HSCT EXHAUST SYSTEM ANTICIPATED SEAL NEEDS

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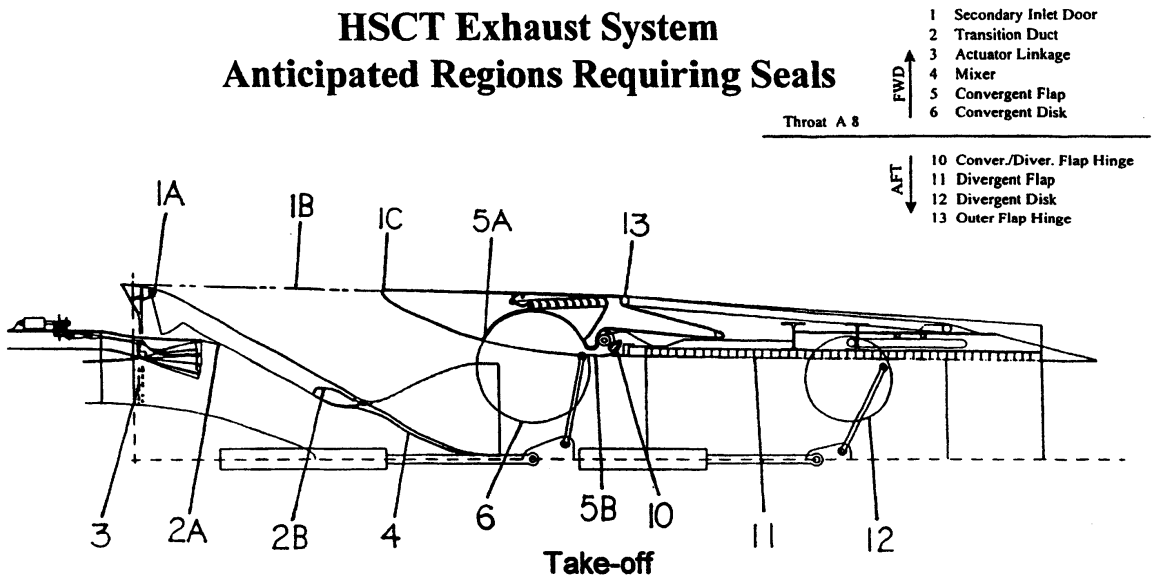


HSCT

HIGH SPEED CIVIL TRANSPORT

Chart 1 shows the HSCT Exhaust Nozzle in the Take Off or the Suppressed Position. In this position the Secondary Inlet Doors are open to allow secondary air to be entrained into the nozzle for cooling and noise suppression. The key sealing areas in this position are the Secondary Inlet Doors (against the Transition Duct Region 2A and the Tie Beam Region 2B) and the Convergent Flaps (against the Mid Frame Structure Region 5A and the Sidewall Acoustic Liners Region 5B).

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 2

HSCT Exhaust System
Anticipated Regions Requiring Seals

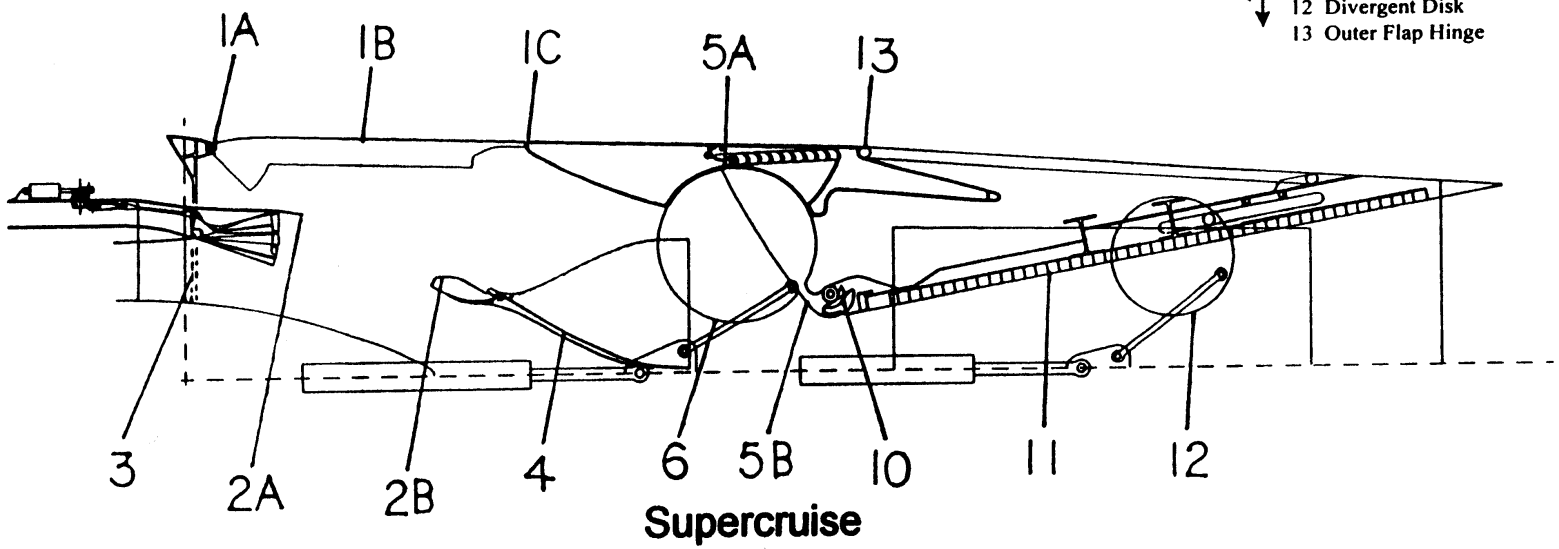
1 Secondary Inlet Door
2 Transition Duct
3 Actuator Linkage
4 Mixer
5 Convergent Flap
6 Convergent Disk

FWD

Throat A 8

AFT

10 Conver./Diver. Flap Hinge
11 Divergent Flap
12 Divergent Disk
13 Outer Flap Hinge



Supercruise

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Chart 2 shows the HSCT Exhaust Nozzle in the Supercruise Position. In this position the Secondary Inlet Doors are closed allowing no secondary air into the nozzle. The key sealing areas in this position are the Secondary Inlet Doors (against the Nozzle Outer Structure Regions 1A & 1B and Mid Frame Structure Region 1C) and the Convergent Flaps (against the Mid Frame Structure Region 5A and the Sidewall Acoustic Liners Region 5B).

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 3

HSCT Exhaust System
Anticipated Regions Requiring Seals

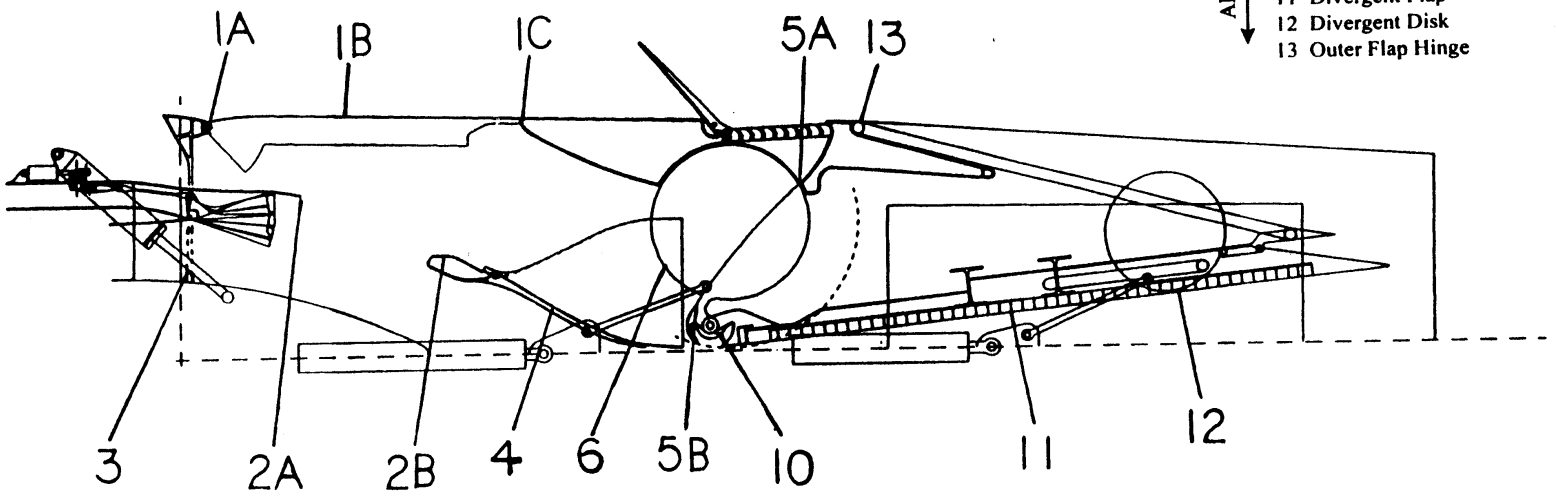
1 Secondary Inlet Door
2 Transition Duct
3 Actuator Linkage
4 Mixer
5 Convergent Flap
6 Convergent Disk

FWD

Throat A 8

AFT

10 Conver./Diver. Flap Hinge
11 Divergent Flap
12 Divergent Disk
13 Outer Flap Hinge



REVERSE

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HSCT

HIGH SPEED CIVIL TRANSPORT

Chart 3 shows the HSCT Exhaust Nozzle in the Reverse Position. In this position the Secondary Inlet Doors are closed and the Convergent Flaps closes off the main core stream directing the flow out the Reverser Cascades. The key sealing in this position is the Convergent Flaps (against the Mid Frame Structure Region 5A and the Sidewall Acoustic Liners Region 5B).

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 4

HSCT Exhaust System Seal Region Descriptions

Region	Priority: Performance	Priority: Safety	Interface Description	Possible Seal Types	Temperature	Pressure ΔP	Amount of Seal Motion-Max	Seal Length	Number of Corners
1A	A	C	Secondary Inlet Door/Hinge Interface	E - Seal or Fixed Leaf Seal	850 °F	35 Psi	.10"	71"	
1B	A	C	Secondary Inlet Door/Sidewall Interface	E-Seal, Fixed Leaf or Braided Ceramic Rope Seal	850 °F	35 Psi	.25"	50"	4Per Door/8Total
1C	A	C	Secondary Inlet Door/Midframe Interface	E-Seal, Fixed Leaf or Braided Ceramic Rope Seal	850 °F	35 Psi	.25"	71"	
2A	B	B	Secondary Inlet Door/Transition Duct Edge Interface- (Suppressed)	Fixed Leaf Seal or Braided Ceramic Rope Seal	1000 °F	35 Psi	.40"	104"	2 Per Door/4 Total
2B	A	C	Secondary Inlet Door/Mixer Tie Beam Interface	Fixed Leaf Seal or Braided Ceramic Rope Seal	1200 °F	30 Psi	.25"	71"	

eg. Seal Compression

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 5

HSCT Exhaust System Seal Region Descriptions

Region	Priority: Performance	Priority: Safety	Interface Description	Possible Seal Types	Temperature	Pressure ΔP	Amount of Seal Motion-Max	Seal Length	Number of Corners
3	B	B	Bulk Head/Secondary Inlet Door Actuator Linkage Interface	Metal Bellows or Viton Boot Seal	850 °F	35 Psi	.10"	3"	0
4	B	C	Mixer/Acoustic Sidewall Interface	Fixed or Floating Fishmouth Seal	1200 °F	30 Psi	.50"	36.6"	1 Per Mixer Side Wall/ 4 Total
5A	A	B	Conv. Flap/ Midframe Interface	Plunger Seal or Hinged Leaf Seal	1200 °F	30 Psi	.50"	71"	2 Per Conv. Flap/4 Total
5B	B	B	Conv. Flap/Acoustic Sidewall Interface	Hinged Leaf or Plunger Seal	1200 °F	30 Psi	.50"	3.5"	2 Per Conv. Flap Side/8 Total
6	A	A	Conv. Disk/ Sidewall Interface	C-Seal, Piston Ring or Brush Seal	1200 °F	30 Psi	.050"	85"	2 Per Conv. Flap Side/8 Total
10	A	B	Conv. Flap/Diver. Flap Hinge Interface	Fixed Leaf Seal	1200 °F	12 Psi	.050"	71"	2 Per Conv./Diver. Flap/4 Total

HSCT Exhaust System Seal Region Descriptions

Region	Priority: Performance	Priority: Safety	Interface Description	Possible Seal Types	Temperature	Pressure ΔP	Amount of Seal Motion-Max	Seal Length	Number of Corners
11	B	B	Diver. Flap/Acoustic Sidewall Interface	Hinged Leaf or Plunger Seal	1200 °F	12 Psi	.50"	116.6"	2 Per Diver. Flap/4 Total
12	B	A	Diver. Disk/Sidewall Interface	C-Seal, Piston Ring or Brush Seal	1200 °F	12 Psi	.050"	65"	0
13	C	C	Outer Flap Hinge/Midframe Interface	Fixed Leaf Seal	850 °F	2 Psi	.10"	71"	2 Per Outer Flap/4 Total

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HIGH SPEED CIVIL TRANSPORT

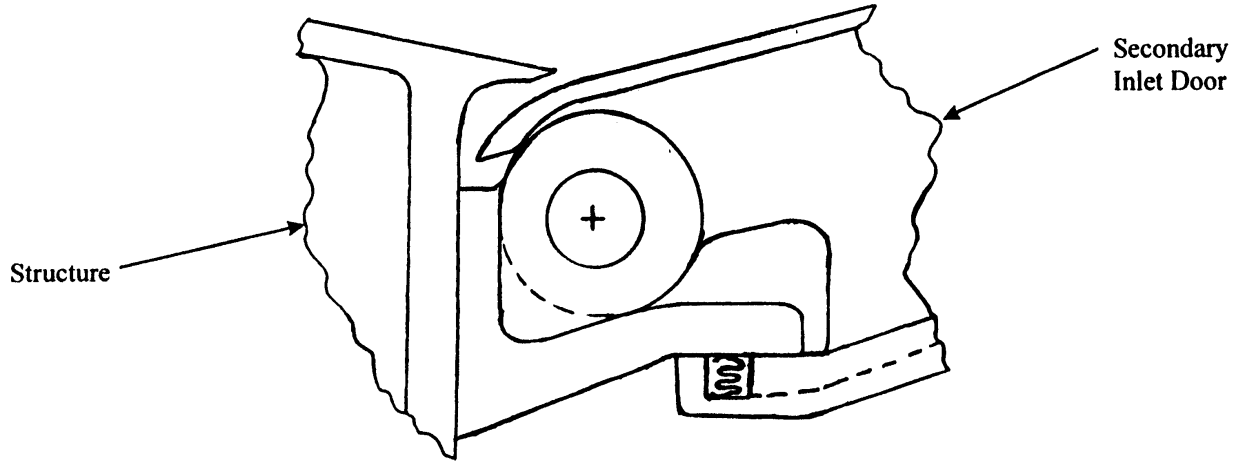
Charts 4, 5 & 6 describes the various HSCT Exhaust Nozzle sealing interfaces. The possible seal types are given for the different regions of the nozzle. The environmental conditions are given as to temperature, pressure, and amount of seal motion required. Priority is given on the amount of leakage, and how it affects performance and safety. An "A" priority would have a significant affect on performance or safety, and "C" would have a minimal affect.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 7

For Region 1A :

- E - Seal



- Seal Material: Inconel X-750
- Door Material: TiAl & Inconel 718
- Requires Ultra-High Flex E-Seal (Very Conformable)
- Access to Seal Difficult with Door Installed

- Installing Door Difficult
- In Secondary Flow Stream when in Suppressed Position
- Preferred Design

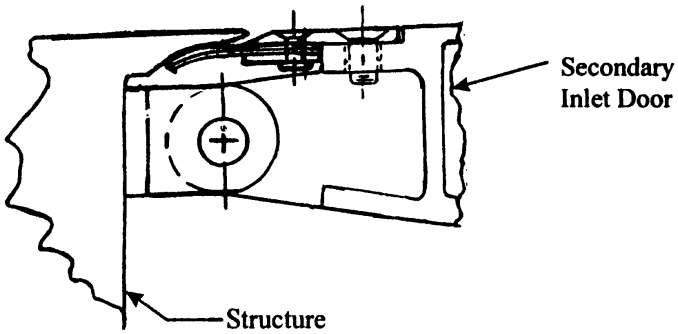
jan/Udrv/vacek_11.ppt

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 8

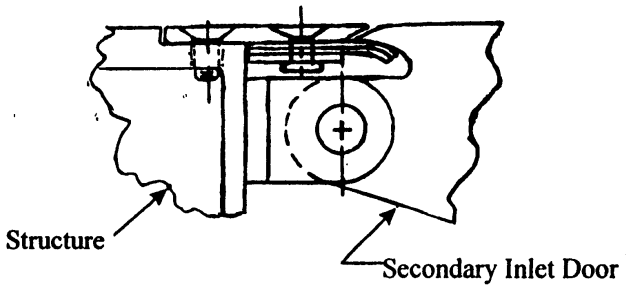
For Regions 1A & 13:

- Fixed Leaf Seal



- Seal Material: Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Seal Removable with Door Installed
- Gives Access to Door Hinge Lugs
- Preferred Design for Region 13

- Fixed Leaf Seal



- Seal Material: Inconel X-750
- Door Material: TiAl & Inconel 718
- Seal Removable from Support with Door Installed
- Gives Access to Door Hinge Lugs

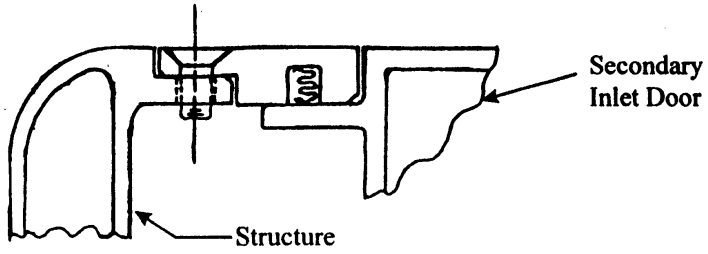
Charts 7 & 8 shows the cross sections of the hinge Region 1A between the Secondary Inlet Door and the Nozzle Structure. A similar hinge joint occurs between the Aft Outer Flap and the Mid Frame Structure Region 13. The seals are shown removable for easy replacement if damaged, and easy installation of the large Secondary Inlet Door except if the E-seal Configuration is selected along the Secondary Inlet Door hinge line.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 9

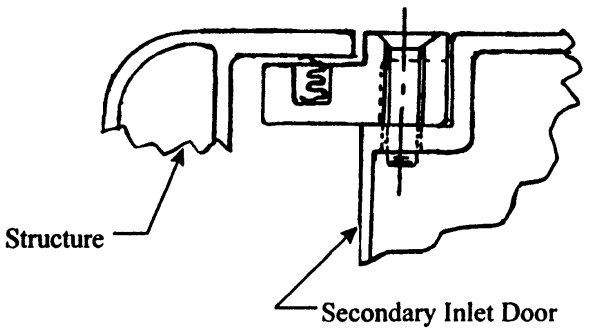
For Region 1B:

- E - Seal



- Seal Material: Inconel X-750
- Door Material: TiAl & Inconel 718
- Requires Ultra-High Flex E-Seal (Very Conformable)
- Seal Removable with Door Installed
- Not in Secondary Flow Stream when in Suppressed Position
- Preferred Design

- E - Seal



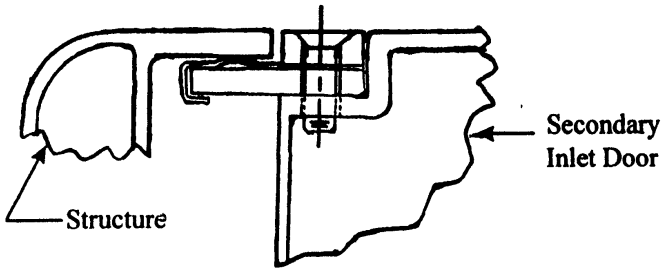
- Seal Material: Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Requires Ultra-High Flex E-Seal (Very Conformable)
- Seal Removable with Door Installed
- In Secondary Flow Stream when in Suppressed Position

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 10

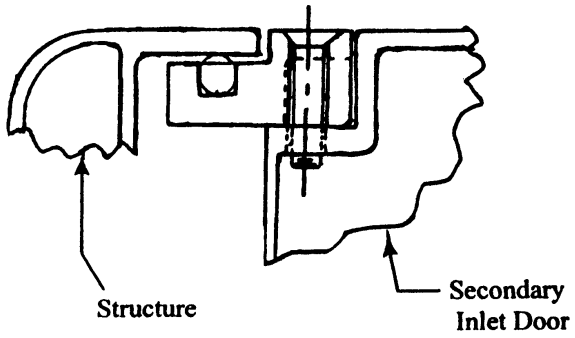
For Region 1B:

- Fixed Leaf Seal



- Seal Material: Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Seal Removable with Door Installed
- In Secondary Flow Stream When in Suppressed Position
- Less Conforming Seal

- Braided Ceramic Rope Seal



- Seal Material: Ceramic & Haynes 188 Sheath
- Structure Material: Ti 6242/Adv. Ti
- Seal Removable With Door Installed
- Reduced Flexibility
- In Secondary Flow Stream when in Suppressed Position

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Charts 9 & 10 shows the cross sections of the interface between the Secondary Inlet Door Region 1B and the Nozzle Sidewall Structure. The Seals are shown removable for easy replacement if damaged, and easy installation of the large Secondary Inlet Door.

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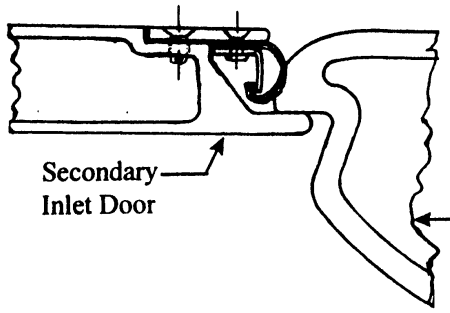
HIGH SPEED CIVIL TRANSPORT CHART 11

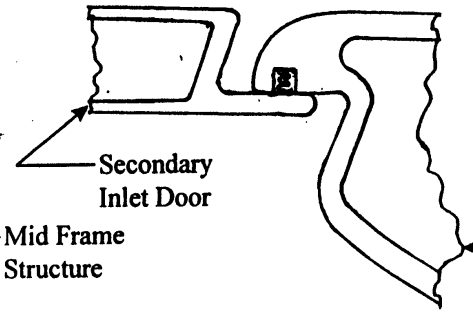
For Region 1C:

- Fixed Leaf Seal



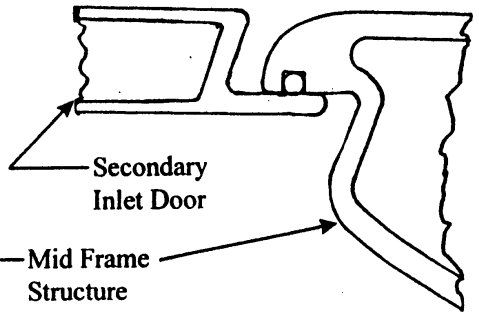
- Seal Material: Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Seal Removable with Door Installed
- Less Conforming Seal
- Requires Less Overlap with Mid-Frame Structure
- Aero Concerns due to Notch in Mid-Frame Nose

- E - Seal



- Seal Material: Inconel X-750
- Door Material: TiAl & Inconel 718
- Seal less Accessible for seal removal
- Requires Large Overlap with Mid-Frame Structure
- Aero Concerns Due to Notch in Mid-Frame Nose
- Seal Very Conformable
- Preferred Design

- Braided Ceramic Rope Seal



- Seal Material: Ceramic & Haynes 188 Sheath
- Door Material: TiAl & Inconel 718
- Seal Less Accessible for Seal Removal
- Requires Large Overlap with Mid-Frame Structure
- Aero Concerns Due to Notch in Mid-Frame Nose
- Reduced Flexibility

jan/Udrv/vacek_6.ppt

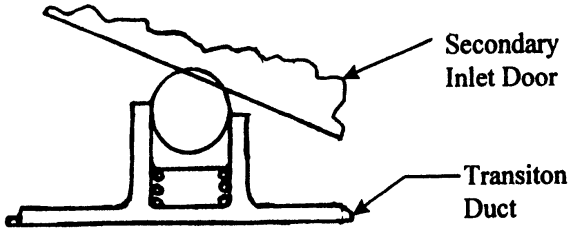
Chart 11 shows the cross sections of the interface between the Secondary Inlet Door Region 1C and the nose of the Mid Frame Structure. In order to get a good seal between the Secondary Inlet Door and the Mid Frame nose requires an overlap. This requires a notch in the nose of the Mid Frame Structure giving aerodynamic flow concerns, when the Secondary Inlet Door is open in the Suppressed or Take Off position.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 12

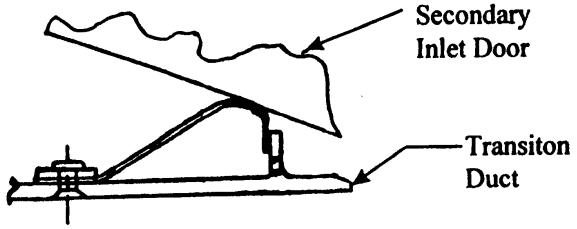
For Region 2A:

- Braided Ceramic Rope Seal



- Seal Material: Braided Ceramic and Haynes 188 Sheath
- Door Material: Ti 6242/Adv. Ti & Inconel 718
- Spring Loaded for large Seal Motion
- Preferred Design

- Fixed Leaf Seal



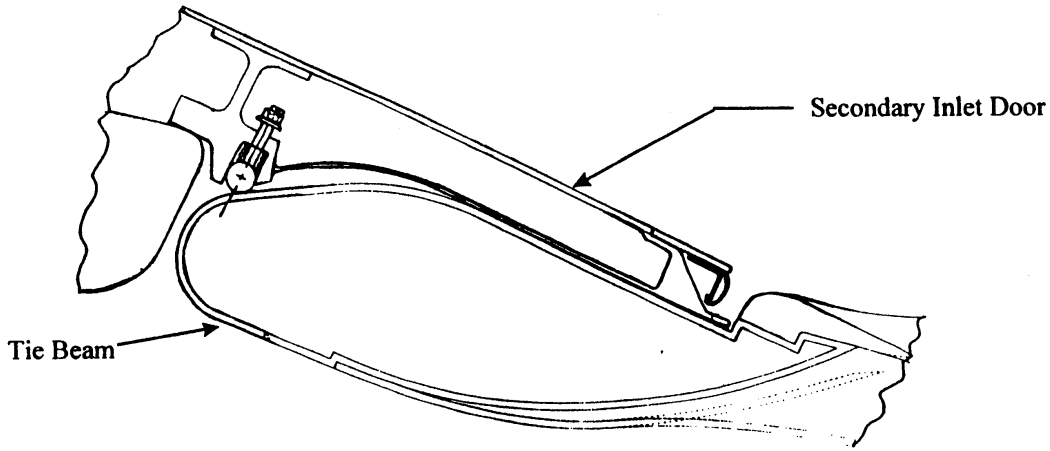
- Seal Material: Inconel X-750
- Door Material: Ti 6242/Adv. Ti & Inconel 718

jan/Udrv/vacek_9.ppt

Chart 12 shows the cross sections of the interface between the Secondary Inlet Door Region 2A and the Transition Duct in the Suppressed or Take Off position. The Seals are shown on the outside of the Transition Duct for easy replacement if damaged.

For Region 2B:

- Braided Ceramic Rope Seam



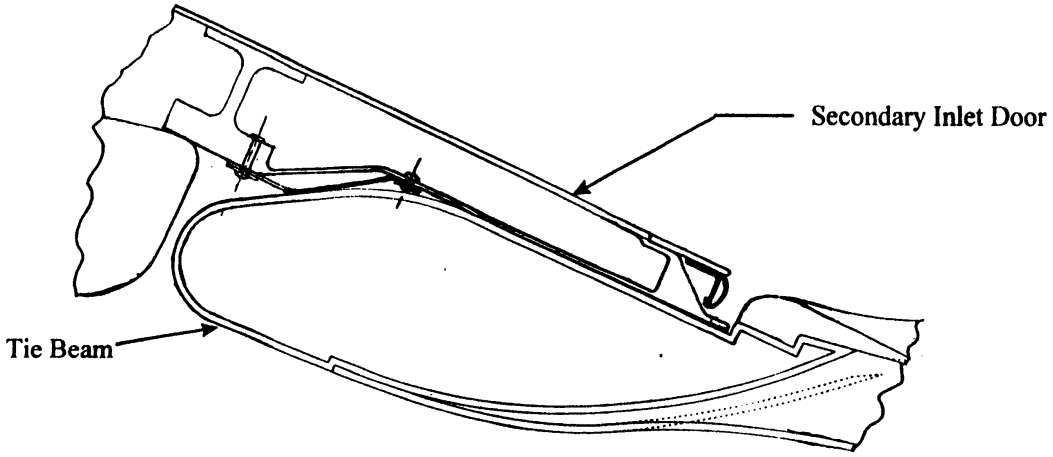
- Seal Material: Braided Ceramic and Haynes 188 Sheath
- Tie Beam Material: R108
- Spring Loaded for Large Seal Motion
- Preferred Design

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 14

For Region 2B:

- Fixed Leaf Seal



- Seal Material: Inconel X-750
- Tie Beam Material: R108
- Less Seal Motion Capability

jan/Udrv/vacek_14.ppt

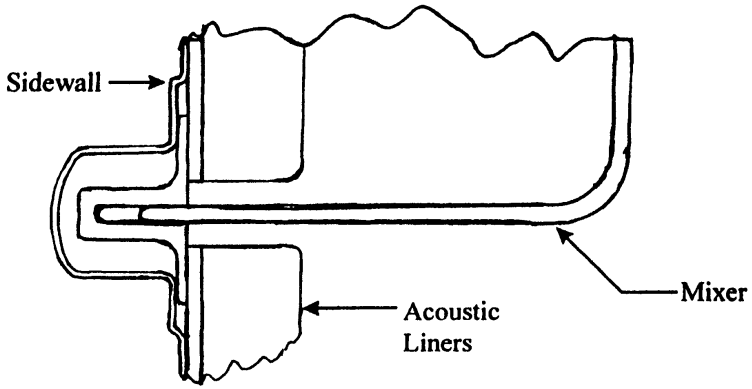
Charts 13 & 14 shows the cross sections of the interface between the Secondary Inlet Door Region 2B and the Tie Beam in the Suppressed or Take Off position. The Seals are shown on the inside of the Secondary Inlet Door. Door must be removed from assembly to replace seal.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 15

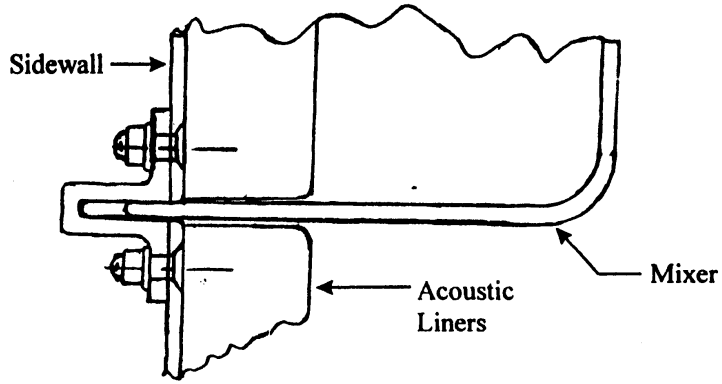
For Region 4:

- Floating Fishmouth Seal



- Fishmouth Material: Inconel 718
- Mixer Material: R108
- Allows Thermal Freedom in all Directions
- Preferred Design

- Fixed Fishmouth Seal



- Fishmough Material: Inconel 718
- Mixer Material: R108
- Allows Less Thermal Freedom

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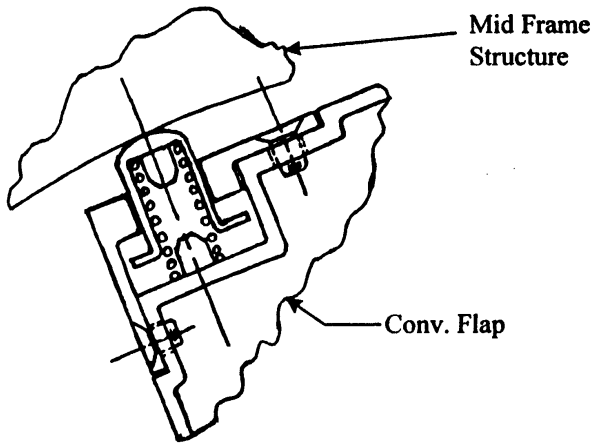
Chart 15 shows the cross sections of the interface between the Mixer Chute Region 4 and the Sidewall Acoustic Liners. The Fishmouth Seal could be interrogated with the Acoustic Liners or be behind the liners.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 16

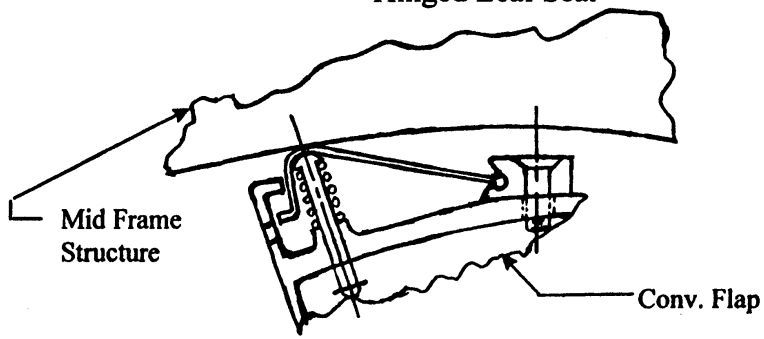
For Region 5A:

- Plunger Seal



- Seal Material: Inconel 718, Spring-Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Requires Minimal Envelope
- Preferred Design

- Hinged Leaf Seal



- Seal Material: Inconel 718, Spring-Inconel X-750
- Structure Material: Ti 6242/Adv. Ti
- Requires large envelope

jan/Udrv/vacek_15.ppt

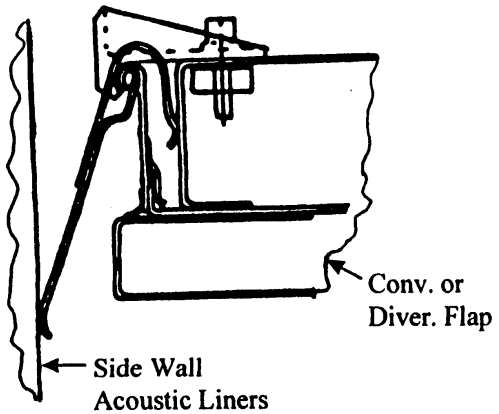
Chart 16 shows the cross sections of the interface between the Convergent flap Region 5A and the Mid Frame Structure. The seal is on the leading edge of the Convergent Flap, and must be as close as possible to the flow path surface due to the limited space for sealing on the Mid Frame Structure.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 17

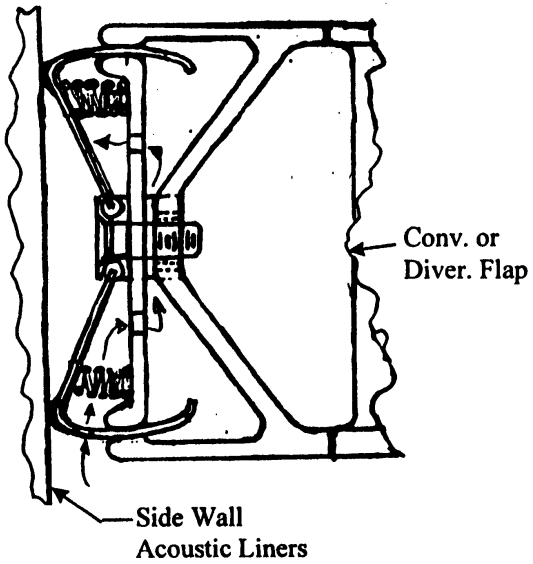
For Regions 5B & 11:

- Hinged Leaf Seal



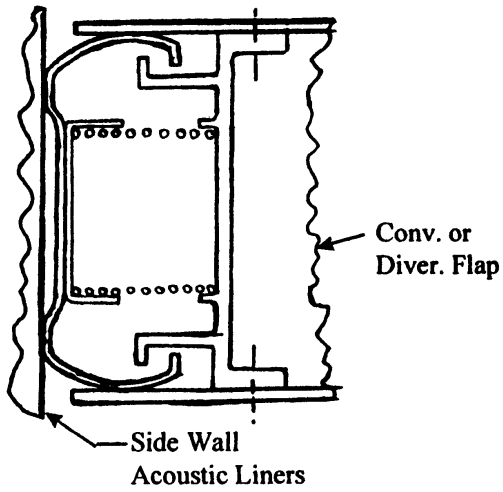
- Seal Material: Inconel X-718
- Conv. Flap Material: Inconel 718
- Diver. Flap Material: TiAl
- Single Sealing Contact
- Simple Design
- Preferred Design

- Hinged Leaf Seal



- Seal Material: Inconel X-718
- Conv. Flap Material: Inconel 718
- Diver. Flap Material: TiAl
- Double Sealing Contact an Advantage with the Acoustic Holes in Sidwall

- Plunger Seal



- Seal Material: Inconel 718
- Conv. Flap Material: Inconel 718
- Diver. Flap Material: TiAl
- Double Sealing Contact an Advantage with the Acoustic Holes in Sidewall

jan/Udrv/vacek_7.ppt

Charts 17 shows the cross sections of the interface between the Convergent Flap Region 5B or the Divergent Flap Region 11 and the Sidewall Acoustic Liners. A wide Plunger seal maybe required to discourage flow past the seal through the holes in the surface of the Acousic Liners.

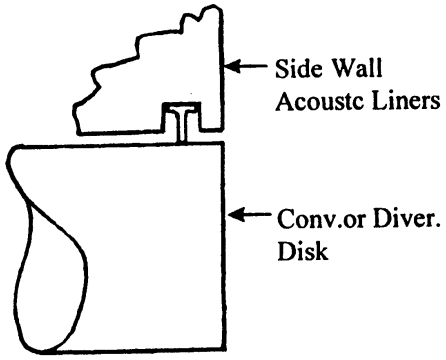
HSCT

HIGH SPEED CIVIL TRANSPORT

CHART 18

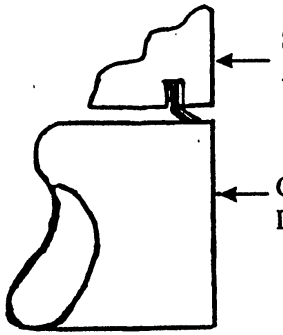
For Regions 6 & 12:

- Piston Ring Seal



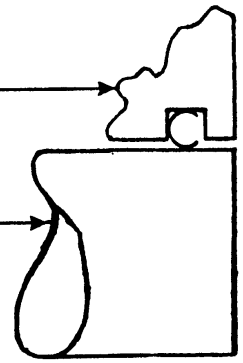
- Seal Material: Inconel X-718
- Sidewall: TiAl
- Preferred Design

- Brush Seal



- Seal Material: Inconel X-718 or Waspaloy Bristles
- Sidewall: TiAl
  Rotation in Two Directions May
- Fatigue Bristles

- C - Seal



- Seal Material: Inconel X-750
- Sidewall: TiAl
- Overlap at Split Difficult to Produce

jan/Udrv/vacek_8.ppt

HSCT

HIGH SPEED CIVIL TRANSPORT

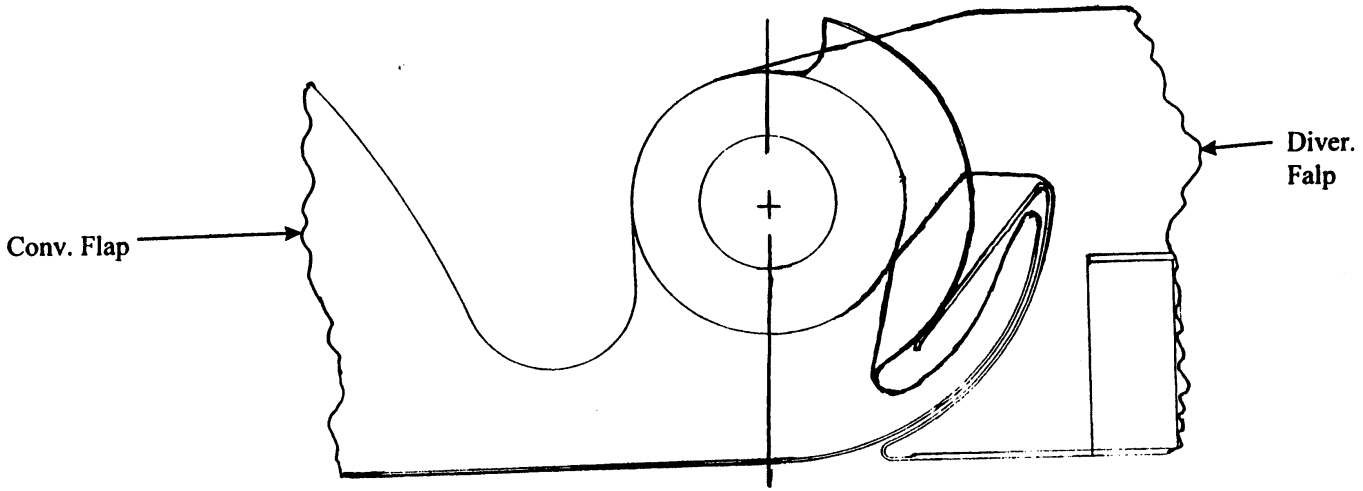
Chart 18 shows the cross sections of the interface between the Convergent Flap Disk Region 6 or the Divergent Flap Disk Region 12 and the Sidewall Acoustic Liners. The seal needs to be as close as possible to the outside surface of the Acoustic Liners to minimize the leakage past the outside ends of the Convergent and Divergent Flaps.

HSCT

HIGH SPEED CIVIL TRANSPORT CHART 19

For Region 10:

- Fixed Leaf Seal



- Seal Material: Inconel X-750
- Conv. Flap Material: Inconel 718
- Diver. Flap Material: TiAl

jan/Udrv/vacek_12.ppt

Chart 19 shows the cross sections of the interface between the Convergent Flap Hinge Region 10 and the Divergent Flap. An outside radius of 4.0" is required per Aero for the Convergent Flap hinge (Throat A_8). The seal is shown on a smaller radius to minimize the space required for the seal allowing more area for the Acoustic Liners on the Divergent Flap.