Classing Offices versus QA Lab in Memphis).

		SFI	SFI	L/UI Predicted	L/UI Predicted
	Sample	Repro.		SF Repro.	SF
Classing Lab	Count	(+/- 1.0)	Bias	(+/- 1.0)	Bias
Florence	7044	59.2	0.40	74.3	0.02
Macon	11192	56.4	-0.29	64.0	0.01
Rayville	2794	52.2	-0.45	61.5	-0.15
Dumas	5583	46.4	0.43	67.8	0.07
Memphis	14086	53.5	0.59	74.6	0.10
Abilene	6020	53.8	0.12	64.2	0.03
Lamesa	6700	57.6	0.10	70.3	-0.04
Lubbock	16454	60.4	-0.02	67.4	0.06
Visalia	3876	65.9	-0.08	78.8	-0.03
Overall	73749	56.2	0.1	69.2	0.0

Conclusion

An accurate, commercially suitable short fiber measurement continues to be difficult to find. The HVI does a good job in the longer length measurements of upper-half-mean length and uniformity index, but measuring fibers at the short end of the scale is challenging. High speed instruments used for marketing purposes, the length and uniformity index measurements appear to be the best short fiber indicators available for now. Alternative short fiber measurement definitions, such as relative short fiber (Heap, 2004) and lower-half-mean length (Cui, 2009), have been proposed, but have yet to be applied or studied in regards to the HVI length distribution.

References

Cui, X. 2009. The Advantage of Lower Half Mean Length in Characterizing Short Fibers. Beltwide Cotton Conference Proceedings. Pp. 1227-1228.

Heap, S.A. 2004. Relative Short Fiber Content. Proceedings of International Cotton Conference. Bremen, Germany.

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