THERMAL PROTECTION SYSTEM DESIGN AND DEVELOPMENT FOR THE X-38

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Crew Return Vehicle

An element of the International Space Station (ISS)

Three Scenarios

- ISS catastrophe
- Emergency medical evacuation
- Period of Space Shuttle unavailability

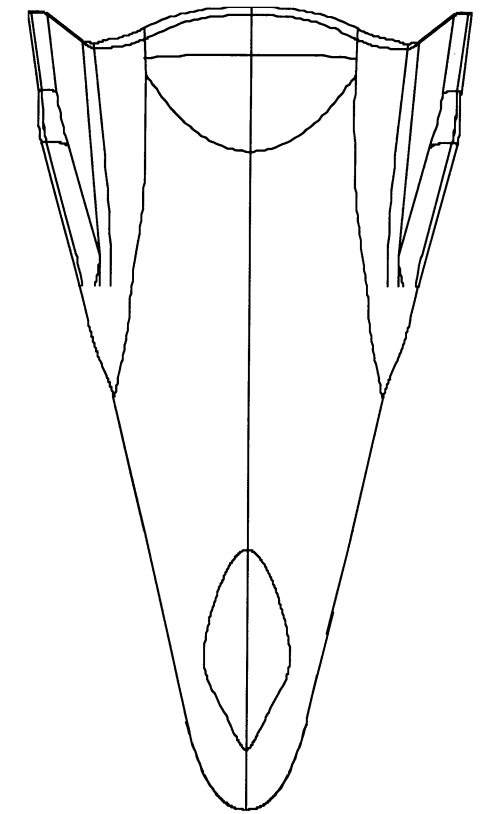
X-38 Program Overview

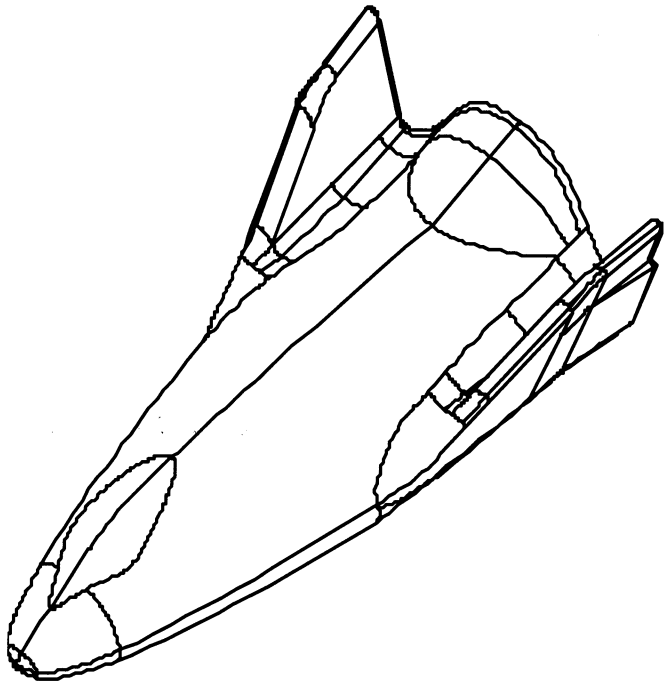
Program Purpose:

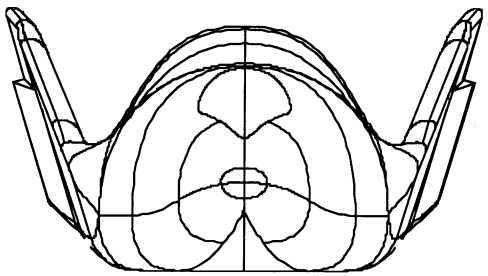
- To greatly reduce the costs and schedule for the development of Crew Return Vehicles (CRV's) and Crew Transfer Vehicles (CTV's) through the use of the rapid development methodology associated with an X-project

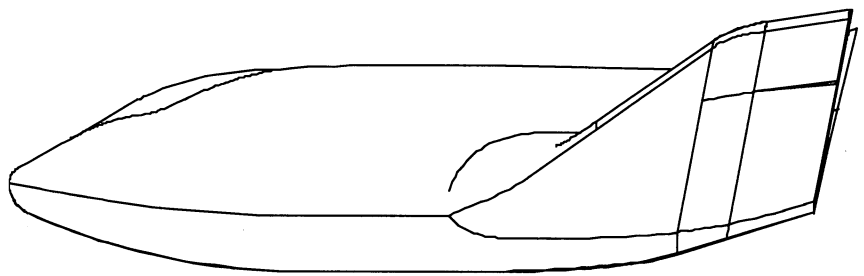
- **Ground Testing**
- **Atmospheric Testing**
- **Space Flight Testing**

X-38 V-201 Outer Mold Line

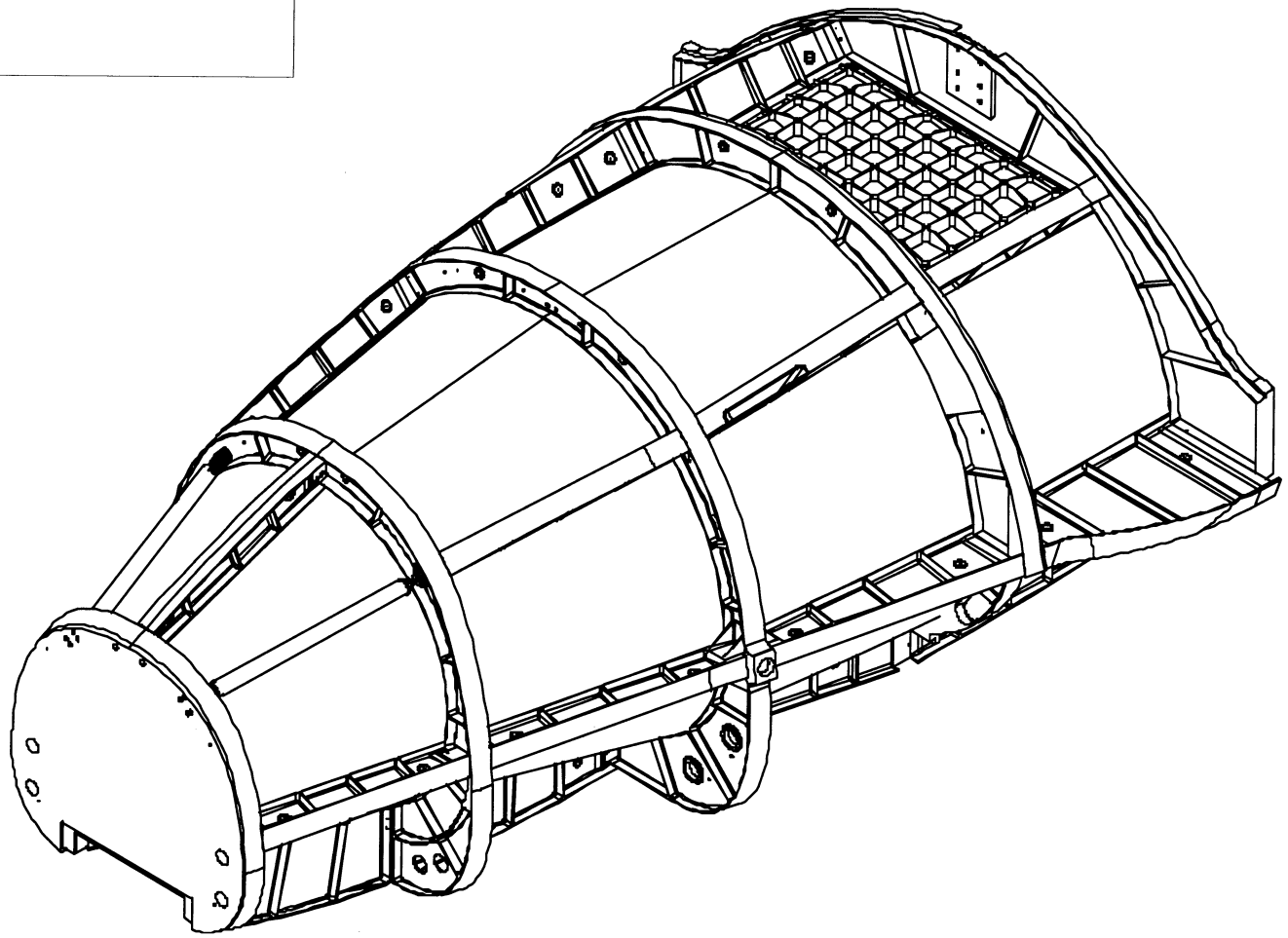






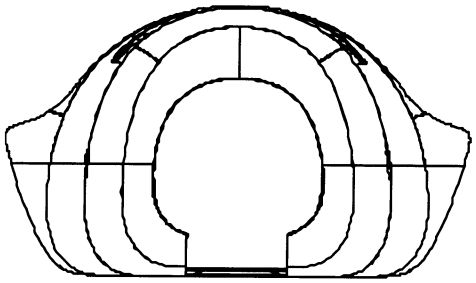


Forward Fuselage (Cabin)

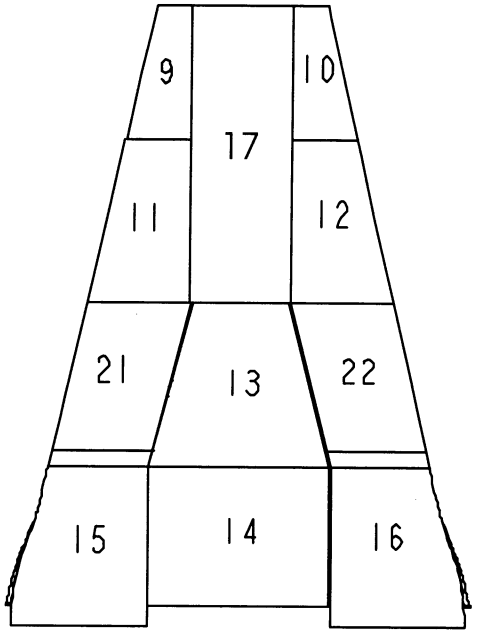


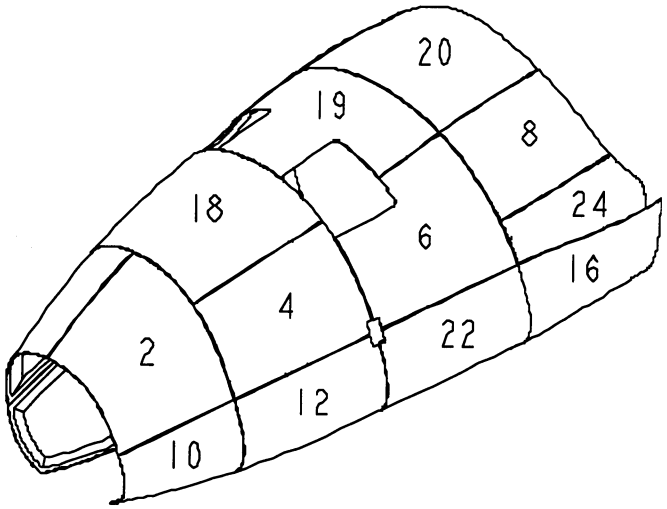
Aeroshell

FRONT VIEW



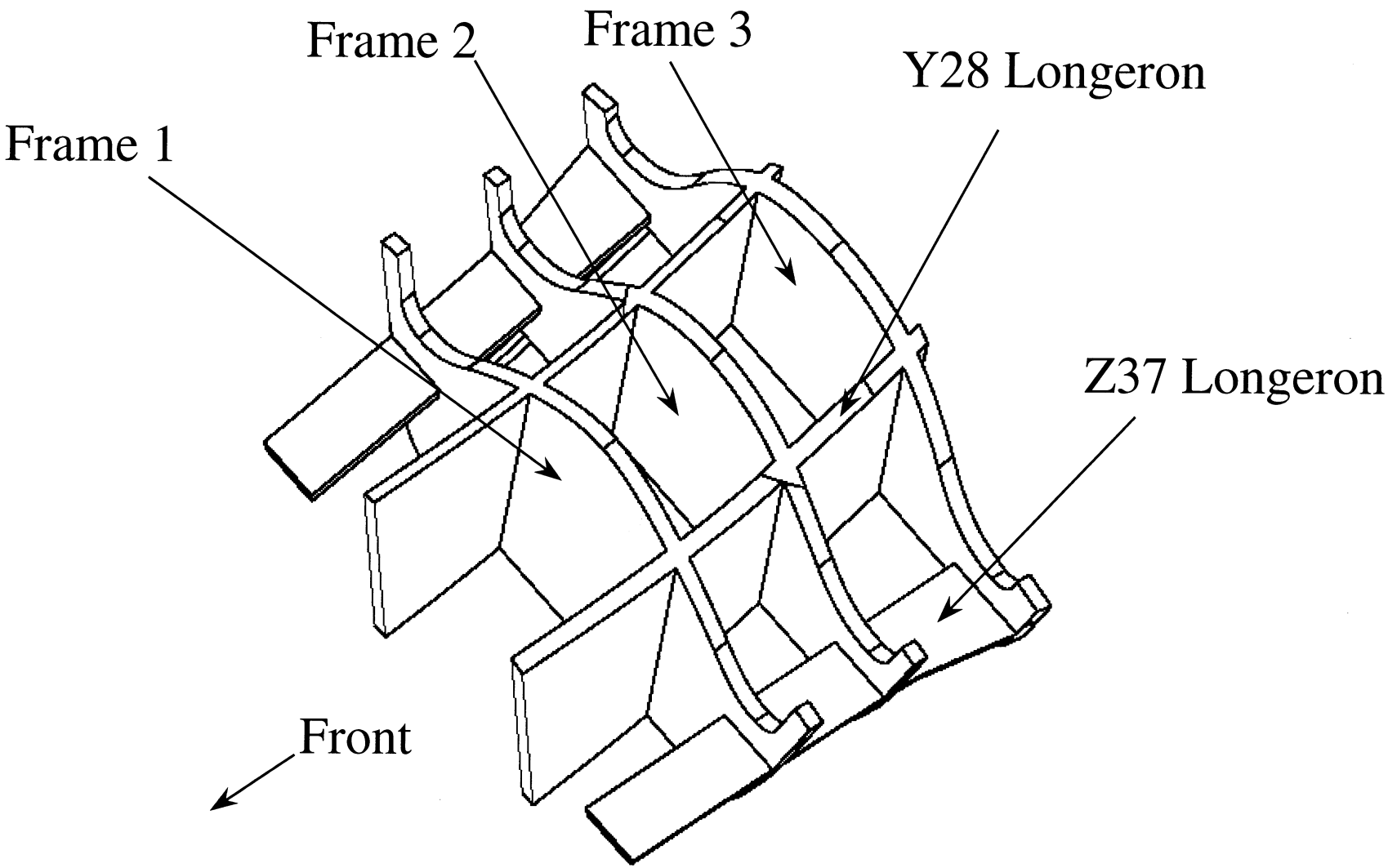
BOTTOM VIEW





Composite panel layout
– forward fuselage

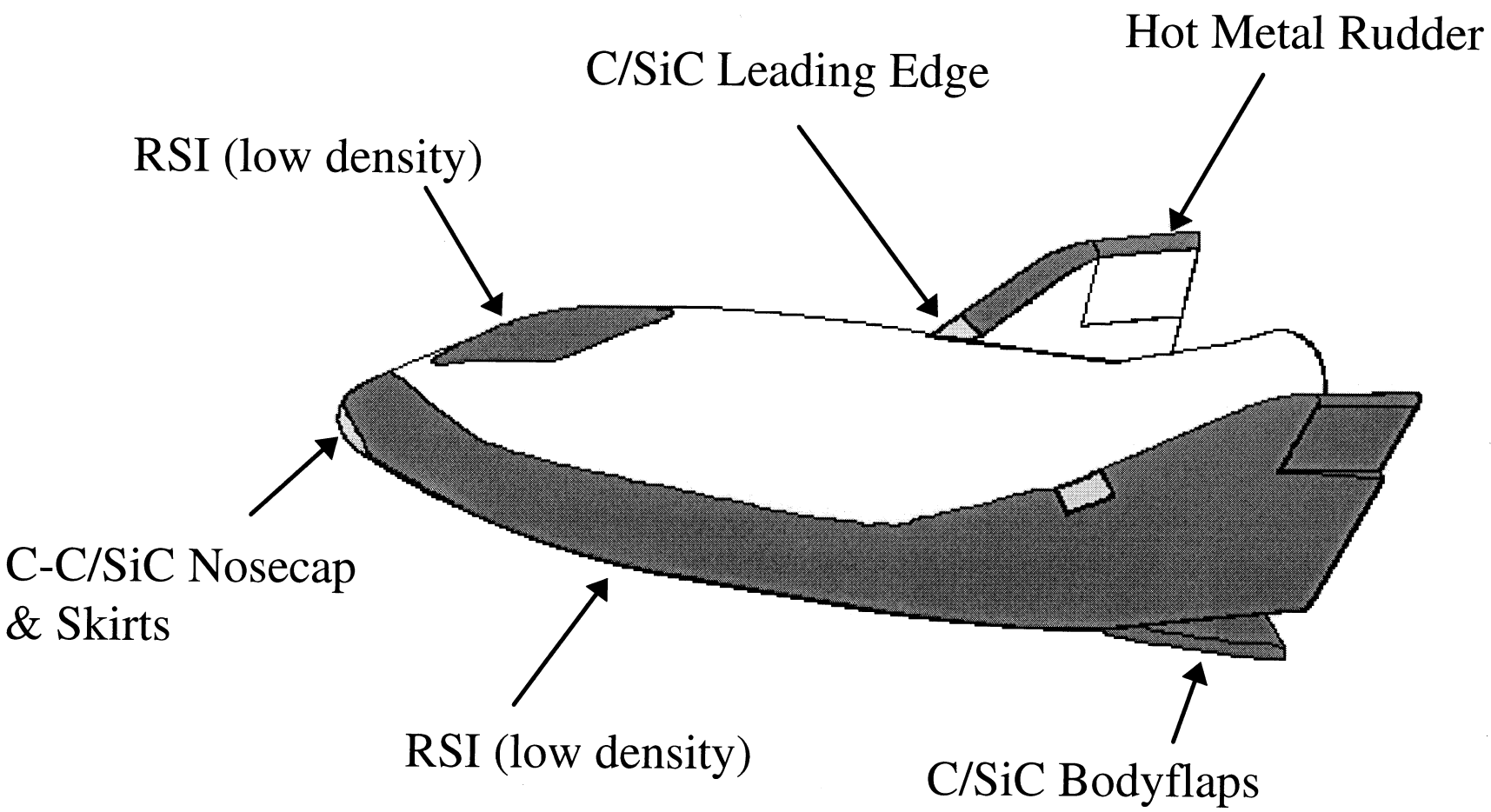
Aft Fuselage Design



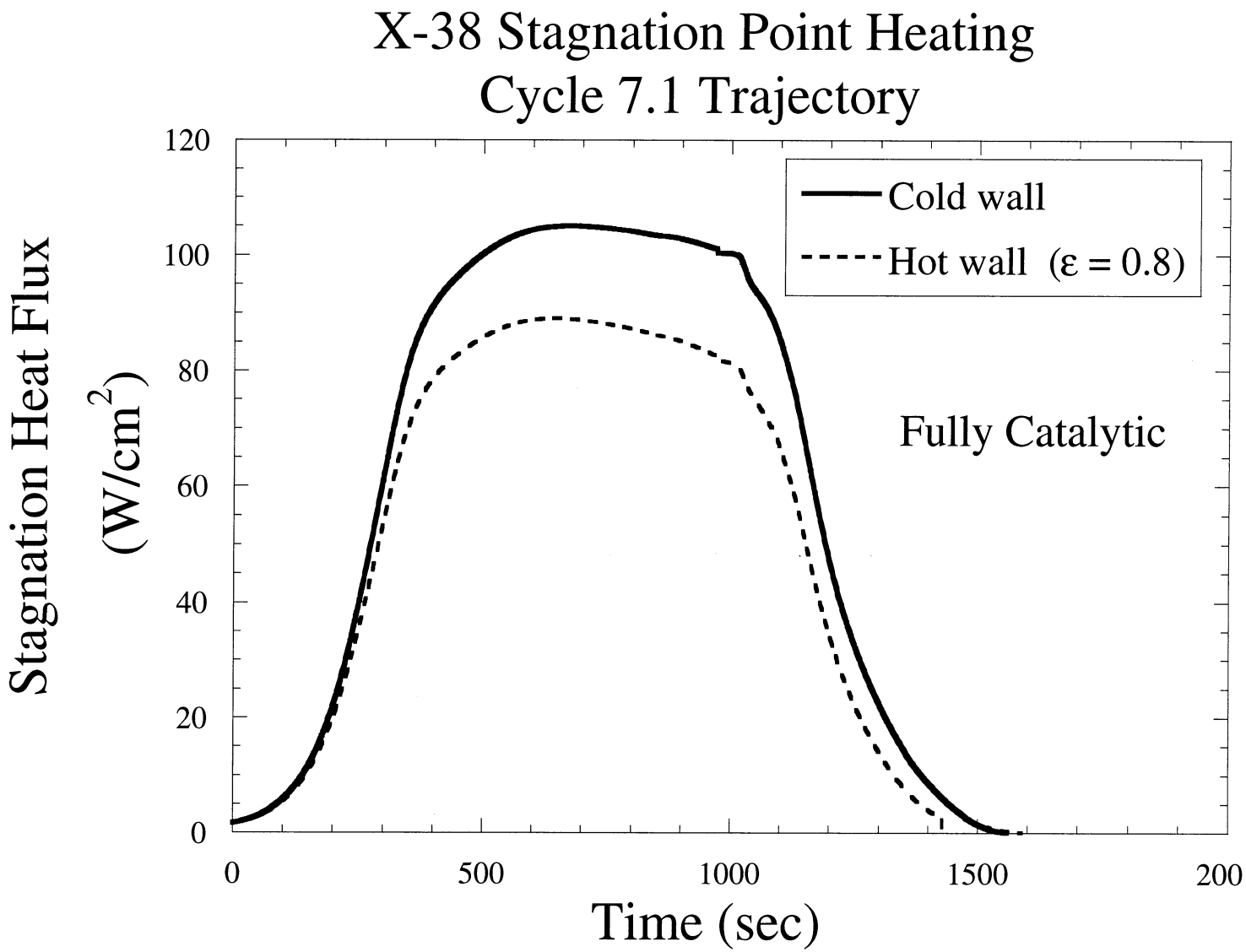
TPS Configuration

- Nose area
  - Carbon/Silicon Carbide (C/SiC)
    - Nosecap provided by DLR (Germany)
    - Nose skirts (2) provided by DASA (Germany)
    - Chin panel provided by MAN Technologie
- Windward Acreage
  - Low density advanced tile
    - AETB-8
  - C/SiC Body flaps
    - Provided by MAN Technologie (Germany)
- Leeward Acreage
  - Quilted blankets
    - Nextel 312 outer cover
    - Silica or Alumina batting
  - Needled Felt Blankets
    - Polybenzimidazole (PBI)/Kevlar/Nomex

TPS Overview



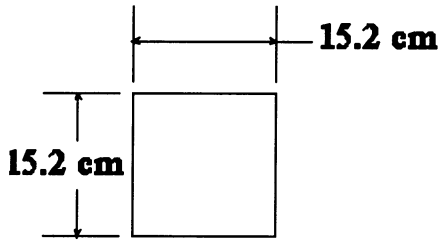
Reference Heating



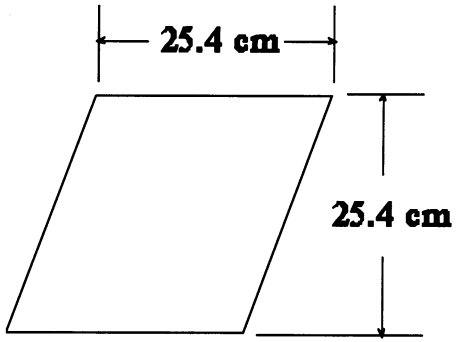
Tile System Description

Materials derived from Space Shuttle Tile System

- Advanced substrate material
  - Higher strength allows larger tiles
    - ⇒ Reduces tile count
- Higher durability coating



Typical Space Shuttle Tile

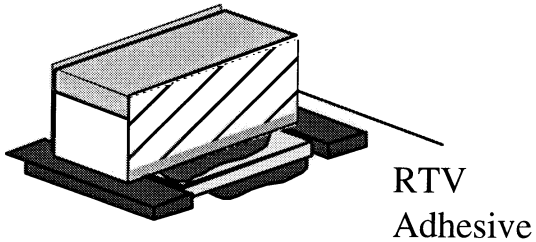


Typical X-38 Tile

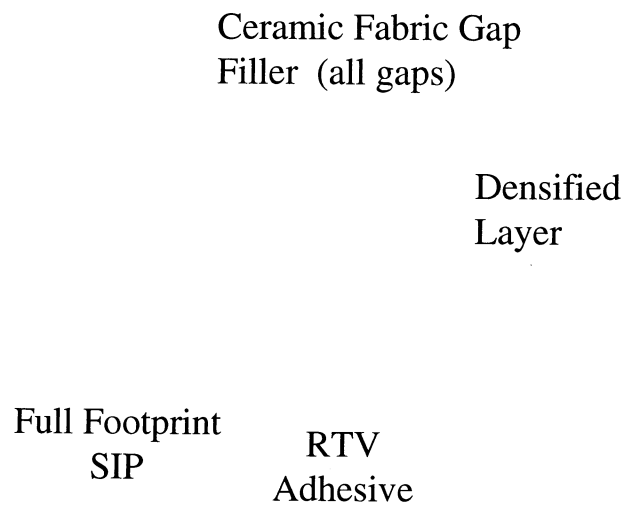
Tile System Comparison

Tile system modified to simplify installation

- System developed for Aeroassist Flight Experiment
- Changes from baseline Space Shuttle System:
  - Eliminates filler bar
  - Full footprint strain isolation pad (SIP)
  - Ceramic gap fillers installed in all gaps



Space Shuttle Orbiter
TPS Tile Configuration

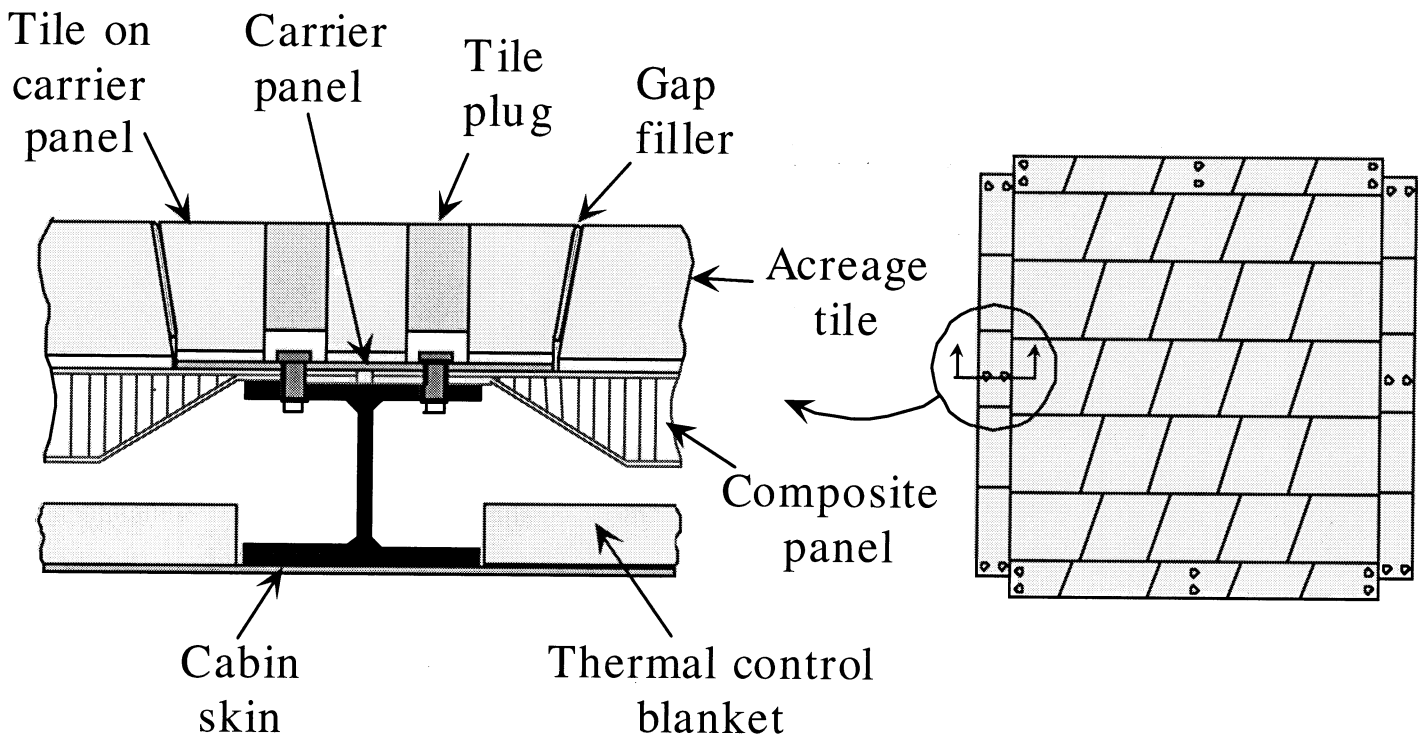


X-38 TPS Tile Configuration

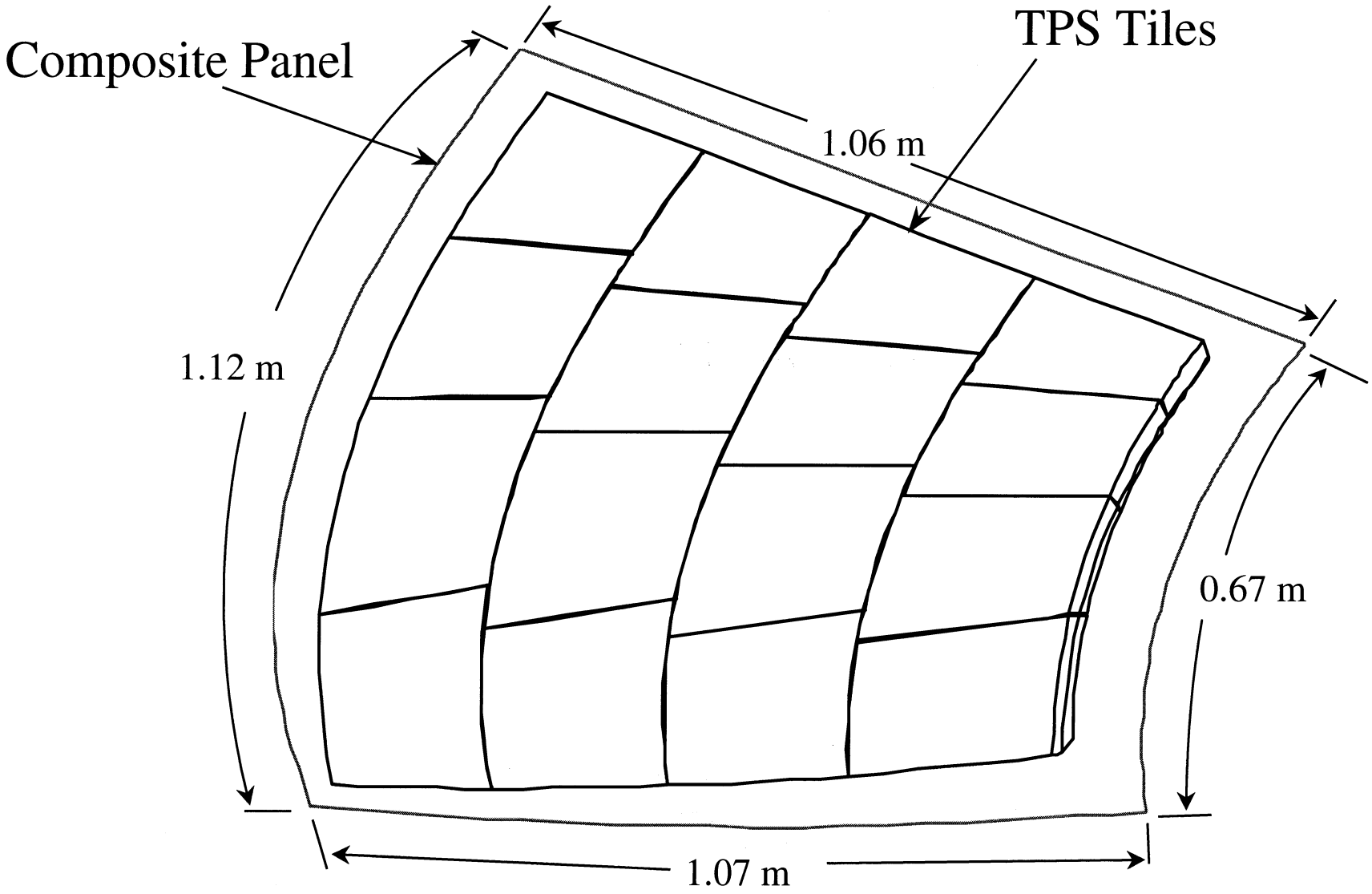
Composite Panel Joint

Vehicle requires ability to remove aeroshell panels quickly

- Necessitates use of tile carrier panel to access fasteners



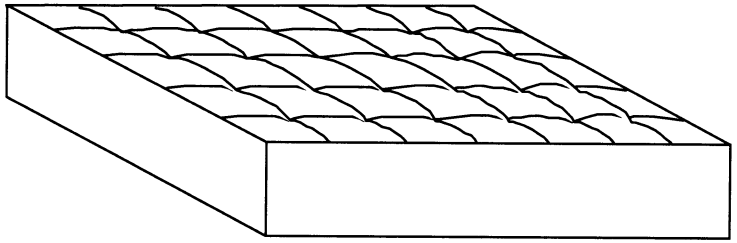
Aeroshell Panel 9 TPS

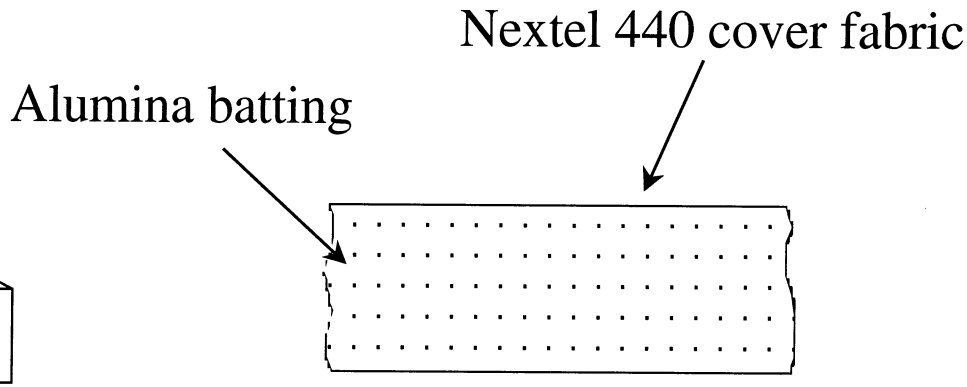


Blanket Selection

Quilted ceramic blanket

- Original baseline
- High temperature AFRSI (HTA)
  - Derivative of Orbiter AFRSI
  - Upgraded cover and insulation material



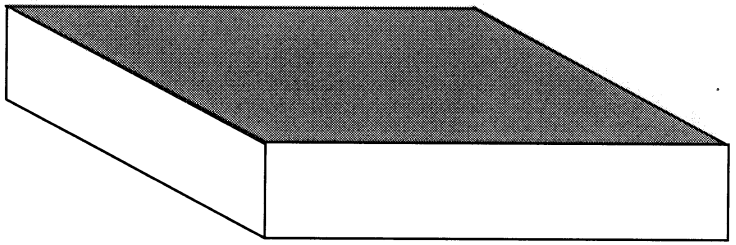


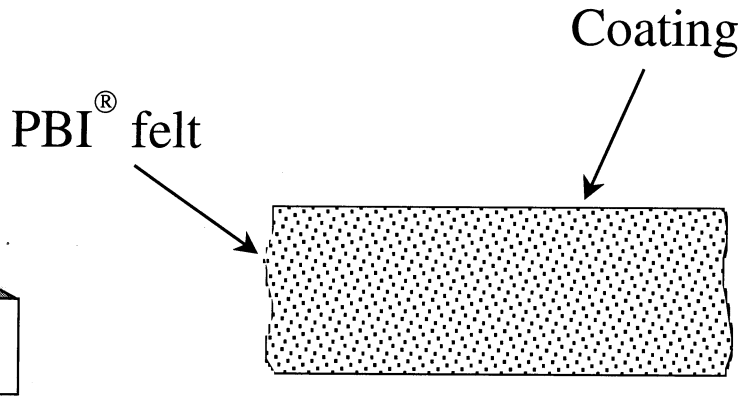
Blanket cross-section

Blanket Selection

Felt blanket

- Reduction in heating allowed for consideration
- Derivative of Orbiter FRSI
  - Needled polybenzimidazole (PBI®) felt
  - Coating investigation in work



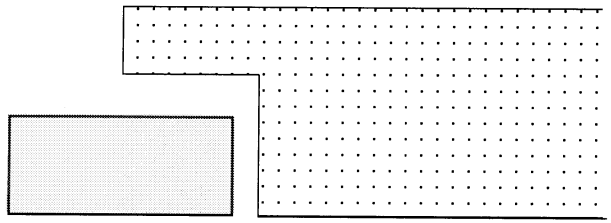


Blanket cross-section

Parafoil Line TPS

Parafoil lines routed on exterior of structure

- Requires TPS which also allows parafoil deployment
- Concept Has been tested for thermal protection and deployment

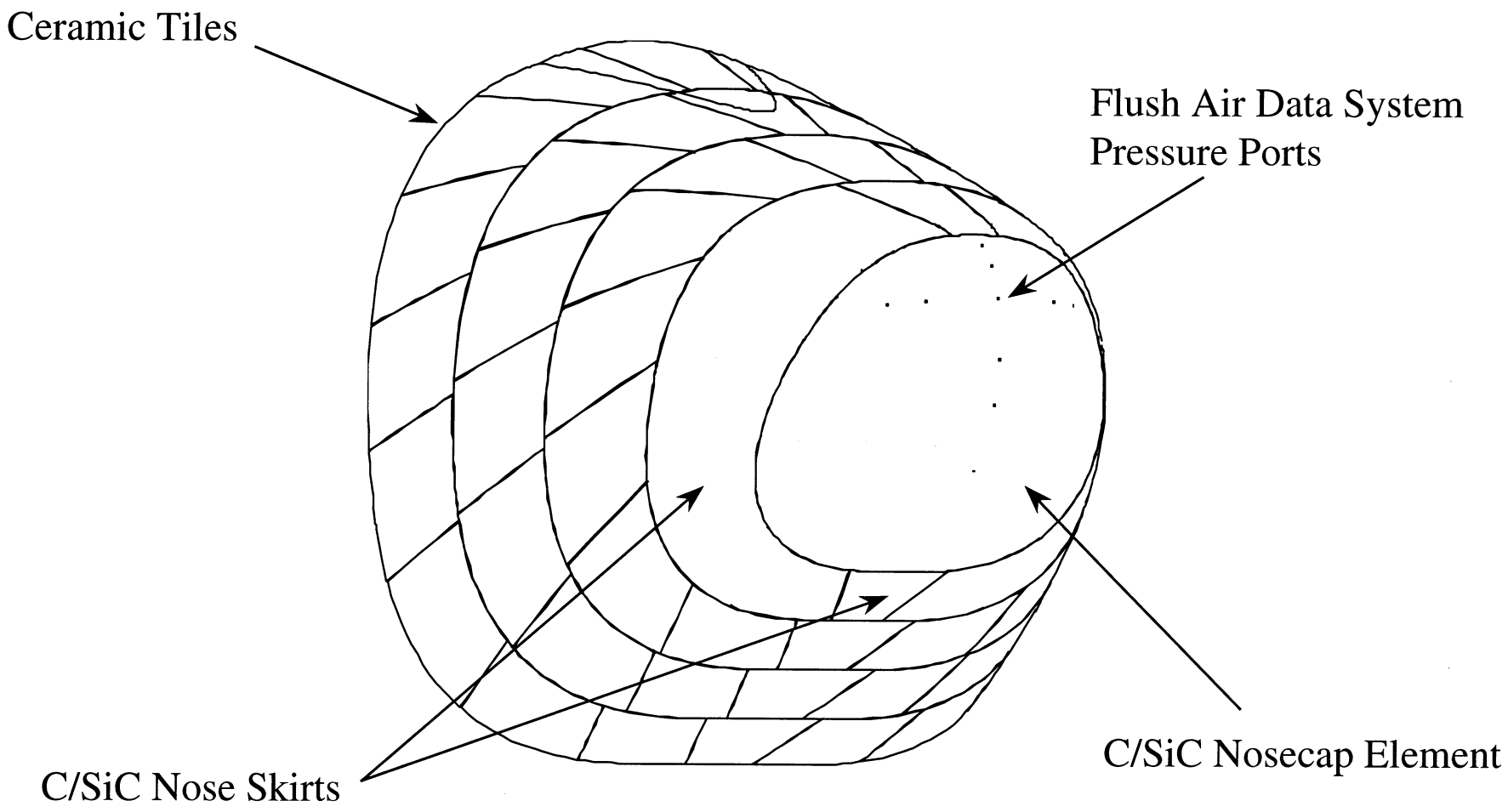


Nosecap

C-C/SiC nosecap element

- Provided by DLR
  - Liquid silicon infiltration (LSI) process
- Size is approximately 750 mm by 750 mm
- Incorporates flush air data system (FADS) pressure ports

Nosecap


Ceramic Tiles
Flush Air Data System
Pressure Ports
C/SiC Nose Skirts
C/SiC Nosecap Element

Body Flaps

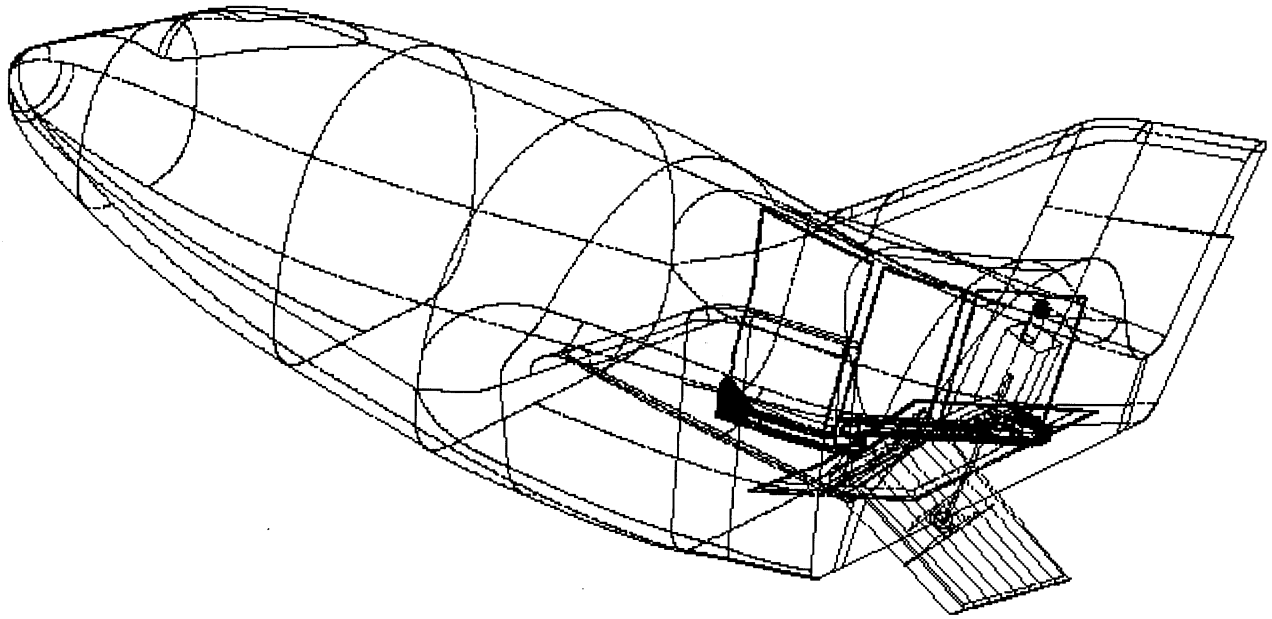
C/SiC bodyflaps

- Provided by MAN Technologie
  - Liquid polymer impregnation (LPI)
  - Chemical vapor infiltration (CVI)
- Size is approximately 740 mm by 640 mm

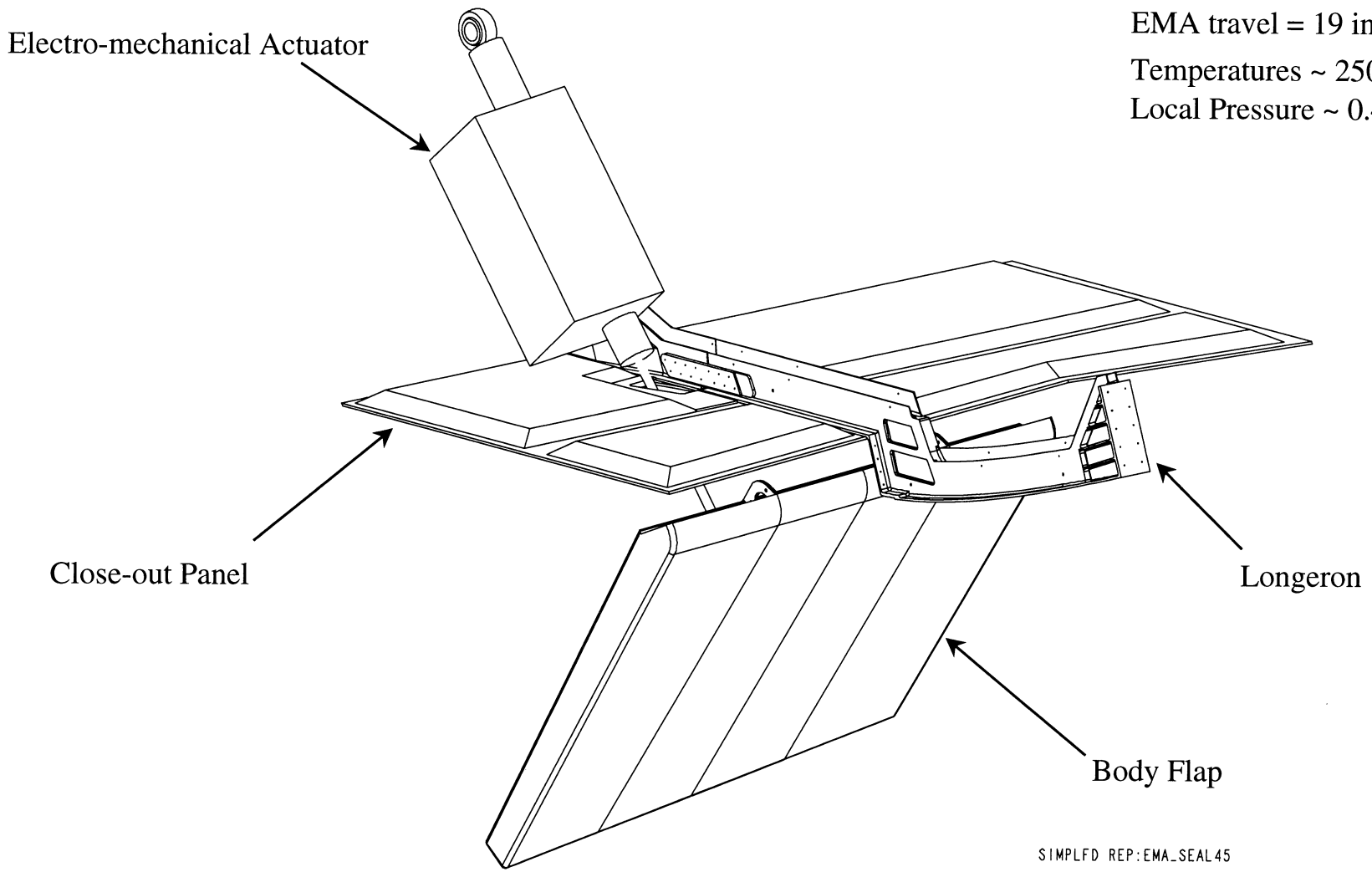
⇒ Hingeline Seal

⇒ Electro-mechanical actuator (EMA) seal

Body Flap

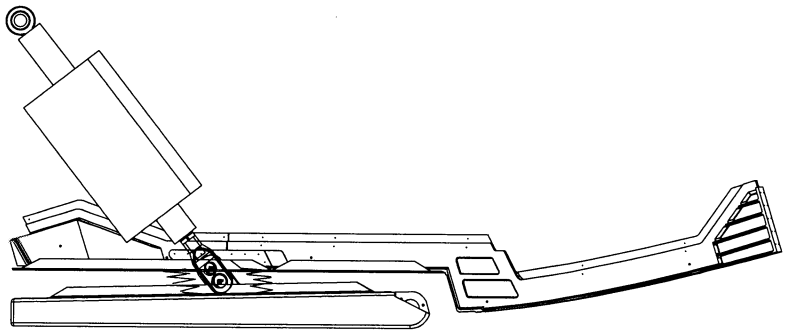


Bodyflap Configuration

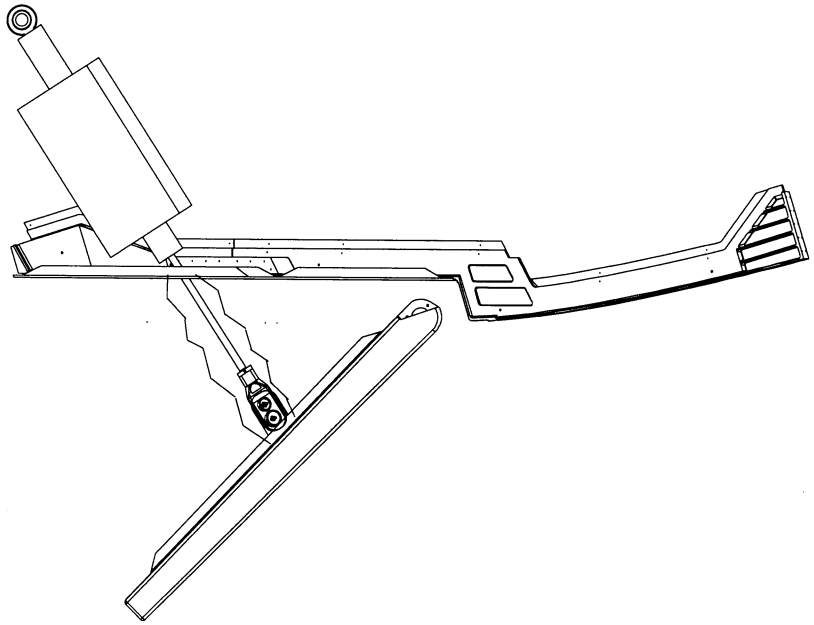


Body Flap EMA Seal

Bellows Seal Concept



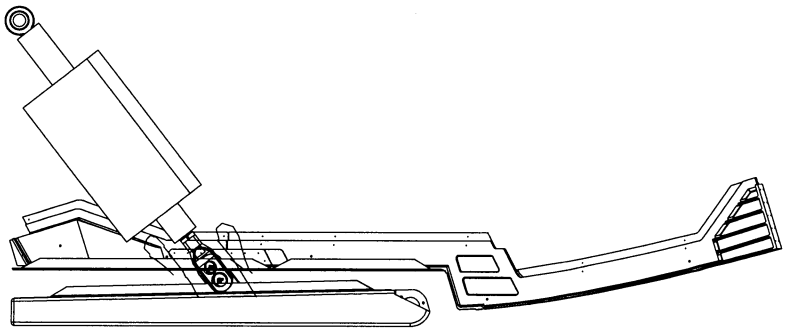
0° Deflection



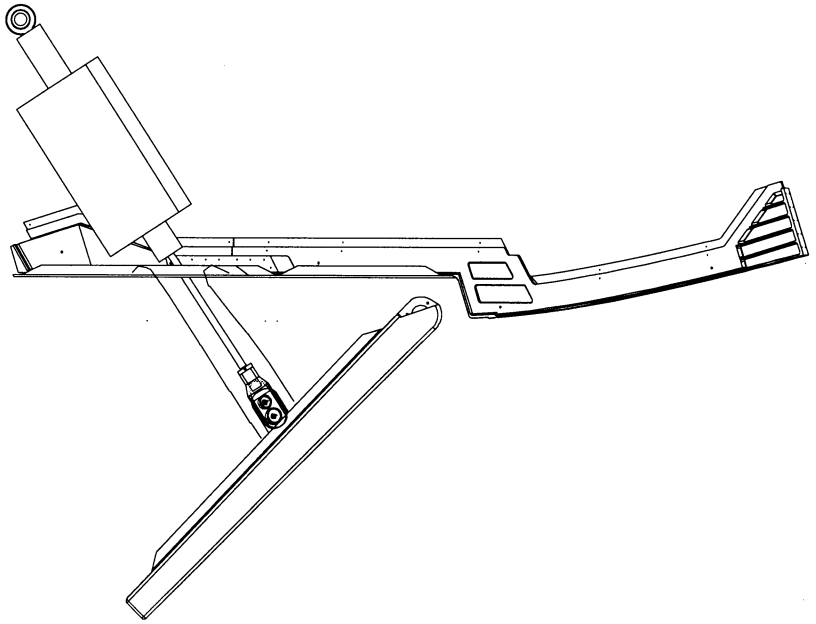
45° Deflection

Body Flap EMA Seal

"Rolling Sock" Concept



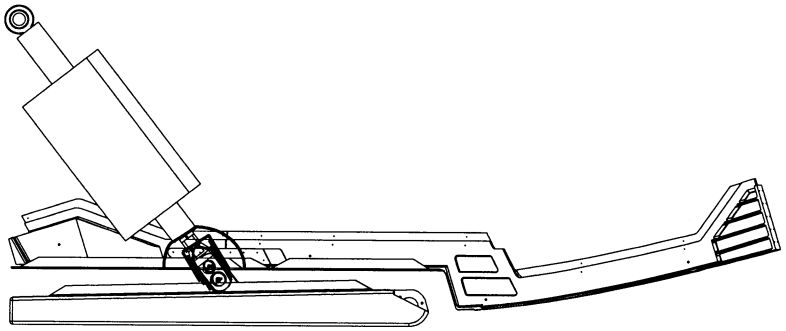
0° Deflection



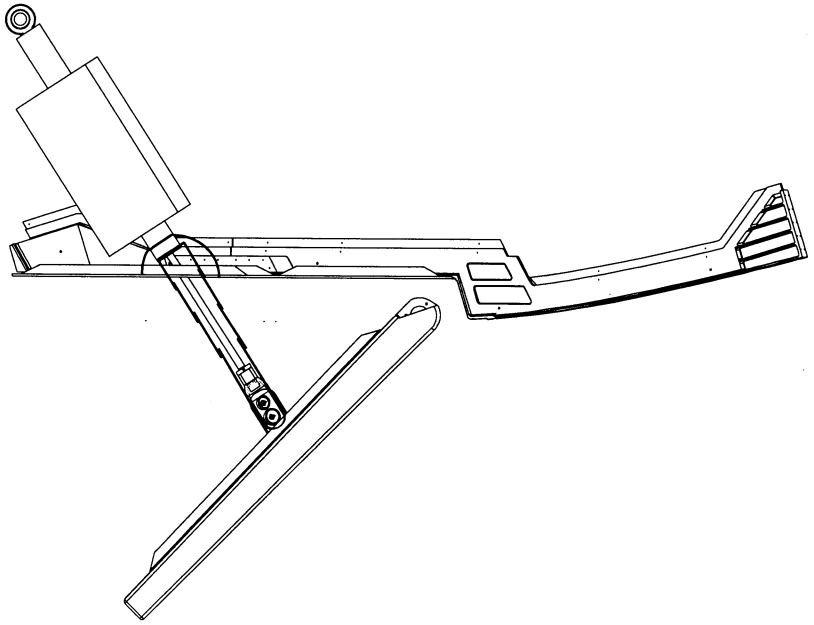
45° Deflection

Body Flap EMA Seal

Rigid Telescope Concept

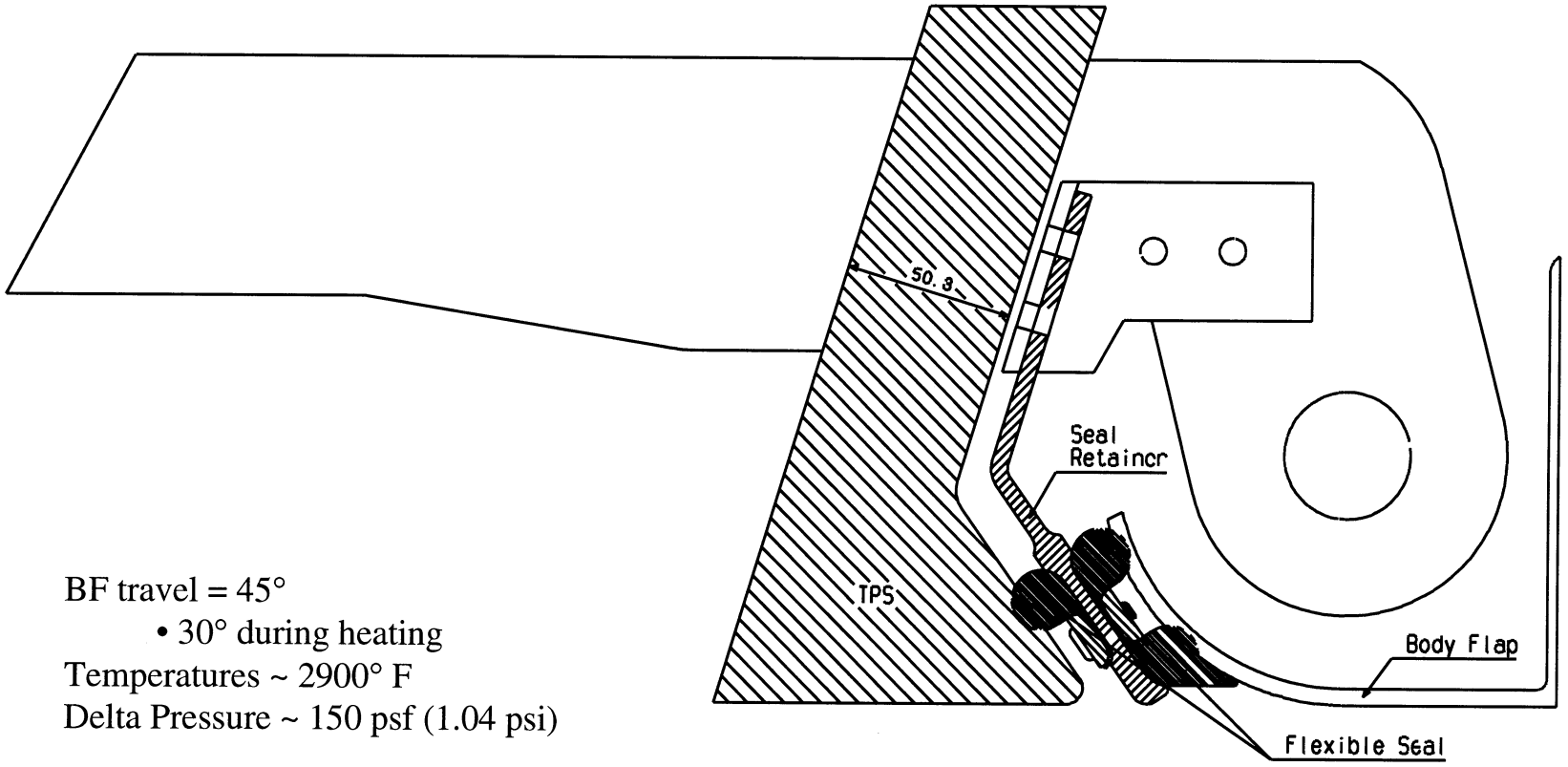


0° Deflection



45° Deflection

Body Flap Hingeline Seal Concept #1



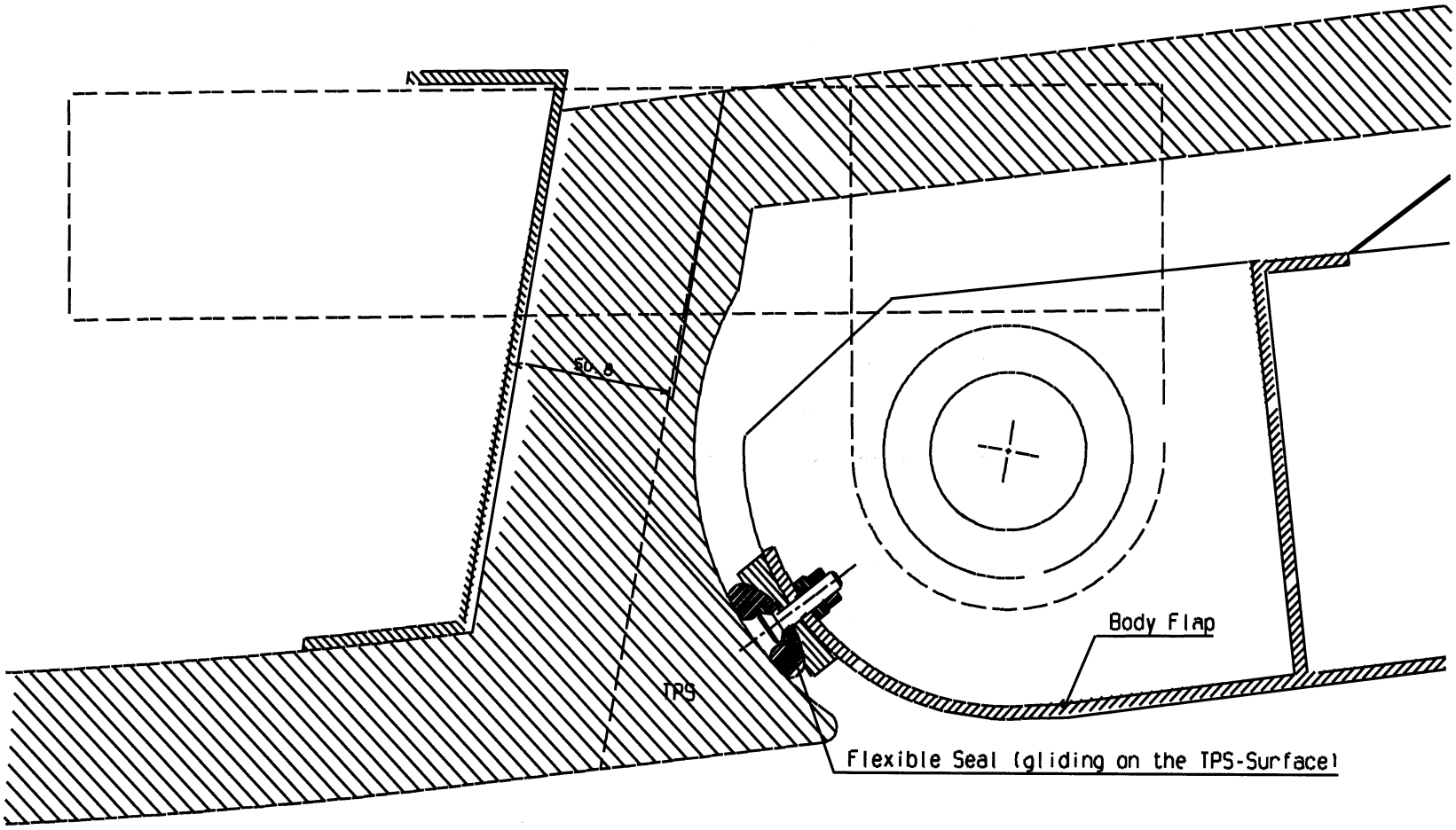
BF travel = 45°

- 30° during heating

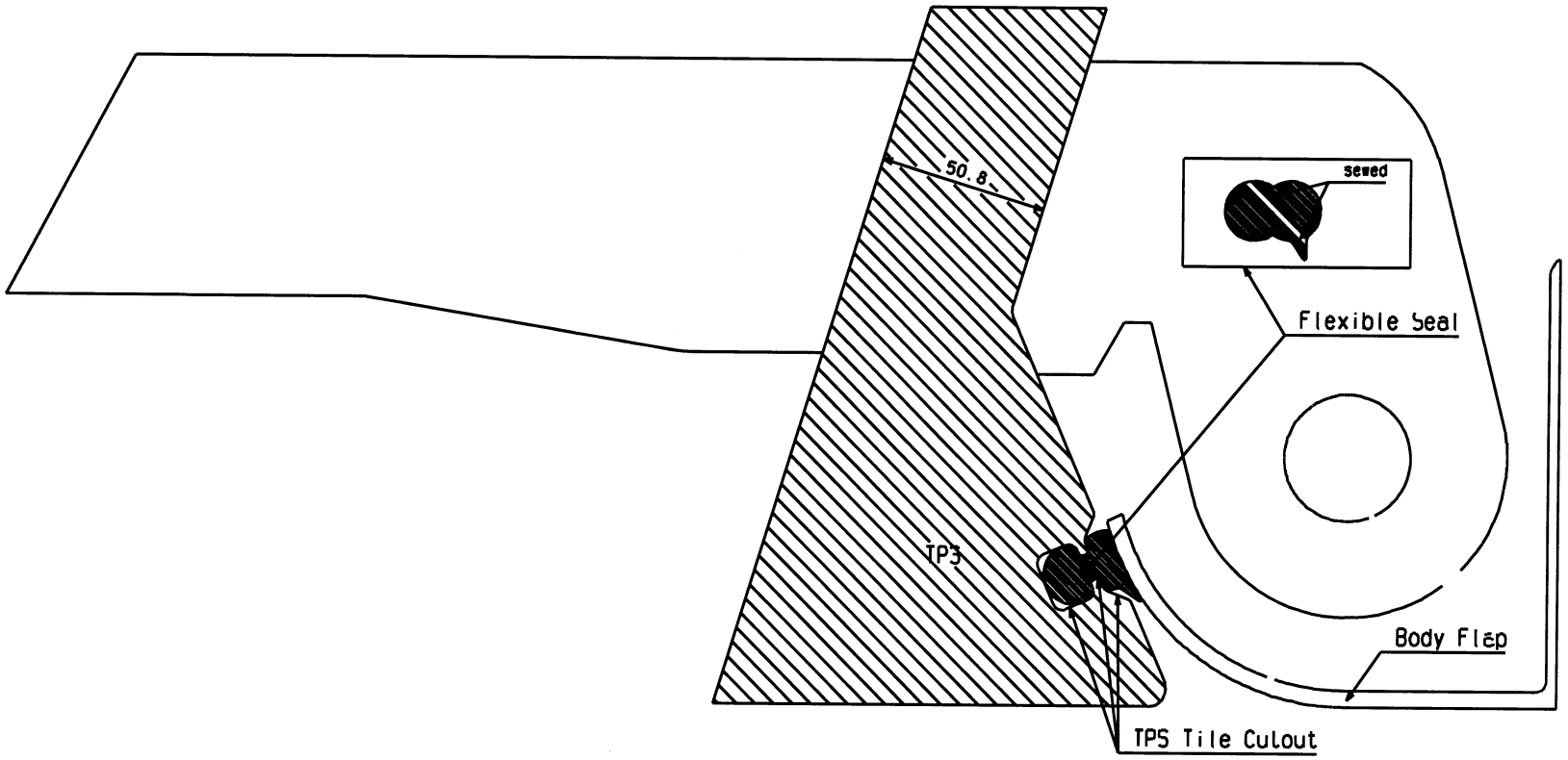
Temperatures ~ 2900° F

Delta Pressure ~ 150 psf (1.04 psi)

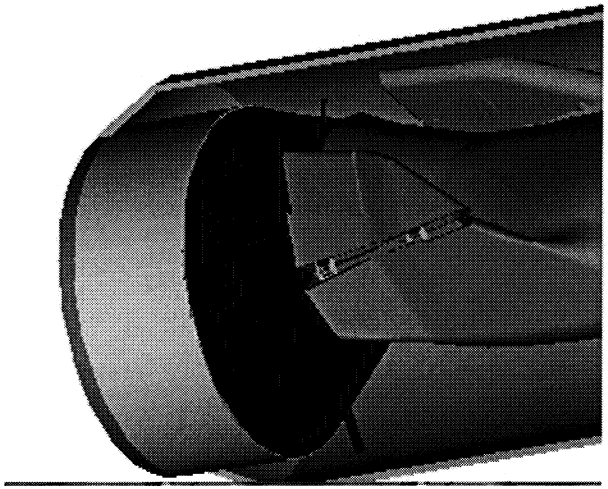
Body Flap Hingeline Seal Concept #2

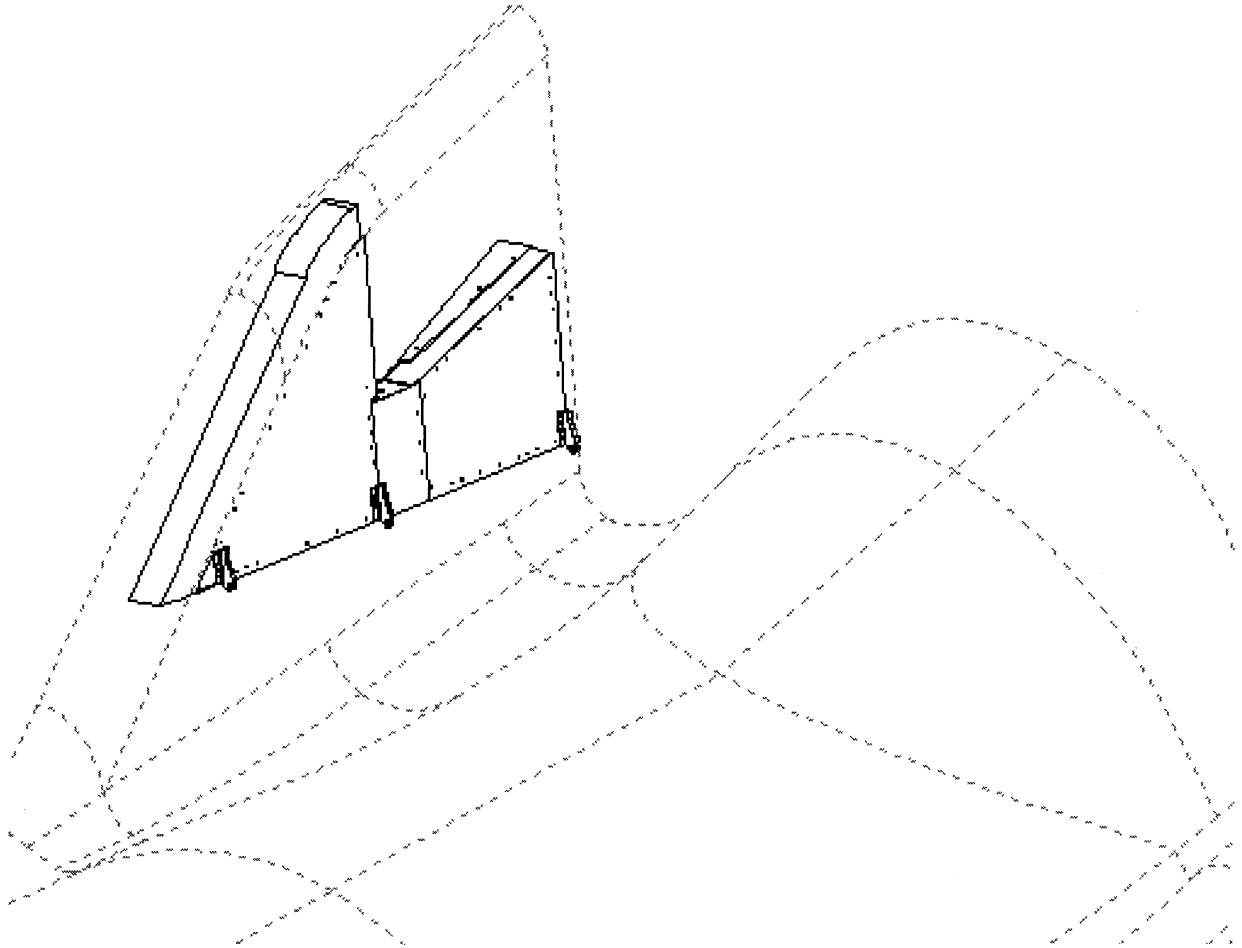


Body Flap Hingeline Seal Concept #3

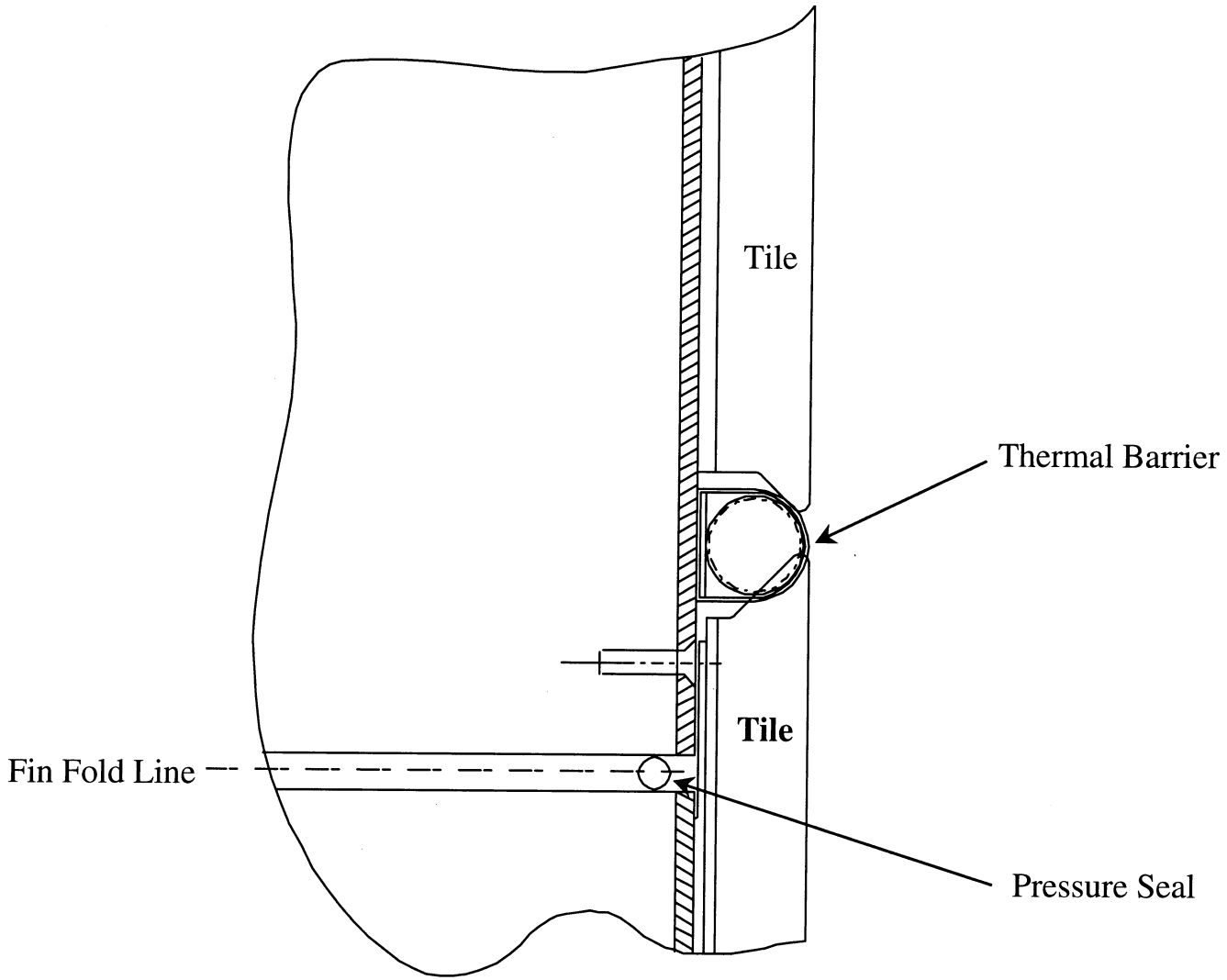


Folding Fin





Fin Fold line Seal



Rudders

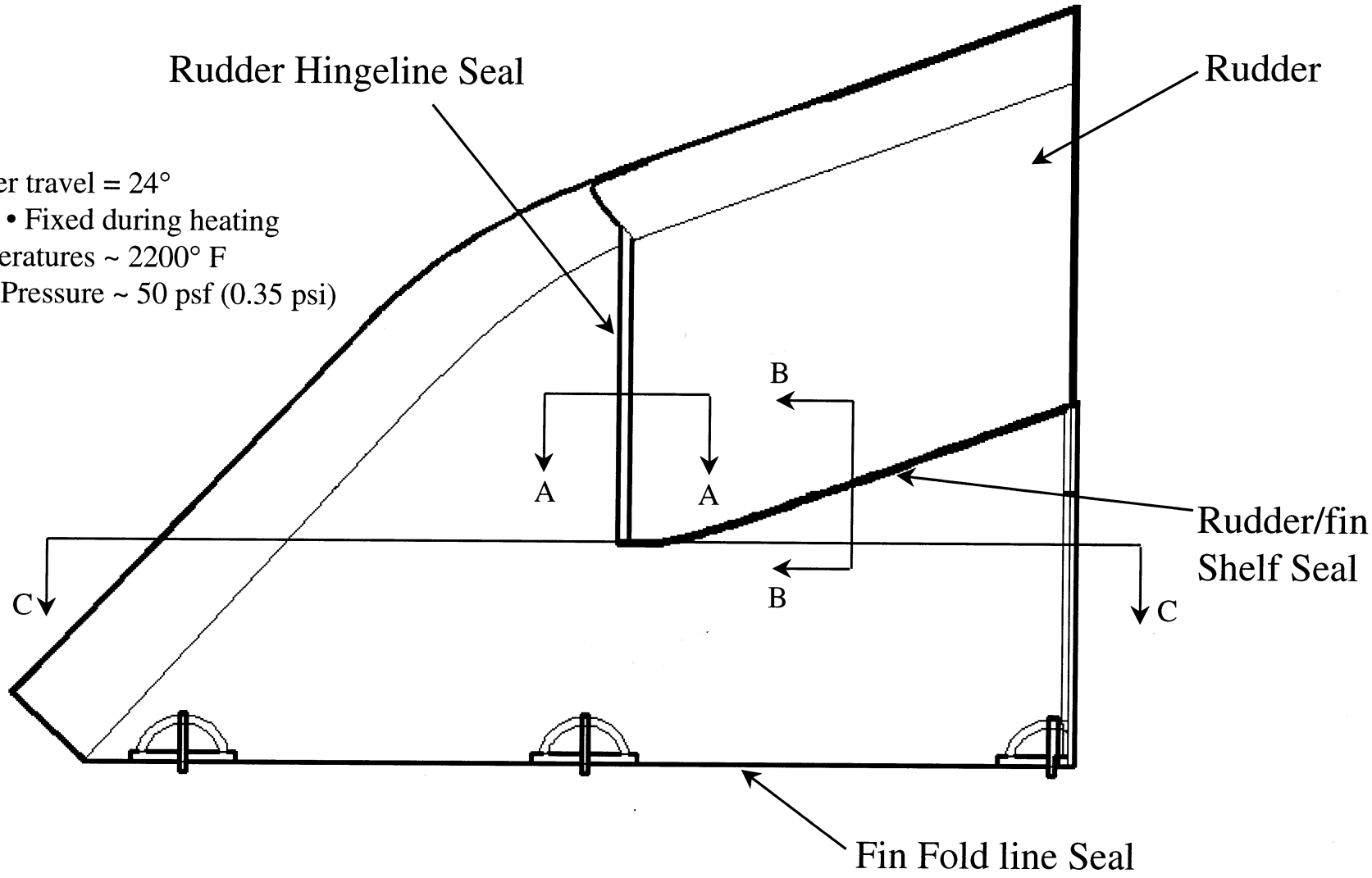
Hot metallic structure rudders

- Provided by Fokker Space
- High temperature nickel and iron based alloys
- Skin-stiffener structural system

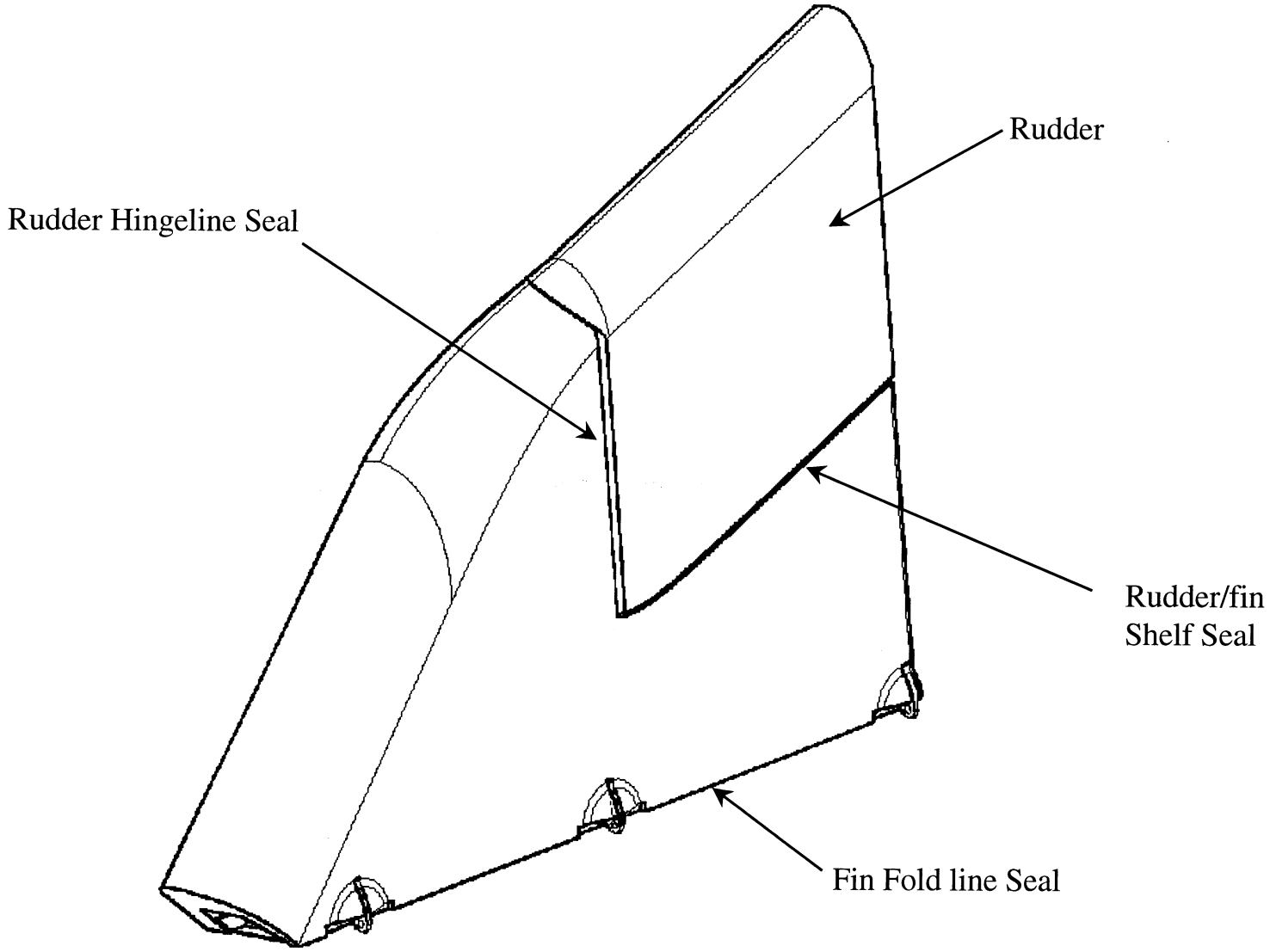
$\Rightarrow$ Hingeline seal

$\Rightarrow$ Rudder/fin shelf seal

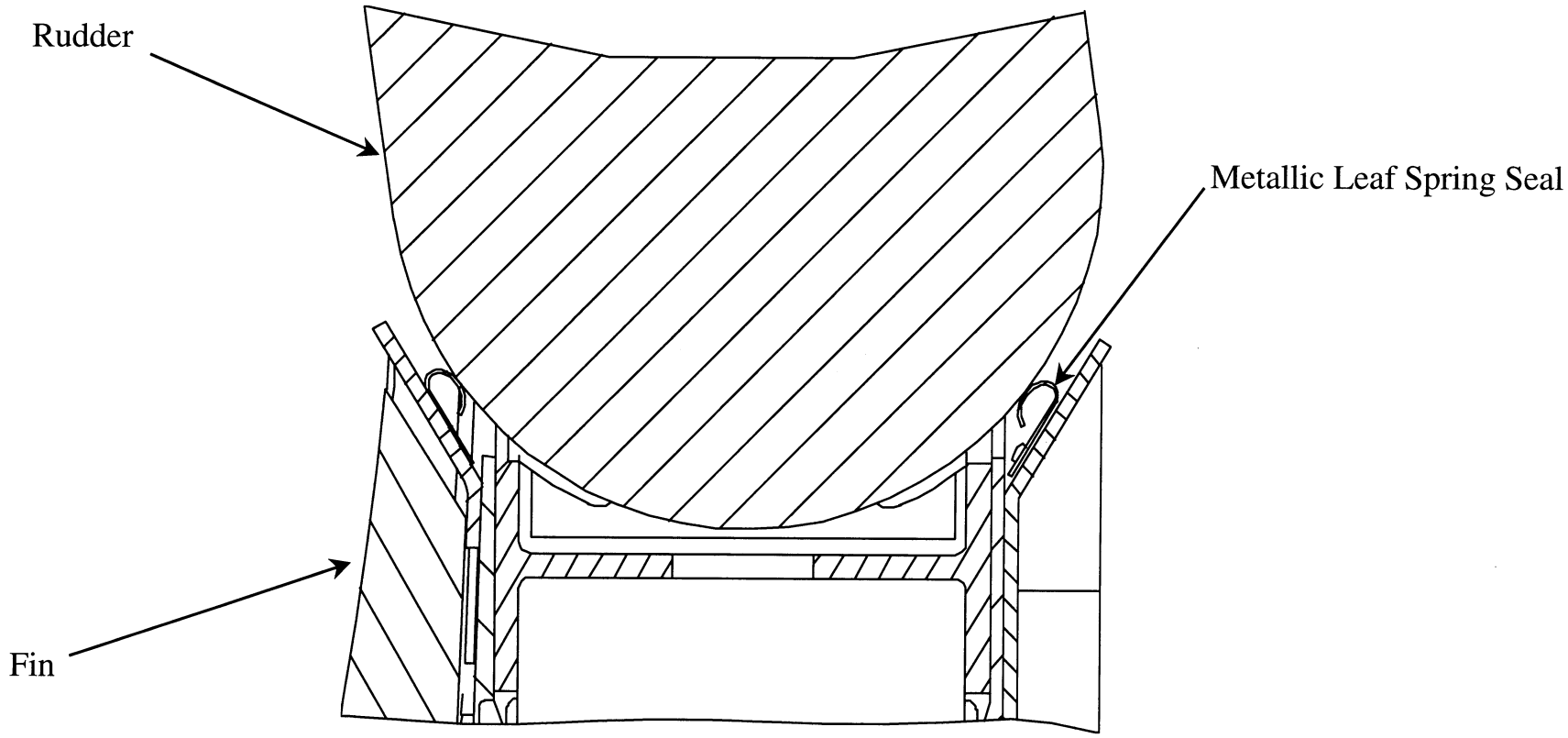
Fin & Rudder Seals



Fin & Rudder Seals

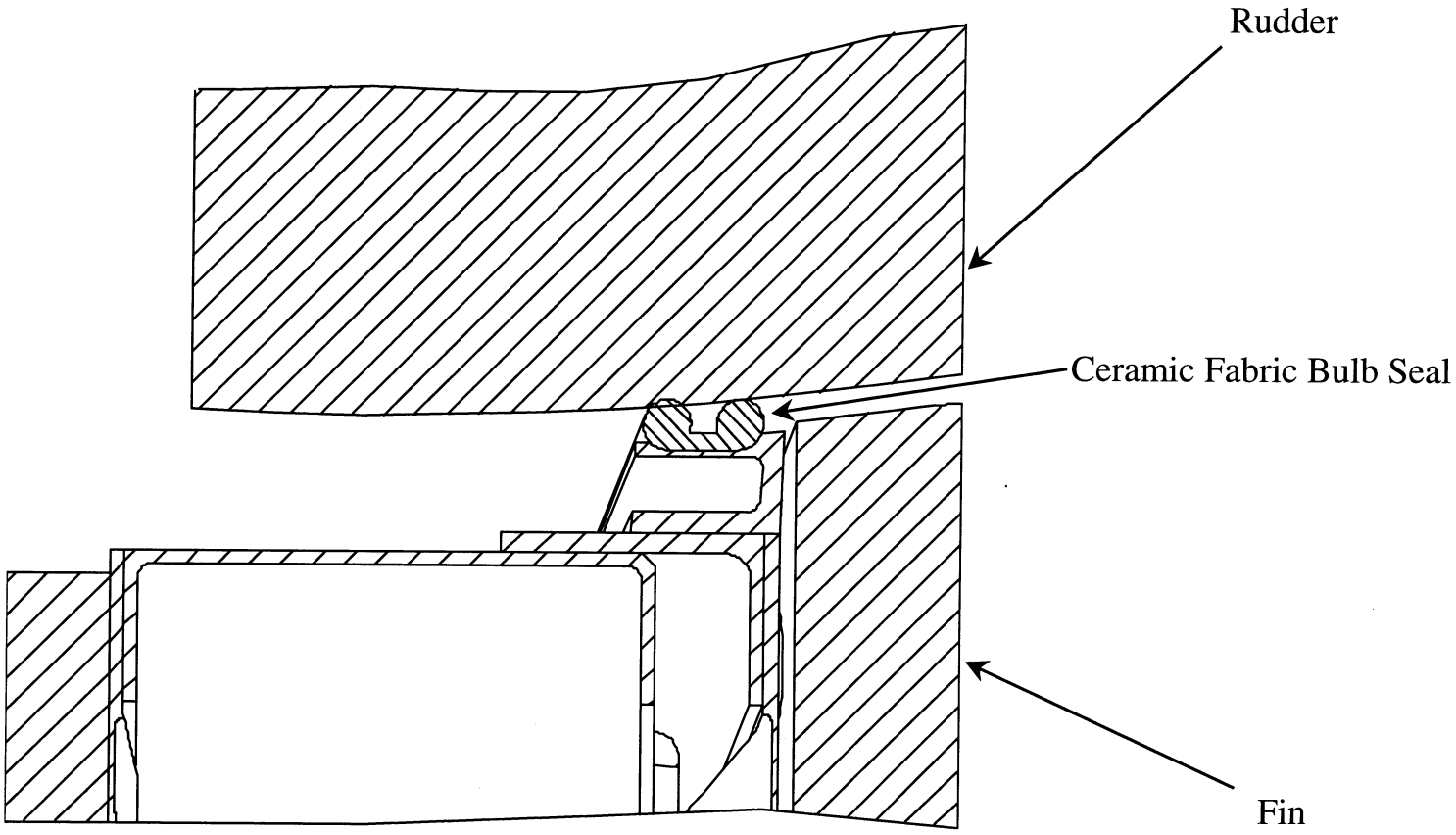


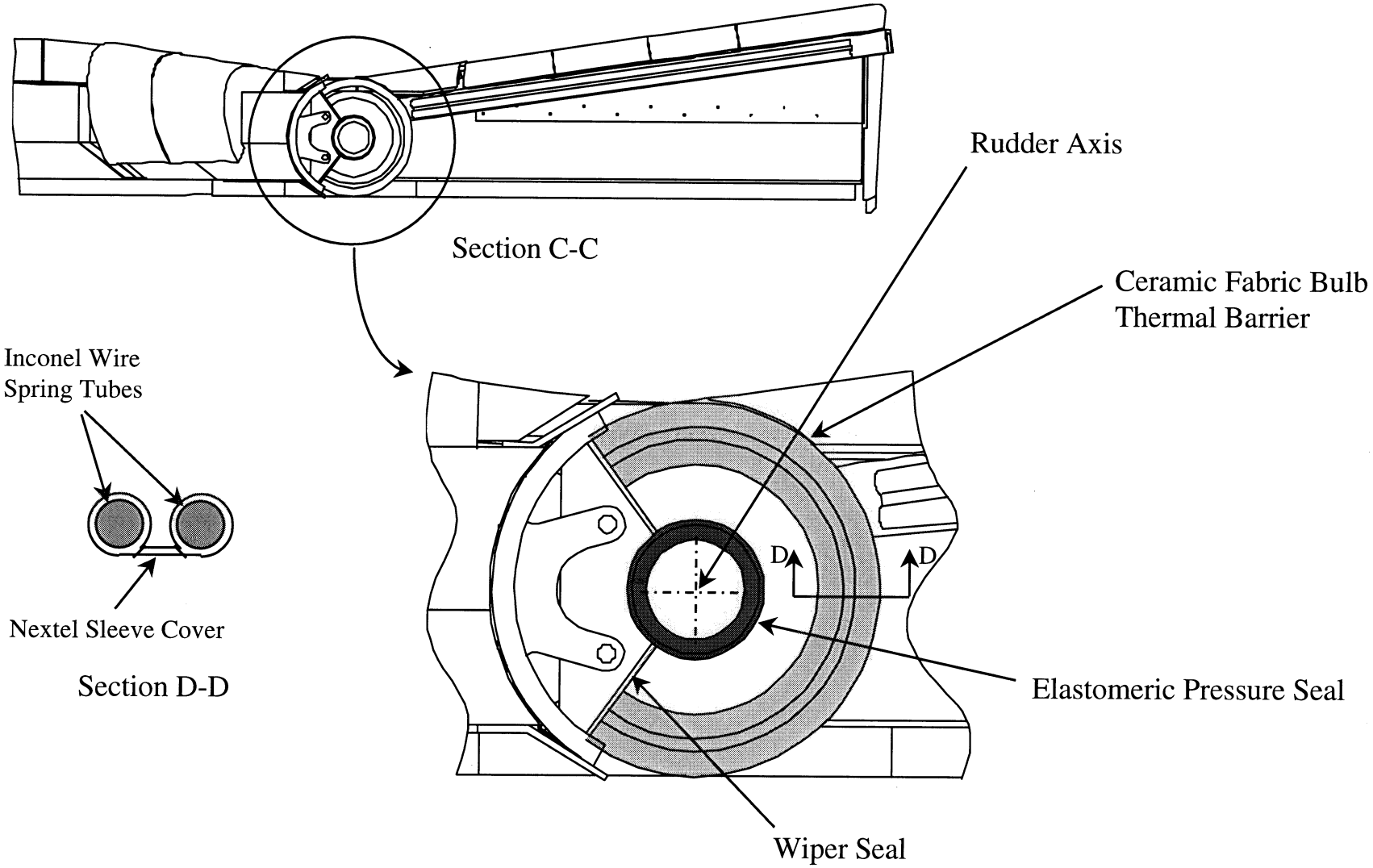
Rudder Hingeline Seal



Section A-A
(rot. 90 CCW)

Rudder/fin Shelf Seal



Section B-B

Rudder Base Rotary Seal