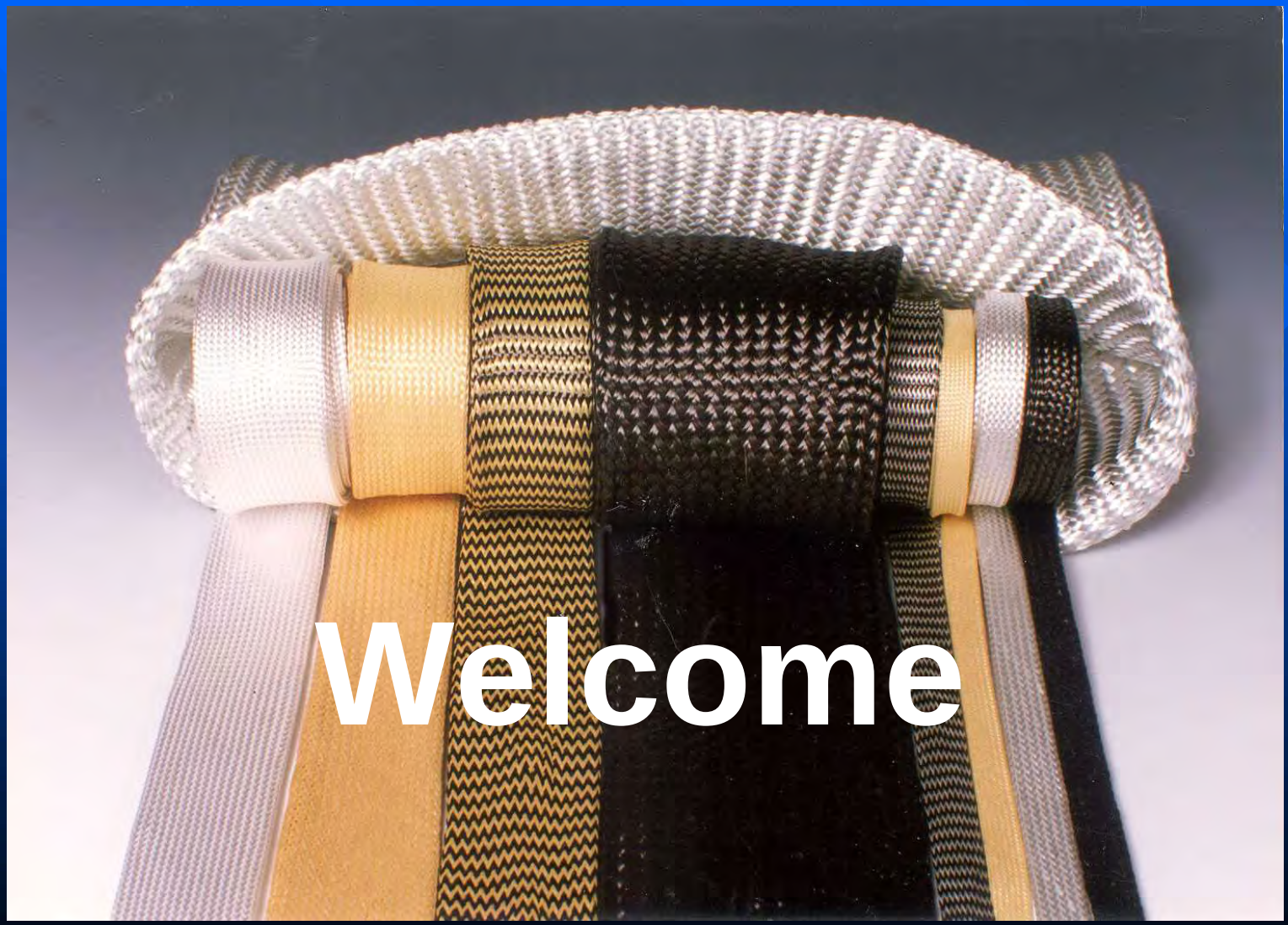
A&P Technology



A&P Technology

APPLICATIONS IN BRAID TECHNOLOGY

- A&P Braiding Capability
- Biaxial / Triaxial Braiding Processes
- Braid Architecture and Construction
- Selected Applications
- Component Testing and Material

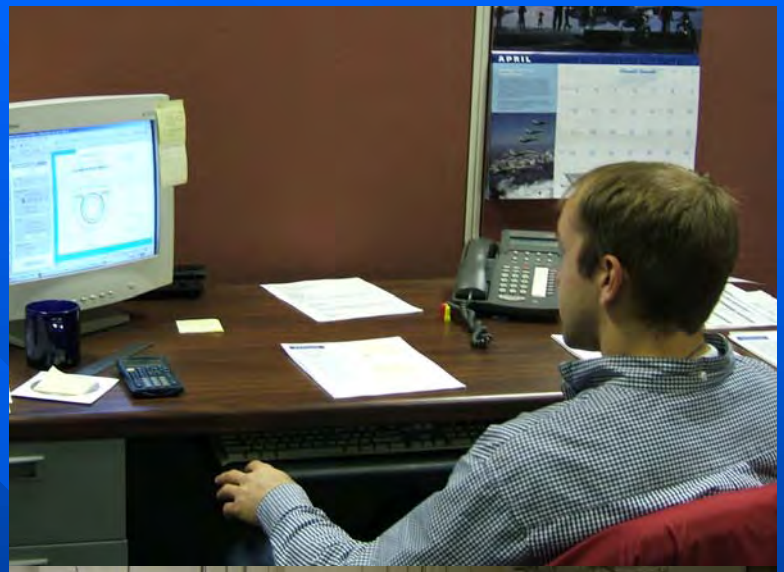
Jason Scharf
March 20, 2008

A&P Technology History

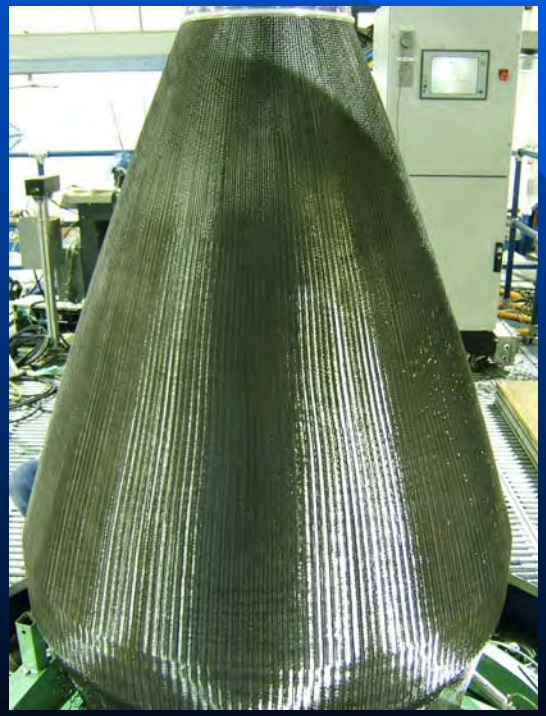
- Started as R&D division of Atkins & Pearce (est. 1817) 1986
- Incorporated in 1995; independent in 1997
- Moved to 80,000 sq.ft. facility in 2000
- Added 35,000 sq. ft. facility in 2002

A&P Technology Braiders

- World leading capacity to design novel braided architectures
- Design and build all textile machinery in-house
- Own and operate the most technically advanced line of braiding machines anywhere

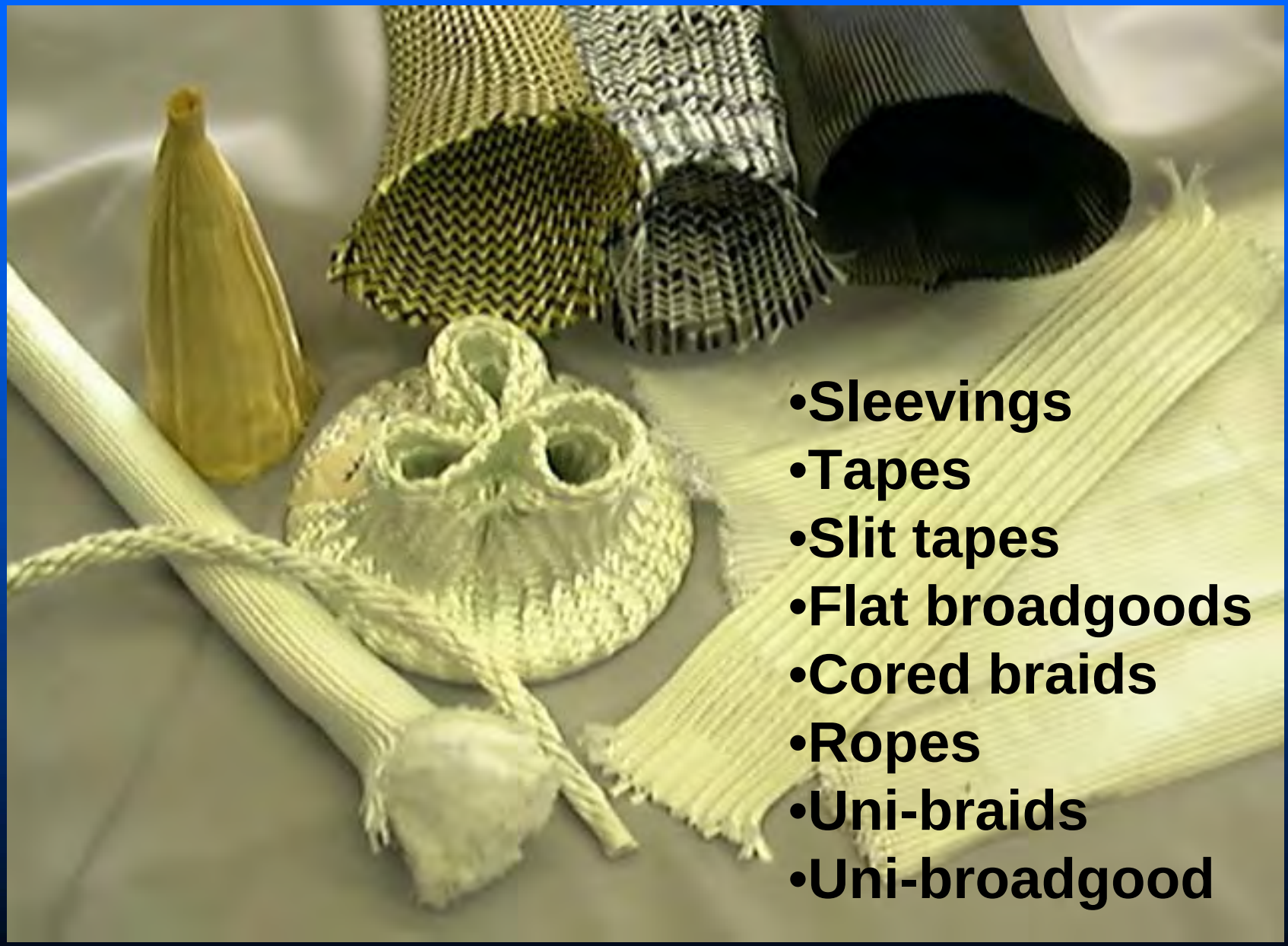


Aerospace Structures



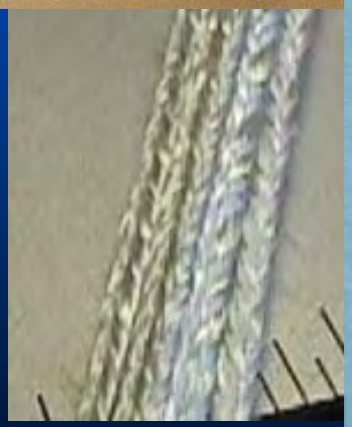
Other Products

Classic Braid Constructions



- Sleevings
- Tapes
- Slit tapes
- Flat broadgoods
- Cored braids
- Ropes
- Uni-braids
- Uni-broadgood

Shaped Braid Preforms



- Overbraids
- Curved Sleeves
- Curved Tapes
- Helical Braids
- Variable
- Jelly Roll Braids
- Filler Noodles

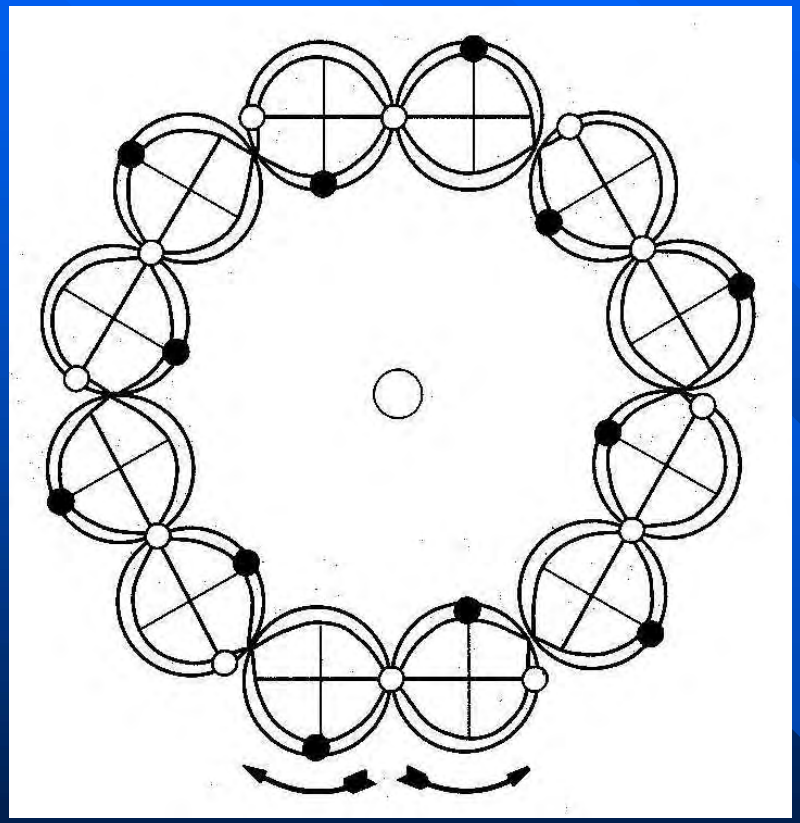
Raw Material Choices

- Fiberglass*
- Carbon
- Aramid
- Polyester
- Vectran
- Spectra®
- Nylon
- Metalized Polyester (Mylar®)
- Ceramic
- Twaron
- Nicalon®

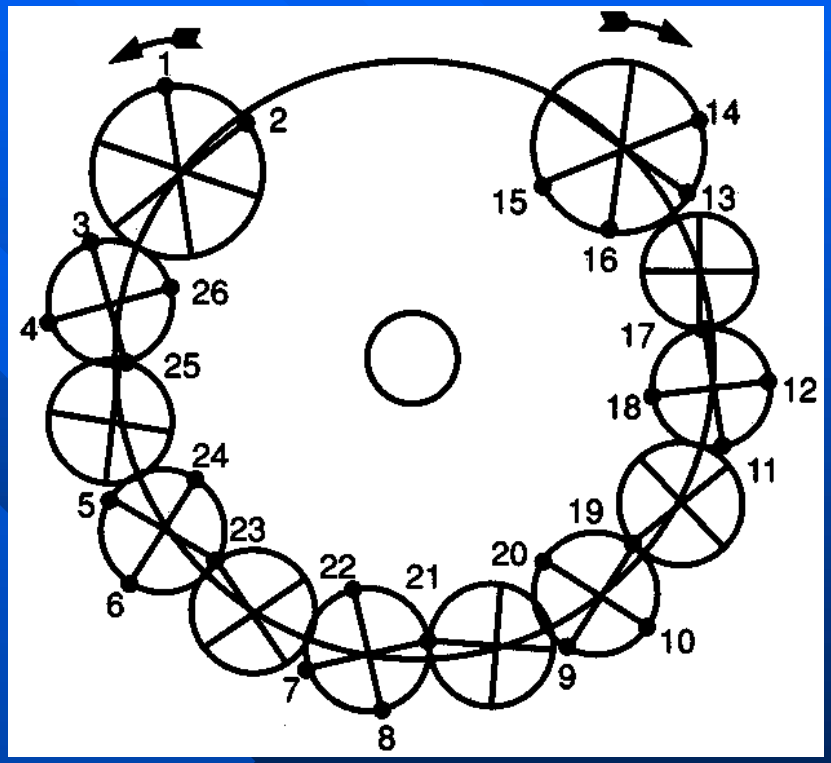
*Also Available as Texturized Fiber

Braided Architectures

Sleeve



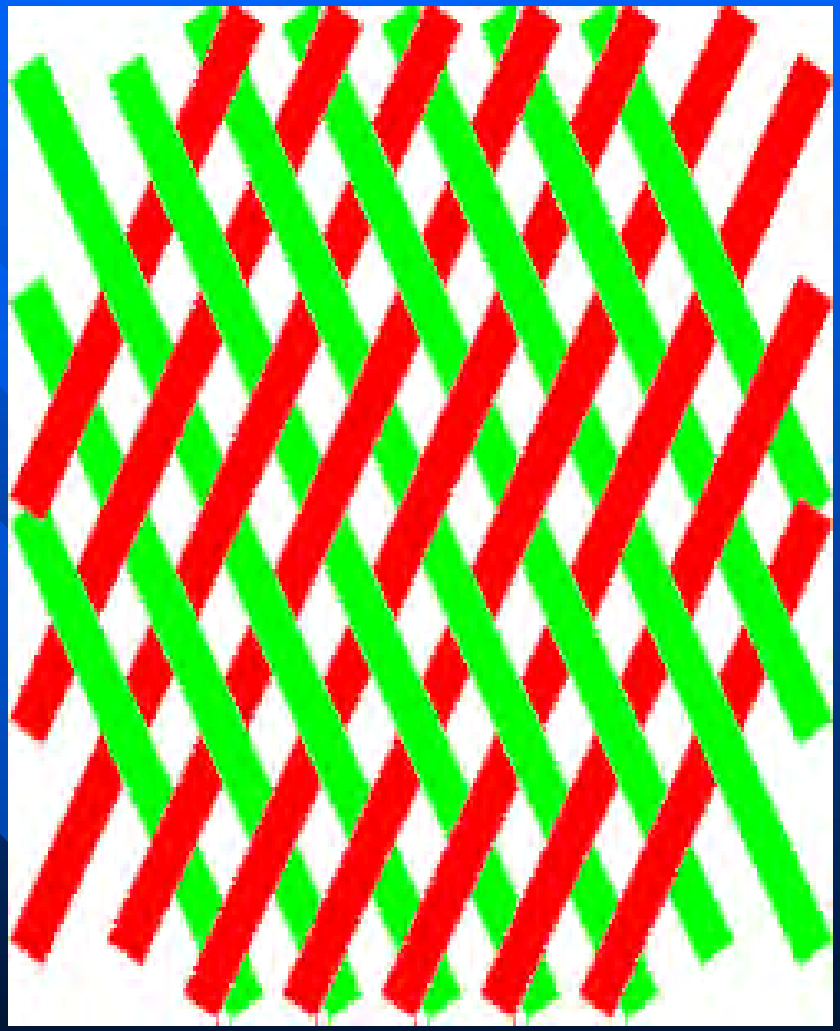
Tape



Width or perimeter is sum of yarn widths

Biaxial

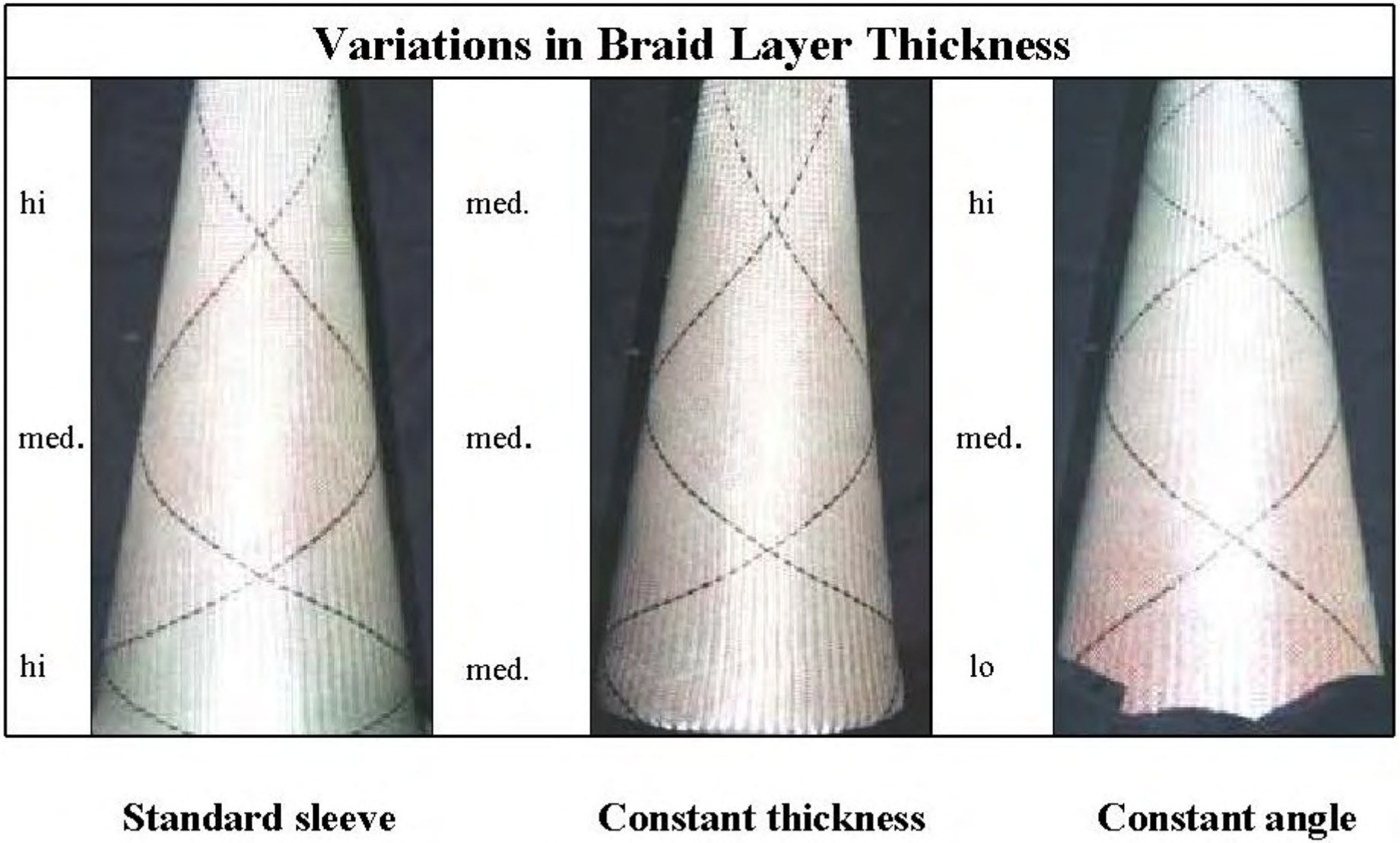
- Flexible diameter, good conformability & drape
- Fibers in the bias direction only
- Construction dependent fiber orientation ranging from 15 to 75 degrees



Bimax™

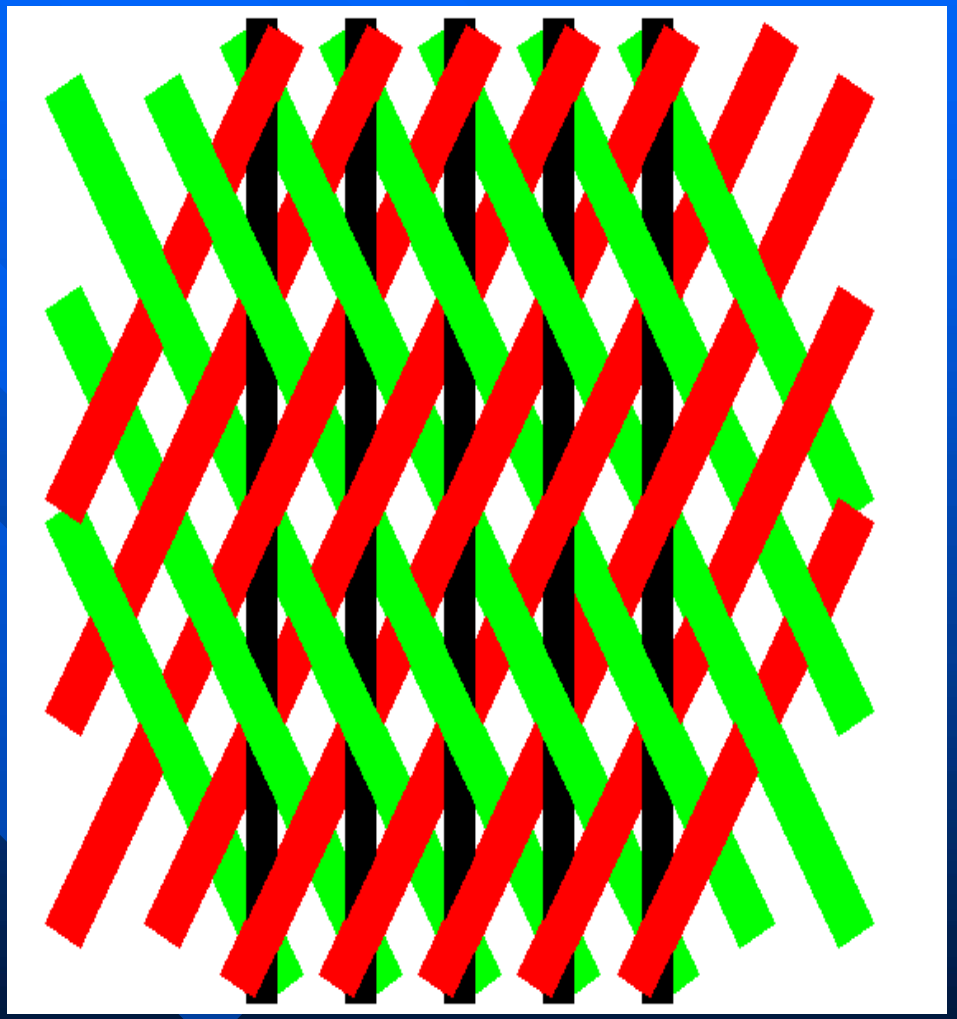
Biaxial Braid

Biaxial Braid Design Options



Triaxial

- Locked diameter or width
- Fibers in both axial and bias directions
- Fiber orientation ranging from 10 to 80 degrees

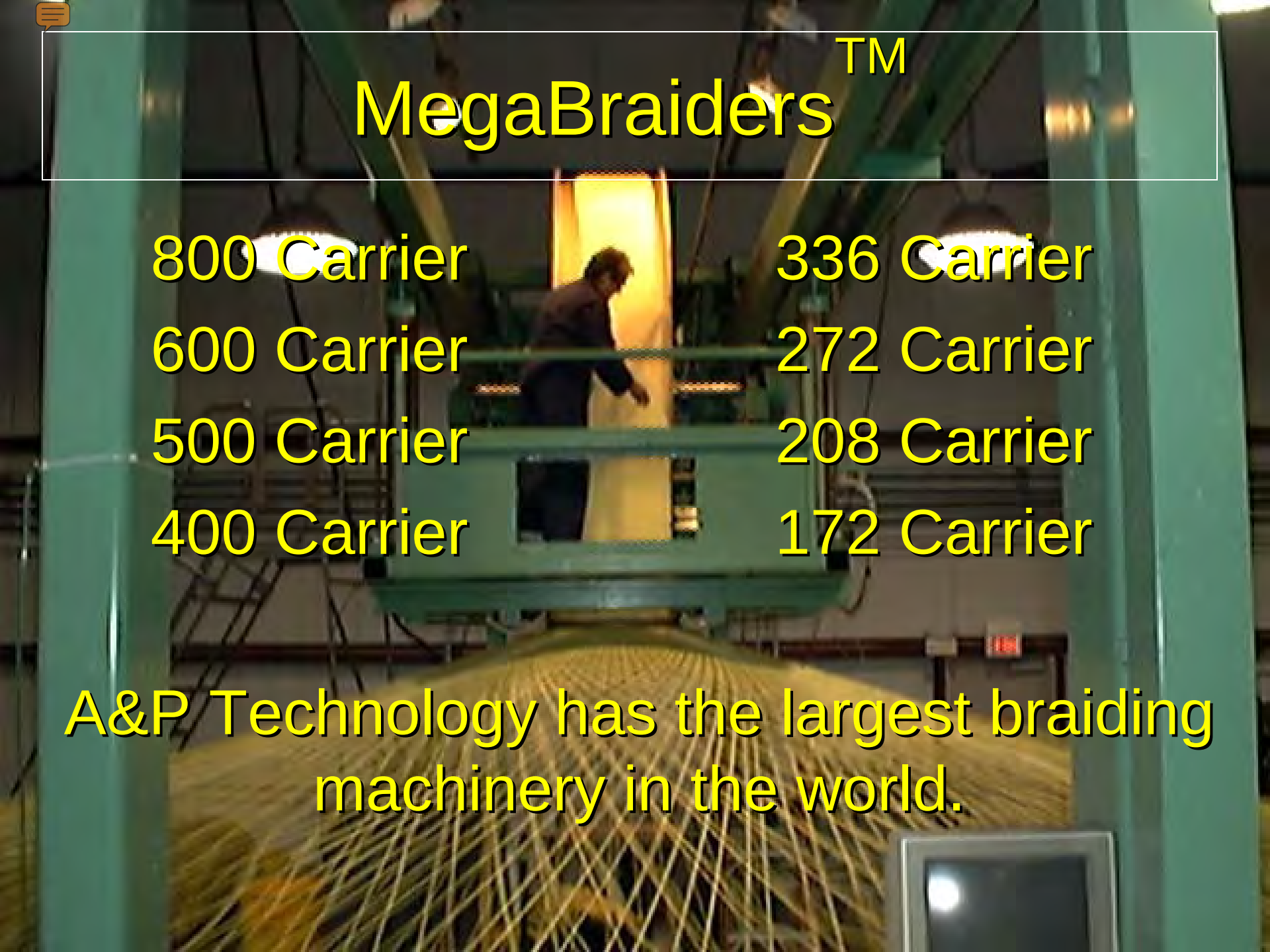


Trimax™

Unidirectional Products

Unimax™ - conformable sleeving available in carbon and fiberglass; small elastic bias yarns enable even distribution of axial yarns.

Zero™ - non-woven unidirectional carbon fabric with virtually no crimp; available in 4 oz/yd² and 9 oz/yd² fabric weights.



MegaBraiders™

800 Carrier	336 Carrier
600 Carrier	272 Carrier
500 Carrier	208 Carrier
400 Carrier	172 Carrier

A&P Technology has the largest braiding machinery in the world.

Why Megabraiders?

- Larger diameter braids/wider bias fabrics
- Smaller unit cell braids (higher picks per inch)
- Smaller yarns resulting in less crimp.

NASA Airlock

800 carrier
Vectran
84” diameter
10’ long

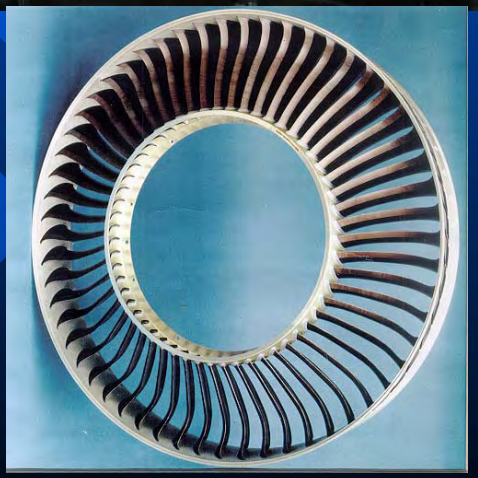
Applications

- Engine Containment
- Propeller Blades
- Missile Nose Cone/Bodies
- Engine Stator Vanes
- Ducting/Tubing
- Fuselage Frames
- Control Surfaces
- Exhaust Nozzles
- Straight and Curved T- and I-Stringers

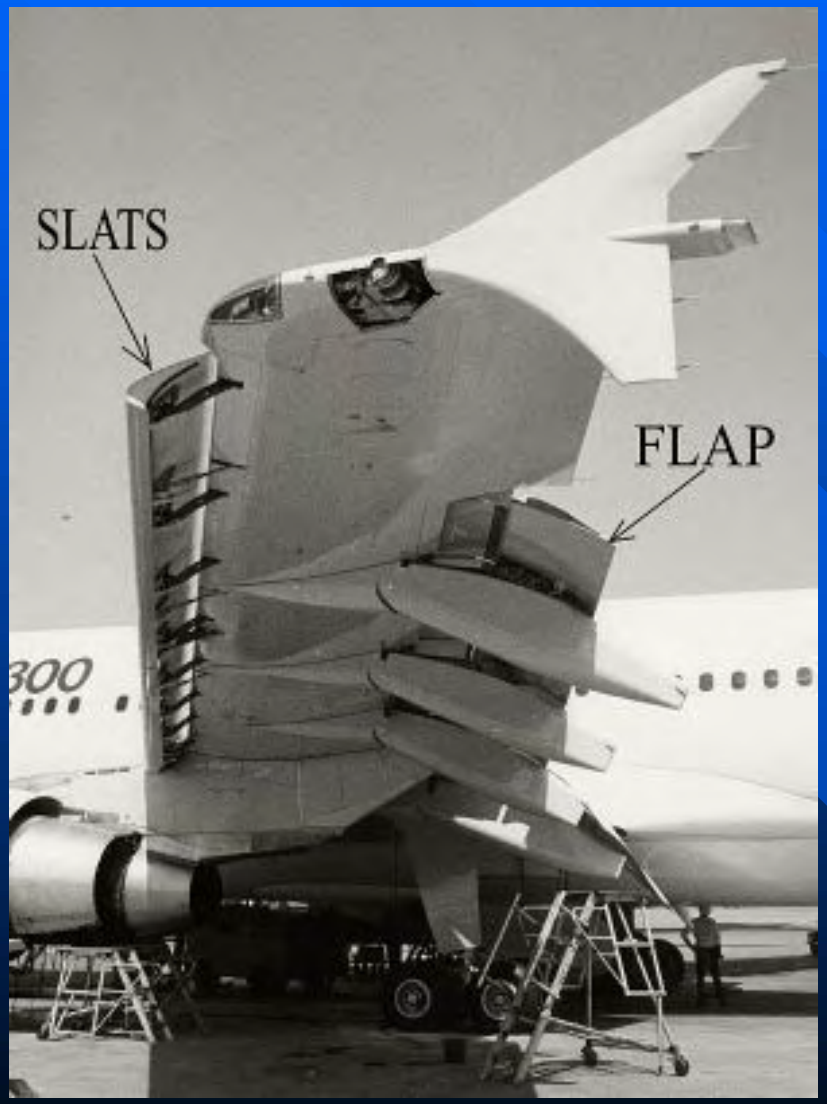
Aircraft Ducting

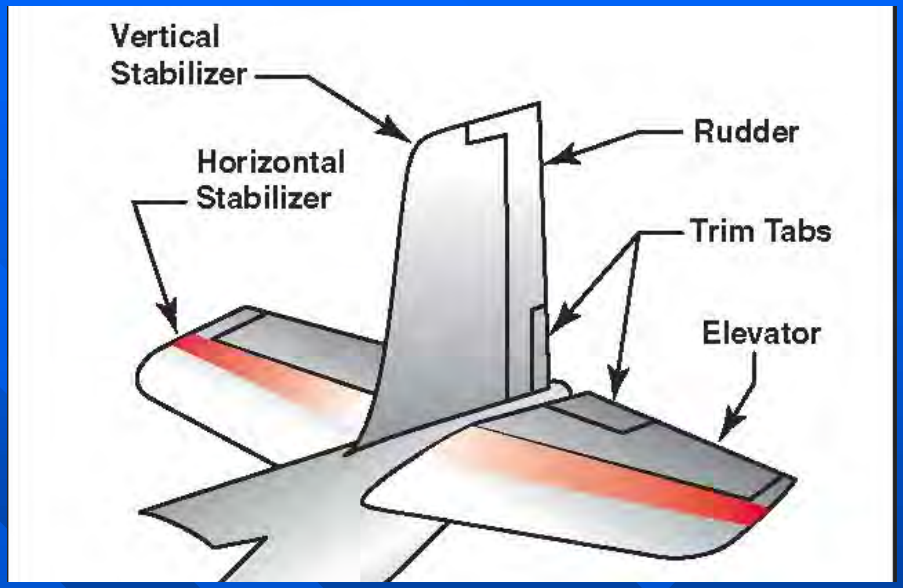
RTM with internal bladder and integral flange using biaxial sleeving

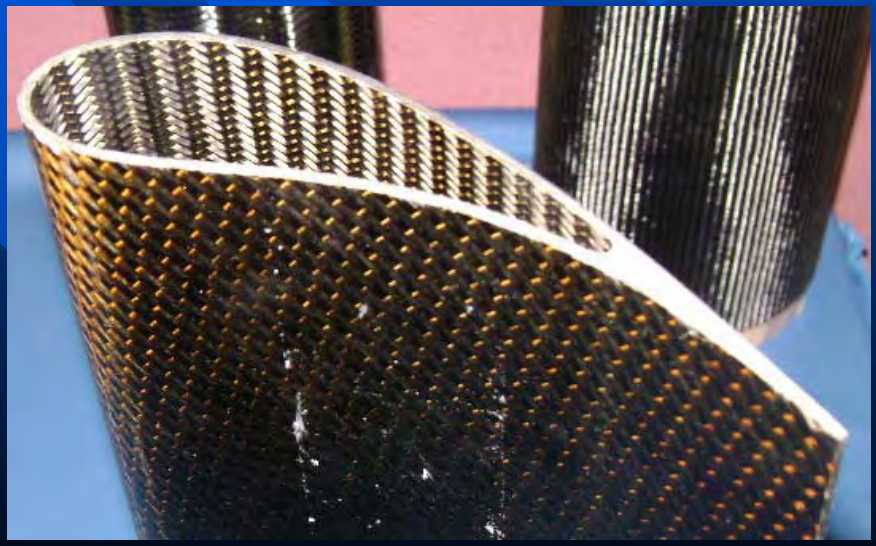
Braided Airfoils



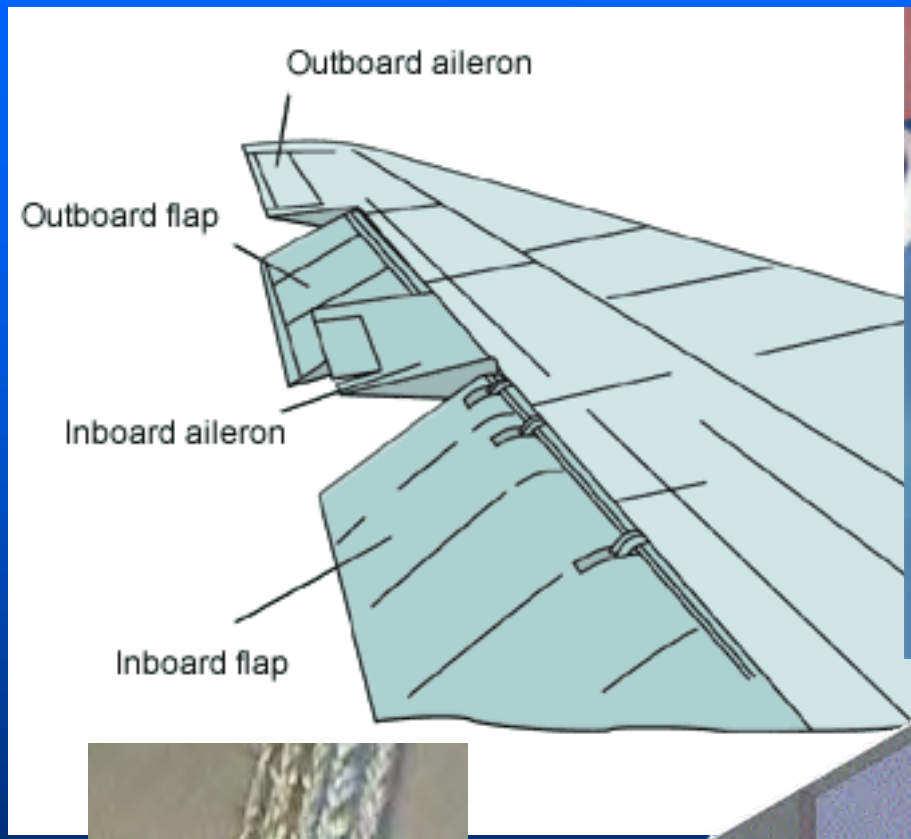
Control Surfaces

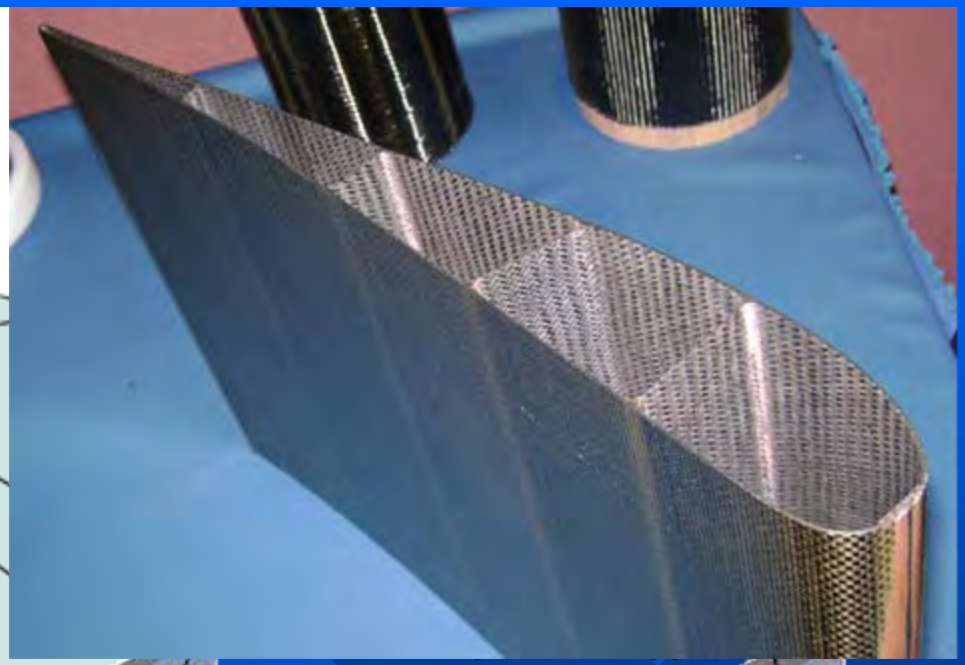


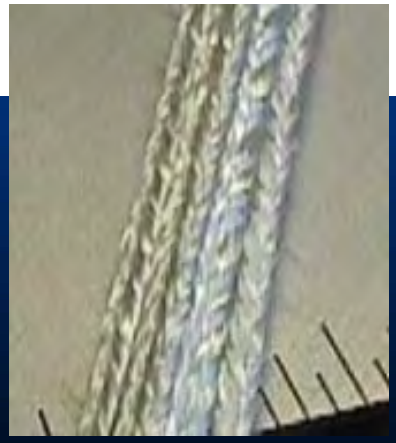


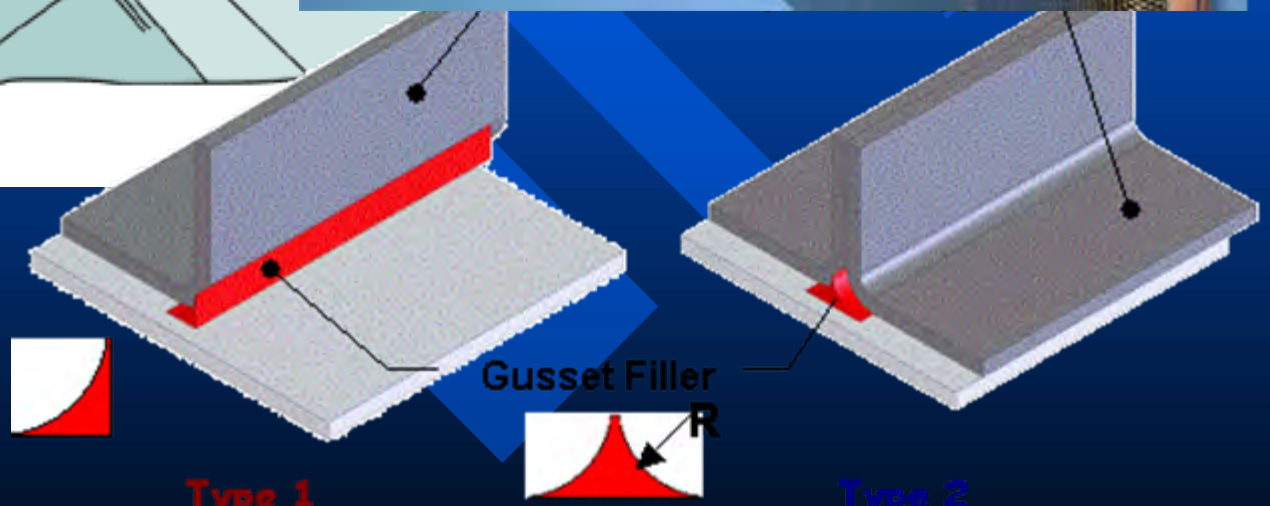


Control Surfaces (continued)



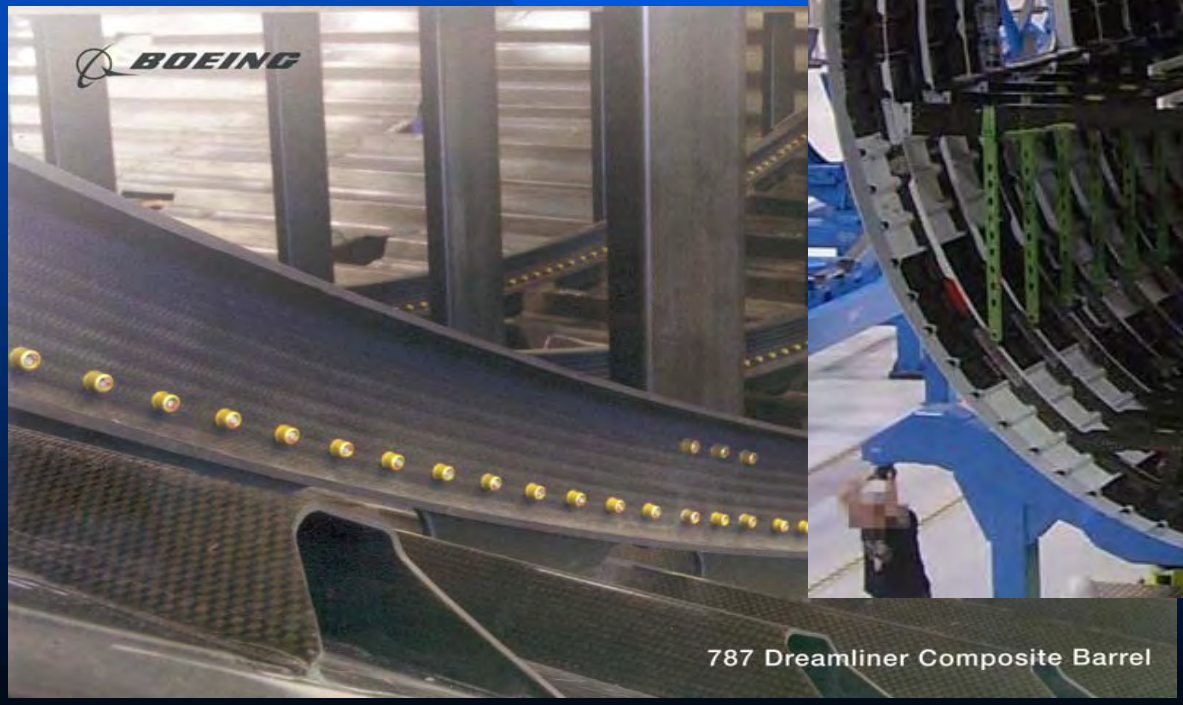






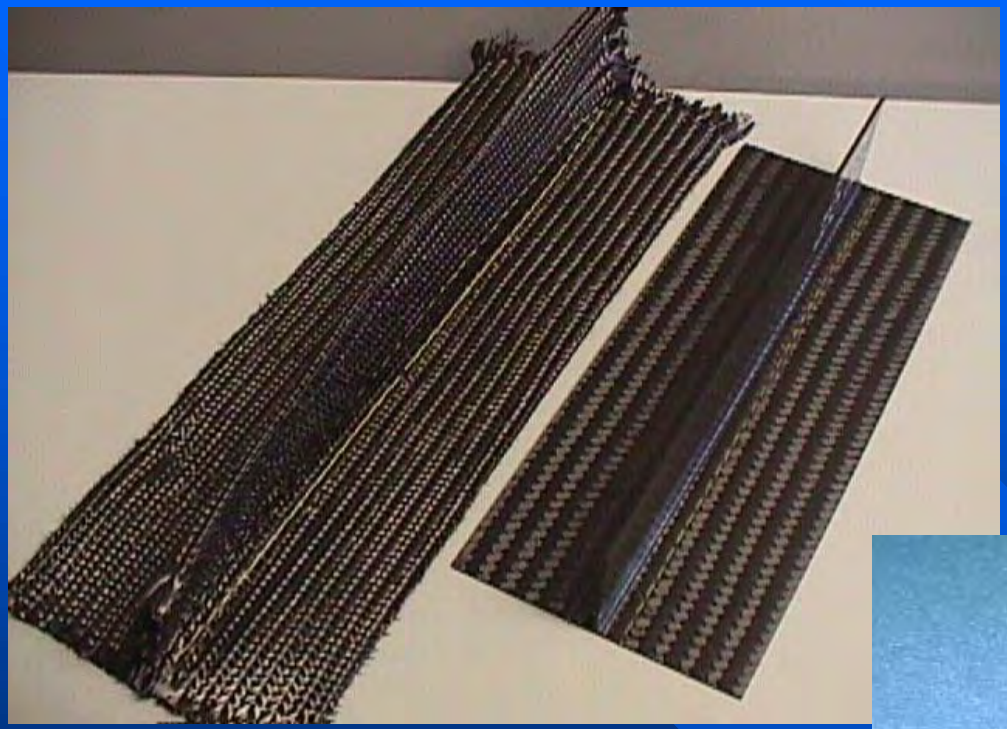
Braid use in Fuselage Frames

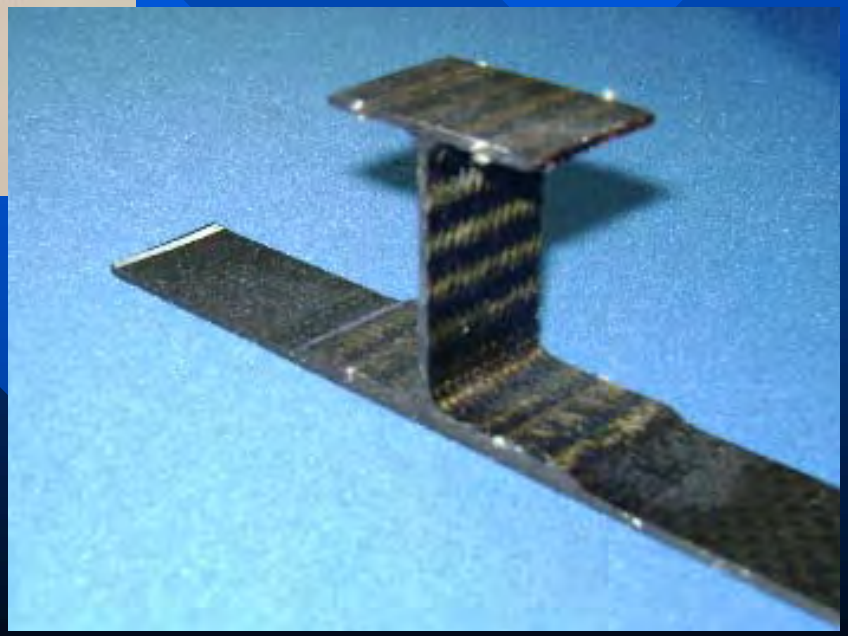
- Braid axis follows skin
- C & L shaped, variable flange angle, variable gage and variable curvature



Curved C-Channel Preform using Triaxial Sleeving

Braided and Stitched T-Section Preform



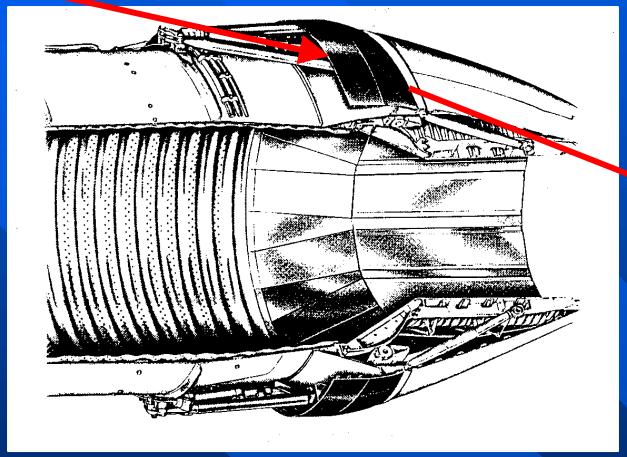


Braided Cases/Ducts

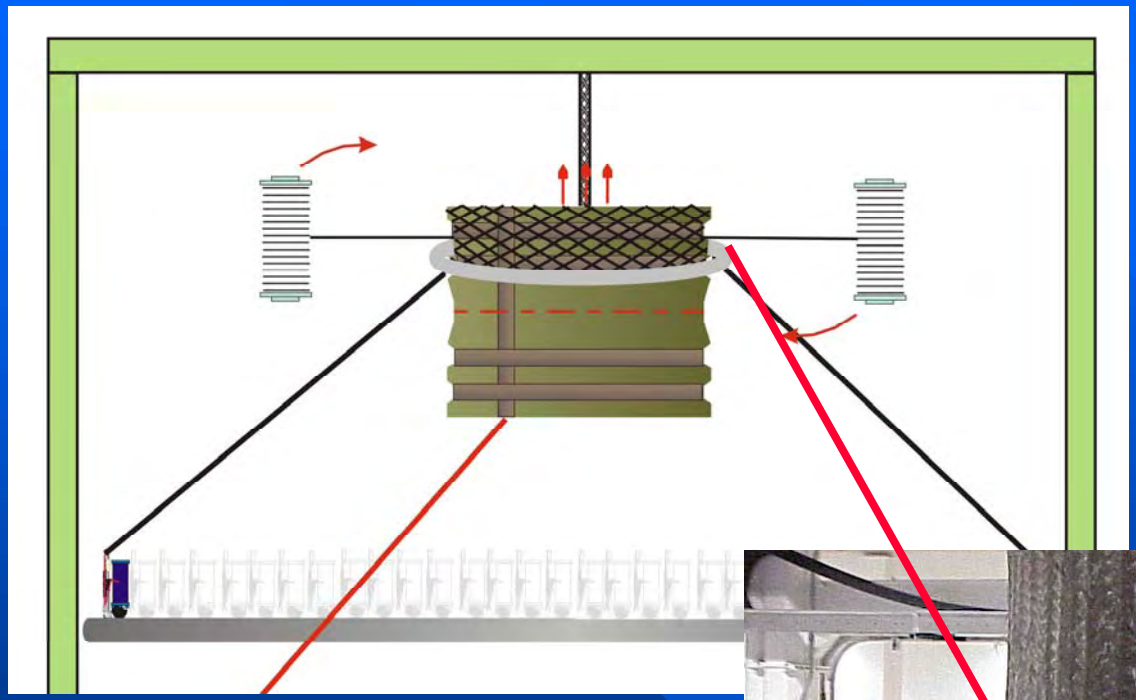
GE F110 Exhaust Shroud

Williams International Jet Engine Fan Case

Multiple Mandrels



Mantis Has Hoop Winding Capability



Localized IM7
for hat stiffener

T700 Wide Tow

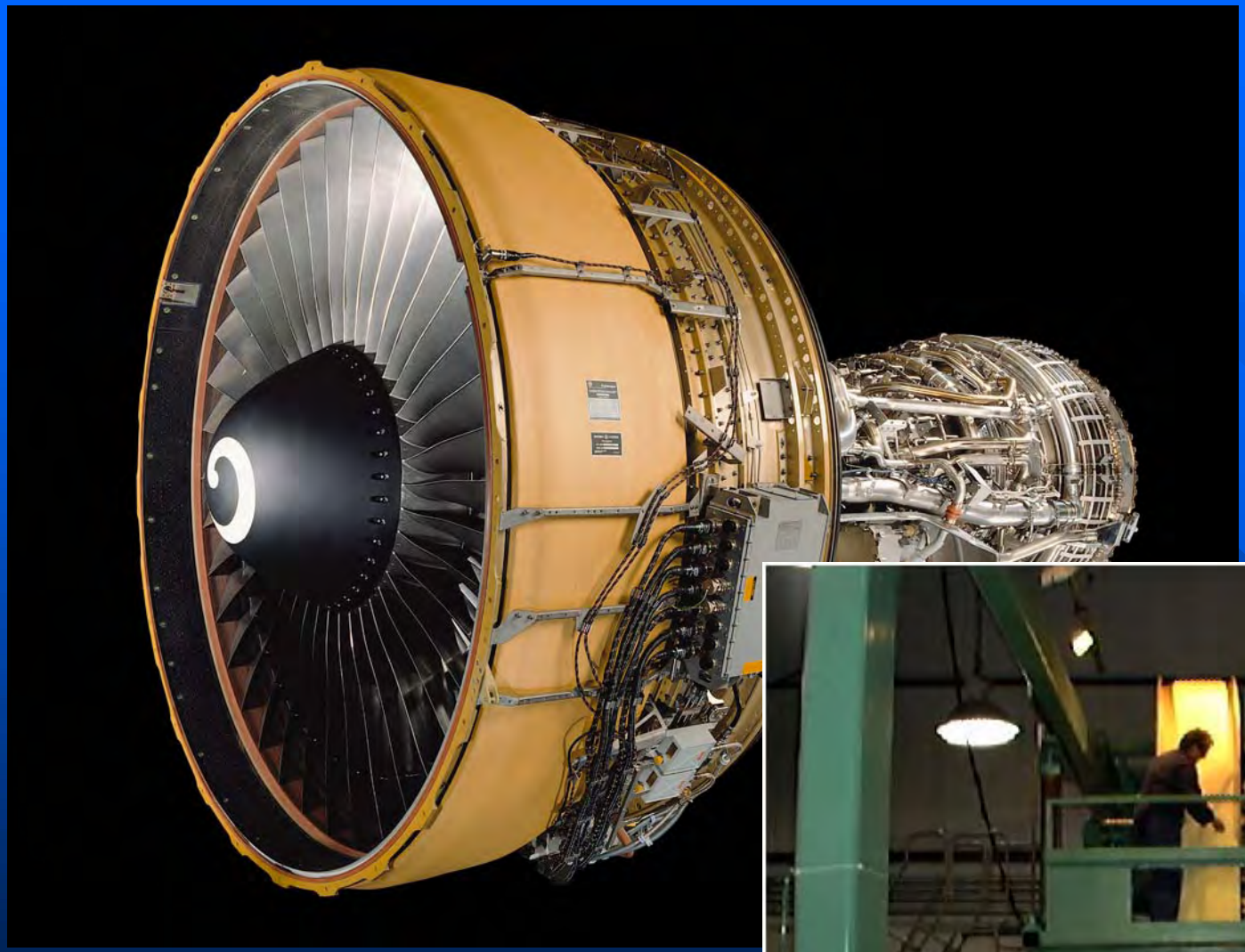
GE F110 Exhaust Shroud Overbraid Process

4 preforms packaged on one overbraid mandrel

4 Pack for Process Demonstration Minus Outer Layers

Capstan Winding - Jelly Roll Braids

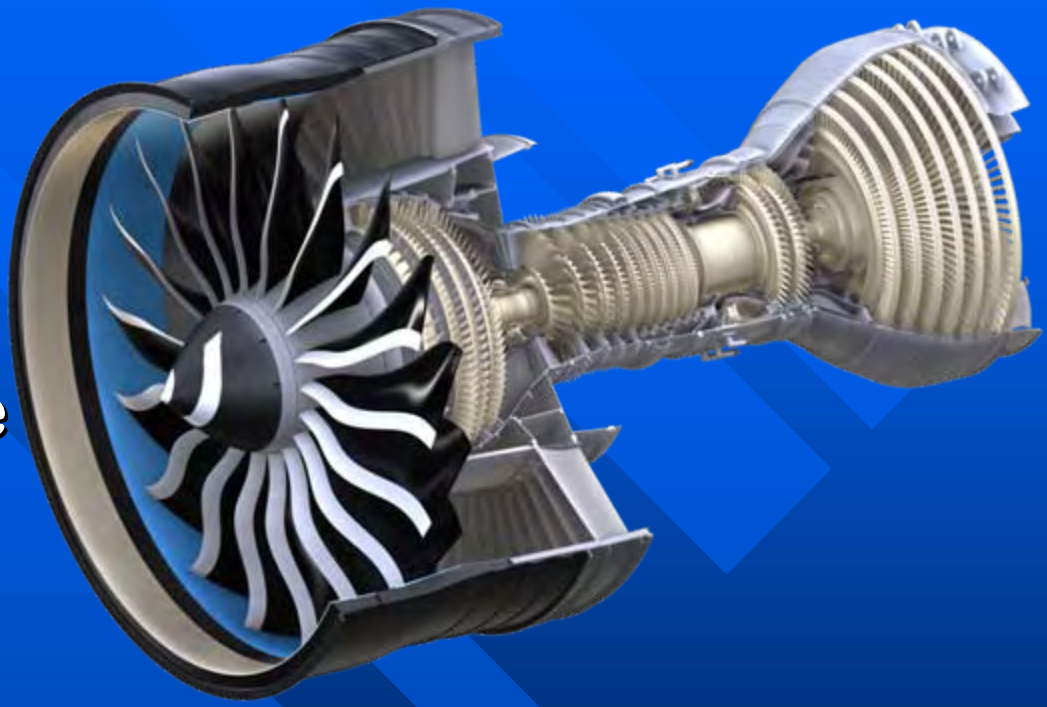
GE CF6-80C2 Braided Kevlar Containment



Dry, triaxial braided tape wrapped circumferentially to achieve cost,weight reduction

GE Fan Case (2005)

- High strength containment necessary to stop failed blade from penetrating fuselage
- Superior damage tolerance
- Composite fan case reduces engine weight by 350 pounds, or 700 pounds in a two engine aircraft



Component Testing

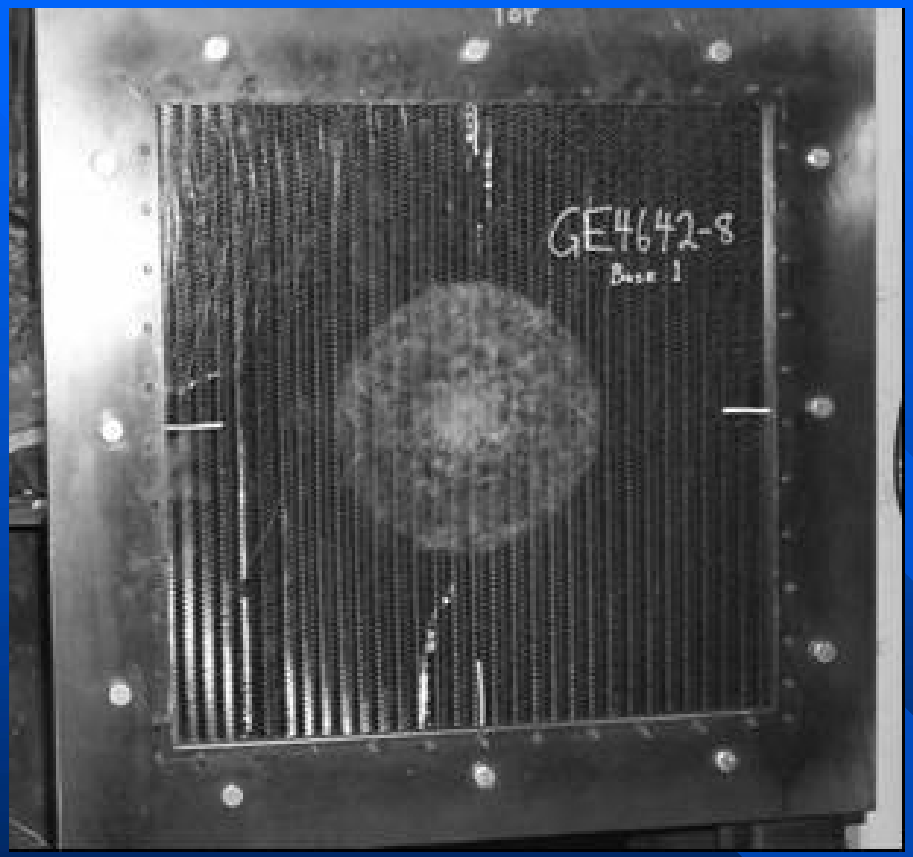
- Engine Containment
- Panel Impact Failures
- Pressure Vessels
- Stator Vane Hail Impact

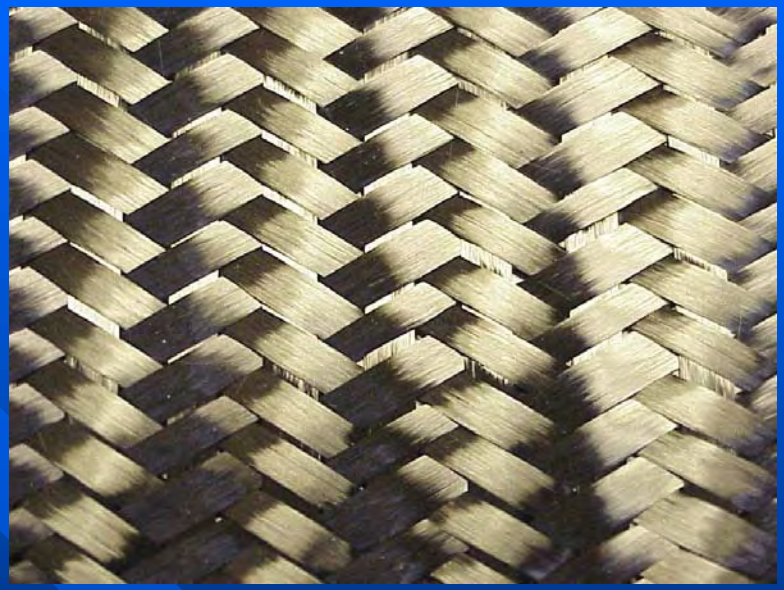
NASA SBIR Program

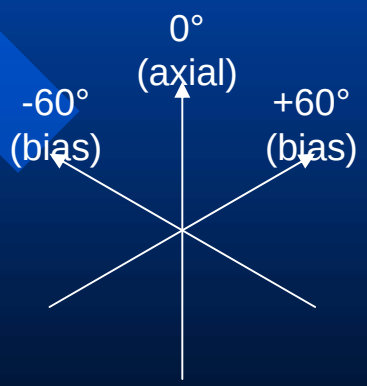
Flat Panel Impact Test Fixture

24” panel

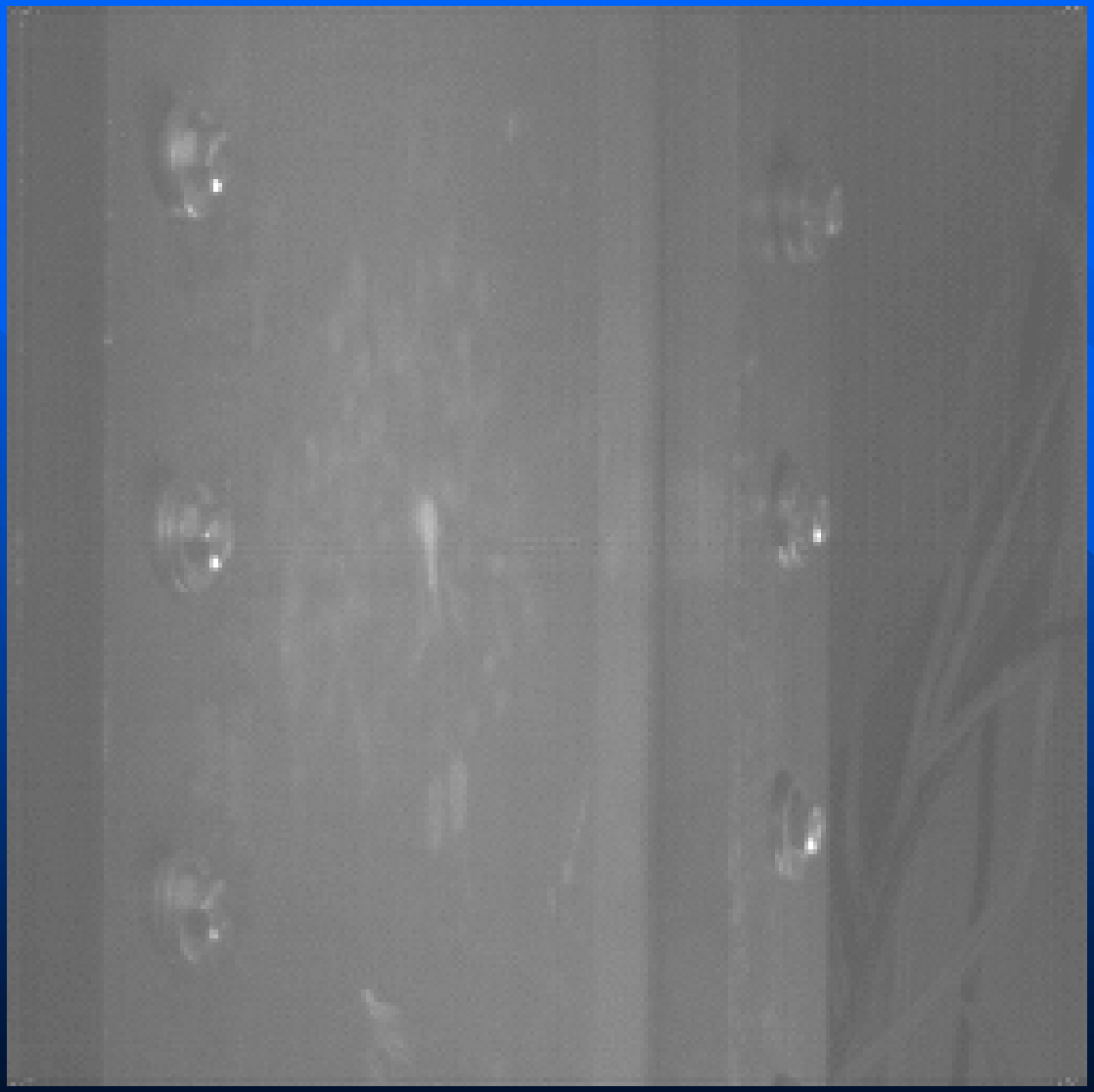
20” or 22” opening



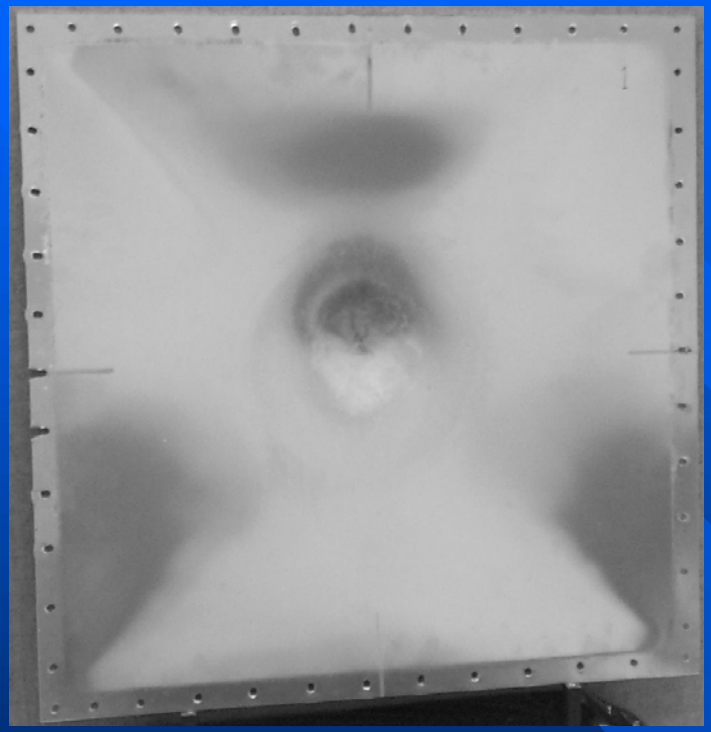




Impact Video of Aluminum Panel



0.071" Aluminum Panels after Impact



V = 513 ft/s (156 m/s)
(Test LG393)

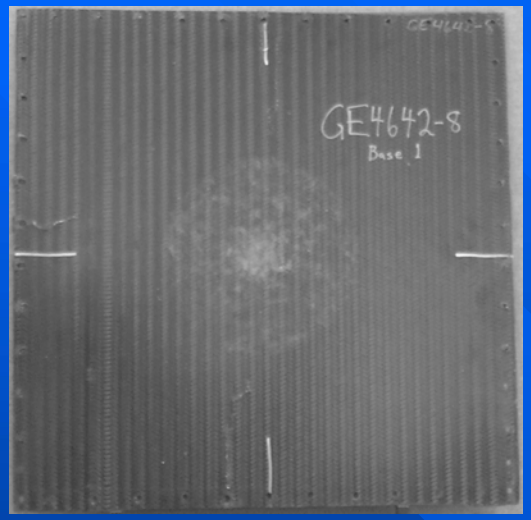
V = 743 ft/s (226 m/s)
(Test LG468)

Impact Video of (0+/-60) Composite Panel
(Velocity below penetration threshold)

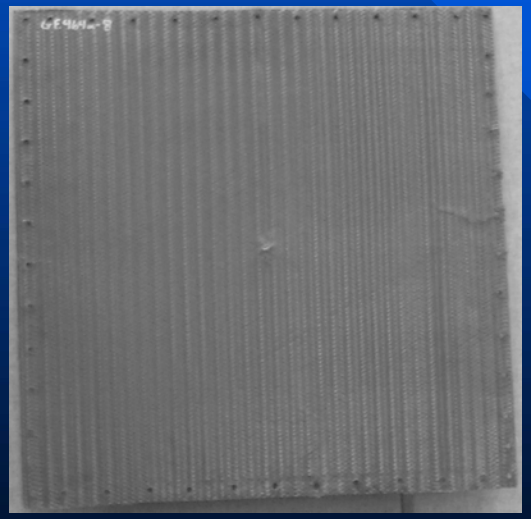
V = 491 ft/s (150 m/s)
(Test LG380, 7,100 pps)

(0+/-60) Composite Panel after Impact
(Velocity below penetration threshold)

Front



Back



Close-up view at center of panel

V = 150 m/s (491 ft/s)
(Test LG380)

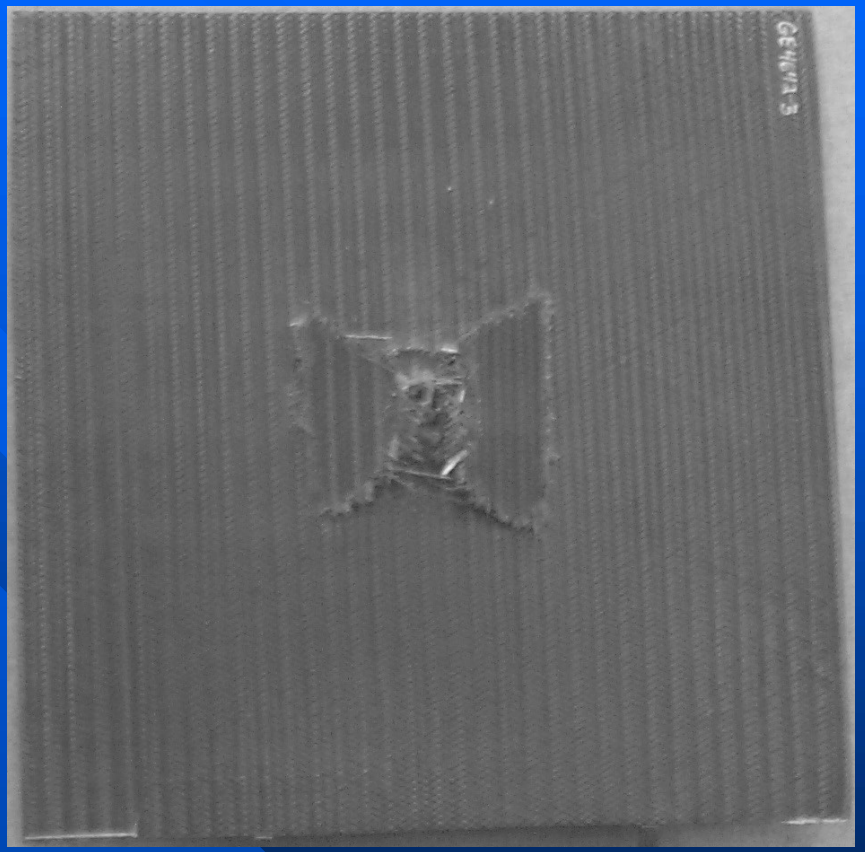
Fiber and matrix failure in back ply

Impact Video of (0+/-60) Composite Panel
(Velocity above penetration threshold)

V = 743 ft/s (227 m/s)
(Test LG375, 7,100 pps)

(0+/-60) Composite Panel after Impact
(Velocity above penetration threshold)

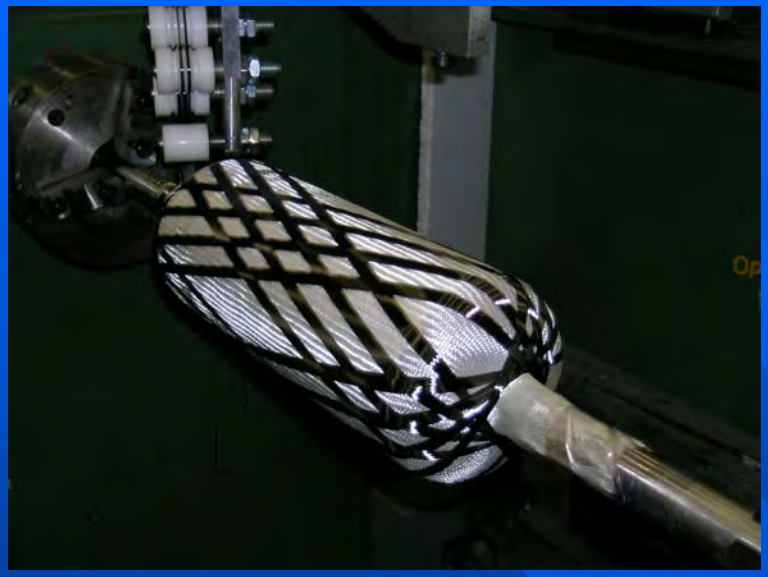
Front

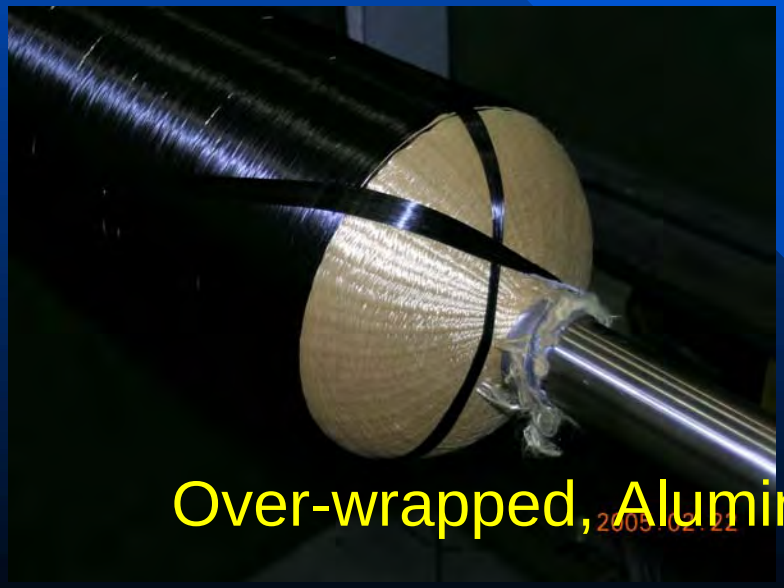


Back

V = 743 ft/s (227 m/s)
Test LG376

Pressure Vessel Testing



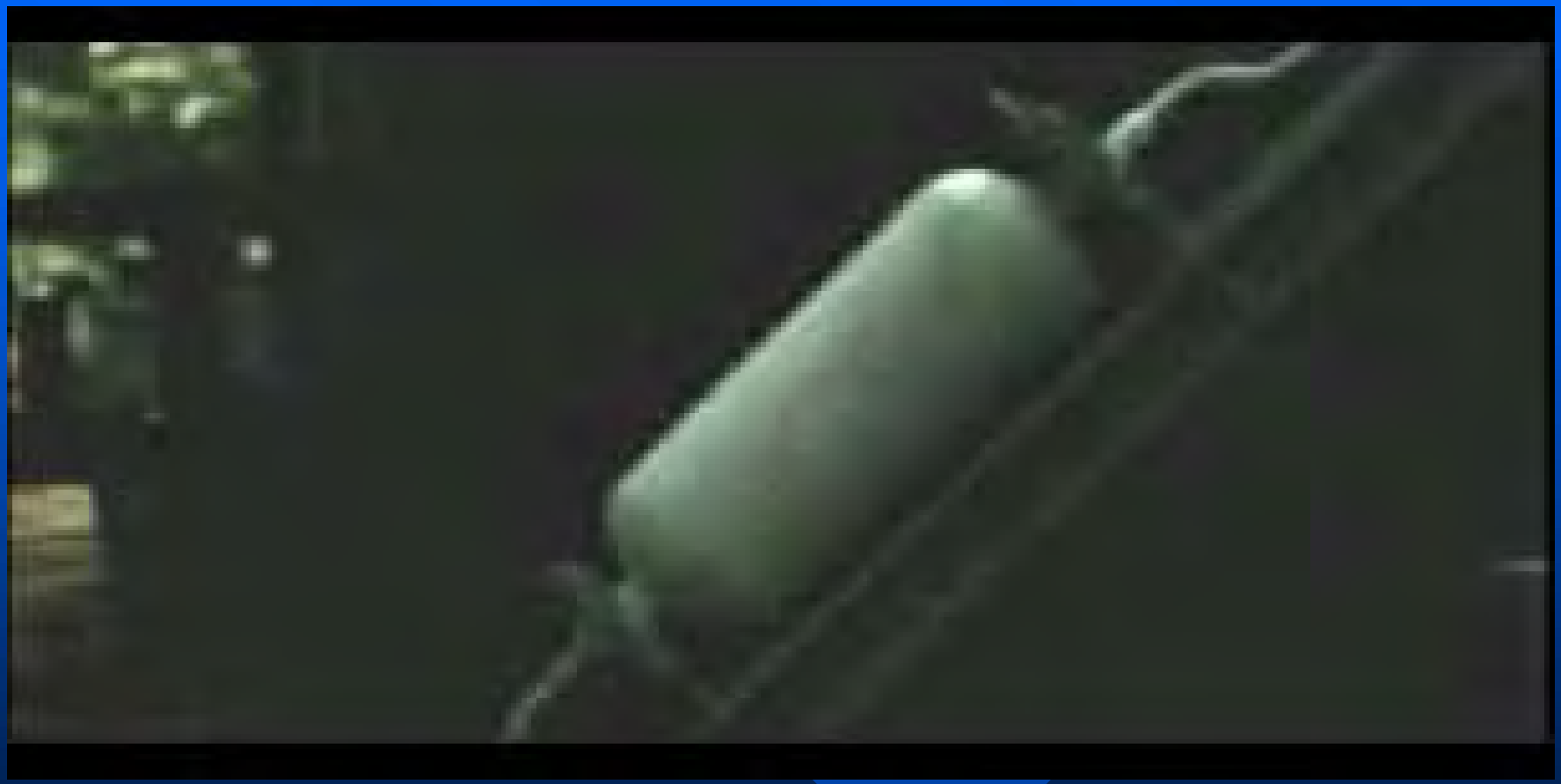


Over-wrapped, Aluminum Lined Pressure Vessels

Filament Wound

Vessels are pressurized with liquid nitrogen (-320F) and shot with a 50 caliber bullet. The 800 grain bullet at 2600 ft/sec has approximately 15,242 joules of energy.

Braided Pressure Vessel



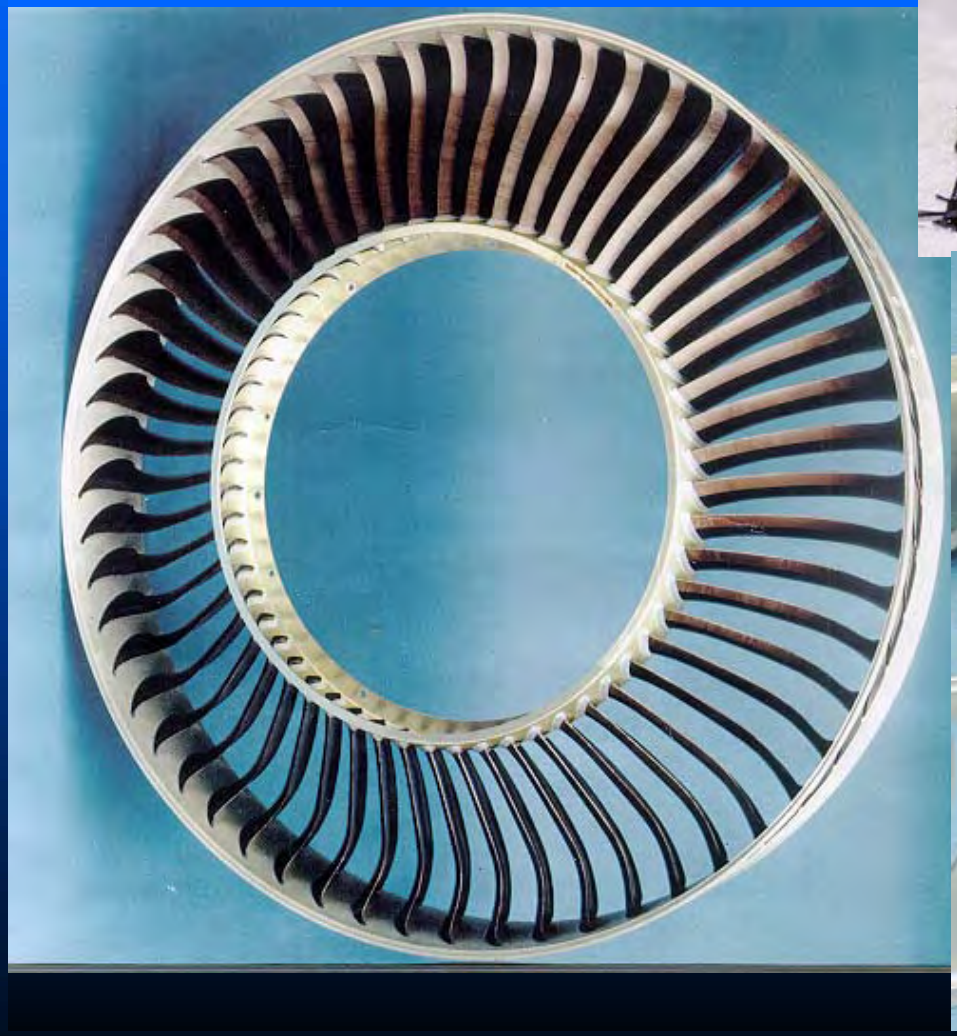
Vessels are pressurized with liquid nitrogen (-320F) and shot with a 50 caliber bullet. The 800 grain bullet at 2600 ft/sec has approximately 15,242 joules of energy.

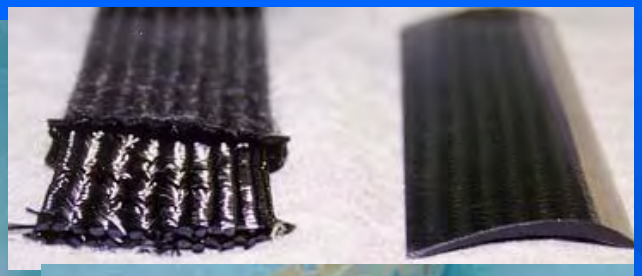
Filament Wound Vs. Braid

Filament Wound

Braid

Stator Vanes





FAA Required Simulated Hailstone Impact Tests
Airfoil Design with Tape

Ice Ball Weight: 65.7 g
Velocity: 293.6 fps

FAA Required Simulated Hailstone Impact Tests
Airfoil Design With Braid

Ice Ball Weight: 63.0 g
Velocity: 296.9 fps

A&P Technology