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# Harmonization of Rapid Machine Testing of Fiber Quality

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## Introduction

The purpose of this paper is to consider what the requirements are for adequate harmonization of high-volume instrument (HVI) test results. In this context harmonization means "to bring into consonance or accord." More exactly, it means that HVI measurements at diverse locations agree with one another within statistically known and acceptable probabilities.

It is a vastly different challenge to utilize an HVI for process control within a textile mill versus using a global network of HVIs to classify, buy and sell cotton on the world market. HVI machines within companies do not have to be harmonized with other machines outside the companies. Thus, these HVIs do not have to be *accurate* (i.e., provide the 'true value' of the fiber property measured). As long as they are acceptably *precise* (i.e., produce measurements that are 'repeatable'), then the operators of the mill can learn how to advantageously apply the measurements toward the effective utilization of cottons.

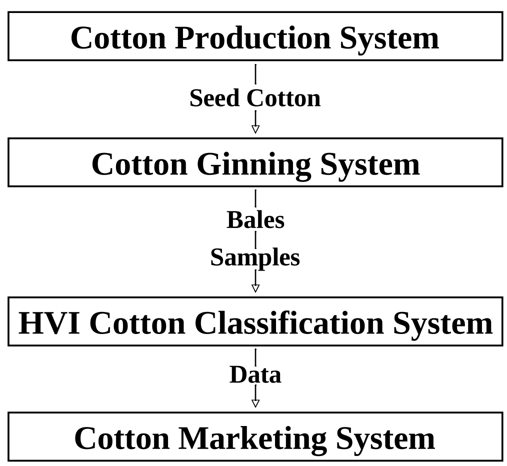
If, however, cotton is to be bought, shipped and paid for based on stipulated values of the fiber properties, then the HVI machines have to be both accurate and precise. The 'official' classification instruments must be the arbiters of what are the 'true values' for fiber properties measured. In an open global market, such authority cannot be mandated; it is a matter of *trust*, which must be earned and justified repeatedly. Therefore, the HVI machines used for official test results must be continuously harmonized with one another over disparate locations and times. Achieving this is both complicated and costly.

## Understanding the HVI and How to Make It Serve a Global Market

The HVI was made possible by applying computerization to the control and delivery of instrument measurements. Before computerization, "high-volume" measurements were fundamentally impossible. The addition of facilitating robotics made sample delivery, preparation and handling of samples go even faster and resulted in fewer errors.

The central question for this paper is:  How can HVI technology be applied over a large geographic area as the basis for buying and selling cotton?  The answer, in summary, is that it requires the imposition of an adequate *system of process and quality controls*.  This system encompasses more than the HVI cotton classification system.  It must extend back toward the cotton production and ginning sectors, through the classification system, and forward toward the cotton fiber market (Figure 1).  Therefore, the system that is developed for different countries or regions of the world must be appropriate for realities existent in the production and marketing sectors.  It may be possible in some cases to alter these controlling realities at the margins, in order to accommodate the system of process and quality controls, but the feasibility of this would have to be evaluated on a case-by-case basis.

**Figure 1.  Sectors Encompassed in a Harmonized HVI System**




The major components of this system of process and quality controls include the following:

- Well engineered and constructed HVIs
- Representative Sampling
- Laboratory conditioning
- Sample conditioning
- Calibration
- Check-tests
- Standards cottons
- Transportation
- Certification and Communication

Discussion of these components is aided by reference to the only large-scale HVI classing system currently in existence, in the United State of America. It bears reemphasizing that the particular approaches used in different parts of the world can, indeed must, be altered to accommodate the structural limitations and differences that exist. However, while the specific approaches to the necessary components may vary, these components cannot be ignored.

Of course, well engineered and constructed HVIs are a 'cornerstone' of a reliable system. The HVI technology is well known, but the quality of the materials and components, along with exacting tolerances of the machining and construction, are critically important. *The central point is that machine error must be minimized, in order that other sources of errors in data generated may be adequately managed.*

The sampling procedures are fundamentally important, for at least two reasons: (1) sample variations are the single largest source of errors in HVI data, and (2) the sample must be *representative* of the larger package of cotton that it is drawn from. In the USA, the large fields and the harvesting and ginning technologies used are conducive to homogeneous, well-blended bale packages. Therefore, it has been determined that an adequately representative sample is obtained by cutting a 115-gram sample from each side of the bale. This ensures detection if the fiber properties are not homogeneous throughout the bale. (In the USA, non-homogeneity will generally occur only if the person harvesting moves to another type of cotton and mixes it in a partially completed seed cotton module.) Procedures to ensure homogeneity would have to be very different if, for example, the fields are typically small, with different cotton varieties, diverse agronomic practices, diverse harvest practices, etc. *The central point is that the sample must be "representative" or the HVI data will be useless.*

Laboratory and sample conditioning procedures deserve a special emphasis for two reasons. First, these are required to achieve *either* accuracy *or* precision in HVI testing. And second, around the world there is a remarkable tendency to fail in meeting this requirement. One apparent cause of this failure is inability to bear the necessary expense. In the U.S., temperature is maintained at 21.1 degrees centigrade, plus or minus 0.6 degree (70°F ± 1°), and relative humidity at 65 percent, plus or minus 2 percent. Doing this requires a sophisticated air conditioning system, a well-insulated building to contain it, and large operation and maintenance expenditures. Without these expenditures, however, the expense to purchase and operate an HVI is wasted.

Another apparent cause of failure to maintain the ambient conditions is lack of appreciation of the sensitivity of test results to conditioning. While not all measurements are sensitive to proper conditioning, some of the most important ones are quite sensitive;

e.g., fiber strength, elongation, length, and length uniformity. Unless the ambient conditions are kept stable, then even a single HVI cannot provide measurements that are repeatable, much less accurate. *The central point is that ambient conditions in diverse laboratories must be kept stable at targeted levels, in order to achieve agreement between measurements produced from them.*

Since cotton fibers will reach equilibrium moisture content under any given ambient conditions, it is necessary for this equilibrium to occur before testing the fibers. In the USA, it has been determined that conditioned samples will have a moisture content between 6.75 and 8.25 percent (dry weight basis). As a matter of standard operating procedure, the samples moving toward the HVI lines for testing are checked to verify that the moisture content falls within this interval.

The time required to achieve equilibrium depends, among other things, on the moisture content of the fibers going into conditioning and the extent of exposure of individual fibers to the ambient conditions. There have been attempts to achieve equilibrium conditioning within air conditioning units incorporated with an HVI, but without success. In the USA, the AMS has found that forcing ambient air from the conditioned room through the cotton fiber samples as they move along an air-permeable feeding line can, if the fibers were put on the line in near-equilibrium condition, adequately condition samples in as little as 10 minutes. Without some 'active conditioning' capability – if 'passive conditioning' is used – the rule-of-thumb is that samples from U.S. cotton bales should be well exposed to the proper ambient conditions for 48 hours before testing. *Regardless of the technologies and procedures used, the central point is that equilibrium moisture content must be achieved if consistent measurements are to be obtained across space and time.*

The calibration and check-test procedures require a designated, centralized quality-control facility. In the USA, this is done at the U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) facility in Memphis, Tennessee. From this centralized facility, top-down guidance about calibration procedures is given to other cotton classing facilities throughout the USA *The central point is that calibration procedures must be adequate and consistent among the satellite HVI facilities.*

In the USA, one percent of cotton samples tested at USDA satellite HVI facilities are randomly selected and air-shipped daily, overnight delivery to Memphis, in order to be tested on the quality-control HVI machines there. Daily check-testing has been found necessary to identify calibration problems and correct them before they become untenable. *The central point is that frequent verification of satellite HVI machines is necessary for adequate quality control.*

Standards cottons are absolutely necessary for meaningful calibration procedures. A designated authority should be the official source of standards cottons. Furthermore, this is one function for which there should be only one authority for the entire world; otherwise, cooperation and collaboration among the different HVI classification systems around the world would be greatly impeded. In the USA and in most other HVI testing facilities around the world, the standards cottons are provided by the USDA, AMS facility in Memphis.

The standards cottons must exhibit very low sample variations; i.e., the fundamental, real-world problem of large natural variations in cotton samples must be systematically alleviated. Lack of homogeneity must be alleviated by careful blending and mixing of the fibers. The more homogeneous the fibers, the less painstaking the blending/mixing will have to be. In past years this was achieved in the USA by searching for relatively homogeneous fibers and applying careful blending/mixing procedures. In recent years, with the advent of modules to bring seed cotton to the gins and automatic module feeders at the gins that vigorously blend the cotton, it has become feasible to find bales that are sufficiently homogeneous to be used as standards cotton without additional blending and mixing. *The central point is that the end result must be standards cottons that are exceptionally homogenous.*

Transportation procedures must be reliable and fast enough for moving the samples of the ginned fibers (1) from the gins or other departure point to the classing facilities and (2) from the classing facilities to the calibration/check-test center. In the U.S., where producers maintain ownership of the cotton after it is ginned, the samples are collected at the gin points. The cotton samples are packaged and labeled as the cotton bales come out of the gin bale press. Trucks under contract with the AMS systematically run designated routes to gins and deliver the collected samples to the classing facilities.

The transportation process for producers' samples is a primary determinant of the locations of classing facilities throughout the USA. The locations must allow for both the production densities and the driving distances existing in the production regions across the country.

As previously mentioned, randomly selected samples are shipped by air transportation to the centralized calibration/check-test center. This is because time is of the essence for maintaining adequate quality control, so that air shipment is a necessary expense.

*For movement from gins to classing facilities, the central point is that the bale record represented by samples must be accurate and delivered in a timeframe that does not interfere with the orderly marketing of the cotton. For movement to a calibration/check-*

*test center, the central point is that samples must be delivered and tested rapidly, in order to maintain the integrity of quality control.*

Certification and communication procedures are indispensable supports for acceptable verification, identity preservation, and efficiency of market transactions. Computerization and telecommunication technologies have revolutionized these components of the system in the USA. At the classing facilities, a bar-coded tag sent with each sample is scanned into the computer database and the data collected on the sample is automatically accumulated in the electronic files, without hand-entry of information. (Exceptions are human classers' determination of leaf grade and extraneous matter, which are entered *one time* by hand.) The result is a combination of high speed, low error rates, and excellent identity preservation that could only be wished for a decade ago. The system is highly reliable, yet does not produce a traditional "paper trail," with paper copies of the information generally occurring only when the owner of the cotton prints it out at his own computer terminal. All these developments have removed substantial costs from the marketing system.

Of course such record keeping and communication of data can be done in a multitude of ways. *The central point is that certification of bale identities and accompanying fiber property data must be reliable and must be communicated in a timely manner.*

## Implications for Globalized HVI Systems

Taken together, the foregoing components of a system of process and quality controls provide indispensable guidance to plan for large-scale harmonization of machine testing of fiber properties. The largest scale possible, of course, is a worldwide scale. But it is quite impossible to make one giant leap and reach a worldwide scale.

The magnitude of the logistical/management issues – especially the timeliness required for reaction and adjustment – immediately recommends that the largest cotton producing countries of the world should first evaluate the establishment of a national HVI cotton classification system, along the lines of that done in the USA. Furthermore, cooperation among these 'large producers' is the most efficient way to achieve a coordinated supranational cotton classification system. Advantages of *national* authorities include the fact that they facilitate funding of capable central authorities (and it is futile to attempt HVI classification without large and sustained funding). Besides funding, national governments can provide an enforceable rule-of-law that cannot be matched in the international arena.

Obviously, the national approach requires that a country produce an amount of cotton that provides economies of scale sufficient to make operation of an HVI classing system cost-effective. For countries with cotton production too small to achieve cost effectiveness with HVI testing, perhaps regional alliances with other countries could be formed to establish sufficient economies of scale. The regulation of the regional authority would be complicated by the lack of a single central government; therefore, it would have a greater need for cooperation with and oversight by an international authority.

It is possible that various national (or regional) authorities could coordinate with one another by engaging in intermittent check-test procedures through a designated international testing program. This might facilitate a supranational 'teamwork' focused on bringing the various systems of process and quality control into better agreement. However, this cooperation would not be a substitute for the frequent check-test procedures that must be executed between the national facility and the satellite HVI stations throughout a country or region.

The structure of national or regional HVI systems must vary according to the national/regional industry structures. For example, in most of the world, cotton producers lose ownership of cotton before it is ginned. They sell the seed cotton before ginning and before HVI testing. Therefore, since the cotton is not sold based on HVI test results, it is not necessary that sampling and reporting of test results be focused at the gin points, as it is in the USA. Both sampling and testing could be done later at one or more collection points in the marketing system. Perhaps these collection points could be at port facilities for cotton exporting countries, which could enable efficient HVI testing on the cotton going into export markets outside the country. (Perhaps domestic users who were interested in HVI results could also source cotton from these collection points.) Such an approach would facilitate the logistical efficiencies and the economies of scale that would make feasible the delivery of harmonized HVI data.

## Conclusion

Nine components that make up an adequate system of process and quality controls for an HVI cotton classification system are the following:

1. Machine error must be minimized by well engineered and constructed HVIs.
2. Cotton samples must be representative of an entire cotton bale.
3. Ambient conditions in diverse laboratories must be kept stable at targeted levels.
4. Equilibrium moisture content must be achieved in the cotton samples before testing.
5. Calibration procedures must be adequate and consistent among the satellite HVI facilities.

6. Calibration of satellite HVIs must be frequently verified by check-tests at central quality-control HVIs.
7. Standards cottons must be exceptionally homogeneous.
8. Bale record represented by samples must be accurate and delivered to HVI facilities within a timeframe that facilitates orderly marketing. Check-test samples going to the centralized quality-control facility must be delivered and tested rapidly.
9. Certification of bale identities and accompanying fiber property data must be reliable and must be communicated in a timely manner.

Given these components that make up an adequate system of process and quality controls, the imperatives of funding, and the realities of training and management, it seems very likely that globalization of HVI classification of cotton must be advanced one country (or, perhaps, region) at a time. The feasible role of an international authority is probably limited to advice, facilitation, and perhaps in some cases a quality-control oversight role. All experience to date tells us that meaningful quality control is a relentless, time-sensitive task, which would make global centralization either too slow or too expensive. If cotton is being tested on a daily basis, then check-testing must be done on a daily basis and the lag between satellite testing and check-testing must be minimized. Otherwise, errors cannot be corrected in a timely manner and the integrity of the data on fiber properties is lost.

Some will argue that harmonization on a level achieved in the USA is not necessary to secure most of the advantages of HVI classification on a global scale. In doing so, they overestimate statistical confidence levels for the USA measurements. A study of these should convince most people that larger margins of error would make some of the important measurements useless to the global textile industry.

The underlying assumption of those who propose a relaxing of the harmonization requirements is usually that the accuracy of the data can be routinely challenged and adjudicated with the use of an established retesting procedure. Unfortunately for the seller of the cotton, this approach would add a new and unacceptable amount of risk to his business. Ultimately, if buyers of the cotton are unwilling to buy based on the authority of relevant HVI data, then the sellers will be unwilling to sell based on these data.