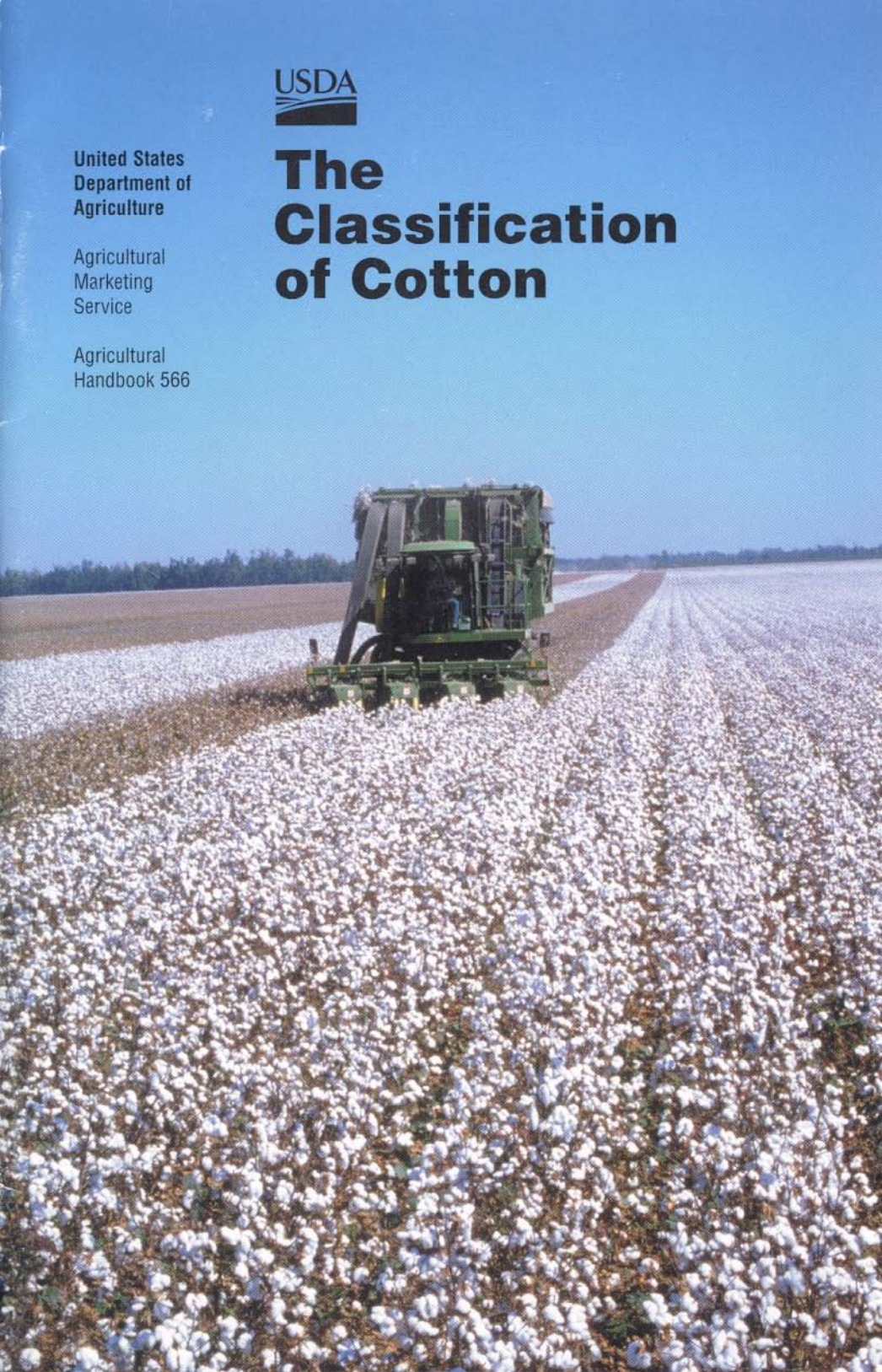
USDA

United States Department of Agriculture

Agricultural Marketing Service

Agricultural Handbook 566

# The Classification of Cotton



USDA

# The Classification of Cotton

Agricultural Handbook 566

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## Contents

## I. Introduction

In 1907, an international group of cotton industry representatives met in Atlanta, Georgia, to address serious problems that had developed in the marketing of cotton. A resolution was passed which recommended the establishment of uniform cotton standards to "eliminate price differences between markets, provide a means of settling disputes, make the farmer more cognizant of the value of his product, and, therefore, put him in a better bargaining position, and in general be of great benefit to the cotton trade." In response to this and similar calls for action over the next several years, laws were passed authorizing the United States Department of Agriculture (USDA) to develop cotton grade standards and offer cotton classification services. Thus began an industry-government relationship which remains strong and viable to this day. This long-standing partnership demonstrates how government and industry can work together, each respectful of the other's role, to produce continuing beneficial results for the nation, and for its customers abroad.

## II. Overview

### Nature of Cotton

Botanically, there are three principal groups of cotton that are of commercial importance. The first, Gossypium hirsutum, is native to Mexico and Central America and has been developed for extensive use in the United States, accounting for more than 95 percent of U.S. production. This group is known in the United States as American Upland cotton, and varies in length from about 7/8 inch to 1-5/16 inches. A second botanical group, G. barbadense, which makes up the balance of U.S. production, is of early South American origin. Varying in length from 1-1/4 inches to 1-9/16 inches, it is known in the United States as American Pima, but is also commonly referred to as Extra Long Staple (ELS) cotton. A third group, G. herbaceum and G. arboreum, embraces cottons of shorter length, 1/2 to 1 inch, that are native to India and Eastern Asia. None from this group is grown in the United States.

*USDA operates 12 cotton classing facilities strategically located across the Cotton Belt. The facilities are specifically designed to use high volume instrument (HVI) classification. Temperature and humidity inside the facilities are tightly controlled to ensure accurate and precise measurement of all samples.*

In a single pound of cotton, there may be 100 million or more individual fibers. Each fiber is an outgrowth of a single cell that develops in the surface layer of the cotton seed. During the early stages of its growth, the fiber elongates to its full length as a thin-walled tube. As it matures, the fiber wall is thickened by deposits of cellulose inside the tube, leaving a hollow area in the center. When the growth period ends and the living material dies, the fiber collapses and twists about its own axis.

### Classification

The term "cotton classification" in this publication refers to the application of standardized procedures developed by USDA for measuring those physical attributes of raw cotton that affect the quality of the finished product and/or manufacturing efficiency. USDA classification currently consists of determinations of fiber length, length uniformity, strength, micronaire, color, preparation, leaf and extraneous matter. Research and development for the technology to rapidly measure other important fiber characteristics, such as maturity, stickiness and short fiber content, continues.

### Authority

USDA cotton classification services are authorized by the U.S. Cotton Statistics and Estimates Act, the U.S. Cotton Standards Act, and the U.S. Cotton Futures Act. All users of the services are charged fees to recover the classification costs.

### Scope

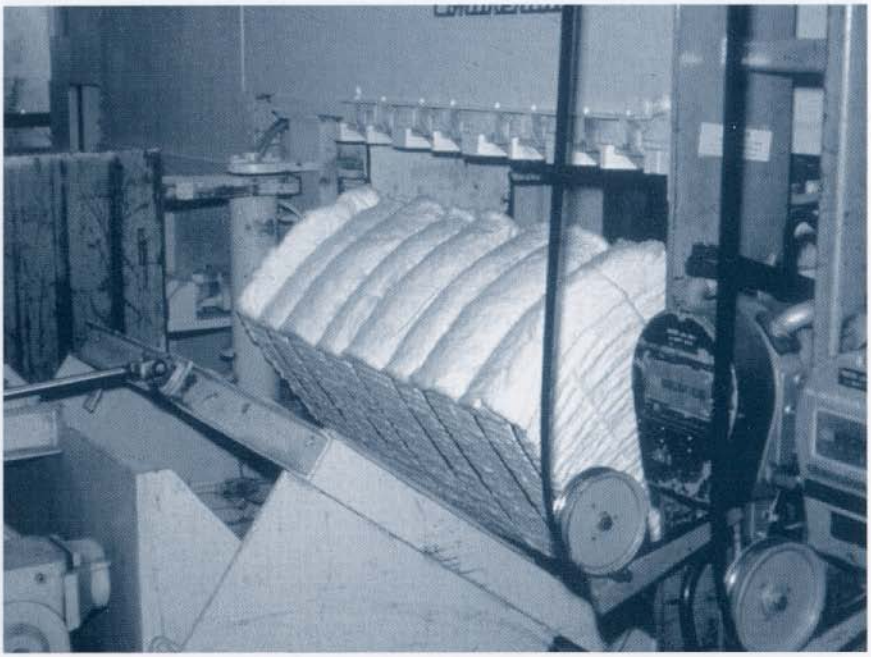
Practically all cotton grown in the United States is classed by USDA at the request of producers. While classification is not mandatory, growers generally find it essential to marketing their crop and for participation in the USDA price support program. USDA also classes all cotton tendered for delivery on futures contracts on the New York Cotton Exchange and provides arbitration classing to the industry. Classification services also are provided to individual buyers, manufacturers, breeders, researchers, and others upon request.

### Facilities

USDA operates 12 cotton classing facilities across the Cotton Belt. The facilities are designed specifically for cotton classification and are staffed exclusively with USDA personnel. Their locations are shown inside the back cover.

### Sampling

At the gin, cotton fibers are separated from the seed, cleaned to remove plant residue and other foreign material, and pressed into bales of about 500 pounds.



*After the cotton fibers are separated from the seed, cleaned to remove plant residue and other foreign material, and pressed into bales at the gin, a 4-ounce sample is taken from each side of the bale by a licensed sampling agent and forwarded to USDA for official classification.*

A sample of at least 4 ounces (115 grams) is taken from each side of the bale by a licensed sampling agent and the 8-ounce (230 grams) total sample is delivered by the agent or designated hauler to the USDA classing facility serving the area. Gin and warehouse operators serve as licensed sampling agents and perform this function under USDA supervision.

### Sample Processing

Upon arrival at the USDA classing facility, samples are conditioned to bring the moisture content to specified ranges before the classing process begins (see Sample Conditioning on page 17). Samples are delivered to classing stations by conveyor. Fiber measurement results are electronically sent to the classing facility's computerized data base and are immediately available to the customer. The classing process stays abreast of the ginning of the crop, providing producers and buyers with crucial quality information at the time of sale. At the peak of the season, USDA classes and provides data on as many as 2 million bales per week, nationwide. Sample remnants are sold by USDA, with proceeds applied to classification costs.

### Classing Methodology

USDA's classing methodology is constantly updated to include state-of-the-art methods and equipment to provide the cotton industry with the best possible quality information for marketing and processing. The system is rapidly moving from reliance on the human senses to the utilization of high-volume, precision instruments which perform quality measurements in a matter of seconds. USDA will complete the transition to all-instrument classification as quickly as the technology can be developed and instruments are sufficiently refined.

### Dissemination of Data

Cotton classification data are available to producers or their authorized agents through computer-to-computer telecommunications, diskettes, tapes, and computer-generated printed documents. The most popular method of dissemination is telecommunications, because it gives the customer immediate access to data upon classification. The data are available to subsequent owners of the cotton, primarily merchants and manufacturers, through a computerized central data base. This data base is accessible by telecommunications and contains classification data for the current and past year's crop. Access to the classification data is limited to the current owner of the cotton.

*Samples are collected from sampling points, usually on a daily basis, and delivered to the USDA classing facility serving the area.*

## III. Classification of Upland Cotton

### A. Instrument Determinations

Measurements for the following quality factors are performed by precise High Volume Instruments, commonly referred to as "HVI" classification.

### Fiber Length

Fiber length is the average length of the longer one-half of the fibers (upper half mean length). It is reported in both 100ths and 32nds of an inch (see conversion chart below). It is measured by passing a "beard" of parallel fibers through a sensing point. The beard is formed when fibers from a sample of cotton are grasped by a clamp, then combed and brushed to straighten and parallel the fibers.

Fiber length is largely determined by variety, but the cotton plant's exposure to extreme temperatures, water stress, or nutrient deficiencies may shorten the length. Excessive cleaning and/or drying at the gin may also result in shorter fiber length. Fiber length affects yarn strength, yarn evenness, and the efficiency of the spinning process. The fineness of the yarn that can be successfully produced from given fibers is also influenced by the length of the fiber.

**Upland Length Conversion Chart**

| *Inches* | *32nds* | *Inches* | *32nds* |
|---|---|---|---|
| 0.79 & shorter | 24 | 1.11 - 1.13 | 36 |
| 0.80 - 0.85 | 26 | 1.14 - 1.17 | 37 |
| 0.86 - 0.89 | 28 | 1.18 - 1.20 | 38 |
| 0.90 - 0.92 | 29 | 1.21 - 1.23 | 39 |
| 0.93 - 0.95 | 30 | 1.24 - 1.26 | 40 |
| 0.96 - 0.98 | 31 | 1.27 - 1.29 | 41 |
| 0.99 - 1.01 | 32 | 1.30 - 1.32 | 42 |
| 1.02 - 1.04 | 33 | 1.33 - 1.35 | 43 |
| 1.05 - 1.07 | 34 | 1.36 & longer | 44 & longer |
| 1.08 - 1.10 | 35 | | |

**Length Uniformity**

Length uniformity is the ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage. If all of the fibers in the bale were of the same length, the mean length and the upper half mean length would be the same, and the uniformity index would be 100. However, there is a natural variation in the length of cotton fibers, so length uniformity will always be less than 100. The following table can be used as a guide in interpreting length uniformity measurements.

Length uniformity affects yarn evenness and strength, and the efficiency of the spinning process. It is also related to short fiber content (fiber shorter than one-half inch). Cotton with a low uniformity index is likely to have a high percentage of short fibers. Such cotton may be difficult to process and is likely to produce low-quality yarn.

| *Degree of Uniformity* | *HVI Length Uniformity Index (Percent)* |
|---|---|
| Very High | Above 85 |
| High | 83 - 85 |
| Intermediate | 80 - 82 |
| Low | 77 - 79 |
| Very Low | Below 77 |

**Fiber Strength**

Strength measurements are reported in terms of grams per tex. A tex unit is equal to the weight in grams of 1,000 meters of fiber. Therefore, the strength reported is the force in grams required to break a bundle of fibers one tex unit in size. The following tabulation can be used as a guide in interpreting fiber strength measurements.

Strength measurements are made on the same beards of cotton that are used for measuring fiber length. The beard is clamped in two sets of jaws, one-eighth inch apart, and the amount of force required to break the fibers is determined. Fiber strength is largely determined by variety. However, it may be affected by plant nutrient deficiencies and weather.

There is a high correlation between fiber strength and yarn strength. Also, cotton with high fiber strength is more likely to withstand breakage during the manufacturing process.

| *Degree of Strength* | *HVI Strength (grams per tex)* |
|---|---|
| Very Strong | 31 & above |
| Strong | 29 - 30 |
| Average | 26 - 28 |
| Intermediate | 24 - 25 |
| Weak | 23 & below |

**Micronaire**

Micronaire is a measure of fiber fineness and maturity. An airflow instrument is used to measure the air permeability of a constant mass of cotton fibers compressed to a fixed volume. The chart below can be used as a guide in interpreting micronaire measurements.

Micronaire measurements can be influenced during the growing period by environmental conditions such as moisture, temperature, sunlight, plant nutrients, and extremes in plant or boll population.

Fiber fineness affects processing performance and the quality of the end product in several ways. In the opening, cleaning, and carding processes, low micronaire, or fine-fiber, cottons require slower processing speeds to prevent damage to the fibers. Yarns made from finer fiber result in more fibers per cross-section, which in turn produces stronger yarns. Dye absorbency and retention varies with the maturity of the fibers. The greater the maturity, the better the absorbency and retention.

**Relationship of Micronaire Readings to Market Value**

*Utilizing the latest technology and equipment, samples are classed on an assembly-line arrangement with fiber measurement results electronically transmitted to the classing facility's computerized data base.*

### Color Grade

The color grade is determined by the degree of reflectance (Rd) and yellowness (+b) as established by the official standards and measured by the HVI. Reflectance indicates how bright or dull a sample is and yellowness indicates the degree of color pigmentation. A three-digit color code is used. The color code is determined by locating the point at which the Rd and +b values intersect on the Nickerson-Hunter cotton colorimeter diagram for Upland cotton (see Exhibit A on page 21).

The color of cotton fibers can be affected by rainfall, freezes, insects and fungi, and by staining through contact with soil, grass, or the cotton plant's leaf. Color also can be affected by excessive moisture and temperature levels while cotton is being stored, both before and after ginning.

As the color of cotton deteriorates due to environmental conditions, the probability for reduced processing efficiency is increased. Color deterioration also affects the ability of fibers to absorb and hold dyes and finishes.

There are 25 official color grades for American Upland cotton, plus five categories of below-grade color, as shown in the tabulation below. USDA maintains physical standards for 15 of the color grades. The others are descriptive standards.

**Color Grades of Upland Cotton Effective 1993**

| | *White* | *Light Spotted* | *Spotted* | *Tinged* | *Yellow Stained* |
|---|---|---|---|---|---|
| Good Middling | 11* | 12 | 13 | -- | -- |
| Strict Middling | 21* | 22 | 23* | 24 | 25 |
| Middling | 31* | 32 | 33* | 34* | 35 |
| Strict Low Middling | 41* | 42 | 43* | 44* | -- |
| Low Middling | 51* | 52 | 53* | 54* | -- |
| Strict Good Ordinary | 61* | 62 | 63* | -- | -- |
| Good Ordinary | 71* | -- | -- | -- | -- |
| Below Grade | 81 | 82 | 83 | 84 | 85 |

*Physical Standards. All others are descriptive.

### Trash

Trash is a measure of the amount of non-lint materials in the cotton, such as leaf and bark from the cotton plant. The surface of the cotton sample is scanned by a video camera and the percentage of the surface area occupied by trash par-

ticles is calculated. Although the trash determination and classer's leaf grade are not the same, there is a correlation between the two as shown in the table below.

### B. Classer Determinations

Although the USDA provides a comparable HVI trash measurement, the traditional method of classer determinations for leaf grade and extraneous matter remains as part of the official USDA cotton classification.

### Leaf Grade

The classer's leaf grade is a visual estimate of the amount of cotton plant leaf particles in the cotton. There are seven leaf grades, designated as leaf grade "1" through "7," and all are represented by physical standards. In addition, there is a "below grade" designation which is descriptive.

Leaf content is affected by plant variety, harvesting methods, and harvesting conditions. The amount of leaf remaining in the lint after ginning depends on the amount present in the cotton prior to ginning, and on the type and amount of cleaning and drying equipment used. Even with the most careful harvesting and ginning methods, a small amount of leaf remains in the cotton lint.

From the manufacturing standpoint, leaf content is all waste, and there is a cost factor associated with its removal. Also, small particles cannot always be successfully removed and these particles may detract from the quality of the finished product.

**Relationship of trash measurement to classer's leaf grade**

| *Trash Measurement (4-yr. Avg.) (% area)* | *Classer's Leaf Grade* |
|---|---|
| 0.13 | 1 |
| 0.20 | 2 |
| 0.34 | 3 |
| 0.51 | 4 |
| 0.72 | 5 |
| 1.00 | 6 |
| 1.25 | 7 |
| 1.57 | 8 |

### Preparation

"Preparation" is a term used to describe the degree of smoothness or roughness of the ginned cotton lint. Various methods of harvesting, handling, and ginning cotton produce differences in roughness or smoothness of preparation that sometimes are very apparent. Abnormal preparation in Upland cotton has greatly diminished in recent years due to improvements in harvesting and ginning practices, and now occurs in less than one-half of 1 percent of the crop. If the cotton has abnormal preparation, that notation is shown under Extraneous Matter on the classification record.

### Extraneous Matter

Extraneous matter is any substance in the cotton other than fiber or leaf. Examples of extraneous matter are bark, grass, spindle twist, seedcoat fragments, dust, and oil. The kind of extraneous matter, and an indication of the amount (light or heavy), are noted by the classer on the classification document.

## IV. Classification of American Pima Cotton

Classification procedures for American Pima cotton are similar to those for American Upland cotton, including the use of HVI measurements. The most significant difference is that the American Upland color grade is determined by instrument measurement, while the American Pima color grade is still determined by highly trained cotton classers. Different grade standards are used because the color of American Pima cotton is a deeper yellow than that of Upland (see exhibit B, American Pima colorimeter diagram on page 22). Also, the ginning process for American Pima cotton (roller ginned) is not the same as for Upland (saw ginned). The roller gin process results in an appearance that is not as smooth as that obtained with the saw ginned process.

There are six official grades (grades "1" through "6") for American Pima color and six for leaf. All are represented by physical standards. There is a descriptive standard for cotton which is below grade for color or leaf. A different chart is used to convert American Pima fiber length from 100ths of an inch to 32nds of an inch. This chart is below.

**American Pima Length Conversion Chart**

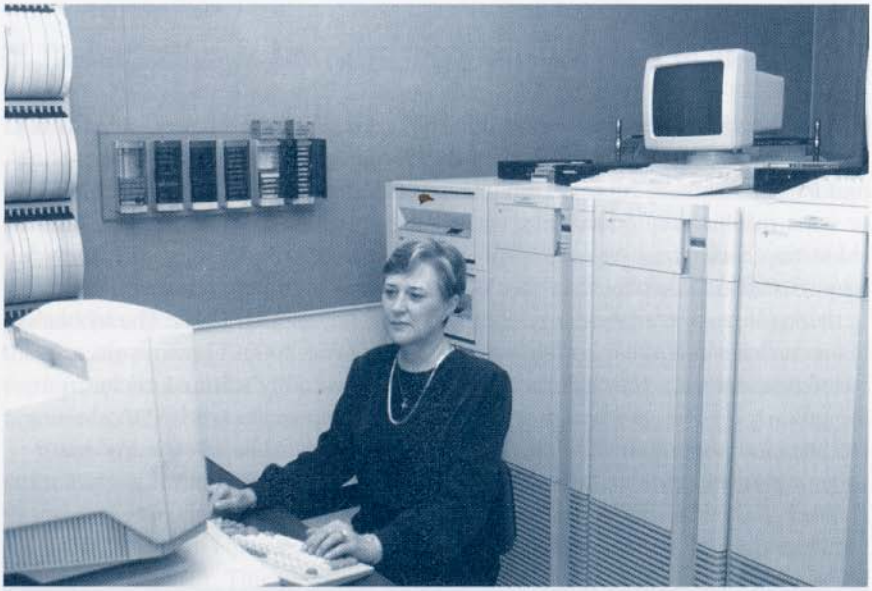
| *Inches* | *32nds* |
|---|---|
| 1.20 and lower | 40 |
| 1.21 - 1.25 | 42 |
| 1.26 - 1.31 | 44 |
| 1.32 - 1.36 | 46 |
| 1.37 - 1.42 | 48 |
| 1.43 - 1.47 | 50 |
| 1.48 and above | 52 |

## V. Reliability of Classification Data

The reproducibility of classing results from one USDA facility to another is the measure used by USDA to determine the reliability of the data it produces. Laboratory-to-laboratory reproducibility is more difficult to achieve than within-lab or same-machine reproducibility, because it is more difficult to maintain identical testing conditions. A comparison of laboratory-to-laboratory results provides a more realistic assessment of the degree of reproducibility that can be expected in the manufacturer's laboratory after shipment to the textile mill. The tabulation below reflects USDA lab-to-lab reproducibility as of 2000. These results are based on more than 100,000 checklot samples, randomly selected, daily, from the production of each instrument line and each classer at each USDA classing facility throughout the 2000 season and retested at the agency's Quality Assurance unit in Memphis.

**Lab-to-Lab Reproducibility of Classing Results 2000 Crop**


*Results were obtained with permitted tolerances of: Length, 0.02 inches; Length Uniformity, 1.0 percent; Strength, 1.5 g/tex; Micronaire, 0.1 units; Color Rd, 1.0 units; Color +b, 0.5 units; Trash, 0.1 percent area.*



*Classification results, maintained by the local classing facility on a computerized data base, are available to growers or their agents immediately upon classification. The standard means of data dissemination is by computer-to-computer telecommunications. Individual bale data is available only to the current owner of the cotton. Upon acquiring title to the cotton, merchants and manufacturers may obtain the data from the Central Data Base.*

## VI. Quality Control

### Process Control

Process control studies of classing equipment operated by USDA are carried out periodically to determine the overall capability of the equipment with regard to accuracy. In turn, the study results are used to establish tolerance limits for measurement variations.

### Equipment Performance Specifications

Minimum performance specifications of classing equipment are an integral part of the USDA procurement process. Specifications for the delivery of new equipment in 2000 included the following maximum allowable tolerances for accuracy and precision.

| *Fiber Property* | *Accuracy* | *Precision* |
|---|---|---|
| Length (inch) | ± 0.018 | ± 0.012 |
| Uniformity (percent) | ± 1.200 | ± 0.800 |
| Strength (g/tex) | ± 1.500 | ± 1.000 |
| Micronaire (units) | ± 0.150 | ± 0.100 |
| Color (Rd) (units) | ± 1.000 | ± 0.700 |
| Color (+b) (units) | ± 0.500 | ± 0.300 |
| Trash (% area) | ± 0.100 | ± 0.040 |

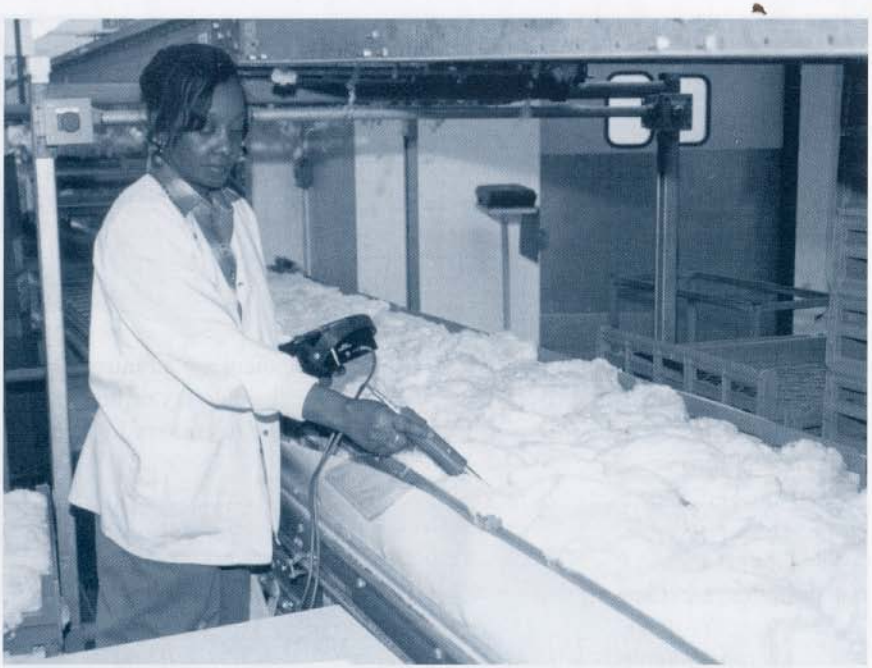
The term "accuracy" refers to how well an instrument measures a certain property in relation to its true value. The term "precision" refers to the ability of an instrument to produce the same measurement result time after time.

### Laboratory Conditioning

Atmospheric conditions influence the measurement of cotton fiber properties. Therefore, the temperature and humidity of the classing laboratory must be tightly controlled. Temperature is maintained at 70°F, plus or minus 1 degree, and relative humidity is maintained at 65 percent, plus or minus 2 percent.

### Sample Conditioning

Samples are conditioned to bring the moisture content to equilibrium with the approved atmospheric conditions. Conditioned samples will have a moisture content between 6.75 and 8.25 percent (dry weight basis). The samples may be conditioned passively or actively.



*Upon arrival at the USDA classing facility, samples are conditioned to standardize moisture content before the classing process begins.*

In passive conditioning, the samples are placed in single layers in trays which have perforated bottoms to allow free circulation of air. The samples must be exposed to the approved atmosphere until the specified moisture level is reached.

In active conditioning, a Rapid Conditioning unit is used in which air at the approved atmospheric conditions is drawn through the sample until the required moisture content for HVI testing is attained. The time required to condition samples properly can be reduced to 10 minutes.

The moisture content of the conditioned samples is checked to verify that the appropriate moisture content has been reached. The moisture content of the samples to be tested should not vary more than one percentage point from the moisture content of the calibration cottons.

#### Laboratory Lighting

Lighting conditions in USDA laboratories are maintained to provide a minimum of 100 foot-candles of illumination at the classing level. Special lamps are used to provide the best true color perception. All surfaces in the laboratories are white, gray, or black, and the walls are off-white, to further enhance color perception.

#### Selection of Cotton for Calibration Usage

Cotton used for instrument calibration must pass rigorous screening procedures. As a first step, USDA conducts an intensive search for the most uniform bales of cotton in the current crop. Candidate bales are screened for uniformity of fiber quality by testing six samples drawn from throughout each bale. Bales that do not produce highly uniform measurement results are eliminated from further consideration. Bales that pass preliminary screening then undergo detailed analysis, as described below, to determine whether they meet USDA's high standards for certification and use as calibration cottons.

#### Establishing Values for Calibration Cotton

In addition to the requirement of high within-bale fiber uniformity, the bales must also have the proper length and strength properties for their intended use. For example, a long/strong calibration cotton bale must have approximate length and strength values of 1-5/32nds of an inch and 33 g/tex, respectively. A short/weak calibration cotton bale must have approximate length and strength values of 31/32nds of an inch and 23 g/tex, respectively.

Candidate bales receive preliminary testing to ensure bale uniformity. Currently, five laboratories work together to establish values for calibration cottons; four are USDA facilities, and one is an independent laboratory from the research community. The independent lab operates under the same rigid specifi-

cations as the USDA. The laboratories perform a total of 180 tests per bale, and the results are used to further evaluate uniformity and to determine the values assigned to calibration cottons. For reference purposes, samples of previously established, or "benchmark," calibration cottons are included in the testing, along with samples from the candidate bales. Benchmark cotton values are established by the five laboratories mentioned above plus two international cotton laboratories. If the test results within a bale exceed prescribed limits, the bale is rejected. If all testing criteria are met, the bale is accepted and its contents packaged for distribution as calibration cotton.

**Calibration of Instruments**

Instruments are calibrated for length, length uniformity, micronaire, and strength by using calibration cottons. Tiles are used to calibrate color and trash measurements. In addition to calibration, samples of known value are tested on each instrument several times each 8-hour shift. If the test value deviates from the known value by more than specified tolerance limits, corrective action is taken. USDA calibration tolerances are:

| *Quality Factor* | *Tolerance* |
|---|---|
| Micronaire (units) | ±0.100 |
| Color Rd (units) | ±0.400 |
| Color +b (units) | ±0.400 |
| Trash (% area) | ±0.050 |
| Length (inches) | ±0.007 |
| Uniformity (percent) | ±0.700 |
| Strength (grams/tex) | ±0.500 |

**Checklot Program**

USDA's Checklot Program ensures that all USDA classification facilities across the Cotton Belt provide uniform test results. Under this program, random samples are computer selected from the production of each instrument line and classer during each work shift. These samples are forwarded by overnight delivery to USDA's Quality Assurance unit in Memphis, Tennessee, where they are retested. Results are compared with the original classification, and this information is immediately telecommunicated back to the originating office where level adjustments are made as necessary. USDA maintains a record of comparisons for each instrument and classer on a daily, weekly, and seasonal basis. Results of the Checklot Program for the 2000 crop are reported on page 15.

# HVI COLOR GRADES FOR AMERICAN UPLAND COTTON

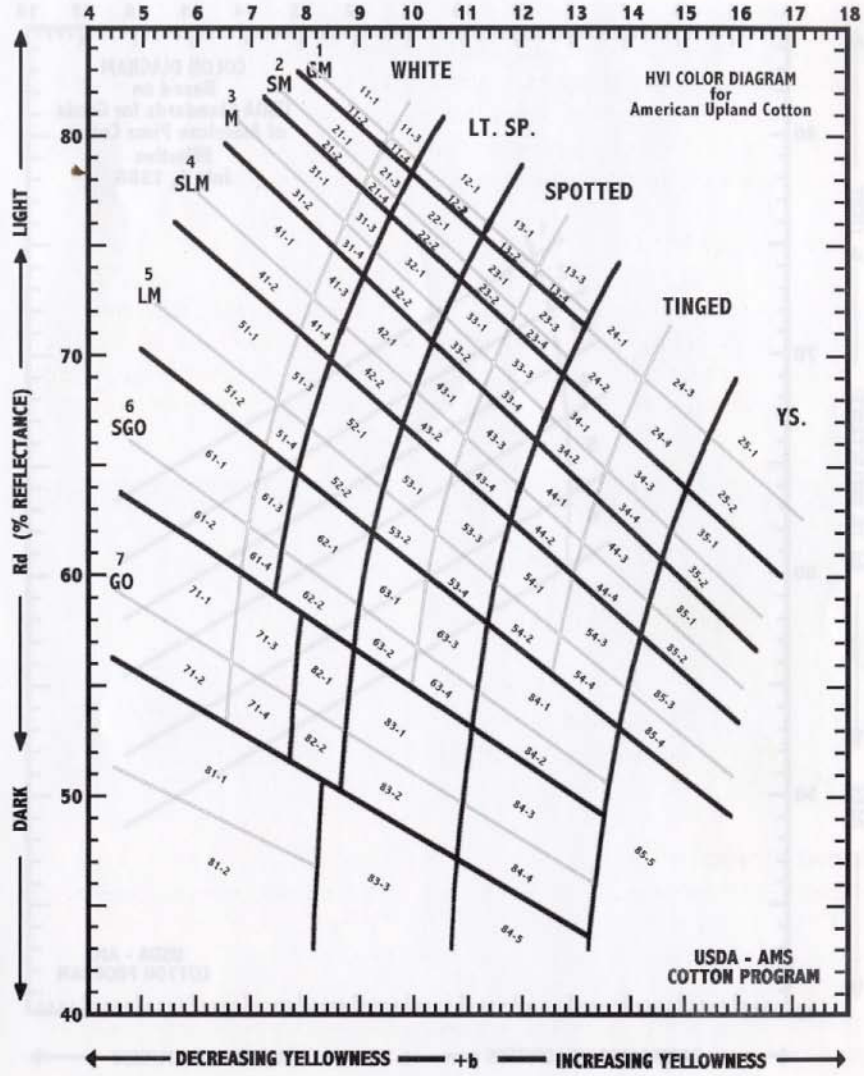



**Exhibit A**

*HVI Color Chart for American Upland Cotton*

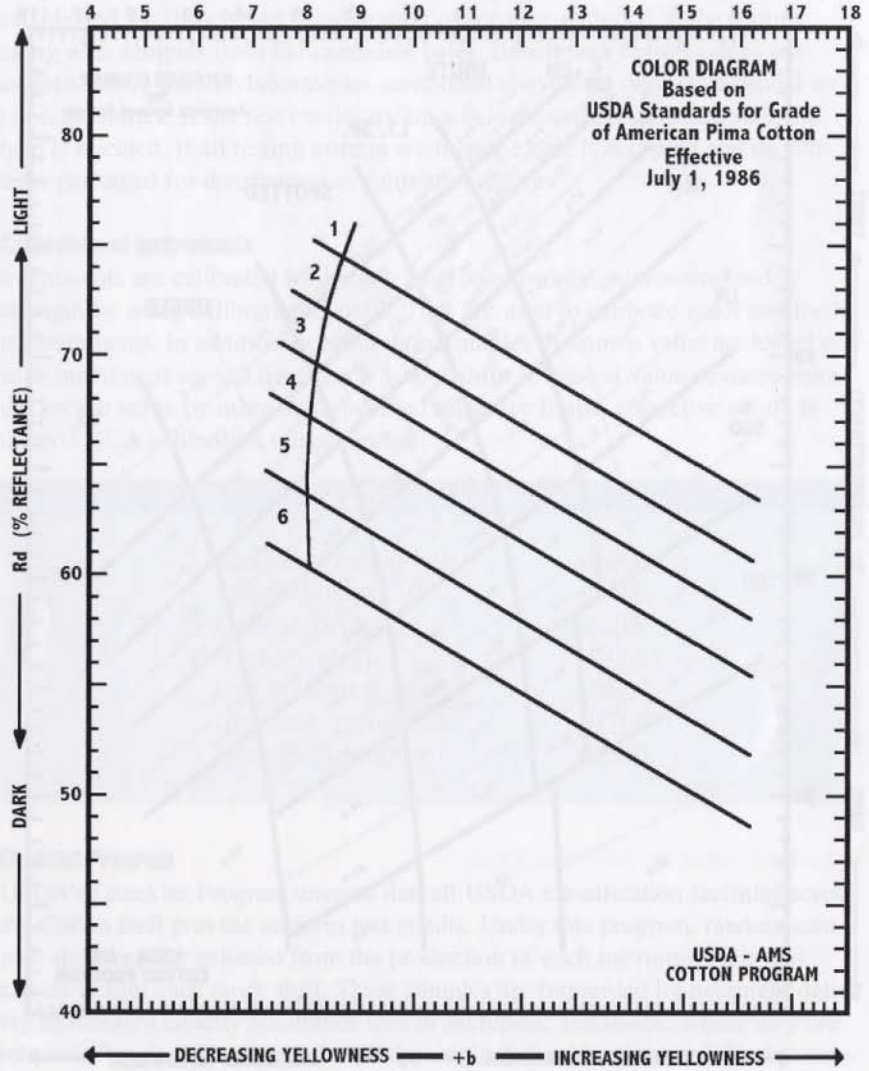
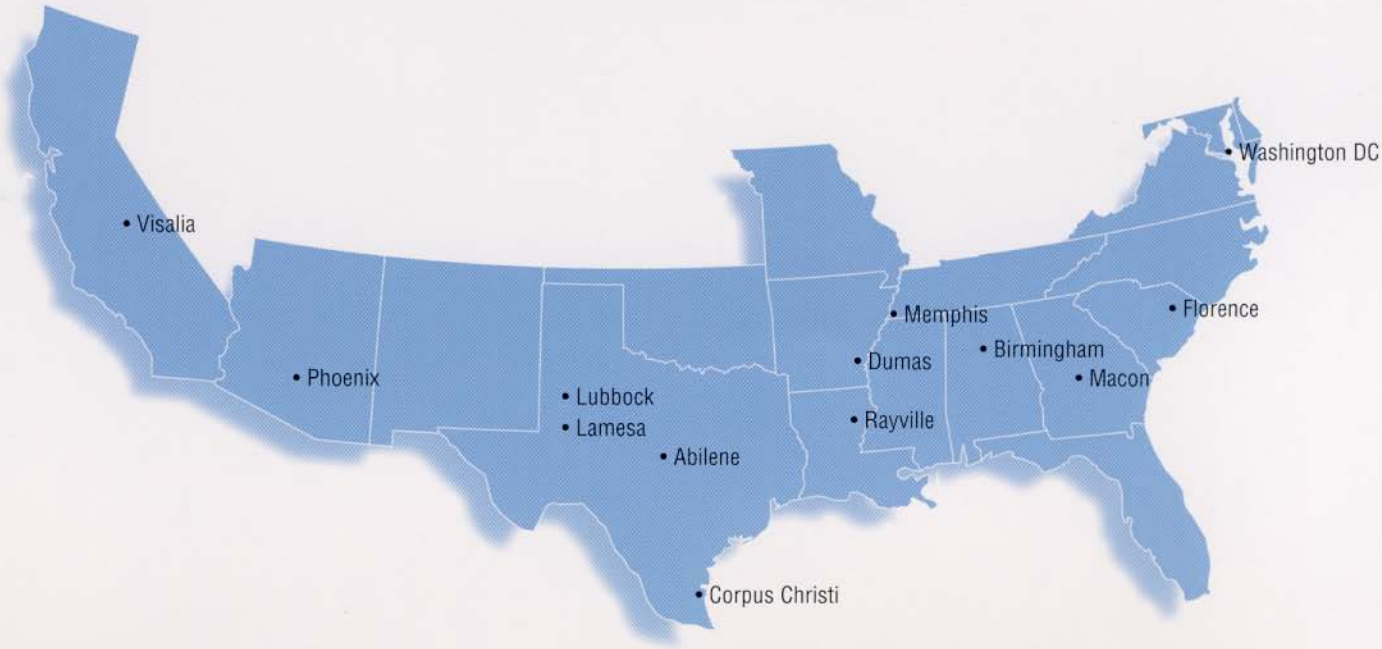



**Exhibit B**

*HVI Color Chart for American Pima Cotton*

## USDA, AMS, Cotton Program Facilities



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Additional information about the Cotton Program activities is available on the World Wide Web at the Cotton Program's home page:

**http://www.ams.usda.gov/cotton/**