COTTON IN RUGS AND CARPETS

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Abstract

Cotton has made a comeback in the area rug business. Demand increased in the past 5 years from 11-28%. This is mainly due to yarn developments making cotton fiber in yarn form more resilient and reduced surface shedding when made up into rugs. Another major contributing factor is breakthroughs in dyeing and finishing to maintain color fastness, better cleaning, and flame retardancy.

Why Cotton in Rugs

Market Rationale

- Cotton rugs have excellent potential for growth.
- Market share increased from 11% to 28% in 5 years.
- Area rug sales for all fibers jumped nearly 20% in one year.
- Focus group data show that consumers like cotton rugs and will pay more for 100% cotton rugs.
- Cotton rugs are an upscale impulse purchase. They are perceived by consumers to have added-value.
- Cotton Incorporated's cotton seal trademark identification on cotton rugs is a proven positive marketing tool.

Fashion Rationale

- Cotton rugs fit today's natural life-style.
- Cotton rugs have a non-static, soft, pleasing touch.
- Cotton rugs are attractive on wood floors. They are bright, colorful, and coordinate well with other home furnishings.
- Cotton rugs can be used in every room in the house, even over broadloom carpeting.

Technical Rationale

- New breakthrough developments in cotton pile yarns for area rugs and carpets.
- New cotton yarns have improved resiliency, tuft definition is enhanced.
- Cotton rugs pass government flammability requirements.
- Cotton rugs are absorbent. They can be washed or easily cleaned.
- Cotton rugs and carpets can be dyed to any color.
- Cotton rugs are colorfast. They resist sunlight fading and are color fast to cleaning solutions.
- Cotton rugs exhibit excellent wearability.

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Guidelines for Manufacturing Rugs and Carpets

Cotton Incorporated has done extensive research over the past 10 years and developed comprehensive technology which will be of benefit to the rug and carpet industry and their customers.

Based on growth from 11-28% in 5 years, the focus was mainly on bath and area rugs. However, in recent years, Cotton Incorporated in cooperation with carpet companies, developed larger 100% cotton area rugs and broadloom carpets

Fiber selection, blending, spinning systems and yarn, tufting and weaving, dyeing, finishing, wear-testing, soil release, lightfastness, flame retardancy, color fastness when cleaning, and wearability all were tested to accomplish our objective of "a well constructed rug/carpet to meet customer requirements".

This report will describe many options how to produce well engineered rugs and carpets to satisfy necessary consumer requirements and be profitable to you "The Manufacturer". The following established technologies can be implemented at the manufacturer's production facilities:

- In blending and spinning of cotton with low melt polyester or other low melt synthetic fiber, when exposed to heat, the low melt synthetic fiber is converted to an adhesive and spot adheres the cotton fibers. This will result in much reduced surface fiber shedding, maintain better tuft definition and resiliency of cut pile.

- Blends of 95/5% - 90/10% - 85/15% - 80/20% cotton/low melt polyester were evaluated. To maintain good tuft definition, it was determined that a 90/10% cotton/low melt polyester blend will suffice and produce good results in both loop and cut pile. However, for heavy traffic areas, a blend of 80/20% cotton/low melt polyester is recommended, especially for cut pile rugs and carpets.

- Heat set conditions to melt the low melt polyester were established using both Suessen and Superba equipment. Both are satisfactory in melting the low melt polyester and spot adhere the cotton fibers within the blended yarn. It appears that using the high pressure steam technique (Superba) that the yarn has additional bulk.

- All yarn ends, when tight together, should be spliced if possible. If knotted, a thin weavers knot should be used and the long knotted ends should be cut off. This will allow yarn to go smoothly through needle holes while tufting. When tufting cotton yarn into primary backing material, woven monks cloth or other plain weave fabrics are recommended for piece

dyeing cotton rugs. Nonwoven synthetic substrates can also be used; however, some are not dyeable. Depending upon customer preferences, manufacturer have a wide range of choices to satisfy all requirements.

- All rug and carpet tufting and weaving equipment are suitable for cotton yarn. Gauge, stitches per inch, and loom set up depends upon yarn size selection. Both ring spun and open end spun yarns are suitable.

- Dyeing of cotton fiber, yarn, or piece goods is well known in the apparel and home products business. The technology transfer to rugs and carpets can be adopted quickly. Cotton can be dyed from pastel to very bright colors and many dyestuff classes have affinity to cellulose. This area will be covered in more detail under "Dyeing and Chemistry Research".

- When flame retardancy is an issue, the surface, cut or loop, should be dense not to allow excessive free oxygen to surround the cotton. Most larger area rug experiments we conducted at Cotton Incorporated did not exceed 1/2" pile heights. For rug sizes up to 4' x 6', longer pile heights are common. All products must be in compliance with federal regulations (see Test Methods, page 27).

- Manufacturers have several options using 100% cotton or blends. To avoid surface shedding, it is recommended to use up to 20% low melt synthetic fiber. If, however, one would choose to produce 100% cotton rugs, the following recommendations are made:

(a) After piece dyeing or washing of already colored rugs, the use of cellulase enzymes in the last rinse cycle is very effective (see page 24 for procedure).

(b) The customer (consumer) could also use "Color Guard Detergent" sold by Procter & Gamble under the trade names "Cheer", "Tide", and "Ivory" in home laundry machines.

(c) When proceeding with (a), (b), or (a) and (b) combined, the reaction will be such that the loose cotton surface fibers dissolve by the activated enzymes during the rinse or wash cycle.

*Note: The low melt synthetic fiber used in blends, in most all colors, does not have to be dyed.

The Engineering of Ne 3/1 Carpet Yarn

I. Suggested Fiber Parameters

Suggested Cotton Profile

Length -	longer than 1"
Short Fiber Content -	lower than 15%
Micronaire* -	4.0 - 5.0
Strength -	higher than 24.0 g/Tex

*High micronaire cotton is recommended to improve yarn resiliency. It is preferable to select a fiber that is 5.0 micronaire or higher.

NOTE: To achieve quality yarn when spinning coarse counts, do not use excessive short fiber contents which at times are part of the blend when spinning O.E. yarns. This is not recommended for rugs or carpets.

Low-Melt Polyester

Melting Point -	110C-130C
Length -	1.25-1.50" (32-38 mm)
Denier -	2.25-4.00

II. Suggested Drawing Parameters

A. 90% Cotton/10% Low-Melt Polyester

Rotor Spinning

Draw Blend (One Process of Drawing)

6 ends up carded cotton
2 ends up carded low-melt polyester
80-95 grains/yd delivery weight

Intimate Blend (One Process of Drawing)

6-8 ends up
80-95 grains/yd delivery weight

Ring Spinning

Draw Blend (Two Processes of Drawing)

Breaker Draw - 6 ends up carded cotton
2 ends up low-melt polyester
85-95 grains/yd delivery weight

Finisher Draw - 8 ends up 90/10 cotton/low-melt polyester
95-100 grains/yd delivery weight

Intimate Blend (One or Two Process of Drawing)

Breaker Draw - 6-8 ends up intimately blended 90/10 cotton/low-melt polyester
85-95 grains/yd delivery weight

Finisher Draw - 6-8 ends up
95-100 grains/yd delivery weight

B. 90% Stock-Dyed Cotton/10% Low-Melt Polyester

Rotor Spinning
Draw Blend (One Process of Drawing)

6 ends up stock-dyed cotton
2 ends up low-melt polyester
80-95 grains/yd delivery weight

Intimate Blend (One Process of Drawing)

6-8 ends up intimately carded
80-95 grains/yd delivery weight

Ring Spinning
Draw Blend (Two Processes of Drawing)

Breaker Draw - 6 ends up stock-dyed cotton
2 ends up low-melt polyester
85-95 grains/yd delivery weight

Finisher Draw - 6-8 ends up
95-100 grains/yd delivery weight

Intimate Blend (One or Two Processes of Drawing)

Breaker Draw - 6-8 ends up
85-95 grains/yd delivery weight

Finisher Draw - 6-8 ends up
95-100 grains/yd delivery weight

C. 90% Multicolored Stock-Dyed Cotton/10% Low-Melt Polyester

Rotor Spinning
Draw Blend (One or Two Process Drawing)

Breaker Draw - 6 ends up stock-dyed cotton (2 colors or 3 colors)
2 ends up low-melt polyester
80-95 grains/yd delivery weight

Finisher Draw - 6-8 ends up
80-95 grains/yd delivery weight

Intimate Blend

Not recommended for multicolor stock-dyed cotton/low-melt polyester yarn unless mill incorporates three or more weigh pan blending system.

Ring Spinning
Draw Blend (Two Processes of Drawing)

Breaker Draw - 6 ends up various colored stock-dyed cotton
2 ends up low-melt polyester
85-95 grains/yd delivery weight

Finisher - 6-8 ends up
95-100 grains/yd delivery weight

Intimate Blend

Not recommended for multicolored stock-dyed cotton/low-melt polyester blends unless mill incorporated three or more weigh pan blending system.

III. Spinning Parameters

The most important considerations during spinning of Ne 3/1 cotton carpet yarns include soft hand and bulkiness of the yarn. Taking those two desired qualities into consideration, the following set-up is recommended on a rotor spinning frame.

Rotor Diameter (mm) -	56	46
Rotor Speed (rpm) -	31,000	40,000
Twist (T.M.) -	3.8 - 4.2	
Navel Type -	Grooved	
Combing Roll (rpm) -	8000 - 8500	

Rotor spinning is the preferred method, however, it is possible to ring spin if a suitable gauge machine is available. A potential problem with ring spinning is the premature melting or glazing of low-melt polyester on the rings and travelers.

Note: Most all yarns developed for rugs and carpets are plied and/or cabled. Most of the yarn research conducted at Cotton Incorporated ranged from Ne 3/2 - 3/2/2 to Ne 8/2 - 8/2/4.

Dyeing and Chemistry Research

Cotton can be dyed in various forms:

- Fiber
- Yarn
- Piece Goods
- Continuous

The following dyestuffs are available to dye cotton:

- Direct Dyes
- Fiber Reactive Dyes
- Sulfur Dyes
- Naphthol Dyes
- Vat Dyes

All these can be used to dye cotton by the following methods:

- Package Yarn Dyeing

- Skein Dyeing
- Piece Dyeing
- Continuous Dyeing
- Stock Dyeing

Below are dyestuff descriptions and their application to cotton.

- Direct Dyes - reasonably priced

  Ease of application using any method.
  Fair-good lightfastness.
  Poor washfastness and shampoo properties.
  Poor chlorine fastness.

- Fiber Reactive Dyes - expensive

  More difficult to apply.
  Long dye cycle.
  Large amount of salt is used for dyeing.
  Fair-good lightfastness.
  Fair-good washfastness and shampoo properties.
  Poor chlorine fastness.

- Sulfur Dyes - reasonably priced

  Dye cycle is more complex when exhaust dyeing.
  Fair-good lightfastness.
  Good washfastness and shampoo properties.
  Poor chlorine fastness.

- Naphthol Dyes - reasonably priced

  Very complex dye cycle - is not recommended.

- Vat Dyes - expensive

  These dyes go through an insoluble-soluble-insoluble procedure to make them very fast.
  Very good lightfastness.
  Very good washfastness and shampoo properties.
  Fair-good chlorine fastness.

In summary, vat dyes have the best overall properties for cotton in rugs and carpets.

Dyeing Methods

- Package Yarn Dyeing
  Package yarn dyeing can be done; however, it is only recommended for patterned carpets. The reason is that shade variations can be experienced within the dyed package. Not suitable for solid colored carpets (streak potential).

- Skein Dyeing
  Only for patterned carpet. Shade variation from skein to skein. Not suitable for solid colored carpets (streak potential).

- Piece Dyeing in Becks or Jets
  Exhaust vat dyeing large carpet lots (500-1000 kg) should be done in an enclosed dyeing machine.

- Piece Dyeing in Rotary Drum or Other Enclosed Machinery
  Small bath and throw rugs can be successfully piece dyed using vat dyes. Direct and fiber reactive dyes can be used in open paddle machines.

- Continuous Dyeing
  Can be done, however, equipment necessary to continuously dye cotton is not available in carpet mills at this time. Machines currently installed can handle synthetic fibers only. Not suitable at present for cotton carpets.

- Stock Dyeing
  The most uniform, solid colored wool carpets are dyed using the stock dyeing method. We adopted this process for cotton using vat dyes. Due to the blending of the dyed cotton fiber, yarn spun from it will be very uniform and suitable for solids and patterned carpets. We believe that stock dyeing is economical and has the necessary versatility required.

In the production mode, we envision the following sequence of an operation:

1. Dye Cotton Stock (any color)

   Bale compress and store in warehouse. One dye lot can be 50-1000kg. or higher. This, of course, will depend on the size of the Kier (dyeing machine). In production, one suggestion is to dye many lots of the same color and, after dyeing, bale compress and store. Bales can then be pulled as desired, blended, and spun into yarn for tufting.

   After tufting, the carpets are finished. The only time that limited moisture would be evaporated is when the carpets are steamed and a topical finish (soil release) is applied.

   Stock dyed cotton fiber can be blended to subtle colored tonal effects. Designers will have the opportunity to achieve an almost unlimited number of tonal effects styling rug and carpet concepts.

Chemical Composition of Raw Cotton

	Percent
Cellulose	94-97
Waxes	0.5-1.0
Pectins	0.5-1.2
Protein	1.0-2.0
Inorganic Matter (Ash)	1.0-1.5

Micronaire

Micronaire is proportional to units of Micrograms per inch and has a direct relationship to fineness and maturity as follows:

Denier/Fineness/Maturity/Micronaire					
	Fineness		Maturity		
Denier	Ug/ Inch	Millitex	Mat Fin	Mat Ratio	Micronaire
0.50	1.41	56	46.28	0.83	1.4
0.75	2.12	83	68.68	0.82	2.1
1.00	**2.82**	**111**	**94.91**	**0.86**	**2.8**
1.25	3.53	139	. . 124.98	0.90	3.5
1.50	4.23	167	158.88	0.95	4.2
1.75	4.94	194	196.63	1.01	4.9
2.00	5.64	222	238.21	1.07	5.6
2.25	6.35	250	283.63	1.14	6.3
2.50	7.05	278	332.88	1.20	7.1
2.75	7.76	305	385.97	1.26	7.8
3.00	8.46	333	442.90	1.33	8.5

Yarn Production Comparison

- Ne 8/1, TM 4.0 @ 95% EFFICIENCY

  - R.S. 1.5 KG/24 HOURS
  - O.E. 13.5 KG/24 HOURS

- Ne 3/1, TM 4.0 @ 95% EFFICIENCY

  - R.S. 4.0 KG/24 HOURS
  - O.E. 36.0 KG/24 HOURS

Heat Setting Conditions

- Superba

  145c - 150c
  45 sec - 55 sec exposure

- Suessen

  160c - 170c
  55 sec - 60 sec exposure

Suggested Bleach Procedure for Cotton Fiber

Bleach base for vat dyeing done at 6:1 liquor ratio. Flow is top to bottom in dye kier.

1. Load fiber in machine and set bath at 80F (27C).
2. Add: 2.0 g/l NaOH, 50% Liquid
   2.0 g/l Alkaline scouring agent
   2.0 g/l Non-foaming wetting agent/detergent
3. Heat to 190F (88C), run 30 minutes, drop.
4. Fill machine and overflow rinse for 10 minutes.
5. Set bath at 80F (27C) and add chemicals:
   1.0 g/l Non-foaming wetting agent/detergent
   0.4 g/l Organic stabilizer
   4.0 g/l NaOH 50% liquid
   5.0 cc/l H_2O_2, 35%
6. Heat to 200F (93C), run 45 minutes, drop.
7. Refill and top wash until neutral.

Suggested Vat Dyeing Procedure for Cotton Fiber at 6:1 Liquor Ratio

1. Set bath at 80F (27C), add auxiliary chemicals, (dispersing agent, leveling agent), run 5 minutes.
2. Add prediluted dyes, run 5 minutes.
3. Add sodium hydroxide over 10 minutes, run 5 minutes.
4. Heat to 170F (77C) and hold 10 minutes.
5. Add sodium hydrosulfite, run 10 minutes, then check reduction.
6. Cool to 140F (60C) at 4F/min. (2C/min.), run 15 minutes for light shade or 20-30 minutes for heavy shade.
7. Overflow rinse 80F (27C) to pH 10.
8. Set bath, add hydrogen peroxide and dispersing agent, then heat to 120F (49C). Run for 20 minutes.
9. Heat to 200F (93C) and hold 20 minutes.
10. Drop, overflow rinse until pH is approximately 7 and bath is clear.
11. Drop, fill, set bath 8OF (27C), add sodium hydroxide, acetic acid, lubricant, run 10 minutes.
12. End of cycle.

* Note: For Step 11, 1.0 g/l of sodium hydroxide, 50% and 2.2 g/l of Acetic Acid, 56% are added to form Sodium Acetate. This will aid in the elimination of static during the carding operation.

Suggested Bleach Procedure for Cotton Yarn Package Dyeing Machine

* Bleach dye base for vat dyeing done at 15:1 liquor ratio. Flow is inside-out and outside-in.

1. Load yarn into machine, set bath at 80F (27C).
2. Add: 0.5 g/l Anionic/non-ionic non-foaming wetting agent
   1.0 g/l Non-foaming wetting agent/detergent
   0.4 g/l Organic stabilizer
   4.0 g/l Sodium Hydroxide 50% Liquid
   5.0 g/l Hydrogen Peroxide 35%
3. Heat to 200F (93C), run 45 minutes, drop.
4. Run a series of drop/fills at 160F (71C) until neutral.

* Actual liquor ratio of 15:1 was used. Plant conditions will dictate production liquor ratio.

Suggested Vat Dyeing Procedure for Cotton Yarn

1. Load packages. Set bath at 80F (27C), add auxiliary chemicals (dispersing agent, leveling agent) and dyes, run 8 minutes.
2. Add Sodium Hydroxide, run 8 minutes.
3. Heat to 170F (77C), run 12 minutes.
4. Add Sodium Hydrosulfite, run 10 minutes, then check reduction.
5. Cool to 140F (60C) at 4F/min. (2C/min.), run 20 minutes.
6. Overflow rinse 80F (27C) 8 minutes to pH 10.
7. Set bath at 120F (49C), add Hydrogen Peroxide and dispersing agent. Hold 20 minutes.
8. Heat to 210F (99C), hold 20 minutes.
9. Cool to 190F (88C), drop, fill, heat to 120F (49C), hold 5 minutes and drop.
10. Refill, rinse, drop.
11. End of cycle.

* Actual liquor ratio of 15:1 was used. Plant conditions will dictate production liquor ratio.

Scour, Bleaching, and Dyeing Procedures for Cotton Rugs and Carpets using Fiber Reactive and Direct Dyes

A. Scour

1. Set bath at 90F (32C)
2. Add chemicals

Light scour	
sequesterant/detergent	2.0 g/l
scouring agent	2.0 g/l
180F (82C) x 30 minutes	
Strong scour	
Alkaline detergent	2.0 g/l
NaOH, 50%	2.0 g/l
180F (82C) x 30 minutes	

3. Rinse well

B. Bleach

1. Set bath at 90F (32C)
2. Add chemicals

scouring agent	1.0 g/l
organic stabilizer	0.4 g/l
NaOH, 50%	4.0 g/l
H_2O_2, 35%	5-10.0 g/l

(peroxide content may vary depending upon trash content and dye shade)

3. Heat to 200F (93C)
4. Run 30-45 minutes
5. Cool to 160F (71C)
6. Drop
7. Rinse well until neutral

C. Reactive Dye (Migration Method)

1. Set bath at 90F (32C)
2. Add auxiliaries and salt*
3. Add dye
4. Heat to temperature 140-175F (60-79C)
5. Run 20 minutes
6. Add alkali**
7. Circulate 45 minutes
8. Sample
9. If okay, drop
10. Rinse well (overflow or drop/fill)
11. Check pH (should be below 8.5)
12. Fill
13. Heat to 190F (88C)
14. Run 10 minutes
15. Drop
16. Rinse well

* Auxiliaries and salt will depend upon dyestuff and depth of shade.
** Alkali amounts will depend upon dyestuff and depth of shade.

D. Direct Dye

1. Set dyebath 90F
2. Add auxiliaries
3. Add dye
4. Heat to 200F at 3F/min.
5. Circulate 15 min.
6. Add salt*
7. Cool to 180F
8. Circulate 15 min.
9. Sample
10. If ok, cool to 160F
11. Drop
12. Overflow rinse cold
13. Set bath volume
14. Add aftertreat and/or softener
15. Heat to 120F at 3F/min.
16. Circulate 15 min.
17. Drop
18. Unload

* In portions: 1/6, 1/3, 1/2

Cellulase Enzyme Treatment For Cotton Rugs and Carpets

1. Set bath at 80F (27C)
2. Add buffer or acetic acid to pH 4.5-4.8
3. Heat to 135F (57C)
4. Check pH, adjust if needed
5. Add cellulase enzyme
   For acid stable cellulase, 2 g/l at 10:1 liquor ratio.
   Higher liquor ratio may require less.
6. Run 30-60 minutes, depending upon surface conditions
7. Drop
8. Rinse well
9. Fill
10. Deactivate
    180F (82C) x 10 minutes or
    2 g/l soda ash at 120F (50C) x 10 minutes
11. Drop
12. Rinse well until neutral

This procedure is for acid stable cellulase.

Check stability of dyestuff to this pH and to the pH conditions of the deactivation step before proceeding.

Finishing of Cotton Carpet

Finishing Solution	% on Wt. Bath
Velvetol 77-47 JR ([1])	6
Baygard SF-A2 ([2])	3
Foaming Agent ([3])	1

Applied at 15% wet pickup
Dried as normally done

([1])Rhone Poulenc.
([2])Bayer. May also use Scotchgard LC12204.
([3])Used if foamed. Finish may also be sprayed.

Removal of Food Stains from Cotton Carpet

Food stains on cotton carpet can be readily removed. Cleaning the stains as soon as possible is best. The cleaning procedure should be conducted for the first time on an inconspicuous area of the carpet to determine if there will be an adverse effect on the appearance.

As much stain as possible is first removed with a damp cloth. The stain is saturated with full strength Parsons' Ammonia All-Purpose Cleaner followed immediately with a liberal amount of hydrogen peroxide available in the first aid supply section of the supermarket. The area is massaged gently, permitted to soak for thirty minutes, and blotted with a paper towel. This procedure is repeated until the stain is removed. After cleaning, the area is dampened with water and blotted several times to remove any residual cleaner that would otherwise hurt the soil resistance. The drying may be accelerated by using a hair dryer. If necessary, the carpet pile may be re-oriented by vacuuming or brushing.

Test Methods

Lightfastness
Water Cooled Xenon Arc Lamp, Continuous Light
AATCC Test Method 16E-1993 - 40 hours

Washfastness
AATCC Test Method 61 - 2A and 5A

Stain Resistance: Pile Floor Coverings
AATCC Test Method 175-1993

Surface Flammability
DOC FF 1-70/FF 2-70 (Methanamine Pill)

The methanamine pill test involves the ignition of the pill on a horizontally mounted carpet sample in a draft-free environment. A sample passes the test if the charred area does not extend to within 1 inch of the edge of the 8 inch hole in the flattening frame at any point.

Radiant Panel Test
ASTM E648

A radiant heat energy panel is inclined at 30° to and directed at a horizontally mounted carpet sample. The test is initiated by open flame ignition. The distance burned to flame out is converted to yield the critical radiant flux. The test is designed to simulate carpet in a building corridor exposed to a fire in an adjacent room.

National Fire Protection Association (NFPA) Criteria:

Watts/cm²	Class	Use
≥0.45	I	Health care facilities, some corridors.
0.22 - 0.44	II	Public facilities such as large meeting rooms.
<0.22	Failure	

The actual distance to burnout varies with the flux profile of the radiant panel tester. In general,

Burnout	Watts/cm²
≈ 45 cm	0.45
≈ 60 cm	0.22

Note that each locality may have different criteria.

Test Method ASTM D3884
Abrasion Resistance of Textile Fabrics

Test Conditions	
Abrasion Wheels	H-18
Load Applied	1,000 Grams
Number of Cycles	100 Cycles

Test Number	Sample ID	Removed Residual Fiber Weight
33214	100% Cotton	0.22 Grams
33215	90/10 Cotton/Low Melt Poly	0.10 Grams
33216	95/5 Cotton/Low Melt Poly	0.10 Grams
33217	85/15 Cotton/Low Melt Poly	0.08 Grams
33218	80/20 Cotton/Low Melt Poly	0.06 Grams

Summary

Cotton Incorporated has conducted extensive rug and carpet research over the last ten years. Depending on the requirements of the consumer, we can meet all requirements necessary to produce quality added-value products.

The Technical Services group of Cotton Incorporated can assist you at your facilities to produce performing rugs and carpets to be added to your existing product line.

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