TECHNICAL BULLETIN

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GUIDE TO EVALUATING AND REDUCING HOLES IN KNITTED FABRICS

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INTRODUCTION

Apparel manufacturers often find holes in garments during final inspection that were not detected during manufacturing. This technical bulletin lists how to evaluate a hole in greige fabric, processed fabric, or garments to determine the cause and how to prevent hole formation.

CAUSES

A. Knitting

1. Yarn Properties as Related to Knitting

   a. Incorrect yarn size: If yarn size is too large for the machine gauge or the needle hook, then stresses on the yarn and fabric during knitting can result in holes in the fabric.

   b. Thick and thin yarns: Variation in yarn diameter can result in variations in yarn tensions resulting in holes and drop stitches.

   c. Yarn strength: If yarn strength is too low for the knitting parameters being used, [tightness factor, yarn tension, stitch length, etc.] holes can result.

   d. Yarn twist: If yarn twist is too high, twist liveliness can result causing the yarn to kink. This changes the yarn diameter and yarn tensions, which can result in holes or drop stitches.

   e. Yarn knots or unsatisfactory splicing: Incorrect yarn splicing or knot tying can cause high and variable yarn tension, which can result in holes and drop stitches. Also, long tails from knots result in doubling or tripling of the yarn diameter.

   f. Yarn hairiness: A yarn with excessive hairiness can increase yarn tension and fiber shedding, which can result in increased yarn tension and lint buildup, causing holes and drop stitches.

   g. Yarn Trash Content: Yarns with high levels of trash can create problems with tightness stress, weak spots in the yarn, and variation in yarn tensions.

2. Machine

   a. Stitch length: The length of the stitch affects the weight, width, hand, shrinkage, and knitability of a fabric. If the stitch length is too short, added stress placed on the yarn and knitting elements can result in holes. If the stitch length is too long, drop stitches are more likely than holes.

   b. Yarn tension: The tension of the yarn while being fed to the knitting elements is critical. If the tension is too high, excessive stress could cause yarn breakage. If the tension is too low, feeding of the yarn at the knitting elements could cause improper yarn positioning, which could result in drop stitches.

c. Yarn feeder: The proper position of the yarn feeder and the yarn placement to the needles in the knitting cycle is of great importance. Yarns should be fed to the needle before the clearing cam and stitch cam causes needle latch movement in the knock-over cycle. Too early or late a placement of the yarn can cause holes or drop stitches.

d. Yarn Creeling: The placement of yarn packages on the creel should be free of any obstructions [rubbing against each other, rubbing next to a creel post, yarn unwound at an improper angle causing high tension and stress on the yarn.]

e. Yarn Path: The yarn moving from the creel to the knitting elements must be free from obstruction and excessive tensions. Proper threading of the yarn through stop-motions, tension devices, and yarn guides are critical to avoid excessive tension problems.

f. Take-down tension: The tension of the fabric between the knitting elements and take-down rollers should be adjusted to avoid excessive tension. Sufficient tension should be maintained to prevent the previous knitted loops from riding up and causing problems during the knitting cycle.

g. Take-down rollers: The proper roller tension and roller spacers should be adjusted to provide proper fabric alignment and to avoid excessive stress.

h. Knitting systems checks: All knitting elements, needles, sinkers, cams, and tricks need to be checked for wear and defects. Needle hooks become stretched, bent, and worn, cams can become worn and out of true shape, dials and cylinders get out of center, all of these can be the cause of holes and other fabric defects.

i. Accessories check: Flutter blowers, needle detectors, and fabric scanners all need to be checked to see if they are properly set and working. Accessories that are set wrong or not working properly can interfere with the proper knitting process and cause defects.

j. Sinker Timing: The sinker timing during yarn feeding and knock-over must be properly set as not to interfere with the knitting needle during the knitting cycle and proper yarn feeding has taken place.

k. Timing of Cylinder and Dial: From synchronized to delayed timing, yarn positioning to the knitting cycle is critical to yarn and fabric forming stresses. When delayed timing is used, cylinder stitch length should be large enough to allow the yarn to be robbed back when forming the dial stitch length.

3. Housekeeping

   a. Machine lubrication and cleaning: Maintaining the proper lubrication of the needle beds and knitting elements will minimize fabric forming stresses and machine wear. Also, proper cleaning of the knitting elements, creel, and machine will avoid problems occurring from lint buildup, machine grime, and yarn wax. They are major players in causing knitting defects. All of these affect the knitability and stresses of fabric formation.

   b. Yarn staging: Proper yarn staging should provide an adequate supply of yarn to the knitting machine for optimum knitting efficiency. Yarn should be staged in such a way to maintain yarn package integrity. The storage and handling of the yarn should ensure that the yarn is not damaged and proper package winding is maintained. It should be free from contamination of foreign matter, such as lint, and trash, and other fibers. All yarns and boxes should be marked properly to avoid the mixing of different lots, sizes, and types.

   c. Creeling and double creeling yarn: The proper handling and tying of yarn, to avoid fabric defects caused by improper knot size and yarn breaks due to tension stress, is a key element that is often taken lightly.

B. Processing Physical Damage

1. Fabric is snagged on sharp burrs on various surfaces throughout processing such as trucks, spreaders, or rolls.

2. Tubular fabric is spread too wide on the spreaders and stretched with enough force to break yarn and create a hole.

3. Fabric is pinched in the compaction zone on a compactor.

4. Needle cutting during garment assembly around seams.

C. Processing Chemical Damage

1. A high specific concentration of iron in fiber, yarn, or fabric that results in over activation of hydrogen peroxide bleach that weakens the yarn causing a break.

2. The iron may be introduced to the fabric from various sources such as the water, the machine, or even the substrate.

3. Over processing of fabric, such as stripping, re-dyeing, and/or making an add, can cause thin or weak places in yarn to break.

4. Fabric over cross-linked with resin will cause thin or weak places in yarn to break.

PREVENTION

A. Knitting

1. Yarn properties needed to knit fabric without creating holes:

    a. Check for correct size yarn for machine gauge (see enclosed list for suggested yarn count ranges).

    b. Do not use yarn with high imperfections, especially very thin or thick segments.

    c. Know yarn characteristics and knitting parameters. Yarn needs to be strong enough to meet knitting parameters being used.

    d. The twist multiple range should be 3.2 to 3.8 for ring spun yarn and 3.6 to 4.2 for OE. Higher twist yarn can cause problems.

    e. Make sure knots are tied correct so that they will not cause a problem.

    f. Do not use excessively hairy yarns.

    g. Do not use yarn with high levels of trash.

2. Machine setup checks:

    a. Know parameters such as: stitch length, yarn tension, yarn feeders, take-down tension, and take-down rollers. All knitting elements, sinker timing, and timing of cylinder and dial.

    b. Yarn should be creeled at a proper angle so as not to be rubbing against anything.

    c. Yarn path from creel to the knitting elements must be free from obstruction and excessive tensions.

    d. All accessories – such as flutter blowers, needle detectors, fabric scanners – need to be checked and set properly.

3. Housekeeping:

    a. Make sure needle beds and knitting elements are clean and properly lubricated.

    b. Yarn should be staged and stored in clean area, so it will not be damaged.

B. Processing Physical Damage

1. Audit process on a regular basis checking everything the fabric passes over for potential snagging burrs. Plastic surfaces as well as metal can have rough jagged edges that can snag the fabric.

2. Train personnel for proper processing setup so that styles are not over spread too wide.

3. Train personnel for proper setup of compactor. Inspect fabric on the compactor and other opportunities.

4. Audit finish to make sure proper amount of softener is applied for sewability. Do not over-dry fabric and make sure natural moisture regain of 6-7% is in the fabric for sewing.

C. Processing Chemical Damage

1. Make sure hydrogen peroxide is properly chelated for iron. Monitor the bleaching system for the correct amount of peroxide to be left in the bath. The minimum amount should be 15-20%. Audit fabric by checking burst strength, pH, total alkalinity, and residual peroxide. A pH of 5-7 and total alkalinity 0.05% NaOH is recommended. There should be minimal residual peroxide left in the goods after rinsing.

2. Audit water quality on a regular basis. Ideal water conditions for textile wet processing are listed in the enclosed tables.

3. All reworked lots should be inspected one hundred percent. Evaluate fabric strength at each processing step to monitor wet and dry dye house processes.

4. Check bursting strength during resin finishing to make sure fabric is not over cured or over treated.

HOLE EVALUATION – KNITS

A. Greige Fabric

1. If a hole is found in greige fabric, investigate the hole without using destructive methods. Determine how many yarns are broken or separated causing the hole.
2. Look at the hole under magnification. If only one yarn is separated, determine if it is cut or broken.

3. If more than one yarn is involved, determine the number. If this cannot be ascertained and more holes of similar nature are present, unravel one of the holes to count the number of yarns involved.

4. If the yarn appears cut, is there more than one hole on the same wale? A hole on one wale indicates a problem with that particular needle.

5. If there is more than one hole on the same wale, check the knitting machine for bad knitting elements.

6. If yarn is pulled apart, check if it was a thick or thin place in the yarn.

7. Check yarn quality throughout the fabric and in inventory for thick and thin imperfections.

8. Check the bursting strength of the greige fabric.

9. Check the yarn tension on the knitting machine, making sure all feeds are the same.

10. Check the tightness factor of the fabric (Refer to enclosed Tightness Factor Chart).

11. Usually when lint builds up and breaks the yarn, lint can be found knitted into the fabric.

B. Bleached Fabric softened and dried only

1. When holes are found in white fabric, look at the hole under magnification to see if the yarn was cut or pulled apart.

2. Determine how many yarns are separated causing the hole by de-knitting.

3. Look at the ends of the yarn to see if they are frayed. If frayed, the yarn was broken before or early in the wet processing stage.

4. Look around the hole to see if the unbroken yarns around the hole are abraded, also indicating the hole was there before wet processing.

5. When only one yarn in the hole is broken and the ends are frayed, the hole most likely was produced during knitting. (See list of causes from knitting)

6. If one yarn is pulled apart and the ends are not frayed, a weak place in the yarn could have broken when over spread during processing.
7. If there are many holes and they look frayed, they could have been caused by chemical damage.

8. Bleached fabric can be tested for chemical damage. The test methods used are listed here and are enclosed:

   a. Harrison’s Test to detect reducing groups in chemically damaged cellulose.

   b. Fehling’s Solution Test to detect reducing groups in chemically damaged cellulose.
   c. Turnbull’s Blue Test to detect carboxyl groups in chemically damaged cellulose.
   d. Ferrocyanide Method for Iron

9. When performing the chemical damage tests, check both the hole and normal areas.

10. Fabric with large holes and many broken yarns could have been snagged thereby tearing a hole. Normally, a snagged hole distorts the construction.

11. Fabrics with holes of several severed yarns could have been caused by being pinched during pad finishing causing the fabric to burst. The hole will look similar to Mullen or ball burst “test” holes.

C. Bleached fabric softened and compacted

   1. Holes produced by metal roll and blade type compactors distort the stitches at the hole. More than one yarn can be cut or pulled apart.

D. Dyed Fabrics softened and compacted

   1. Evaluate the holes the same way you would a bleached fabric. The dyed fabric cannot be tested for chemical damage because the dye interferes with the colored indicators used in the test.

HOLE EVALUATION – WOVENS

A. Greige Fabric

   1. To have a hole in a woven fabric, the warp and filling yarns must be broken. Therefore, holes in greige woven fabrics are normally caused by snagging or cutting the fabric to produce a hole.

B. Bleached Fabric

   1. Woven fabrics can get “pin holes” in them during peroxide bleaching if iron or rust is in the fabric. The holes can be tested with the chemical damage tests to confirm the type of chemical damage.

C. Dyed Fabrics

   1. Pinholes found in dyed fabrics cannot be evaluated with the chemical damage tests.
   2. Large holes in woven fabrics are normally due to snags and cuts.

CORRECT YARN SIZE FOR KNITTING

Following are suggestions for range of yarn counts (Ne/1) for different fabrics and different machine gauges.

Jersey	
Gauge	Ne/1
14	12-18
16	12-20
18	16-24
20	18-26
22	20-30
24	24-36
28	30-45
32	40-60

Interlock	
Gauge	Ne/1
18	20-32
20	24-36
22	28-40
24	32-48
28	40-60
32	48-74

1x1 Rib	
Gauge	Ne/1
10	10-16
12	14-20
14	16-24
15	20-28
16	20-30
18	24-36
20	26-40

TIGHTNESS FACTOR FOR KNITS (TF)
(An expression of "Cover" Factor)

1. METRIC $TF_M = \frac{\sqrt{Tex}}{L_{cm}}$ Where L_{cm} = Stitch length in cm.

2. ENGLISH $TF_E = \frac{9.567}{L_{in} \sqrt{Ne}}$ Where L_{in} = Stitch length in inches.

<u>Tightness Factors for Cotton Knitted Fabrics</u>

Plain Jersey:	14-18
1 x 1 Rib:	14-18
Single Pique:	14-18
Interlock:	10-14
Two-end Fleece:	13.5-16.5

IDEAL WATER CONDITIONS
FOR TEXTILE WET PROCESSING

CHARACTERISTICS	**MEASUREMENT**
Coloration	Colorless
Chlorine	0 mg/L
pH	6.5 to 8.0
Evaporation Residue	1000 mg/L
Combustion Residue	500 mg/L
Copper	0.1 to 0.2 mg/L
Iron	0.1 mg/L
Manganese	0.05 mg/L
Aluminum	0.2 mg/L
Chloride ions	300 mg/L
Sulfate ions	350 mg/L
Silica	<10 mg/L as SiO_2
Total Hardness	<90 mg/L as $CaCO_3$
Total Dissolved Solids	200 mg/L

Reference: Analytical Methods for A Textile Laboratory Second Edition

Harrison's Test

Purpose of Test: To detect reducing groups in chemically damaged cellulose.

Reagents Used: Solution A, 80 grams of silver nitrate per liter of water. Solution B, 200 grams of sodium thiosulfate and 200 grams of sodium hydroxide per liter of water.

Procedure: Mix one milliliter of A in 20 Milliliters of water with two milliliters of B in 20 milliliters of water. Boil sample in this mixture for five minutes. Wash in a solution of one milliliter of B in ten milliliters of water. Wash with water at 70°C.

Results: A gray or black deposit of silver indicates the presence of aldehyde groups. This test can also be used to distinguish chemical damage from physical damage, because reducing groups are almost always present to some extent in chemically damaged cellulose, but are absent from physically damaged material.

Fehling's Solution Test

Purpose of Test: To detect reducing groups in chemically damaged cellulose.

Reagents Used: Solution A, 60 grams of copper sulfate per liter of water. Solution B, 346 grams of potassium sodium tartrate and 100 grams of sodium hydroxide per liter of water.

Procedure: Mix equal parts of Solutions A and B and bring to a boil. Immerse the sample in the boiling solution for ten minutes. Rinse in water at 70°C.

Results: Reducing groups are indicated by a pink or red deposit of cuprous oxide. Examination of the sample under a wide field microscope is often helpful in observing the deposit.

Turnbull's Blue Test

Purpose of Test: To detect carboxyl groups in chemically damaged cellulose.

Reagents Used: Solution 1 contains ten grams of ferrous sulfate per liter of water. Solution 2 contains ten grams of potassium ferrocyanide per liter of water.

Procedure: Immerse the sample in Solution 1 at room temperature and wash with water at 70°C. Place the sample in Solution 2 at room temperature for five minutes. Wash with water at 70°C.

Results: A deep blue color indicates the presence of carboxyl groups.

Iron – Ferro Cyanide Method

Ferric salts in acid solution form Prussian Blue with potassium ferrocyanide.

Procedure on Fabric: A drop of 1*N* HCl is spotted on the fabric and a drop of 5% potassium ferrocyanide solution in water is added. A deep blue color indicates iron.

Procedure in Solution: A drop of acidified test solution is placed on filter paper or in a spot plate and a drop of potassium ferrocyanide solution is added.

Strong reducing agents such as sodium hydrosulfite will cause the blue color to disappear.

Identification limit: 0.1 mg/L Fe

Dilution limit: 1:500,000

The statements, recommendations and suggestions contained herein are based on experiments and information believed to be reliable only with regard to the products and/or processes involved at the time. No guarantee is made of their accuracy, however, and the information is given without warranty as to its accuracy or reproducibility either express or implied, and does not authorize use of the information for purposes of advertisement or product endorsement or certification. Likewise, no statement contained herein shall be construed as a permission or recommendation for the use of any information, product or process that may infringe any existing patents. The use of trade names does not constitute endorsement of any product mentioned, nor is permission granted to use the name Cotton Incorporated or any of its trademarks in conjunction with the products involved.

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Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber to yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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