



***CHEMICAL AND BIOLOGICAL BARRIER  
MATERIALS  
FOR COLLECTIVE PROTECTION***

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# OVERVIEW

## ❖ PURPOSE

- ❑ Educate

## ❖ BACKGROUND

- ❑ Brief History of CB Barrier for Collective Protection

## ❖ TECHNOLOGY DEVELOPMENT AREAS

- ❑ Near-Term Solution
- ❑ Mid-Term Solution
- ❑ Long-Term solution

## ❖ WHAT NEXT?

- ❑ Collaborative Effort



# BACKGROUND

## ColPro Shelters

- \*Heavy
- \*Cumbersome
- \*High Logistic Burden
- \*Very Expensive

## Barrier Materials

- \*Butyl Rubbers
- \*Chlorinated Aliphatics
- \*Fluorinated Polymers

## Characteristics of a Barrier Material

Permeability of a “Challenge Agent”

**VS.**

- \* Thermal Stability
- \* Flame Resistance
- \* Ease of Decontamination
- \* Longevity
- \* Leakage Points
- \* Weight
- \* Durability (Flexibility, Abrasion, Crackle)
- \* Cost

**DEGREE OF PROTECTION?**



# CHEMICALLY PROTECTIVE BARRIER

## NO BARRIER IS PERFECT

### Threat Permeability ?

- Polarity
- Chemical Structure
- Size of Molecule
- Driving Force (Concentration)
- Temperature

### Properties of Barrier Film

- Material
- Thickness
- Inertness
- Condition

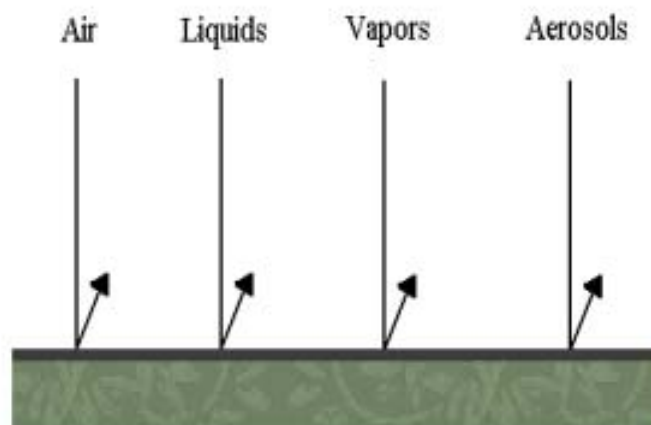
## SEVERAL COMPONENTS

→ Base Material or Substrate

\*Provides Physical Properties

→ Impermeable Barrier

\*\*Provides CB Protection





# HISTORY

## M51

1<sup>st</sup> ColPro Shelter System  
-1960's

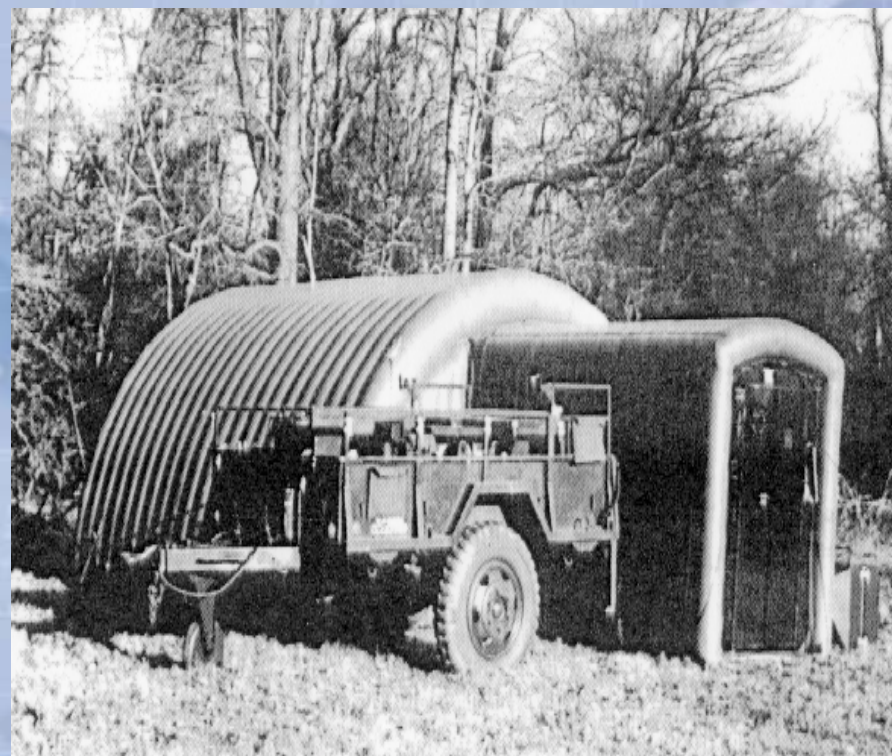
⚡ Neoprene/Dacron<sup>®</sup>/Tedlar<sup>®</sup>

Effective Barrier Material?

✓ YES

100 minutes for Mustard (HD)

200 minutes for GB (Sarin)



M51 Collective Protective Shelter



# M51 DEFICIENCIES

## ⌘ Logistically Burdensome

- 5,700 lbs.
- Took 5 persons 30+ minutes to erect
- Needed generator/blower to run 24/7

## ⌘ Material Flaws

- Expensive \$\$\$
- Difficult to weld/bond
- Heavy
- **Tedlar<sup>®</sup>**
  - \* Flex Cracking (Folding, Cold)
  - \* Abrasion
- ✗ Dedicated Vehicle





# WHAT NEXT?



## 1980's Investigation



**\*Need New CB Material**

**\*2 Areas Investigated**

- ✓ Outer Shelter Skin
- ✓ Inner Liner Material

## CANDIDATE MATERIALS

✓ Butyl Nylons

✓ Teflon<sup>®</sup>/Kevlar<sup>®</sup>

~~Tedlar<sup>®</sup>/Vinyl coated Dacron<sup>®</sup>~~

~~Teflon<sup>®</sup>/Nomex<sup>®</sup>~~

✓ Polyester/Tedlar<sup>®</sup>/Kevlar<sup>®</sup>



# TEFLON<sup>®</sup>/KEVLAR<sup>®</sup>

## ⌘ CHARACTERISTICS ⌘

- ✓ CB Resistance
- ✓ Flammability
- ✓ Weight
- ✓ Flexibility
- ✓ Durability
- ✓ Manufacturability
- ✓ Cost
- ✓ Decontamination





# TEFLON<sup>®</sup>/KEVLAR<sup>®</sup>

## SUPERIOR QUALITY

- CB Resistance
- Weight
- Mechanical Properties
- Decontaminable
- Heat-Sealable

## HOWEVER...

\$\$\$ High Cost \$\$\$

\*Manufacturing

\*Material



Chemical and Biological Protective Shelter  
(CBPS)



# M28 LINER MATERIAL

## → Secret Service

\*M20

Adopted for GP shelters

↳ **M28**

**Over Pressured Liner**

## Material

\*PVDC or Saranex Barrier Film

\*HDPE Scrim

\*LDPE Coating (Protect Barrier)

Lightweight Inexpensive Solution

## Increased

- ✓ Weight
- ✓ Packing Volume
- ✓ Deployment Time





# 2 OPTIONS AVAILABLE

## Teflon®/Kevlar®

- \*Superior Protection
- \*Lightweight
- \*Decontaminable
- \*Flame Resistant

**HOWEVER...**

**\$\$EXPENSIVE\$\$**



## PVDC/PE (M28)

- \* Inexpensive
- \*Provide CB Protection for GP Shelters

**HOWEVER...**

- \*Increase Weight
- \*Increase Deployment Time
- \*Increase Packing Volume
- \*Not Decontaminable



**OR**



# TECHNOLGY DEVELOPEMENT

## Joint Science and Technology Panel for CB Defense

✱ Investigate/Develop Next Generation CB Material

### GOAL→

- ✓ Lightweight Composite Material
- ✓ UV/Flame Resistant
- ✓ Increased Durability
- ✓ Improved Permeation Properties
- ✓ Decreased Cost (Material & Manufacturing)



# MITIGATE RISK

## Incremental Improvements

### 3 Pronged Approach



#### \* Near-Term Solution

- Fluoropolymer Coating/Lamination of GP Fabrics

#### \* Mid-Term Solution

- Nanotechnological Enhancement of Polymers
- Low-Temperature Processible Fluoropolymers

#### \* Long-Term Solution

- Self-Decontaminating Barrier Materials



# NEAR-TERM SOLUTION

## Improving Barrier Properties of General-Purpose Fabric

Polyester with PVC Coating  
\*Apply Coating or Laminate

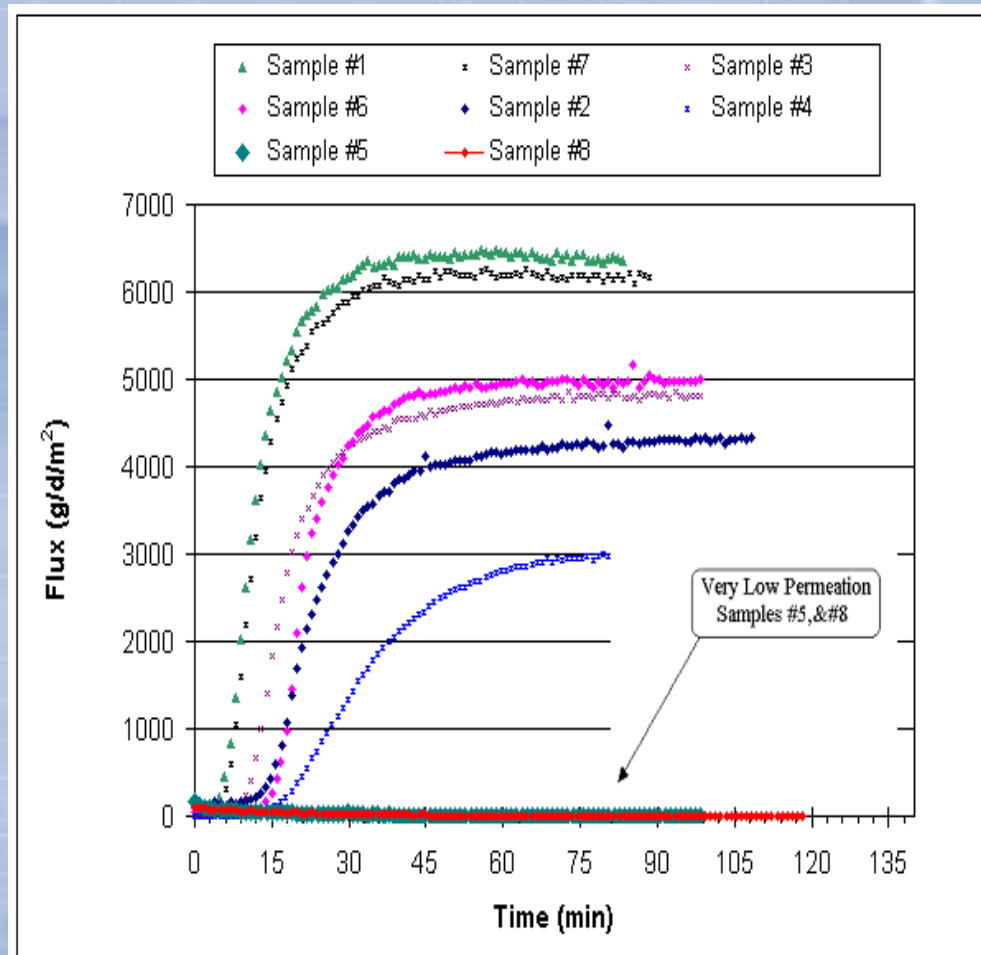
### Duracote Corporation

- Various Laminates
- Very Promising Results

### TCE Simulant

Typical GP Fabric= 17,000 g/d/m<sup>2</sup>

BUT...Delamination



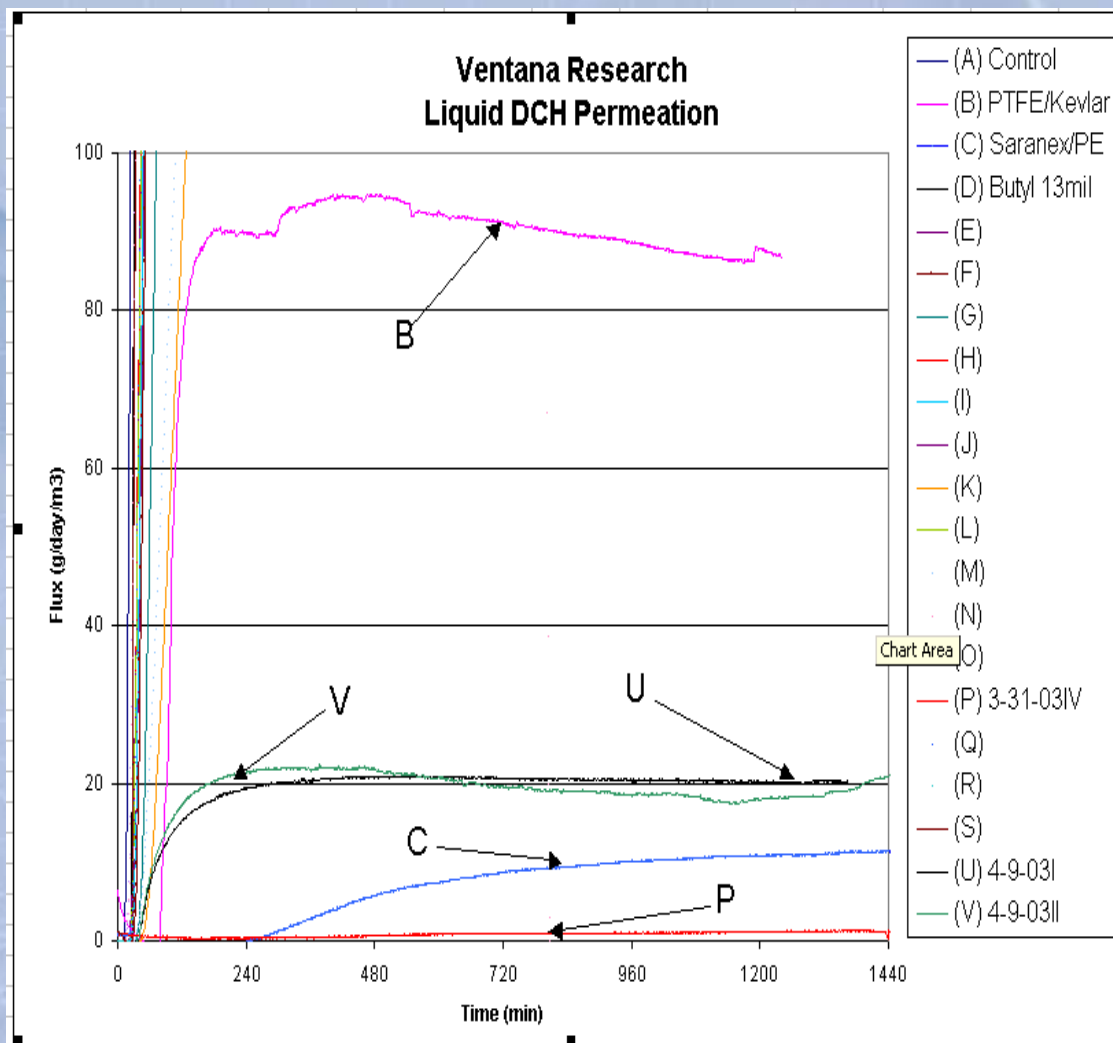
Tetrachloroethane (TCE) Permeation Through Laminated GP fabric



# VENTANA RESEARCH

## CB Barrier Coatings For GP Shelter Fabric

- \*Low cost
- \*Water Soluble
- \*Environmentally safe
- \*Easy to apply





# MID-TERM SOLUTION

**Goal: Transition in 2-4 yrs.**

## **Current Programs**

- ★ **Nanocomposite Films**
- ★ **Low-Temperature Processible Fluoropolymers**

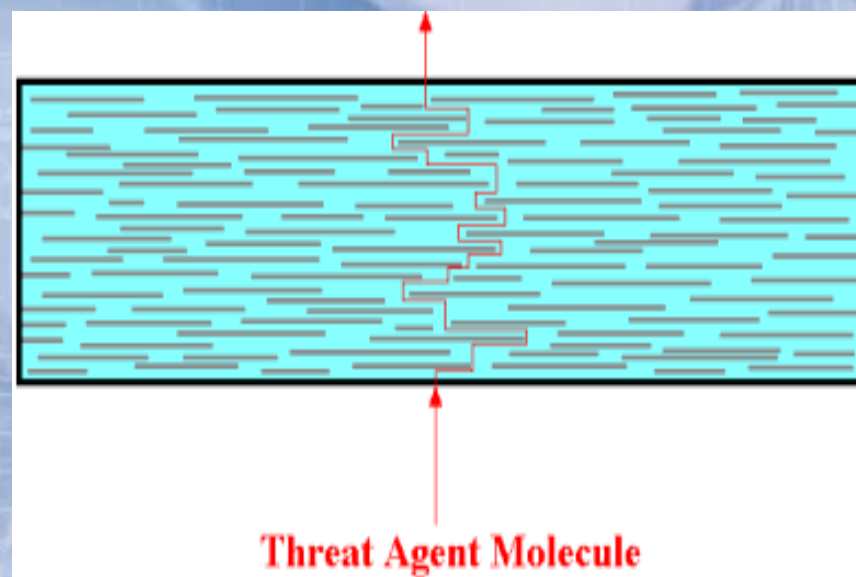
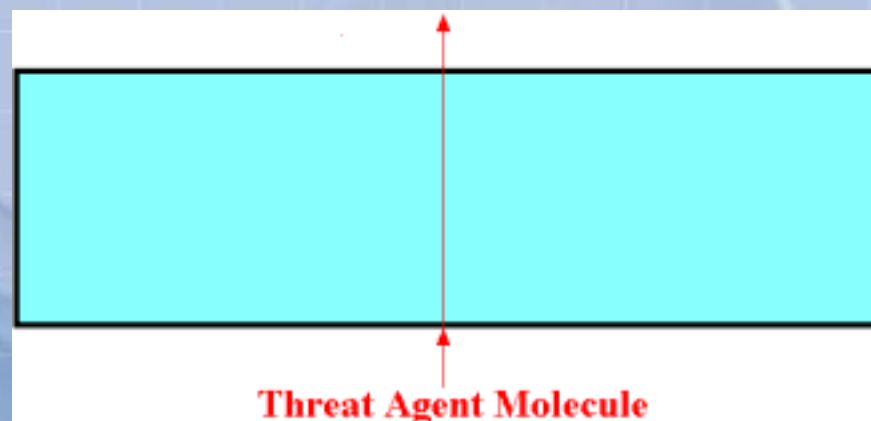




# NANOCOMPOSITE FILMS

## Background

- ↳ Novel patented nanotechnology is based on the use of minute levels (1-5%) of chemically inert inorganic fillers that exhibit a platelet nanostructure
- ↳ Adjustment of chemistry and processing conditions allows nanofillers to self-assemble (stack up) through the thickness of the plastic sheet and parallel to the plane of the barrier film
- ↳ High aspect ration creates a tortuous path for the diffusing chemical species
- \* Increased distance = Increased time for diffusion through thickness of the plastic





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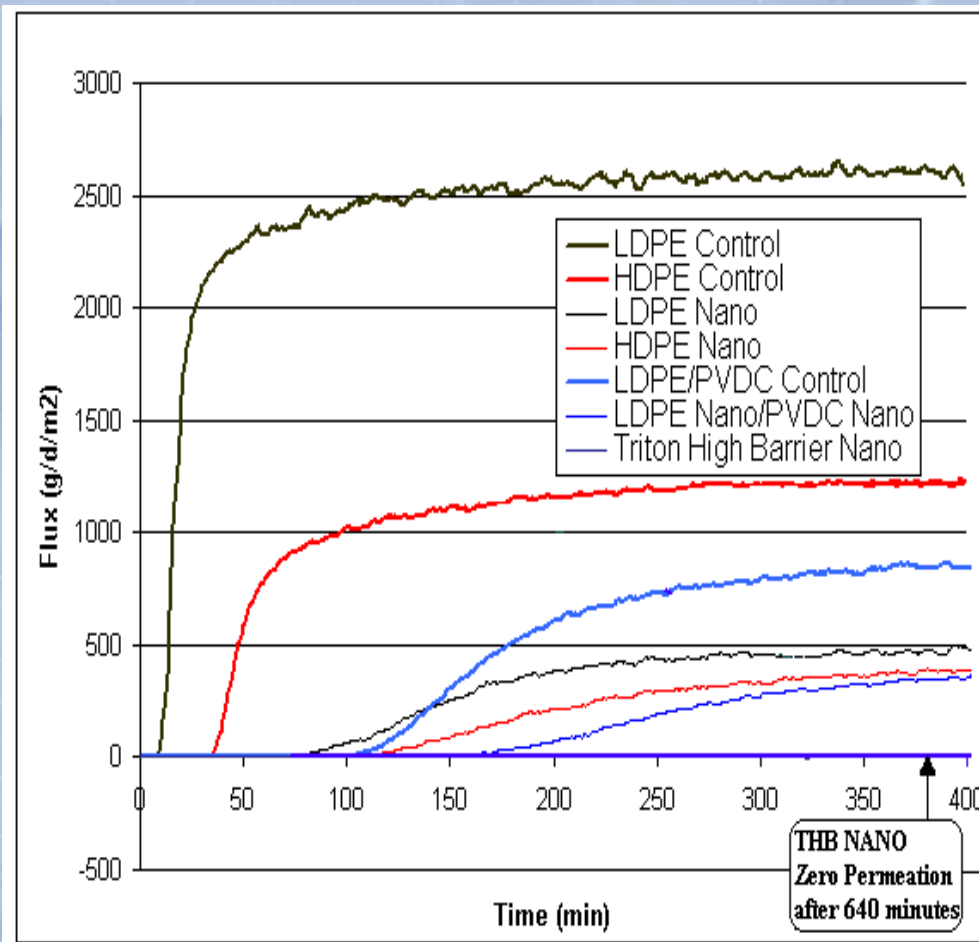


## Accomplishments

✧ Synthesized several nanocomposite films that have shown up to 5X improvement in barrier to CB simulants compared to unfilled barrier films

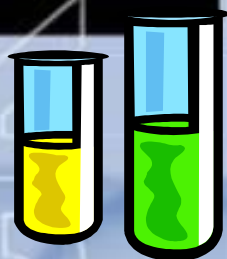
✧ Layered silicates act as a passive flame retardant

- Act as a barrier to the flame by the formation of a ceramic or glassy layer on the surface of the polymer
- High gas barrier also prevents oxygen from feeding the flame, thus starving the fire





# TRITON SYSTEMS INC.



## LIVE AGENT TESTING

✕ Developed a multi-layer laminate system that achieved greater than 24-hour exposure to liquid HD mustard chemical agent with NO penetration

		Sampling Intervals (Hours from Start)									
		$(\mu\text{g}/\text{cm}^2)$									
Agent	Sample	(0-2)	(2-4)	(4-6)	(6-8)	(8-12)	(12-24)	(24-48)	(48-72)	Cumulative	
HD	Neat	ND	ND	ND	ND	ND	ND	0.1	0.15	0.25	
	TSI Barrier Film	ND	ND	ND	ND	ND	ND	ND	0.2	0.2	
GB	Neat	ND	ND	ND	ND	ND	0.00016	0.00036	0.00037	.00089	
	TSI Barrier Film	ND	ND	ND	ND	ND	ND	ND	ND	ND	



# ***TRITON SYSTEMS INC.***



## **CURRENT EFFORTS:**

### **Scaling up Technology → Prototype Shelters**

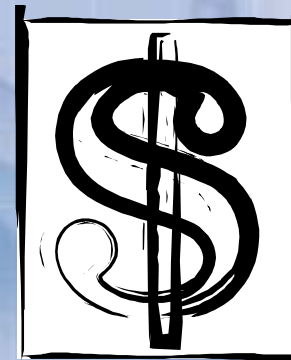
- ✓ Non-Decontaminable Barrier Liner Material
- ✓ Decontaminable High Barrier CB Outer Skin Fabric



## LOW-TEMP PROCESSIBLE FLUOROPOLYMERS

### ARAMIDS (KEVLAR<sup>®</sup>, NOMEX<sup>®</sup> etc.)

- ✓ High Strength
- ✓ Light Weight
- BUT...
- \*High Cost



Needed to Survive the High Temperature During Manufacturing

Low-Temperature Fluoropolymer = Lower Cost Substrate



# FEDERAL FABRIC-FIBERS INC.

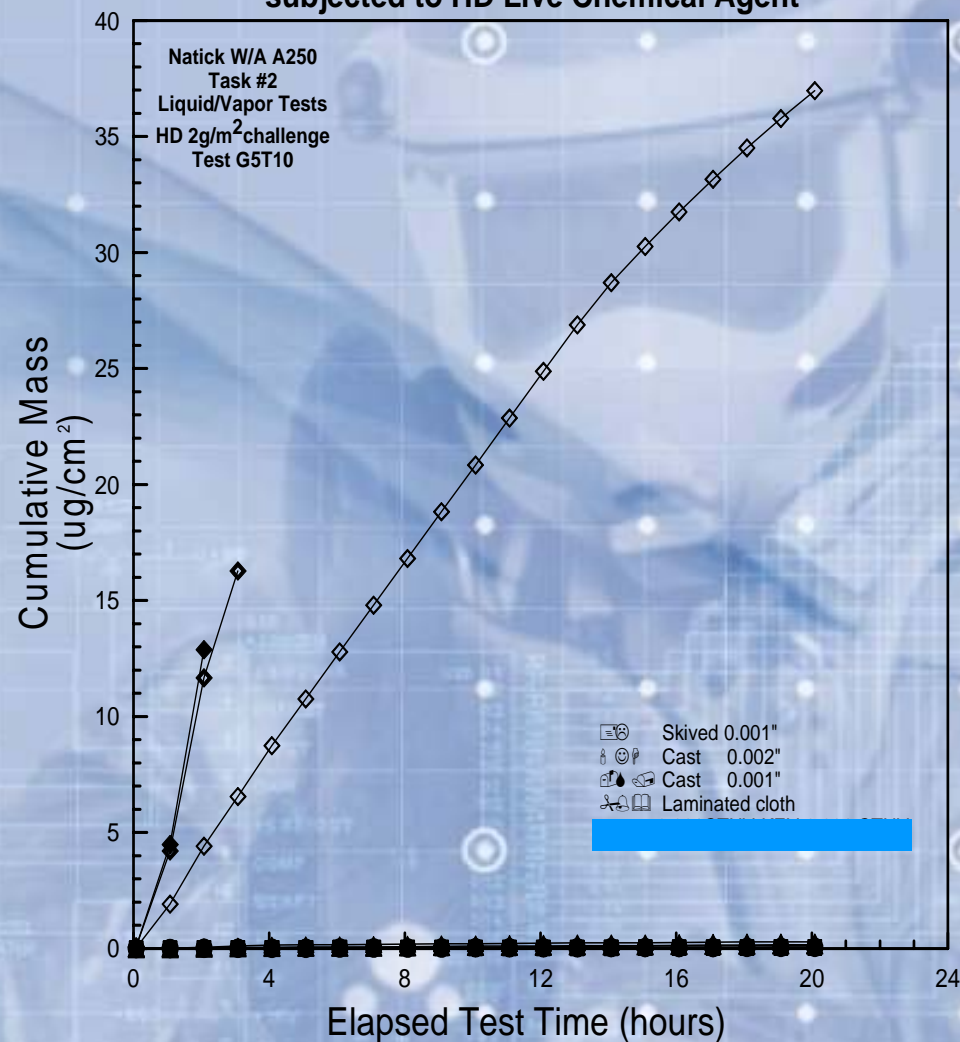
**Work From building blocks**

**Create:**

- \*Void Free Fabric Substrate**
- \*CB Resistant Barrier**

- ➔ Low Cost
- ➔ Lightweight
- ➔ Decontaminable

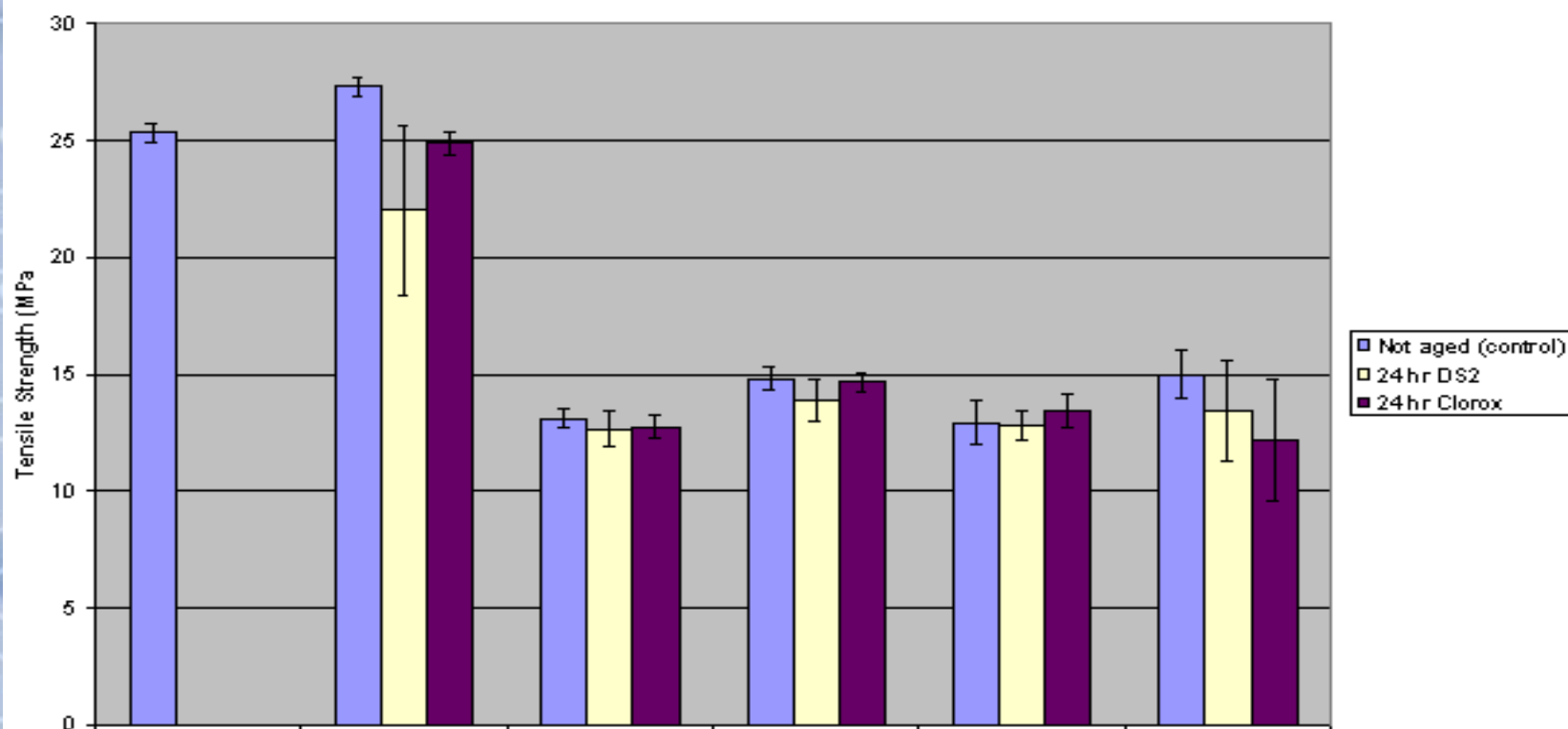
**Films and Laminate  
subjected to HD Live Chemical Agent**





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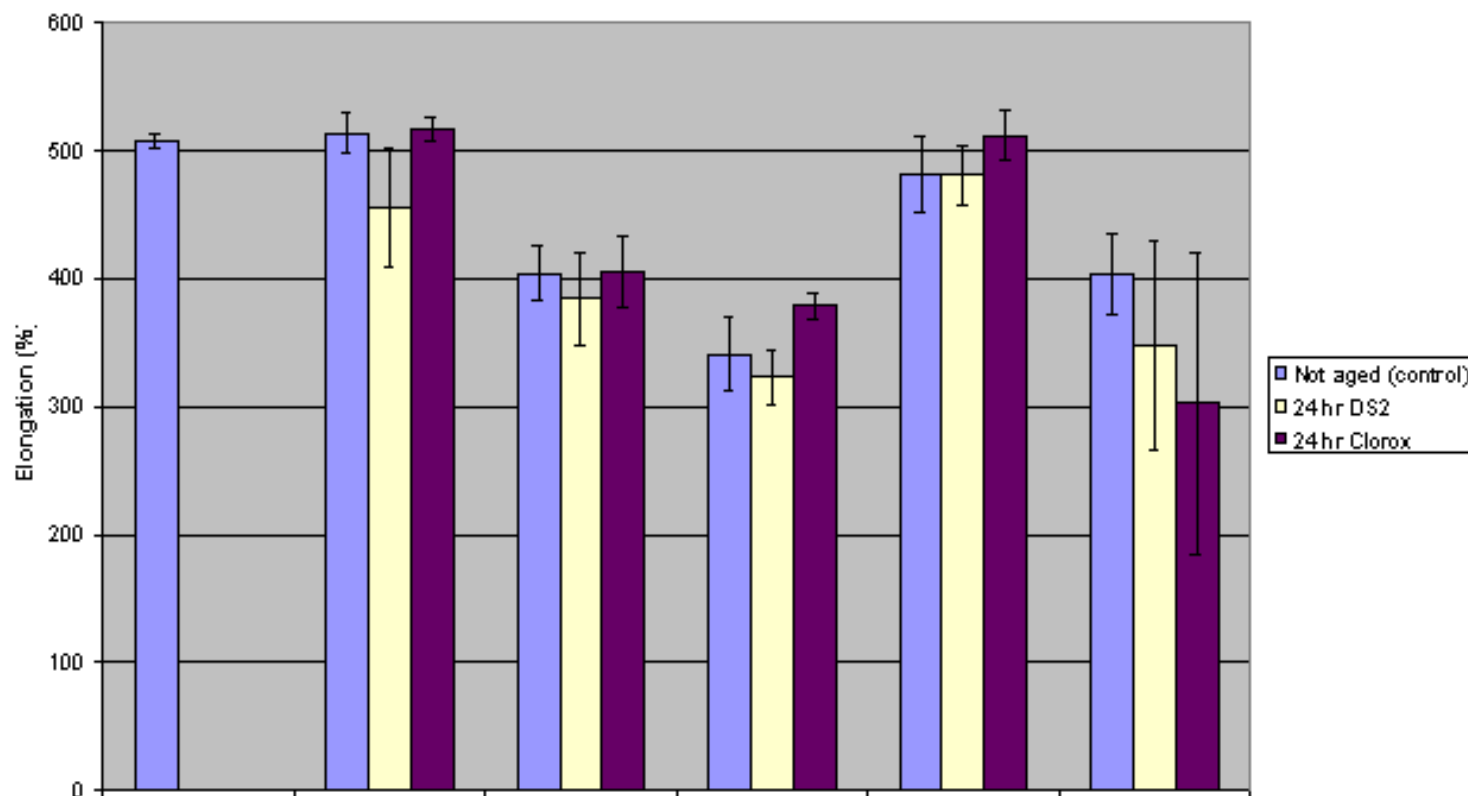
Tensile Strength at Break (23°C)  
ASTM D638 Type D dogbones





## FEDERAL FABRIC-FIBERS INC.

Elongation at Break (23°C)  
ASTM D638 Type D dogbones





# FEDERAL FABRIC-FIBERS INC.

## CURRENT EFFORTS:

- ✓ Have equipment in place and have completing a limited production run

### Production?

Improving:

Efficiency

Quality

Consistency of entire process



# LONG-TERM SOLUTION

**Self-Decontaminating Barriers  
Incorporating  
Catalytically Reactive Membranes**

**\*Newly funded program with  
Ventana Research**



## TECHNOLOGY WATCH

- ✓ Academia
- ✓ Industry
- ✓ Government
- ✓ Foreign Military





# CONCLUSION

## 2 Currently available Options

→ Kevlar/Teflon

→ M28 Liner (PVDC/PE)

### Mitigate Risk

※Near-Term Solution※

Coated/Laminated Barrier Fabric

※Mid-Term Solution※

Integrating Nanocomposites into Commodity Polymers

Low-Temperature Processible Fluoropolymers

※Long-Term Solution※

Self-Decontaminating Barrier Materials Incorporating Catalytically Reactive Membranes

➤ Need to work together to bridge technology gaps and identify novel solutions



**THANK YOU**

**Questions?**