ELECTRON-BEAM CURED FILAMENT WOUND COMPOSITE PRESSURE VESSELS

Richard Foedinger and David Rea
Technology Development Associates, Inc.

Robert Grande and Craig Davis
Carleton Technologies Inc. Pressure Technology Division

Robert Norris and Christopher Janke
Oak Ridge Center for Composite Manufacturing Technology

Thomas Walton
Aeroplas Corporation International, Inc.

Terry Vandiver
U.S. Army Aviation and Missile Command

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PHASE I TECHNICAL OBJECTIVES

- **DEMONSTRATE THE FEASIBILITY OF DEVELOPING FASTER, MORE ECONOMICAL MANUFACTURING TECHNIQUES FOR FILAMENT WOUND COMPOSITE MOTORCASES FOR SMALL DIAMETER TACTICAL ROCKET MOTORS**

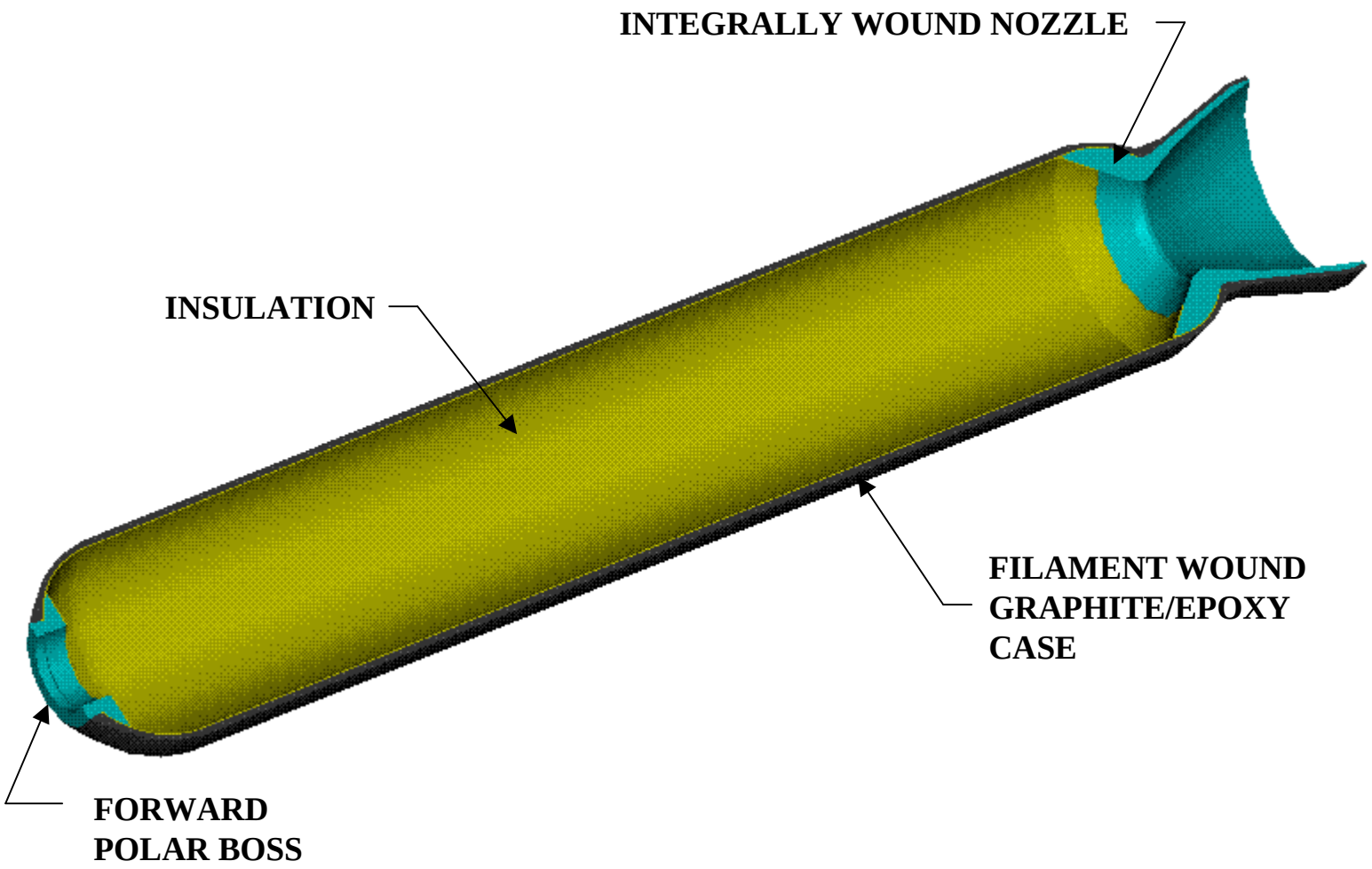
  - **IDENTIFY AND EVALUATE E-BEAM CURABLE RESIN SYSTEMS FOR FILAMENT WOUND COMPOSITE ROCKET MOTORCASE APPLICATIONS**

  - **EVALUATE LOW COST TOOLING MATERIALS**

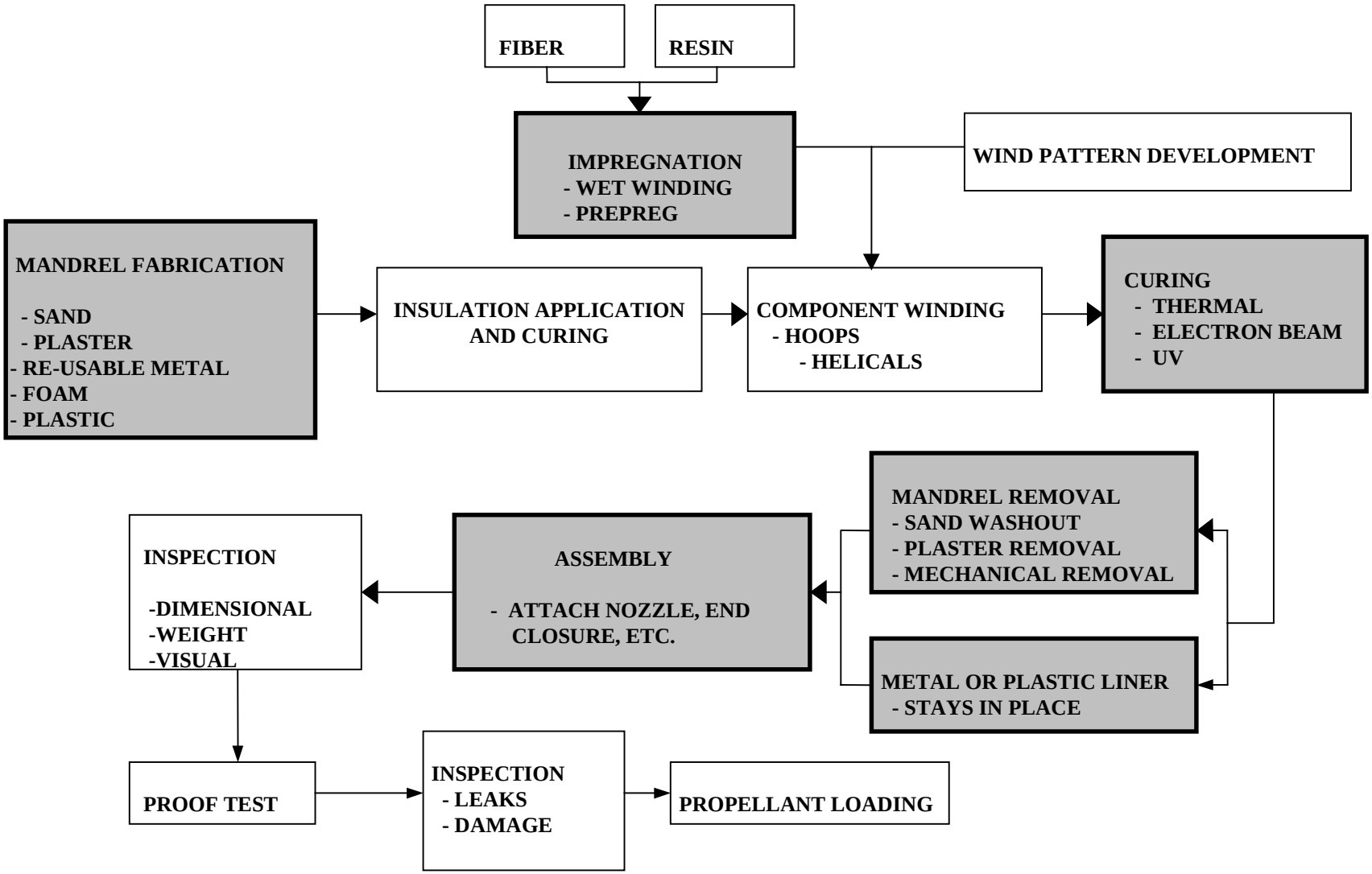
  - **DEVELOP EFFICIENT ASSEMBLY METHODS AND JOINT DESIGNS TO ENHANCE PRODUCIBILITY AND REDUCE MANUFACTURING COSTS**

- **IDENTIFY THE MOST PROMISING AND TECHNICALLY FEASIBLE MATERIALS AND MANUFACTURING TECHNIQUE(S) FOR FURTHER DEVELOPMENT AND DEMONSTRATION IN PHASE II**

ROCKET MOTOR CASE GEOMETRY



MANUFACTURING FLOW DIAGRAM FOR FILAMENT WOUND COMPOSITE MOTORCASE

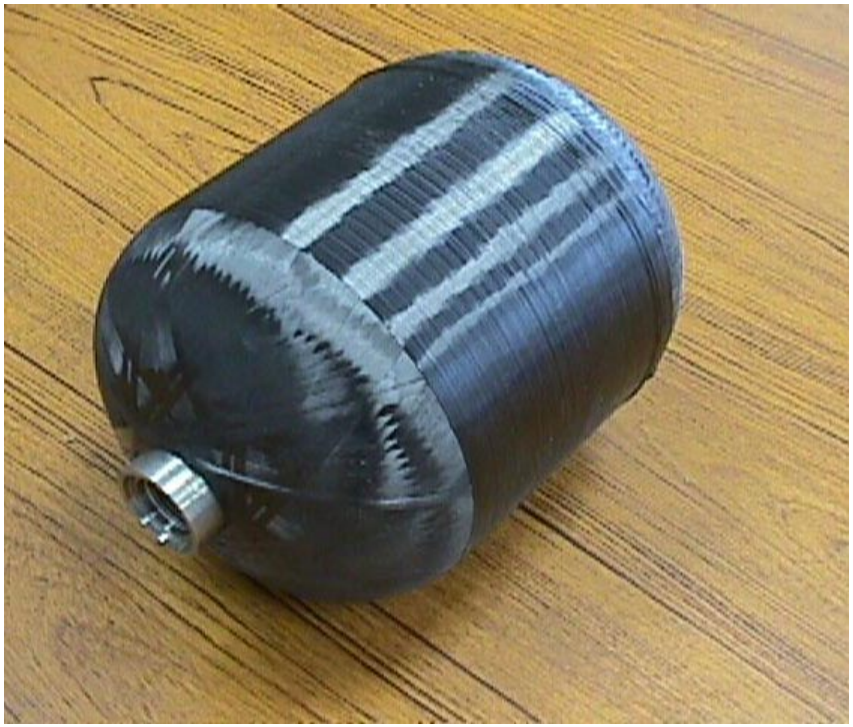


WHY E-BEAM CURING?

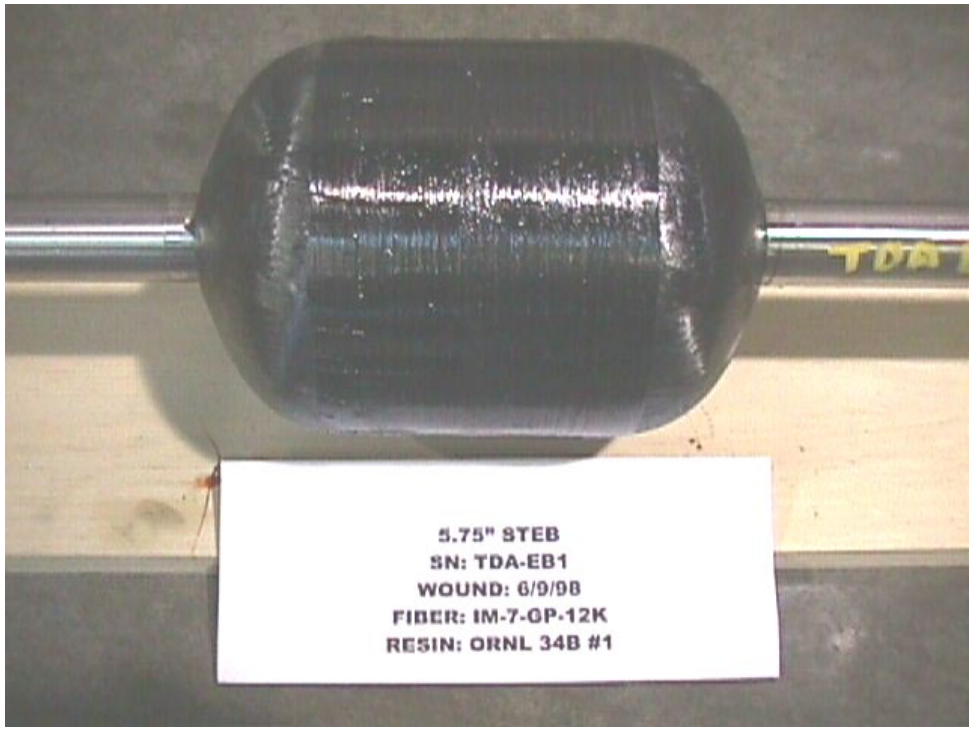
- REDUCED MANUFACTURING AND TOOLING COSTS
- SHORTER CURE TIMES ⟶ IMPROVED THROUGH-PUT
- SIMPLIFIED TOOLING
- IMPROVED PART QUALITY AND PERFORMANCE
- SIMPLIFIED PROCESSING AND HANDLING
- ABILITY TO CO-CURE WITH DIFFERENT FIBERS/RESIN SYSTEMS
- REDUCED ENVIRONMENTAL, HEALTH AND SAFETY CONCERNS
- REDUCED RESIDUAL THERMAL STRESSES
- IMPROVED MECHANICAL PROPERTIES
- LOWER SHRINKAGE

FILAMENT WINDING OF 5.75" DIA. ASTM PRESSURE VESSELS

BASELINE THERMAL ANHYDRIDE CURED AND E-BEAM CURED FILAMENT WOUND PRESSURE VESSELS

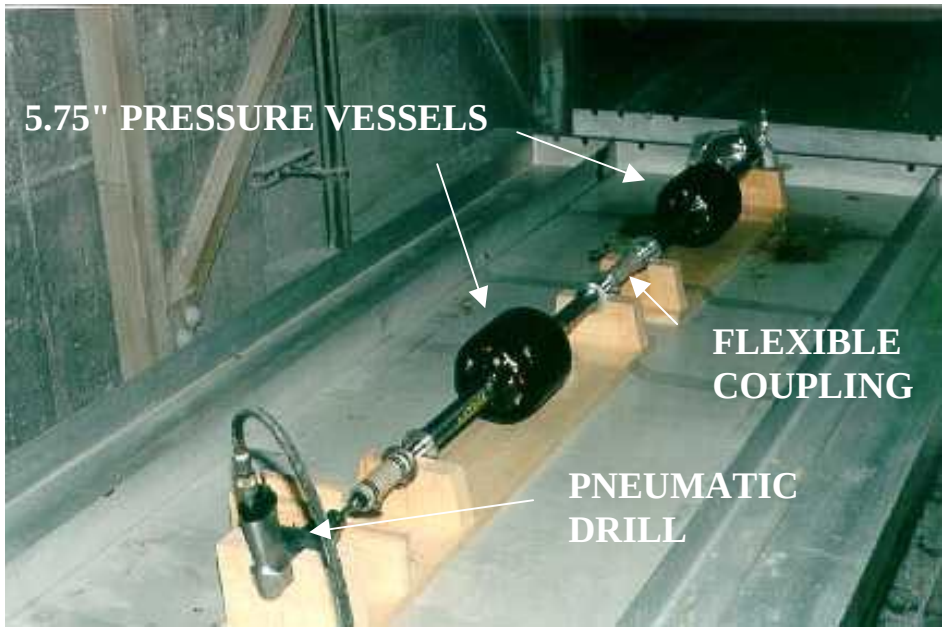


BASELINE IM7-GP-12K/EPON 826



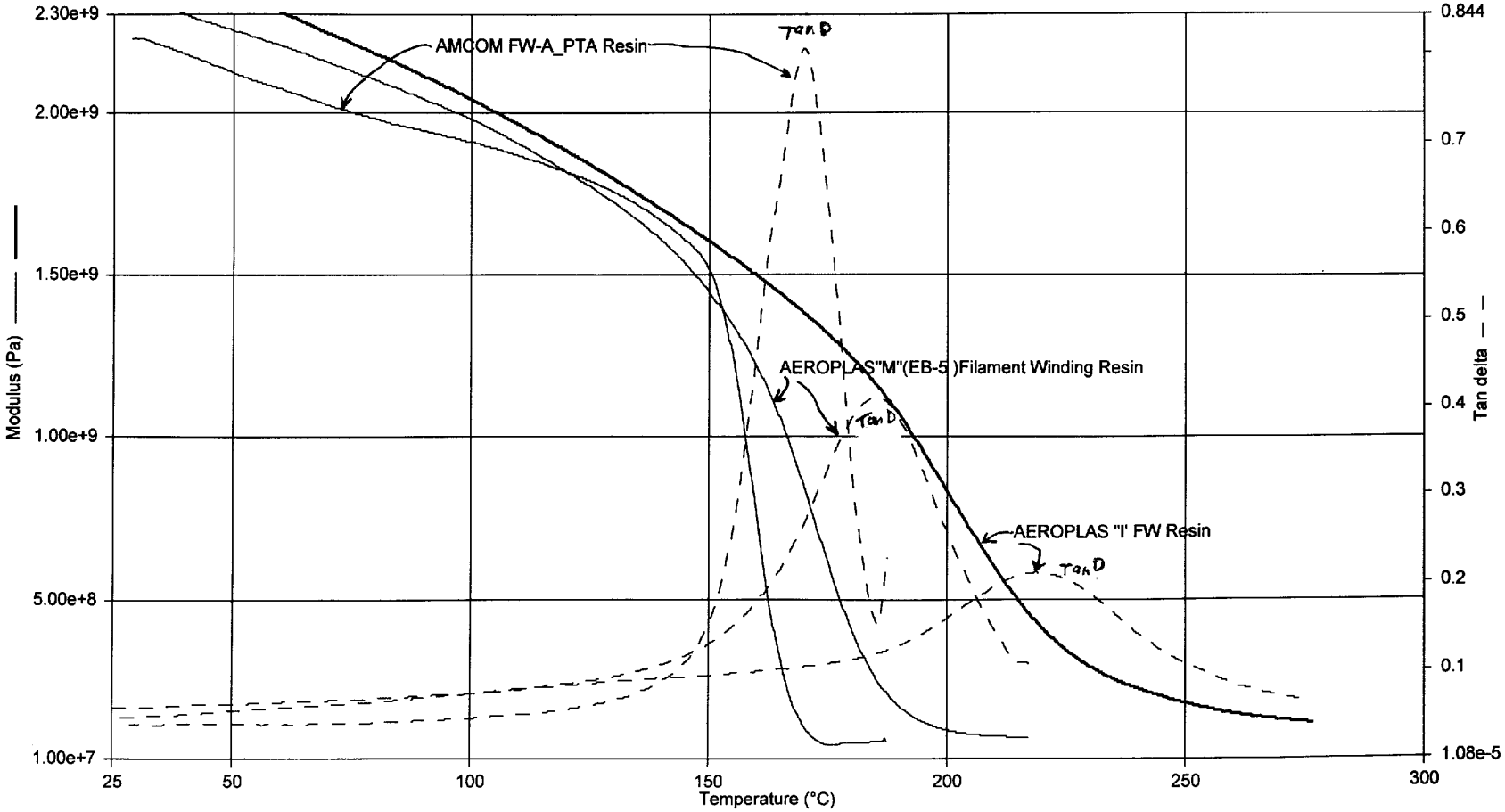
IM7-GP-12K/ORNL 34B

E-BEAM CURING OF 5.75" DIAMETER PRESSURE VESSELS



Pass Number	Voltage (Mev)	Scan (in)	Power (kw)	Speed (fpm)	Product Height (in)	Dose Set (Mrad)	Actual Dose (Mrad)
1	10	18	50	11.6	10	2.5	2.4
2 -- 5	10	18	50	9.1	10	3.2	3
					Total	15.3	14.4

COMPARISON OF AMCOM THERMAL ANHYDRIDE CURED FILAMENT WINDING RESIN WITH STATE OF THE ART E-BEAM CURED RESINS



- E-BEAM RESINS CURE IN 1/10TH LESS TIME AND HAVE Tgs 20-50°C HIGHER

BURST TESTING OF E-BEAM CURED PRESSURE VESSEL

BURST TEST RESULTS FOR 5.75" DIA. PRESSURE VESSELS

BASELINE THERMALLY CURED PRESSURE VESSEL

E-BEAM CURED PRESSURE VESSEL

Test Item Designation	Burst Pressure (psi)	Delivered Strength (psi)	Translation (%)
Baseline-1	3,170	552,369	70.1
Baseline-2	3,900	679,678	86.3
Baseline-3	3,690	643,080	81.6
EB-1	3,810	663,993	84.3
EB-2	3,903	680,201	86.3
EB-3	3,110	541,999	68.8
EB-4	3,328	579,992	73.6
EB-5	3,780	658,765	83.6

CONCLUSIONS AND RECOMMENDATIONS

- DEMONSTRATED LOW-COST FOAM TOOLING TECHNOLOGY FOR ASTM 5.75" DIAMETER PRESSURE VESSEL GEOMETRY

- DEMONSTRATED RAPID E-BEAM CURING TECHNOLOGY FOR THIN WALL COMPOSITE PRESSURE VESSELS USING FIVE DIFFERENT RESIN FORMULATIONS

- DELIVERED STRENGTHS FOR E-BEAM CURED 5.75" DIAMETER PRESSURE VESSELS COMPARE FAVORABLY TO THOSE FOR BASELINE THERMALLY CURED PRESSURE VESSELS

- FURTHER DESIGN DEVELOPMENT, INCLUDING OPTIMIZATION OF E-BEAM RESIN FORMULATION, AND FULL-SCALE MOTORCASE DEMONSTRATION TO BE PERFORMED AS PART OF PHASE II PROGRAM