

NIST Barrier Fabric Workshop

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Acknowledgement

We are grateful to NIST for
the opportunity to present our
research.

FR Greige Cotton Barrier Technologies: Fire Barrier For Mattresses To Comply with 16 CFR Part 1633

**D.V. Parikh, N. Prevost, J. Smith,
H. Solhjoo, SeChin Chang, B. Condon**

Southern Regional Research Center, USDA, New Orleans, LA

Outline

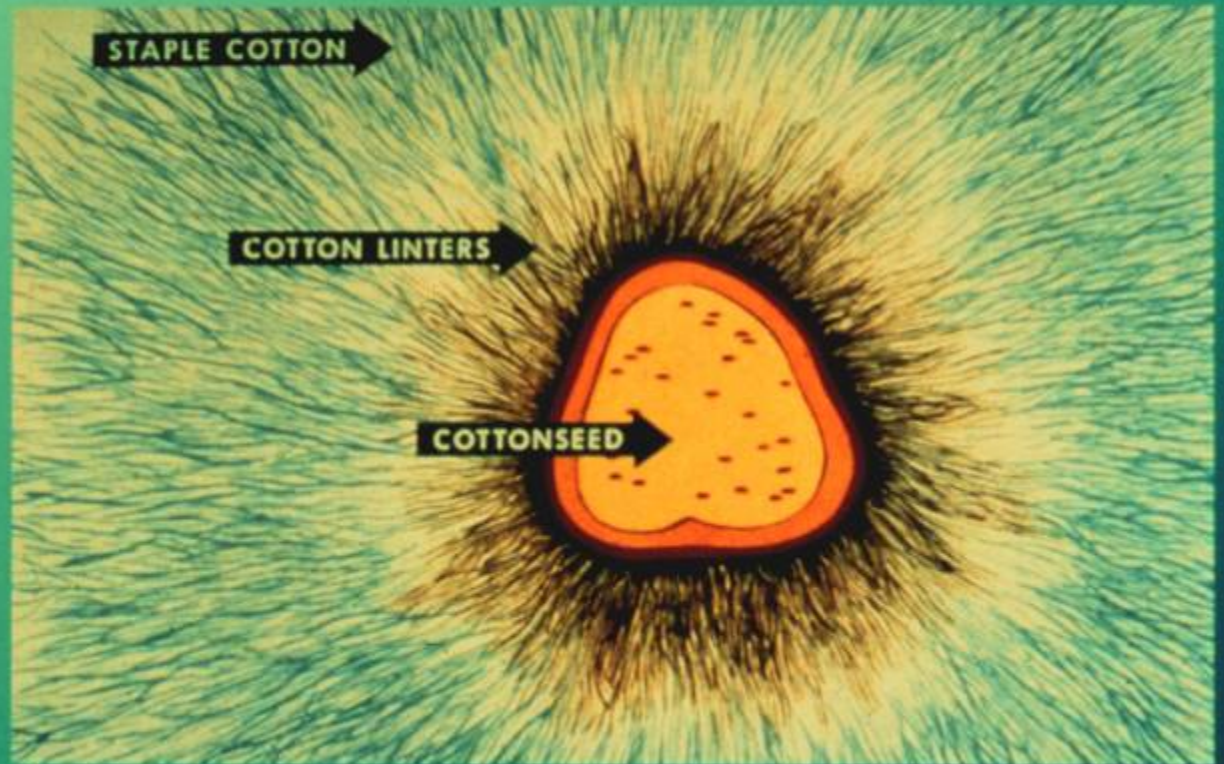
- Overview of cotton fiber
- Mattress industry: U.S. Market
- Compliance of Federal Regulation CFR1633
- Ways to produce FR barrier fabrics
- Needle punched FR greige cotton fabric
 - SRRC formulation and Compliant “F”
 - Test results & TGA profiles of films SRRC Formulation and Compliant “F”
- Summary
- Conclusions

Overview of Cotton Fiber

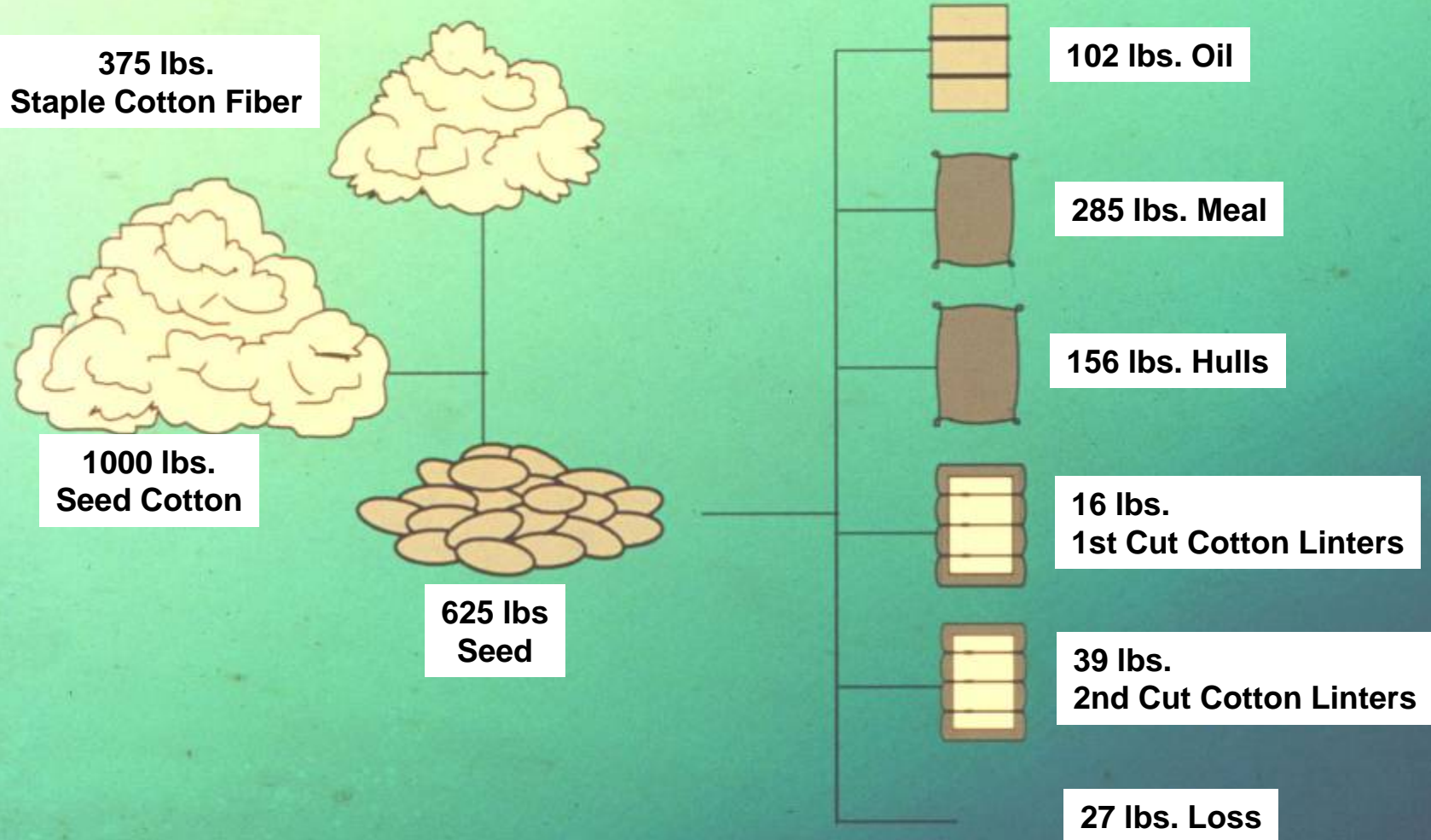


Two fibers grow from the cotton seed:

- Staple cotton
- Cotton linter



Products from cotton:



COTTON PHYSICAL PROPERTIES MEASURED BY HVI

- * length
- * length uniformity
- * strength
- * elongation
- * micronaire

MICRONAIRE

has units of Micrograms per inch

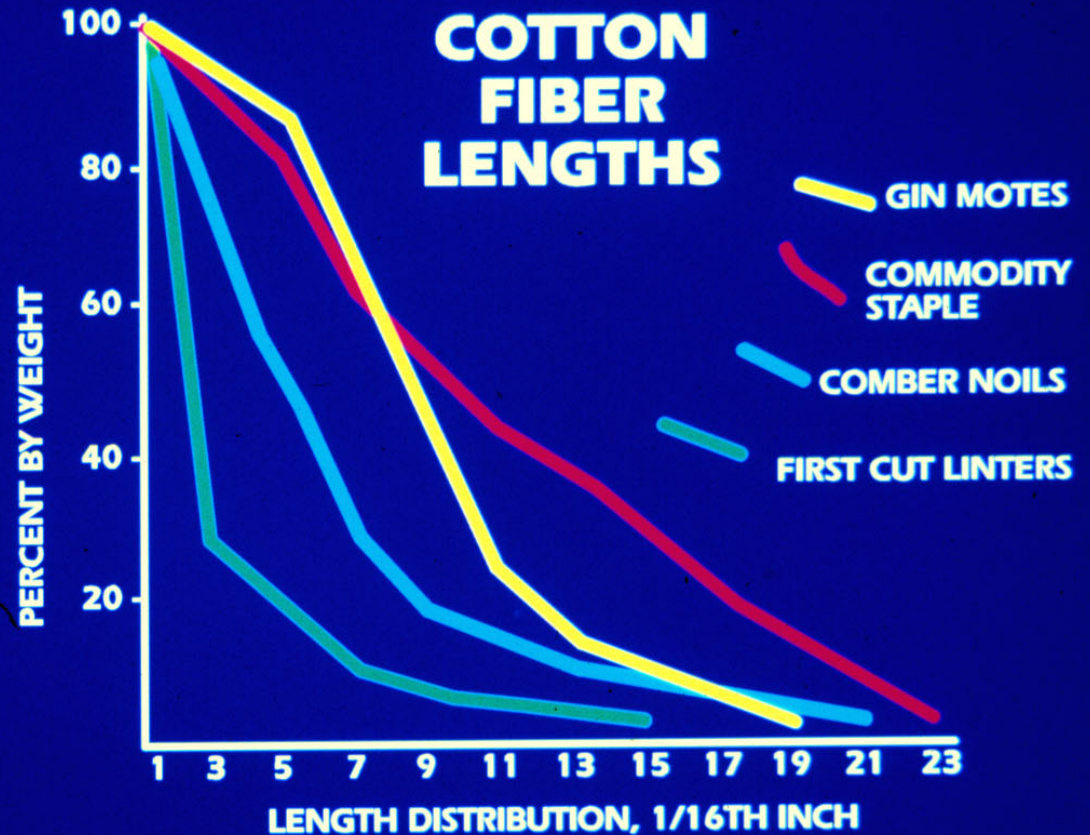
$$\text{Denier} = \frac{\text{Micronaire}}{2.82}$$

Range for Cotton:

Micronaire = 2.0 - 6.5

Denier = 0.7 - 2.3

COTTON FIBER LENGTHS



STRENGTH (g/tex)

	Dry	Wet
Cotton	27 - 45	30 - 54
Rayon (regular)	22 - 27	10 - 14
Polyester	27 - 54	27 - 54

Cotton Properties

- Absorbent
- Breathable
- Stronger when Wet
- Biodegradable (under certain conditions)
- Excellent Wicking
- Sterilizable by All Industrial Methods
- Low Static Potential
- Dyeable
- Chemically Modifiable
- Renewable Resource
- In Demand by Consumers

Mattress Industry: U.S. Market

Today's Luxury Mattress 22" to 25" Thick



Mattress Industry: U.S. Market Forecast Sept. 2008

Mattress Shipment				Forecast		
	2005	2006	2007	2008	2009	2010
\$ Value (Billions)	\$6.475	\$6.779	\$6.871	\$6.218	\$6.479	\$7.095
% Change	12.0%	4.7%	1.4%	-9.5%	4.2%	9.5%
Units (Millions)	41.734	41.150	40.274	37.253	37.700	39.962



Barrier Fibers: U.S. Mattress

- Cotton: 20 Million Lbs
- Visil®: 65 Million Lbs
- Post Treated Rayon:
- Wool
- Blends:
 - Modacrylic+ Polyester

■ Total: 100 Million Lbs

Compliance of Federal Regulation CFR1633

EFFECTIVE July 1, 2007

16 CFR 1633: Fire barrier material

effective July 2007

- The open-flame standard for 16 CFR 1633 has led to new approaches for protecting polyurethane foam from fire. One approach is to employ fire barrier material in the manufacture of mattresses (under the ticking).
- The fire barrier material is designed to protect and prevent ignition of the major cushioning component of the mattresses and thereby prevent a self-propagating fire.

Fire barrier fabric: How does it save life?

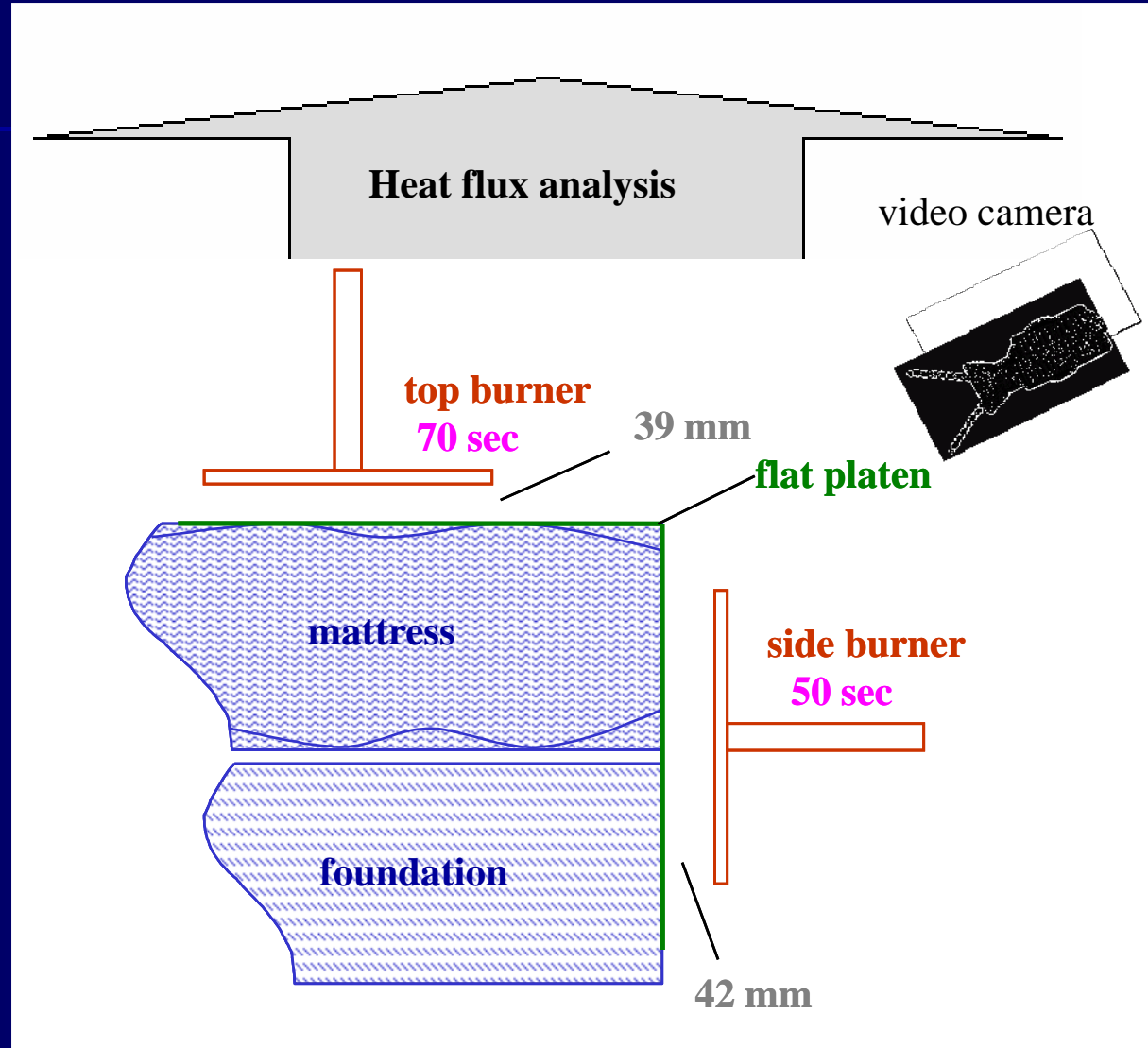
- Provide occupants more time to escape
- Retard Combustion
- Lower Heat Release
- Slow Down the flame
- Extinguish the fire

CFR 1633 Requirement

- A Full Scale mattress burn test is required.
- Using a dual burner, apply open flame to both top and sides of mattress and box spring. Mimic the real-life situations.
- Must not exceed a peak heat release rate of 200 KW during 30 min test.
- Total heat release for the first 10 min of the test not to exceed 15 mega joules.

Full Mattress Burn Test

6 CFR Part 1633



Mattress Flammability Comparison

Both Products Pictured Two Minutes After Start of Fire



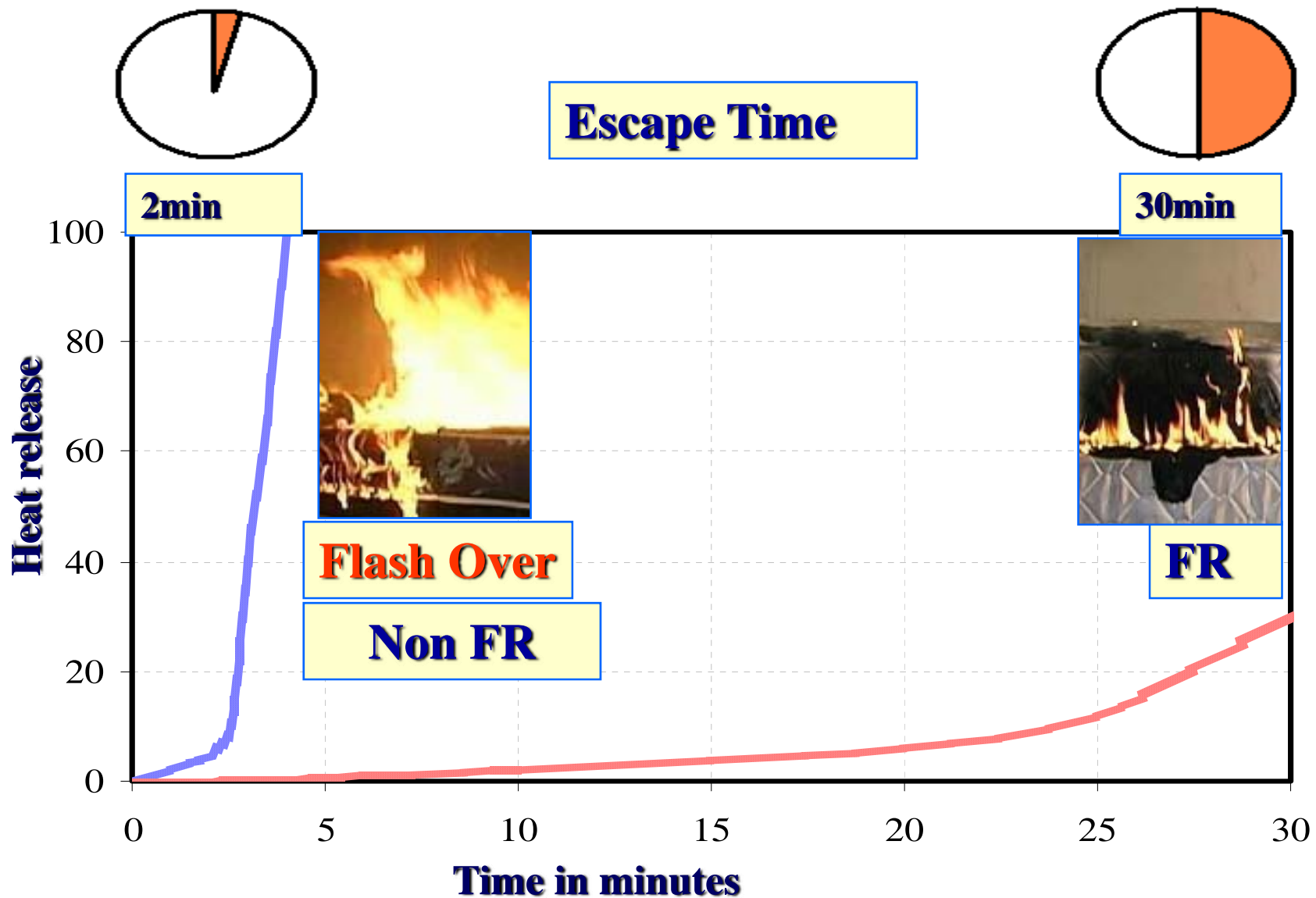
Earlier Mattress

Earlier mattress found in homes ignites easily with small open flame and then burns intensely, filling room with heat and smoke.



Improved Products

Mattress and box spring built to meet new safety standard are subjected to open flame for 70 seconds, but resist fire for 30 minutes.



Escape time increase through FR

Ref: www.bhfti.ca.gov & www.specialchem4polymers.com

Flash Over

- The point at which the heat in the area is high enough to ignite all flammable materials simultaneously.
- Smoke and other gases may further impair rapid escape of the occupants.

FR Greige Cotton Barrier NWs: Fire Barriers for Mattresses to Comply 16 CFR Part 1633

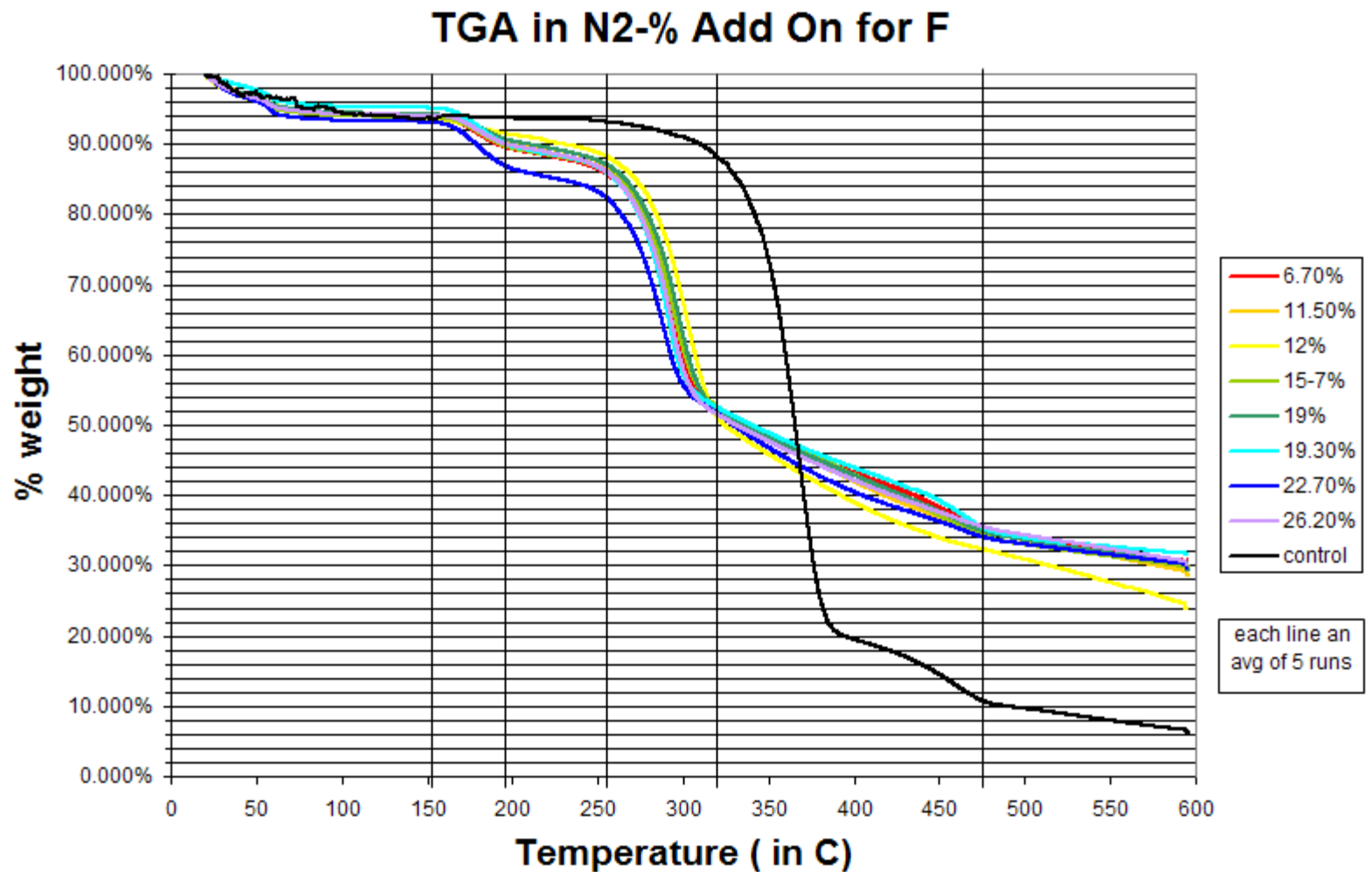
Two ways to produce FR barrier fabrics:

- By treating cotton Needle punched (NP) fabric with FR formulation via pad-dry or, pad-dry-cure.
- By treating cotton fiber with FR formulation,
 - NP fabric from FR cotton.
 - Thermal bonded high loft NW from FR cotton.

Tests Performed on NP Fabric: FR Evaluation

- TGA (Thermal Gravimetric Analysis)
- Flame Resistance: Vertical AATCC Flammability Test Method 5903
- Limiting Oxygen Index (LOI): ASTM D 2863-06a
- % Nitrogen: Dumas Combustion
- % Phosphorus: AOAC 986.15 with ICP finish
- Breaking Strength: (Grab Test) ASTM D5034-95

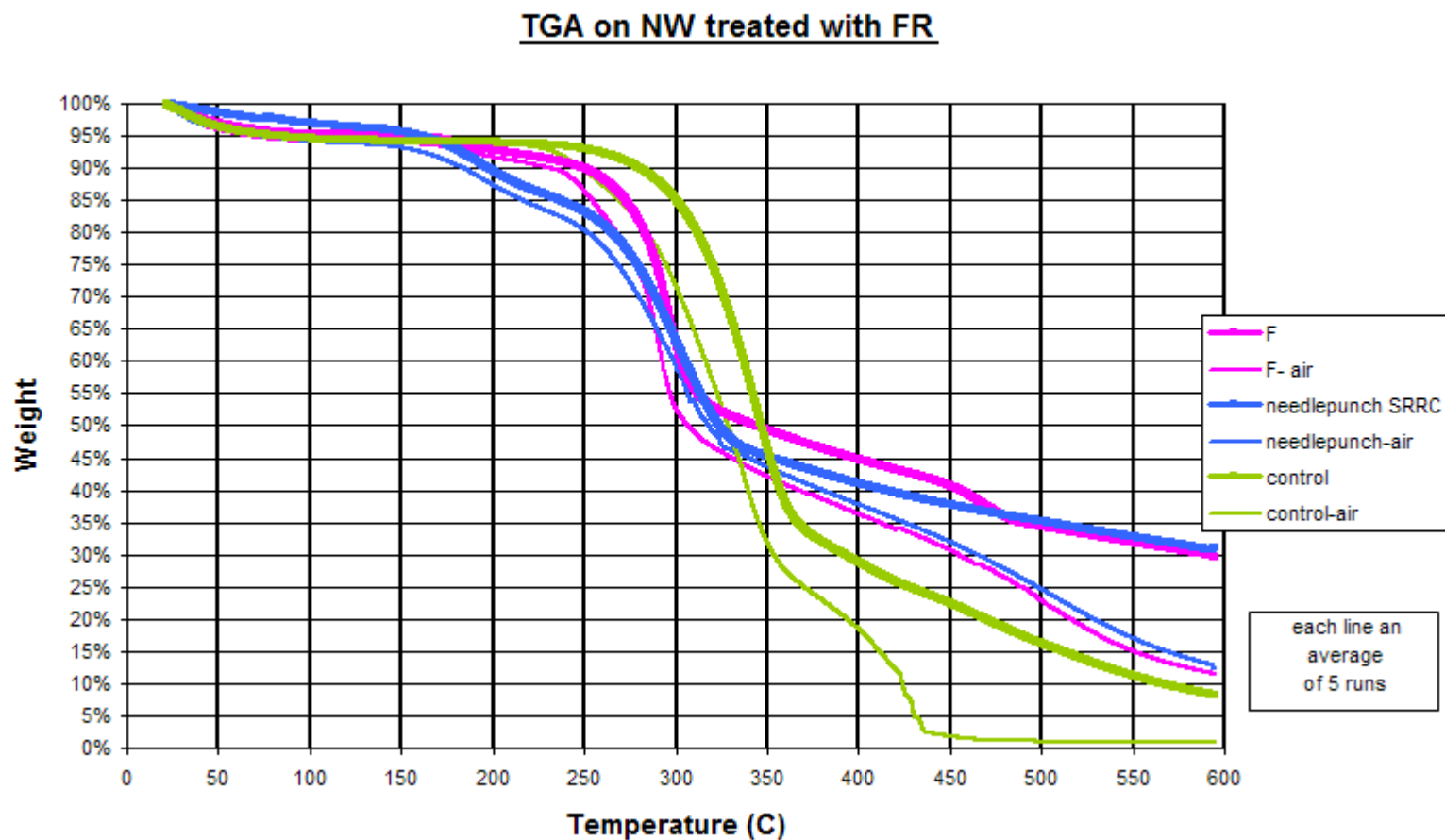
TGA Data: compliant formulation



FR Formulation Evaluated

Formulation	#1
	%
DMDHEU	5.0
Diammonium Phosphate	10.0
Urea	5.0
Triton X-100	0.7
Polyethylene Emulsion	1.5
Mg Cl ₂ , 6H ₂ O	1.0
Citric Acid	1.0
Water	75.8
Total	100.0

TGA Data, contd.



Flammability Test Method 5903

% Add -On	Char length, mm
22.7	12.70
19.3	10.58
19.0	11.64
17.3	23.82
14.8	34.59
14.1	25.40
13.2	13.67
12.1	20.67
7.8	6.88
Control (Burns)	0.00

All FR samples showed zero afterflame and zero afterglow.

- Char is less than 15%
(Specimen: 300mm X 76mm)
- Control burns
instantaneously leaving no
char.

Char (intumescent)

- The char acts as a thermal barrier that is effective in reducing amount of heat that is transmitted through it. This reduction in heat prevents materials behind the (barrier) fabric from igniting.
- The char primarily insulates the underlying substrate from intense heat of the fire and also acts as a barrier preventing flammable volatile breakdown products from reaching the flame front.

Flammability Terms: LOI:

minimum concentration of oxygen that will just support the flame

LOI < 21:	Flammable
LOI = 21:	Marginally Stable
LOI > 100:	Intrinsically non-flammable
LOI between 21-28:	Slow burning
LOI between 28-100:	Self Extinguishing

LOI and Breaking Strength

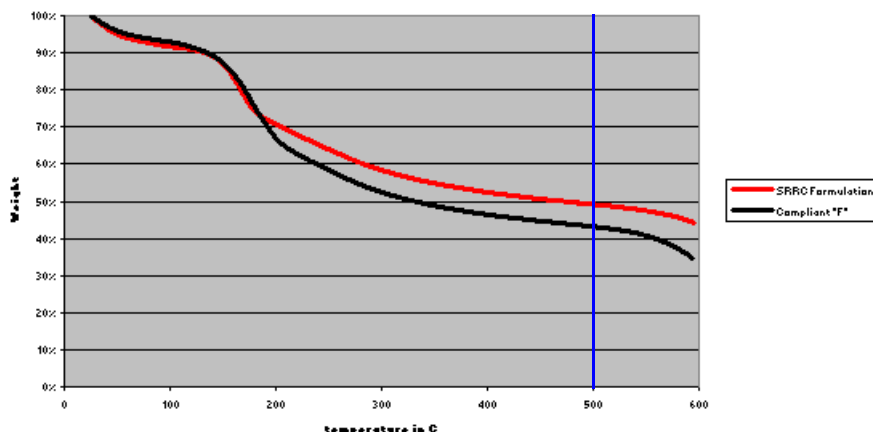
% Add- On	LOI	Breaking Force (lbs)	Breaking strength, Retained (%)	Elongation(%)	Elongation Retained (%)
26.2	40%	26.25	136.22	108.58	93.93
21.9	38%	28.80	149.46	107.78	93.24
19.0	37%	23.45	121.69	102.58	88.74
15.8	34%	22.54	116.97	110.63	95.70
14.7	34%	23.80	123.51	131.13	113.43
12.1	34%	20.83	108.10	118.69	102.67
6.7	37%	19.73	102.39	108.25	93.64
Control 0.0	21%	19.27	100.00	115.60	100.00

Nitrogen % and Phosphorus%

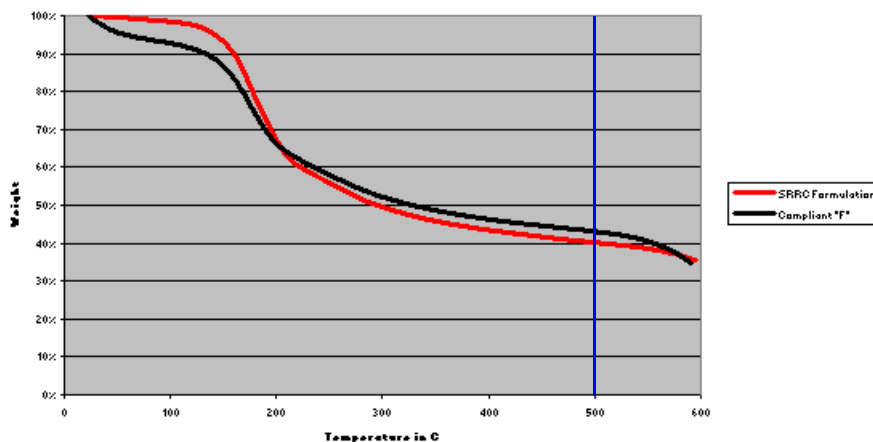
% Add-On	% N	% P
22.7	6.62	3.50
19.3	6.73	3.90
19.0	6.60	4.50
15.7	5.31	2.70
12.1	3.66	1.84
11.5	4.51	2.20
10.1	3.60	1.86
7.8	3.86	1.84
Control – Nil	Negligible	Negligible

TGA Profiles of Films with SRRC Formulation and Compliant “F” (with and without DMDHEU)

TGA Profile: Films without DMDHEU



TGA Profile: Films with DMDHEU



TGA Data of Films: Char %
@ 500C

SRRC
Modified
without
DMDHEU

50%

Compliant F

43%

Summary of Results

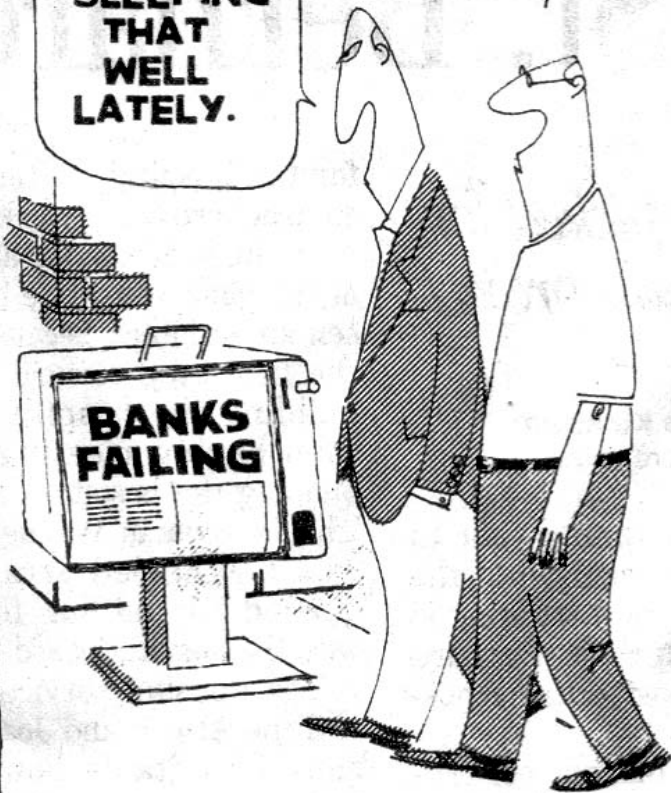
- FR samples have excellent FR quality without afterflame /afterglow. Control is highly flammable.
- LOI of the FR fabrics are quite high, 34-40, confirming high FR quality. LOI of control is 19-20.
- Cotton NW with FR does not cause adverse effect on strength, % elongation properties.
- SRRC FR formulation is comparable to the compliant commercial FR formulation.
- SRRC modified formulation shows greater promise.

Conclusion

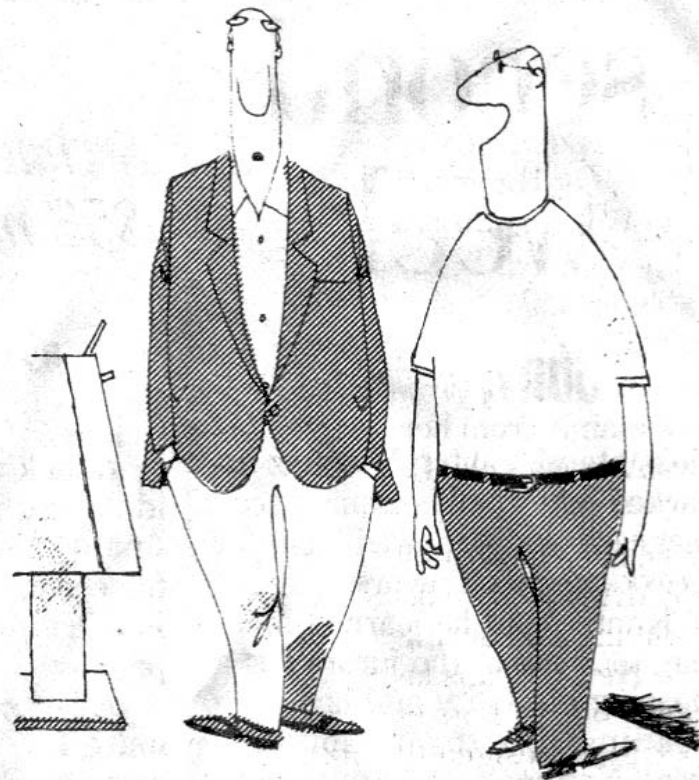
- Cotton provides renewable resource, biodegradable, green fiber.
- Cost effectiveness is important, particularly for low to medium value mattresses/futons.
- FR Cotton fiber provides greater opportunity in cost effectiveness and in FR quality.
- Cost effectiveness is further increased using waste/recycled/short length cotton

I
HAVEN'T
BEEN
SLEEPING
THAT
WELL
LATELY.

TOO
MUCH
STRESS?



NO, I STUFFED
ALL MY MONEY
INTO MY
MATTRESS...



THANK YOU

WORKSHOP AGENDA