Reusable Barrier Fabrics: Design, Function and Use

Workshop: Medical Textiles Network and Biocomplexity
University of California, Davis
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Speaker Background Information

Positions
Vice President – Standard Textile Co., Inc.
Past President – American Reusable Textile Association

Education
Bachelors Degree – Chemistry, Oberlin College
Masters Degree – MBA, Xavier University

Standards Involvement Includes:
US Delegate to European Committee for Standardization (CEN)

Committee Member - Canadian Standards Association (CSA)

Committee Member - US Association for the Advancement of Medical Instrumentation (AAMI)

•and participating writer/contributor to the following US standards:

Performance standard for surgical gowns and drapes PB70 2003
Processing standard for surgical gowns and drapes ST65:2000
Industrial steam sterilization
Hospital steam sterilization
Biological Indicators
Table top sterilizers
Outline

• Reusable Surgical Fabrics: The Technology Revolution of the 1980”s.
  - Improving the “State-of-the-Art”
  - Global Growth and Presence

• Technology Overview - Microfibers

• International Standards

• Keys to Successful Reusable Programs

• Benefits vs. Single Use Products

• Questions
Improving the State-of-the-Art

• Historically reusable surgical fabrics were traditional fabrics that found application in the clinical setting…

  Muslin was turned into surgical wrappers
  Bed sheets became surgical drapes
  Cotton apparel items became surgical gowns

• In the 1980’s, the reusable industry specifically set out to develop and market a new generation of reusable surgical fabrics. The end result is a growing family of barrier fabrics based on extruded filaments, fibers and yarns.
Global Growth and Presence – Filament Polyester Surgical Products

- **1990**: Yellow
- **2001**: Green
- **2006**: Blue

The map illustrates the growth and presence of Filament Polyester Surgical Products globally, with regions color-coded to represent the years 1990, 2001, and 2006.
Technology Overview:

Survey of the industry indicated that two characteristics of traditional surgical fabrics needed to be improved upon – linting and barrier performance.

1. Linting: Particles including lint are a safety related concern in the OR and have been identified as the source of contamination that cause potential infections and pyrogenic affects.

2. Barrier: Not only protection of the patient from infection was a concern but protection of the healthcare worker due to infectious diseases like AIDS also focus attention on the need for improved barrier properties for surgical fabrics.
Engineering Fabrics with Low Lint Properties

• Traditional spun yarns used in cotton fabrics and spun laced disposables are both constructed with “staple fibers”. The ends of each fiber is a potential source of lint.

• Filament barrier fabrics use continuous filaments that do not have fiber ends.
Extruding Filaments/Yarns
Linting

- Cross sectional photos show that the surface of the fabric has no protruding fibers and therefore has very little propensity to lint.
Lint Comparison

Lint Generation

No. Particles

Cotton Spun Laced SMS ComPel
Engineering Fabrics with Barrier Properties

In order to engineer a barrier fabric to meet the changing needs, three areas were addressed:

1. Selection of a hydrophobic fiber.


3. Use of chemical finishes to enhance barrier performance.
Selection of a Hydrophobic Polymer: Polyester
Moisture Regain...
Polyester = 0.3%
Cotton = 7-8%

\[
\begin{align*}
\text{CH}_3\text{OOCCOOCH}_3 + \text{HOCH}_2\text{CH}_2\text{OH} & \xrightarrow{\text{acid or base}} \text{CH}_3\text{OH} \\
\text{Methyl terephthalate} & \quad \text{Ethylene glycol} \\
\end{align*}
\]

Dacron
A polyester
Weaving and Compaction of Yarns:
Pore size can be as low as 2 microns
Finishing

Fluorocarbon treatments are used on all “Standard” performance barrier fabrics – microfibers, spun laced, and spun bonded.

These finishes are responsible for providing up to $\frac{3}{4}$ of the barrier properties of these fabrics.
How the Liquid “Barrier” Works

• Question: If the pore size of the fabric is 2 microns but blood cells, water molecules, and other potential contaminants are smaller than 2 microns, how can the fabric act as a barrier?

• Answer: The single most important attribute that allows microfibers to work is the “surface tension” of the liquids it comes in contact with.
• Several conclusions can be drawn from understanding the role surface tension and its affects on the barrier properties of the fabric. They are:

1. The higher the surface tension of liquids that come in contact with these fabrics, the higher the barrier performance (hydrostatic resistance) will be.

2. For liquids like alcohols that have low surface tensions, these fabrics will only have fair barrier resistance as compared with blood and water. Water has a surface tension around 70 dynes, blood approximately 50 dynes, and alcohols 20 dynes or less.

3. In order to maximize the barrier performance of these fabrics, residual detergents from the laundering process and/or ineffective rinsing of hand scrubs should be avoided.
Performance Expectations – Barrier Performance

![Graph showing Repellency Performance over Number of Cycles](chart)

- **Horizontal Axis (Bottom):** Number of Cycles
- **Vertical Axis (Left):** Hydrostatic Rating (cm)
- **Legend:** Data points and trend lines indicate changes in hydrostatic rating over cycles, showing expected performance expectations.
Reusable Protection

Hydrostatic Resistance (cm) vs. Number of Cycles

- Microfiber w/Laundry Enhancement
- Microfiber
- A
- B
- C
- T-275
Variation: Antistatic Filaments

- Due to the low moisture content of polyesters, they are known to have static issues (water is one of the best antistats). Specialized filament have been developed that utilize a carbon core to control static.
Two important characteristics of static and these filaments are:

1. Static is a surface phenomena and is characterized as a probability of the static existing at any one point on a product.

2. Products with carbon core yarns have a “finite” and not an “infinite” capability to dissipate static. Once the carbon is fully charged, static will again start to travel on the products surface and if it reaches discharge levels, static can exist.

In designing these fabrics, it is therefore not necessary to have carbon core yarns throughout the product as long as it is in the product in sufficient quantities. Use of carbon core yarns only in the back panel of surgical gowns is recommended.
Direction and Focus of International Standards

- The following international standards have been developed with a primary focus on barrier protection offered by surgical gowns and drapes. In addition, many of the standards include other performance requirements such as being low linting, durable and strong.

  Europe TC 205 WG 14 “Surgical drapes, gowns and clean air suits, used as medical devices for patients, clinical staff and equipment”


  Canada CSA Z314.10 “Selection, Use, Maintenance, and Laundering of Reusable Textile Wrappers, Surgical Gowns, and Drapes for Health Facilities”
### Levels of Performance (PB-2003)

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<th>Level</th>
<th>Test Method</th>
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<tr>
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<td>AATCC 127</td>
<td>≥ 20 cm</td>
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<tr>
<td>3</td>
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Keyes for a Successful Laundry Operations – A Focus on Quality and Customer Service

- Each step in the process from receipt of goods, laundering, inspection, folding, packing, and sterilization are controlled by documented procedures, product testing, employee training and interface with the customer to ensure their ongoing satisfaction.
US Standards Relating to Laundering Surgical Products

- AAMI/ANSI ST65:2000 “Processing of Reusable Surgical Textiles for Use in Health Care Facilities”.
Laundry

Quality Programs
Microprocessor controlled/automated processing equipment

Laundry Formula Cycle Verifications

Laundry Formula Chemical Titrations

Periodic Product Testing

Environmental Stewardship
Use of:
Biodegradable Detergents
Water Reuse Systems
Heat Reclamation Systems
Pack Room

**Quality Programs**
Visual Inspection over Light Tables

Established Folding Procedures/Methods

Device Master List for each pack produced including contents, configuration, wrapping technique and labeling

Established policy for patching, mending and staining, i.e., what is and is not acceptable with the end user
Sterilization

Quality Programs
Automated/microprocessor controlled sterilization equipment
Use of a dedicated steam generator to ensure the highest quality of steam
Establishment of cart loading procedures
Utilization of an “overkill” saturated steam sterilization process that is validated, i.e., prevacuum cycle with 132°C set point and a 4 minute exposure
Daily pre-production testing including chamber warm up and leak tests
Periodic cycle validation, bowie-dick testing, unit calibration and an established preventative maintenance program
Production/lot controls including both chemical and biological indicators
Advantages vs. Single Use Products

- More Homogeneous Fabric – Less Variability in Protection/Highest Level of Protection
- Elimination of “Hazardous” Waste
- Reduced Environmental Impact – Life Cycle
- Lower Cost per Use
- Employment Opportunities for the Community
- Retrieval of Surgical Instruments
Comparison vs. Single Use Products

A picture is worth a thousand words.....

Spun-Laced

Spun-Bonded

ComPel
“Environmental Benefits”

The amount of waste generated is dramatically less than when a disposable system is used. In addition, this usually eliminates the “hazardous” waste category as the eventual retirement of reusable items are not “hazardous” but “general” waste. There will also be less waste than older cotton systems because not only are they lighter in weight, they will also last longer in the system due to the better durability of the fabric. The result is significantly less poundage being discard on an annual basis.

A European life cycle assessment of barrier microfibers versus both cotton and single use items, clearly demonstrate that filament polyester is by far the most environmental sound choice during a cradle to grave assessment.
### Financial Review

**Winter Haven Hospital, Winter Haven, Florida**

<table>
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<th>Procedures Annually</th>
<th>Old System</th>
<th>New System</th>
<th>Actual Year End Results</th>
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</table>

**Disposable Costs**

- **Disposal Acquisitions**
  - FY 2001: 83,999
  - FY 2002: 132,491
  - FY 2003: 126,446
  - FY 2004: 129,963
  - FY 2005: 110,540

- **Waste Disposal**
  - FY 2001: 3,390
  - FY 2002: 5,347
  - FY 2003: 5,103
  - FY 2004: 5,245
  - FY 2005: 4,461

- **Instrument Replacement**
  - FY 2001: 420
  - FY 2002: 662
  - FY 2003: 632
  - FY 2004: 650
  - FY 2005: 553

**Reusable Costs**

- **Laundry Cost**
  - FY 2001: 43,010
  - FY 2002: 29,066
  - FY 2003: 67,839
  - FY 2004: 54,752
  - FY 2005: 64,446

- **Packroom Labor**
  - FY 2001: 83,200
  - FY 2002: 62,400
  - FY 2003: 131,230
  - FY 2004: 81,443
  - FY 2005: 125,243

- **Sterilization Cost**
  - FY 2001: 28,050
  - FY 2002: 16,112
  - FY 2003: 44,243
  - FY 2004: 35,708
  - FY 2005: 42,224

- **Packroom Supplies**
  - FY 2001: 3,278
  - FY 2002: 4,663
  - FY 2003: 5,170
  - FY 2004: 12,482
  - FY 2005: 4,934

- **Drape Tape**
  - FY 2001: 0
  - FY 2002: 3,750
  - FY 2003: 0
  - FY 2004: 1,846
  - FY 2005: 0

- **Linen Replacement**
  - FY 2001: 16,830
  - FY 2002: 65,381
  - FY 2003: 26,546
  - FY 2004: 70,908
  - FY 2005: 25,335

**Administrative Costs**

- **Quarterly Audits**
  - FY 2001: 0
  - FY 2002: 5,000
  - FY 2003: 0
  - FY 2004: 0
  - FY 2005: 0

**Start-Up Costs**

- **Implementation Fee**
  - FY 2001: 0
  - FY 2002: 0
  - FY 2003: 0
  - FY 2004: 0
  - FY 2005: 0

- **Facility Conversion**
  - FY 2001: 0
  - FY 2002: 0
  - FY 2003: 0
  - FY 2004: 0
  - FY 2005: 0

- **Inventory Investment**
  - FY 2001: 0
  - FY 2002: 0
  - FY 2003: 0
  - FY 2004: 0
  - FY 2005: 0

**Total Costs**

- FY 2001: 262,177
- FY 2002: 186,372
- FY 2003: 413,529
- FY 2004: 257,139
- FY 2005: 394,661

**Net Savings**

- FY 2001: 345,017
- FY 2002: 230,043
- FY 2003: 345,017
- FY 2004: 383,311
- FY 2005: 383,311

**Cost per Procedure**

- FY 2001: $37.21
- FY 2002: $26.45
- FY 2003: $23.14
- FY 2004: $25.83
- FY 2005: $25.92
Acceptance and Use – Open Heart Case

- Everyday end users around the globe rely on reusable systems to deliver the right product, in the right quantity to ensure not only an effective outcome to the surgical intervention but also protection of their staff from potentially infectious situations. Couple this with the cost and environmental advantages of reusables, it should be the first choice for today’s professional healthcare providers.
Questions....