# TEXTILE TOPICS

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

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## TEXAS INTERNATIONAL COTTON SCHOOL



The October 2003 Texas International Cotton School included the following participants:

Front row:  Ejaz-ul-Murtaza, Manama Textile Mills WLL, Kingdom of Bahrain; Cheng Wang, ACG Cotton Marketing LLC, China;  Mary York, Texas Department of Agriculture, Austin, TX; Mandy Howell, Coordinator;  Anne Canavvan, Plexus Cotton, Ltd., United Kingdom;  Melissa Graehling, Assistant Coordinator;  Tara Ponds, U.S. Department of Agricultire - Risk Management Agency, Missouri;  Selim Makzume, ECOM USA, Texas.

Second Row:  Feroz Alam, Youth Spinning Mills, Bangladesh;  Ernest Harmon, Texas Department of Criminal Justice, Texas;  Kirk Watson, ACG Cotton Marketing LLC, Texas;  Sheraz Eaqar, California Cotton Company, Texas;  Harvey Case, C.T.I., Texas;  Jason Coleman, Wells Fargo Bank, Texas;  Hakan Akay, Gap Pazarlama A.S., Turkey;  Jonas Kwakye, Afristyle Textile & Garment Industry, Ltd., Ghana.

Third Row:  Chul Ho Jeong, Kukil Spinning Co., Ltd. Korea;  Srinivasa Rao, Asian Cotton Mills, Sri Lanka; Dane Degan, ECOM USA, TX.

## ITC TRAVEL

- Eric Hequet to Memphis, TN, October 5.6.  Gave a presentation to the 2003 Fall Meeting of the National Cotton Council Quality Task Force, October 5-6.
- Dean Ethridge and Eric Hequet to Europe, October 18-27. Visited the ENSITM, University of Mulhouse, France; the Institute of Textile Technology and Process Engineering Denkendorf, Germany; Reutlingen University, Germany; and the International Textile Machinery Association's 14th International Exhibition of Textile Machinery, Birmingham, United Kingdom.
- Eric Hequet to Raleigh, N.C., November 12-13.  Gave a presentation at the American Association Textile Chemist & Colorist (AATCC) fall committee meetings.

# MICRO-SPINNING FOR EARLY EVALUATION OF COTTON FIBERS: PRELIMINARY RESULTS

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*Dean Ethridge*

## INTRODUCTION

Laboratory-scale spinning methodology using micro-carding, micro-drawing and micro-spinning has been reported in multiple instances in the literature as the method used for cotton quality potential assessment (Frydrych *et al.*, 1995; Frydrych and Dréan, 2000). This procedure allows production of yarn and eventually fabric from small fiber samples (50g). The possibility of producing yarn from such a small quantity of fibers is useful to cotton geneticists and biotechnologists, because it permits an early indicator of the textile use-value of experimental varieties. For this reason the International Textile Center (ITC) has assembled a laboratory-scale spinning (or a micro-spinning) system to use in conjunction with the available full-scale spinning equipment. This paper presents a preliminary report on results of optimization and validation trials conducted on the micro-spinning equipment.

## MATERIALS AND METHODS

The ITC micro-spinning system includes (Figure 1):
* a Platt mini-card with the flats removed (to function as an opening device),
* a Platt mini-card fully equipped for carding action,
* a Platt mini-drawframe, and
* a 6-spindle SKF Lab-spinner ring spinning frame that is modified for sliver-to-yarn spinning.



a) Mini-card

b) Miniature draw frame

c) 6-spindle SKF Lab-Spinner

**Figure 1: Micro Spinning equipment**
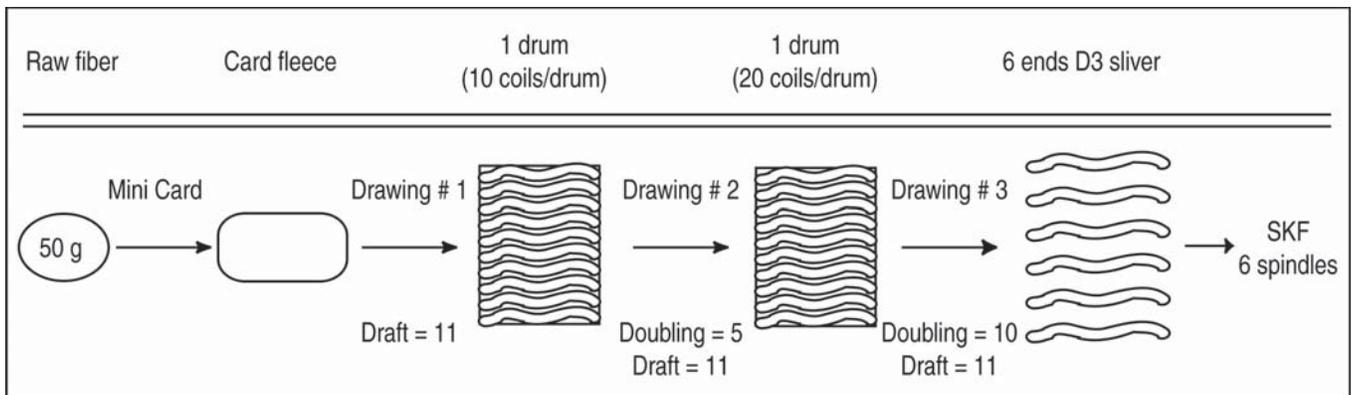
**Figure 2: Schematized micro-spinning operating protocol**

A schema of the operating protocol is given in Figure 2. After manual opening and blending, the cotton is opened through the mini-card without flats, resulting in an opened fiber fleece with large impurities removed. The fiber fleece is then put through the second, fully equipped mini-card to produce a normal card web. The web is collected on the take-up drum in the form of a card fleece. Three passages on the draw frame are then performed. The first is to transform the card fleece into a sliver. The second and third drawing passages are performed to execute doubling and fiber alignment operations similar in principle to the industrial drawing. Six sliver ends weighting approximately 35 grains/yard (2.5 ktex) are produced at the last drawing passage. These are used to feed the SKF Lab-spinner (Figure 1, Figure 2). The spinning frame was modified and adapted for high drafts (100 – 130) to allow the sliver-to-yarn operation. The process is meant to simulate the various operations undergone by the fiber in industrial spinning.

The micro-spinning protocol described above was executed on a range of fiber samples taken from commercial bales prior to industrial-scale spinning tests. For these experiments, special care was taken in the sampling procedure. The cotton bales intended for full scale spinning were opened and sampled on 10 layers and on multiple locations within each layer, in order to get fibers in the

micro-spinning sample that were representative of the full-scale spinning samples.

Weave twist 26 Ne yarn was produced on both systems and tested on UT3 for evenness and hairiness parameters, on Uster Tensorapid for tensile properties, and on Trashcam* for the count and size of Seed Coat Fragments (SCF).

# RESULTS AND DISCUSSION

In order to reliably assess the quality potential of the experimental samples using the micro-spinning methodology, it is necessary to achieve a micro-spun yarn which quality is representative of the targeted industrial yarn. Therefore, the different steps in the micro-spinning process have to be optimized in order to maximize correlations between the micro-spun and the full-scale yarn. Presented in the following paragraphs are the relationships between micro-spun and industrial yarn quality parameters achieved after multiple optimization stages.

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*An image-analysis based instrument developed by CIRAD (France) for counting and sizing seed coat fragments in fiber and on yarn samples (Gourlot *et al.*, 1995; Krifa *et al.*, 1998; Frydrych *et al.*, 1999; Hequet *et al.*, 1999; Bachelier and Lassus, 2000; Krifa *et al.*, 2002).

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## Yarn Tensile Properties

Scatter plots showing yarn breaking strength (Figure 3) and elongation at break (Figure 4) relationships between yarns from micro-spinning and full-scale spinning reveal positive and highly significant correlations. While the performance rankings on strength parameters are not always the same between the two systems, the micro-spinning system appears to be adequate for screening "good" versus "poor" performance by cotton fibers. Yarn strength resulting from new genotypes of cotton may not be predicted accurately from existing tests on fiber properties; therefore, adequate ranking by the micro-spinning system for yarn strength may be important.

## Yarn hairiness and Evenness Parameters

It was expected that the correspondence between the micro-spinning and industrial spinning would be worse for yarn hairiness and evenness parameters, simply because the back-processes possible with micro-spinning cannot possibly produce drawframe slivers that are as even as those from the industrial system. The coefficients of correlation summarized in Table 1 reveal a surprisingly high value for the hairiness index, fairly high values for the CV% and thin places and fairly low values for thick places and neps. All the correlation coefficients are highly significant. It should be noted that all counting data were square root transformed for the purpose of this analysis.

Looking closer at results on yarn thick places and neps, Figure 5 shows the scatter plot for thick places and Figure 6 shows the scatter plot for neps with a nep-detection threshold of +200%. In both figures, the equality line was added to facilitate the examination of the scatter plots. Again, the data is square-root transformed to satisfy the linear regression assumptions.

| Yarn property | Correlation coefficient | Probability |
|---|---|---|
| **Hairiness index** | 0.92 | < 0.001*** |
| **CV%** | 0.76 | < 0.001*** |
| **Thin places** | 0.80 | < 0.001*** |
| **Thick places** | 0.59 | 0.006** |
| **Neps +140%** | 0.66 | 0.001** |
| **Neps +200%** | 0.64 | 0.002** |
| **Neps +280%** | 0.69 | < 0.001*** |

** significant at $\alpha$=0.01, *** significant at $\alpha$=0.001.

**Table 1: Correlation between micro-spun and industrial-scale yarn evenness parameters**



$r = 0.83, p < .001$
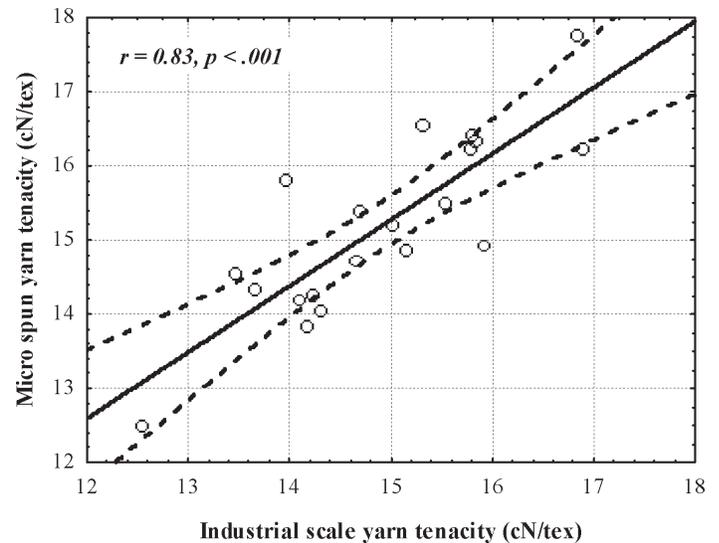
**Figure 3: Relationship between micro-spun and full-scale yarn strength**



$r = 0.94, p < .001$
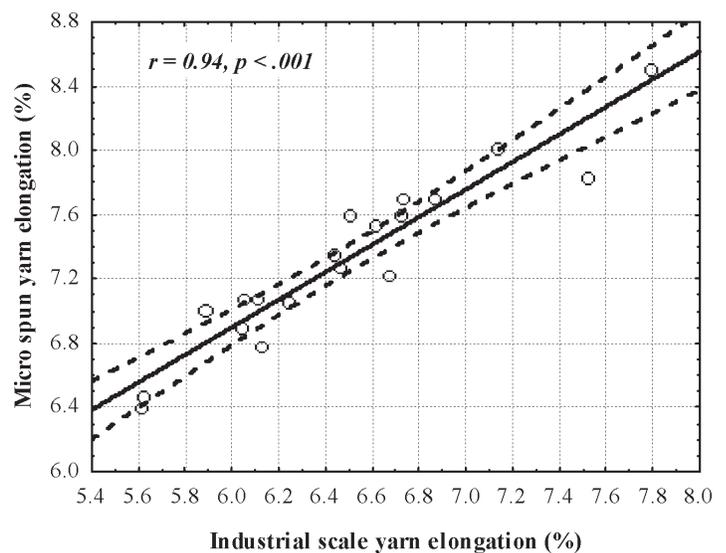
**Figure 4: Relationship between micro-spun and full-scale yarn elongation**
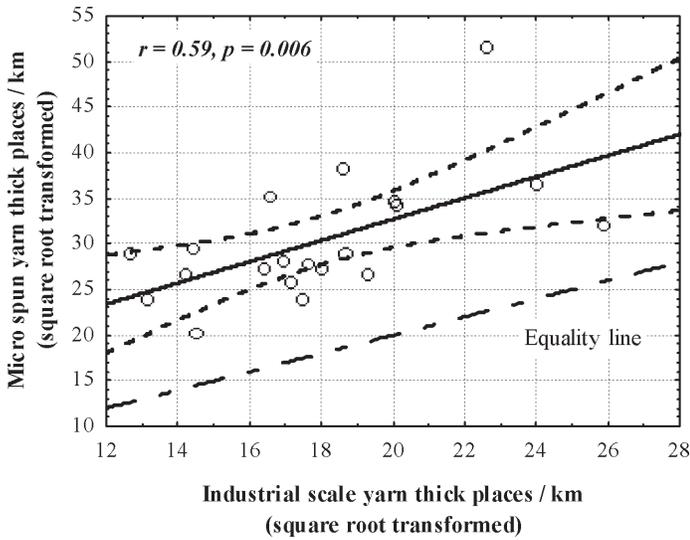
**Figure 5:** Relationship between micro-spun and full-scale yarn thick places



**Figure 6:** Relationship between micro-spun and full-scale yarn neps +200%

The level shifts observed in Figures 5 and 6 are expected and do not present problems. The dispersion is greater than desired (as expected, due to the lower correlation coefficients), which means that the performance rankings of fibers on the two systems will differ more than desired. The nep-detection threshold of +200% (Figure 6) is commonly used in the textile industry. It is worthwhile, however, to compare these results

with those using mass-variation thresholds of +140% and +280%. When this was done, it became apparent that the level shifts were different for the different thresholds on both the micro-spinning system and the industrial spinning system. This is revealed in Figure 7 using three intervals of yarn mass variation: between 140% and 200%, between 200% and 280%, and greater than 280%.
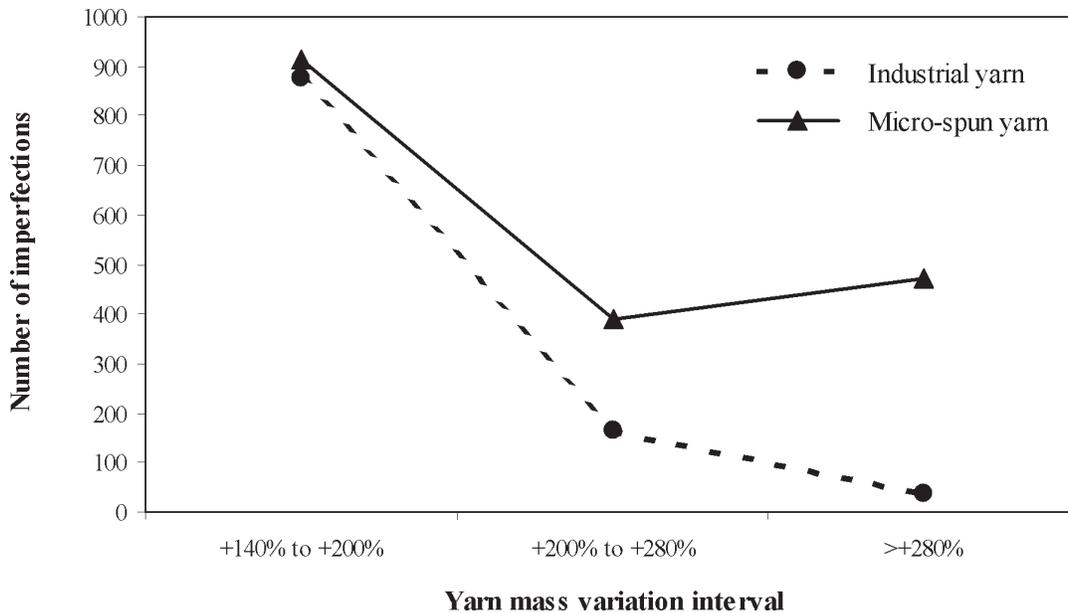


**Figure 7:** Micro-spun and industrial yarn nep counts depending on the mass variation interval

These results show the following:

- The numbers of neps detected were almost equal for the two systems when using a mass-variation interval of +140% to +200%.
- In the +200% to + 280% interval, neps detected declined significantly on both systems, but relatively less on the micro-spinning system.
- Going to the +280% threshold resulted in a further modest decline in the neps detected by the industrial system, but a modest increase in detection for the micro-spinning system.

Yarn Seed Coat Fragments

The yarn CV% and especially thin places are mainly related to drafting defects. However, thick places and neps are greatly affected by impurities present in the fiber. Among these impurities, Seed coat fragments (SCF) are generally most prevalent in the yarn, due to the great difficulty of removing them during the opening and cleaning operations (Krifa *et al.*, 1999; 2000; 2002).

Given the reduced capability for cleaning impurities with the micro-spinning system versus the industrial system, it is possible that the behavior previously observed for the neps could be related to the differences between the contamination of the fibers that are delivered to the spinning machines. To evaluate this, all the yarns spun on each system were tested on the Trashcam, in order to measure both the number and size distribution of seed coat fragments.

As shown in Figure 8, the correlation between the two counts is highly significant.  As expected, a much higher level of seed coat neps are found in the micro-spun yarns, but the system can effectively rank the performance of alternative fibers in terms of seed coat fragments. This is an important result, because the seed coat fragments are proven to be variety-related (Pearson, 1955; Mangialardi, 1986; Bachelier and Lassus, 2000). Therefore, adequate quantification of them is important for cotton breeders.
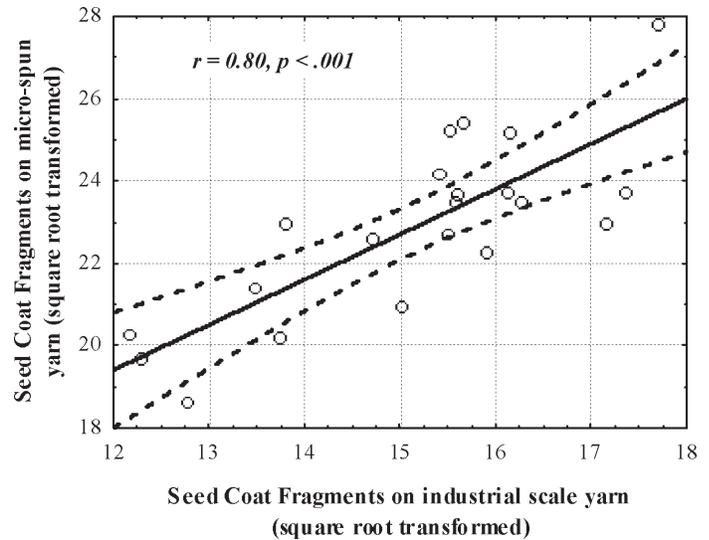


Figure 8:  Relationship between micro-spun and full-scale yarn Seed Coat Fragments

The fact that the micro-spun yarns have larger numbers of SCFs may help explain why they also have larger numbers of neps and thick places than do the industrial yarns.  However, this is of limited use in explaining the behavior of the nep counts with alternative mass-variation thresholds (Figure 7).

In addition to the number of SCFs, the size distribution is an important factor affecting yarn defects. Comparative data on the size distribution of SCFs in this study is depicted on Figure 9. The chart consists of cumulative probability densities plotted against the SFC sizes (expressed in mm$^2$). Given the exponential-like pattern of the distribution, the probability axis is expressed on a logarithmic scale. The straight lines represent exponential fits adjusted to each data series. It is clear from Figure 8 that there is a major difference between the size distribution of the SCFs detected on the micro-spun yarns versus the industrial yarns. The latter distribution consists of much smaller particles. This makes sense, because the industrial opening-cleaning and carding processes would be expected to both (1) remove more fragments and (2) break up the fragments into smaller pieces. This phenomenon applies especially to the cleaning action of the card (Krifa *et al.*, 2002).
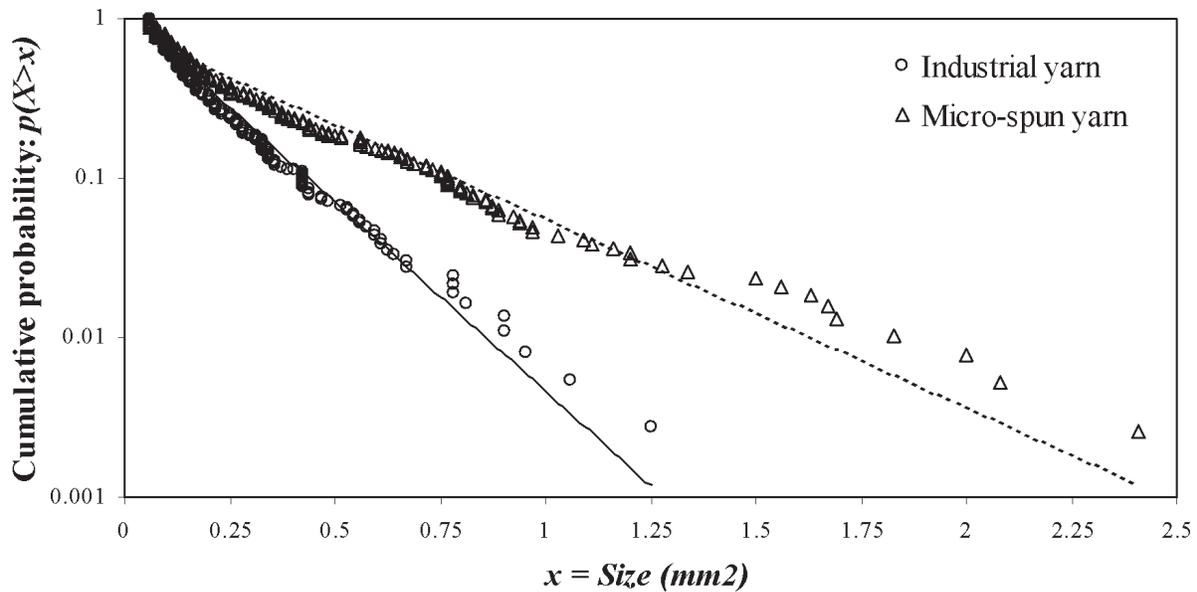
**Figure 9: Seed Coat Fragments size distribution for micro-spun and industrial yarns.**

The SCFs contribute toward multiple types of yarn defects, depending on their size. Larger SCFs are likely to be detected at higher thresholds by the capacitive evenness tester, while smaller ones are detected at lower thresholds, and sometimes not detected at all if they are too small to reach any of the thresholds. Therefore, since the micro-spun yarn contains much larger SCFs than the industrial one, the evenness defects related to these impurities are more likely to be detected by the capacitive evenness tester. Moreover, they are likely to be detected at higher mass variation thresholds. Thus, these impurities will translate into more defects, as detected by the capacitive evenness tester, on the micro-spun yarn than on the industrial yarn, and the difference will be more substantial as higher mass variation thresholds are considered. For all the foregoing reasons, these differing size distributions of SCFs for micro-spinning versus industrial spinning are important for explaining the behavior of the nep counts with varying mass-variation thresholds depicted in Figure 7.

## CONCLUSIONS

The correlation between micro-spun yarn and industrial yarn was highly significant for all yarn quality parameters; however, several yarn properties showed rather dispersed scatter plots. Therefore, the micro-spinning system, as currently configured and used, would result in somewhat different *rankings* of the performance of different cottons. Results indicated that accuracy is quite high for yarn *hairiness,* somewhat lower for *tensile properties*, *CV%* and *thin places*, and much lower for yarn *neps* and *thick places*. Of course additional replications of the trials and measurements would be expected to increase the correlation coefficients. Evaluation of the size distribution of seed coat fragments suggests that these may explain much about the differences in nep counts.

Future work with the micro-spinning system should include:
1.  More experimentation with the opening and cleaning operations in the micro-spinning process,
2.  Careful evaluation of sampling issues and difficulties involved in spinning very small quantities (50g) of fibers, including an assessment of replications needed for adequate results.
3.  Focusing on spinning tests using samples from cotton breeding programs that offer adequate experimental designs (i.e., multiple varieties, multiple locations and adequate replications) for validation of the results obtained.

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