



TACOM

**Lethality, Survivability, Mobility and
Sustainment for America's Army**



ELIMINATING PROPELLANT BAG DETERIORATION

**38TH ANNUAL GUN, AMMUNITION, AND MISSILES
SYMPOSIUM & EXHIBITION
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Presented by

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OBJECTIVES

- **Eliminate rapid deterioration of propellant bag**
- **Improve safety and reliability**
- **Extend service life**
- **Reduce life cycle cost**

ITEM DESCRIPTION



**105mm M1 Cartridge with
M67 Propelling Charge**



BACKGROUND

- **Over three million 105mm rounds in unserviceable conditions due to propellant bag deterioration**
- **Rayon propellant bag deterioration**
 - **Observed in as little as 3 to 4 years**
 - **Bags no longer hold propellant safely**
 - **Require expensive rework (\$114/round)**

INITIAL ASSESSMENT

➤ Early studies determined

- Cloth deterioration caused by propellant outgas and moisture
 - ✓ Nitrogen dioxide + H₂O => Nitric Acid
- Acrylic cloth is significantly more resistant to nitric acid than rayon cloth

TECHNICAL APPROACH

- **Assure chemical compatibility between acrylic and M1 propellant**
- **Maintain proper test controls**
 - **Manufacture two sets of M67 charges:**
 - ✓ “Test charges” with acrylic propellant bags
 - ✓ “Control charges” with rayon propellant bags
- **Establish Evaluation Criteria, comparison of cloths based on:**
 - **Ballistic performance**
 - **Residue evaluation**
 - **Simulated rough handling and transportation**
 - **Shelf Life**

RESULTS

COMPATIBILITY TEST

Requirement:

(MIXTURE GAS) – (ACRYLIC GAS + M1 PROPELLANT GAS) < 3 ml

Result:

6.38 ml – (5.55 ml + 0.35 ml) = 0.48 ml

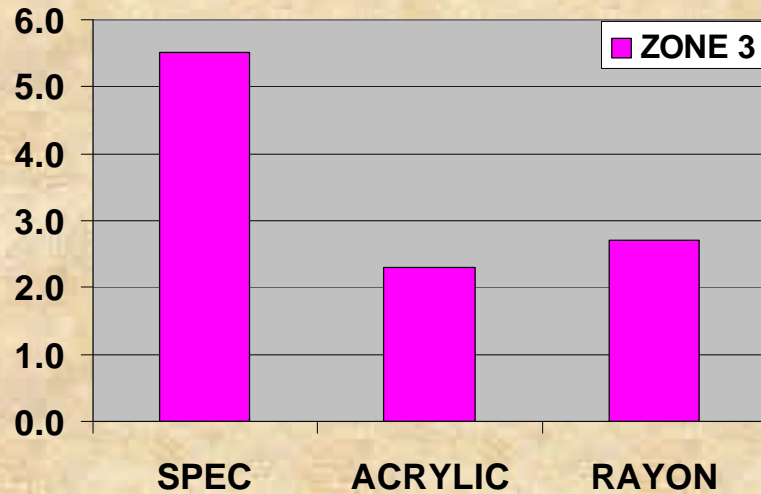


PASS

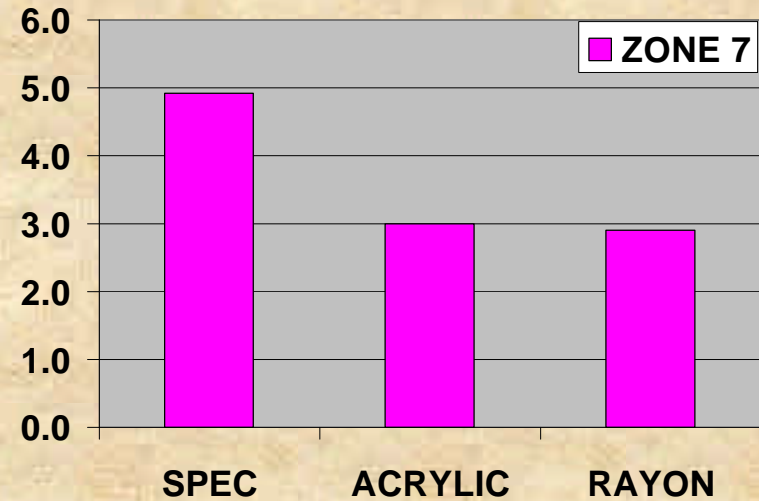
RESULTS (CON'T)

BALLISTIC PERFORMANCE AT +70=F

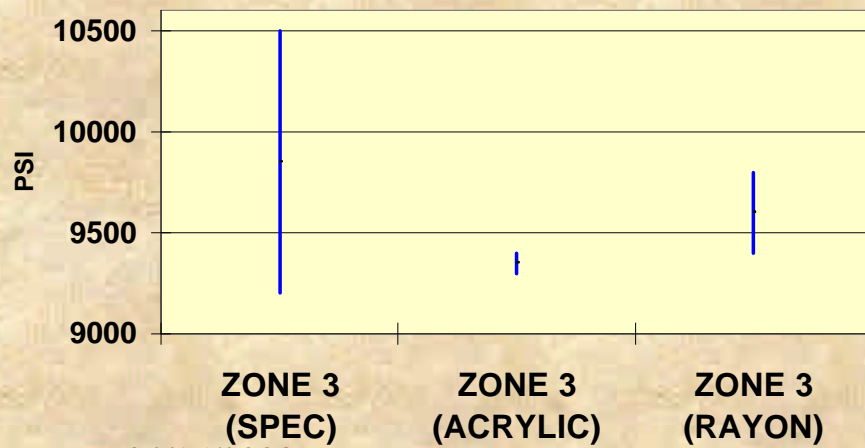
Zone 3 Velocity Standard Deviation at +70 deg F



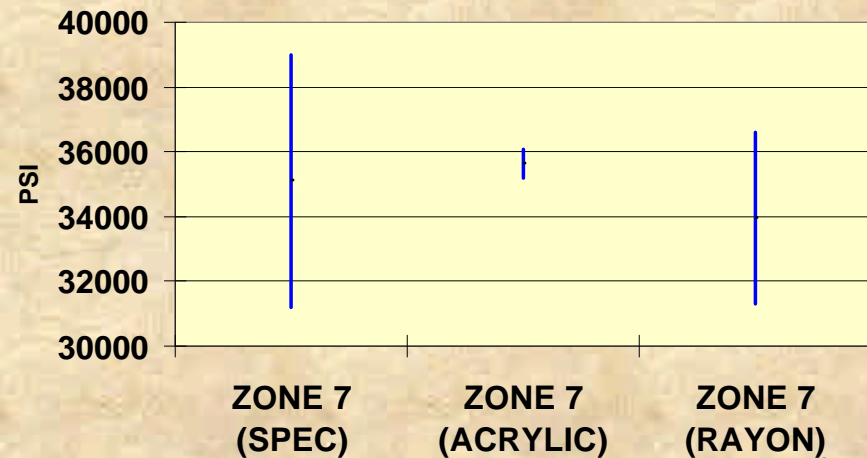
Zone 7 Velocity Standard Deviation at +70 deg F



Zone 3 Pressure Range at 70 deg F



Zone 7 Pressure Range at 70 deg F

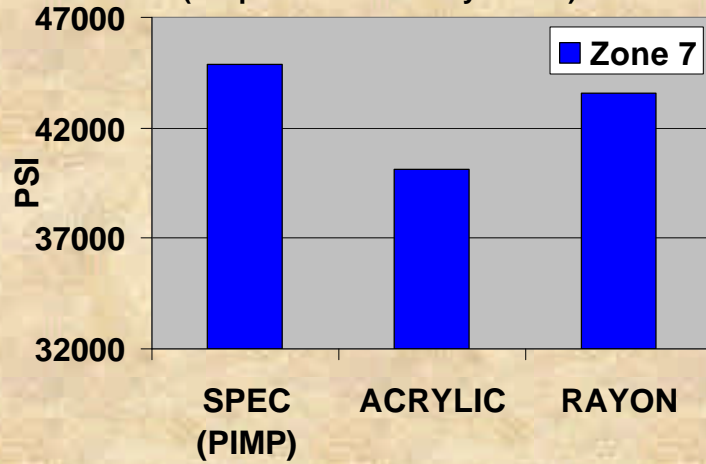


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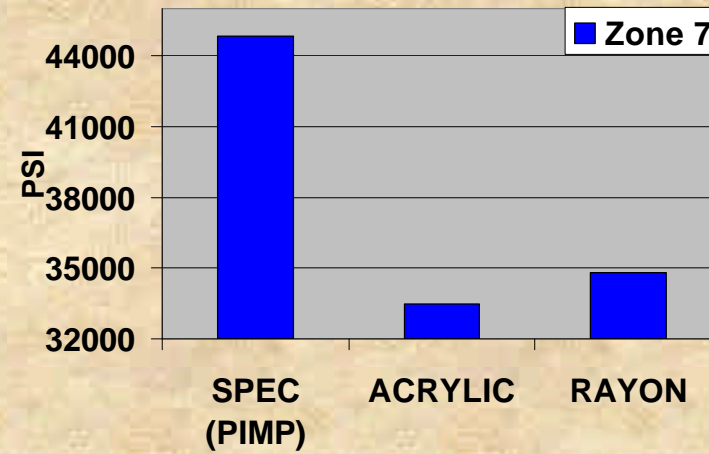
RESULTS (CON'T)

BALLISTIC PERFORMANCE AT -50=F & +145=F

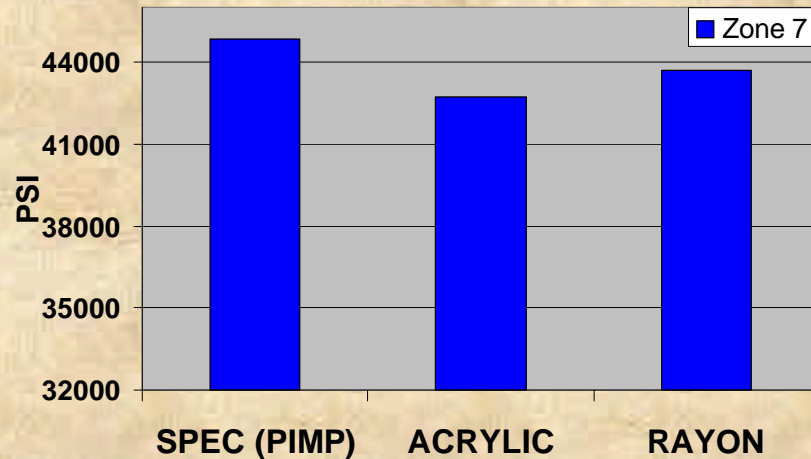
Zone 7 Average Pressure + 4 Sigma at +145 deg F
(Propellant Uniformity Series)



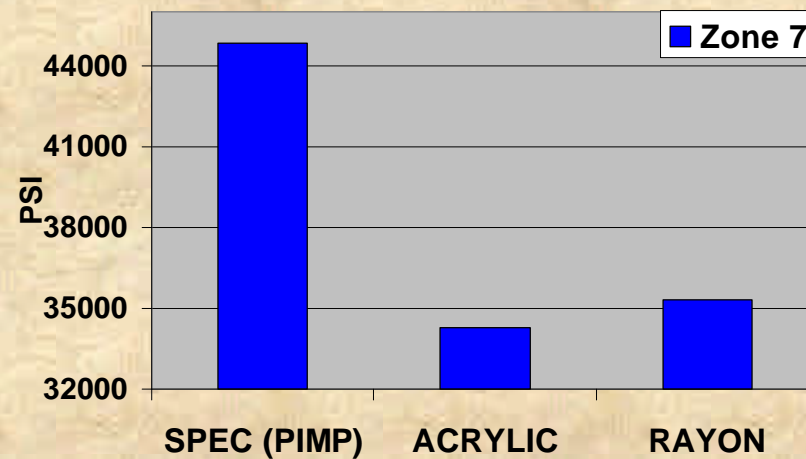
Zone 7 Average Pressure + 4 Sigma at -50 deg F
(Propellant Uniformity Series)



Zone 7 Average Pressure + 4 Sigma at +145 deg F
(Sequential Environmental)



Zone 7 Average Pressure + 4 Sigma at -50 deg F
(Sequential Environmental)



RESULTS (CON'T)

CLOTH RESIDUE EVALUATION

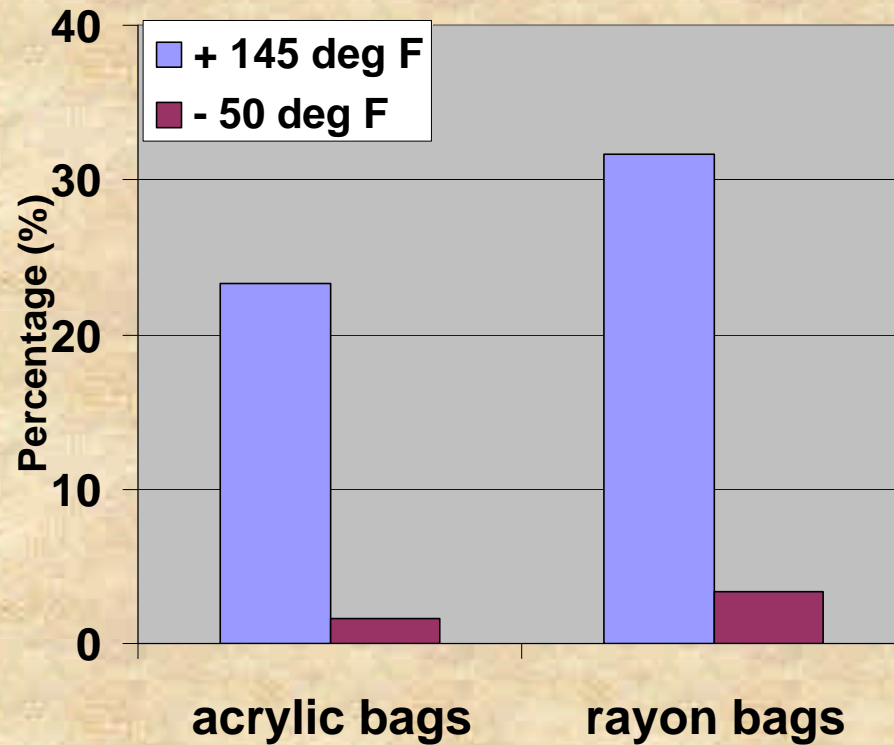
- **ACRYLIC - NO RECOVERABLE RESIDUE**
- **RAYON RESIDUE:**



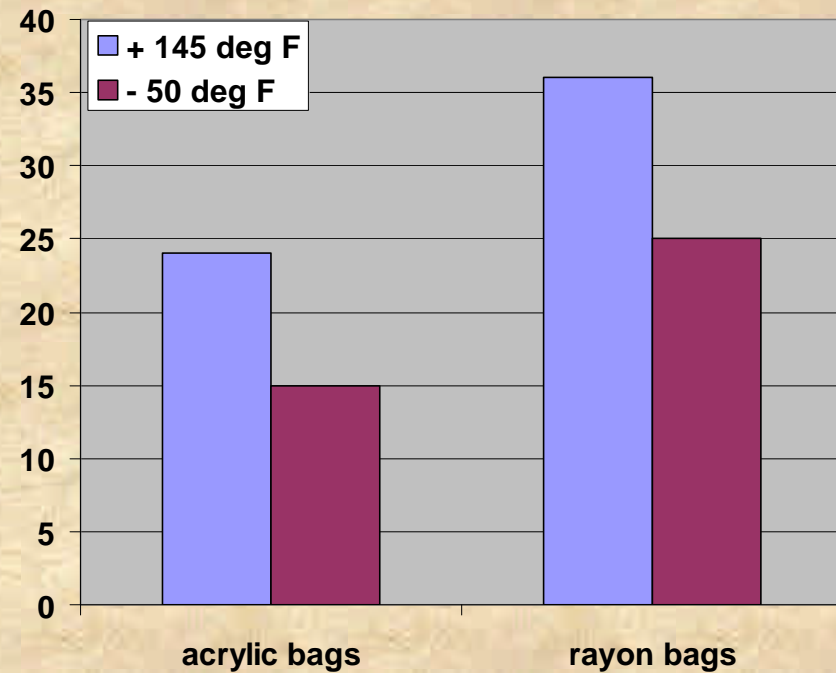
RESULTS (CON'T)

SEQUENTIAL ENVIRONMENTAL TESTS

% DAMAGED M67 CHARGES AFTER LOGISTIC VIBRATIONS



NUMBER OF BAG DAMAGES AFTER LOOSE CARGO VIBRATION



RESULTS (CON'T)

PROPELLANT BAG SHELF LIFE STUDY

➤ EXPERIMENTAL METHOD

- **DURATION:** UP TO 48 WEEKS
- **CONDITIONING:** 65=C, 75=C, 85=C, 95=C AT 75% RH
- **SAMPLING:** WEEKLY (RAYON) & MONTHLY (ACRYLIC)



0 week



Rayon bag
12 weeks

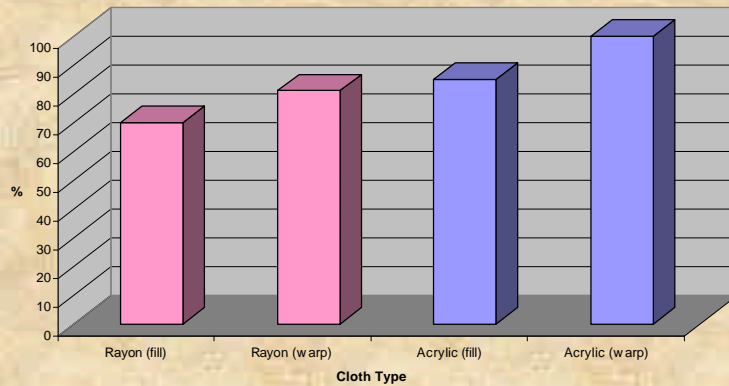


Rayon bag
16 weeks

RESULTS (CON'T)

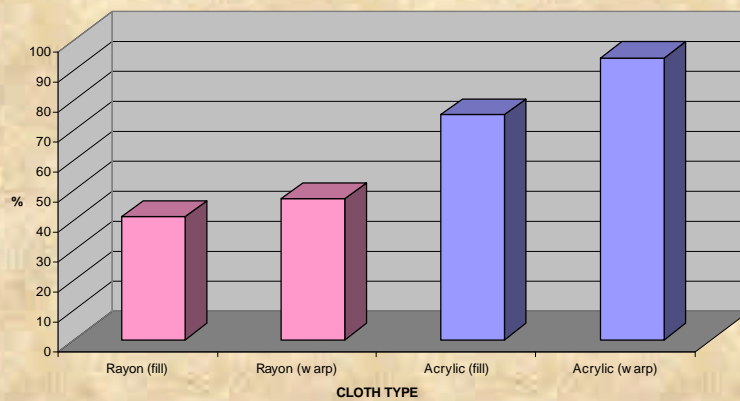
% REMAINING TENSILE STRENGTH AFTER 12 WEEKS

65 deg C

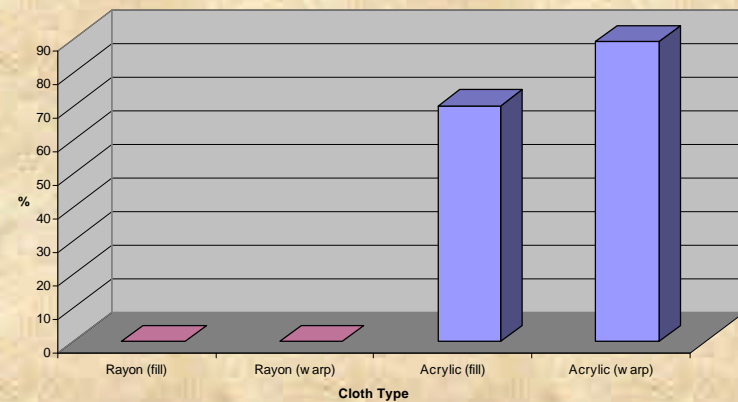


Left bars = Rayon cloth
Right bars = Acrylic cloth

75 deg C



85 deg C



RESULTS (CON'T)

PREDICTED TENSILE STRENGTH LOSS

ARRHENIUS DEGRADATION MODEL²:

$$\text{Log (S)} = a + t \beta \exp (- ? / T)$$

Figure 1. Predicted Fraction Loss in Tensile Strength at 25 deg C & 75% RH

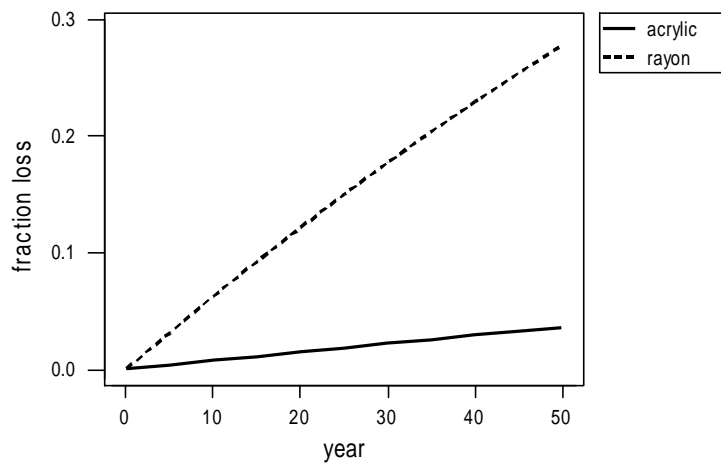
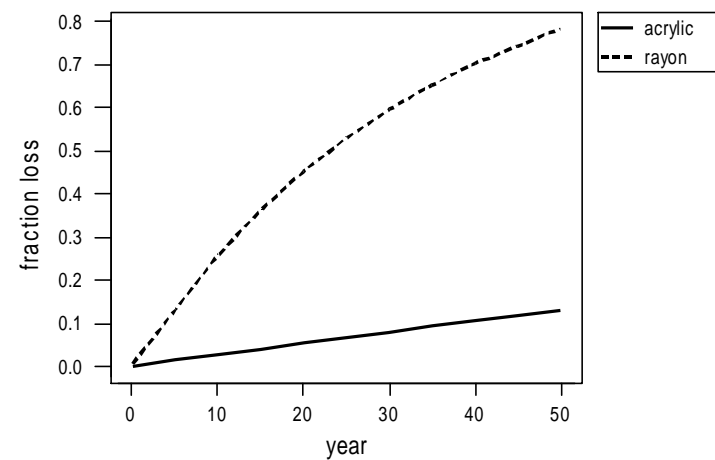


Figure 2. Predicted Fraction Loss in Tensile Strength at 35.38 deg C & 75% RH



PREDICTED SHELF LIFE BASED ON 10% LOSS IN TENSILE STRENGTH¹

	ACRYLIC CLOTH	RAYON CLOTH	ACRYLIC BETTER THAN RAYON BY
25=C & 75% RH	143 years	16 years	9 TIMES
35.38°C & 75% RH	37 years	3.4 years	11 TIMES

SUMMARY

- **Acrylic propellant bags have been successfully qualified as a replacement for rayon bags based on**
 - **High resistance to bag deterioration**
 - **Met shelf life requirements**
 - **Comparable ballistic performances**
 - **Less cloth residue**
 - **More durable for rough-handling and transportation**
- **Eliminate rework of propellant bags**