

GE LOW HYSTERESIS BRUSH SEAL

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Propulsion Technology Transfer Workshop**

Area of Interest #8 - Seals / Secondary Air Delivery

“Low Hysteresis Brush Seal”

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Low Hysteresis Brush Seal

- **Goal**
- **Description**
- **Subscale Verification Test for Seal Selection**
- **GE90 Engine Demo Results**
- **Conclusion**

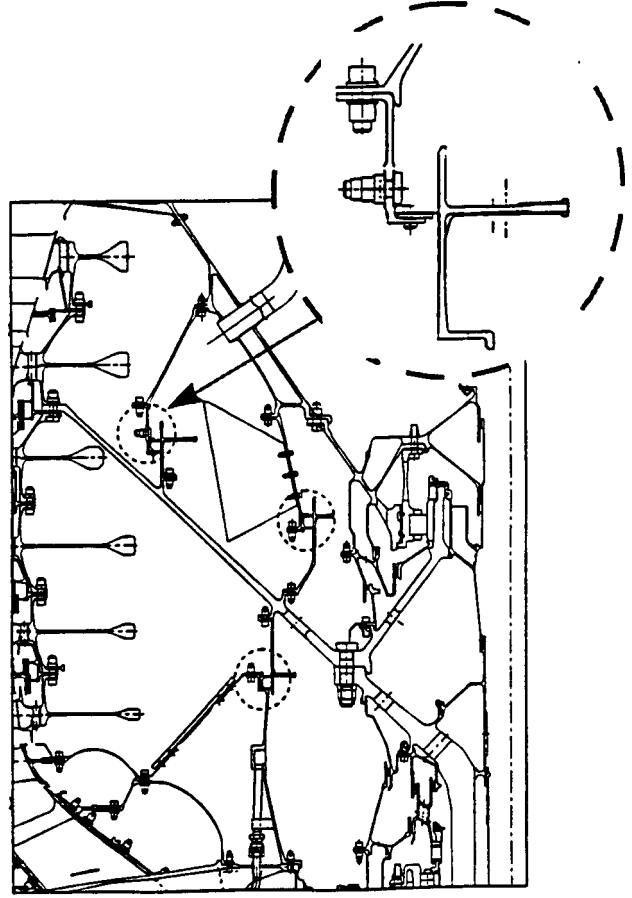
Goal

- **Develop a Single Stage 36-inch Diameter Low Hysteresis Brush Seal and Demonstrate in the GE90 Engine**
 - **Lower Leakage and Better Sealing Retention than the Current GE90 Seal (Goal: 2.6 lb/sec \geq 30% Leakage Reduction @ Worn Seal Condition)**
 - **Relieve Seal Hysteresis at Cruise or Lower Power Setting**

Seal Design Condition

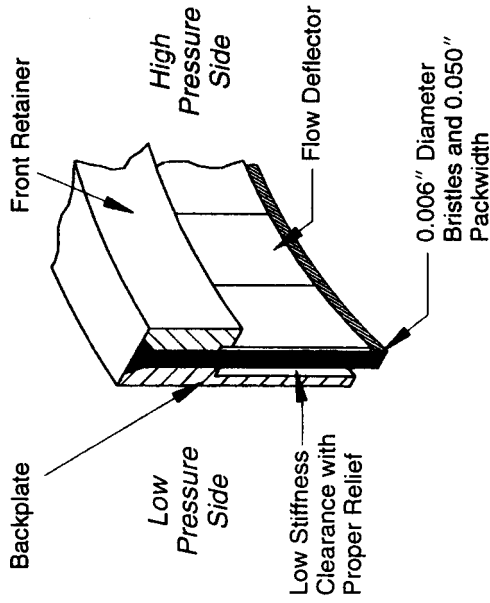
- Seal Diameter = 36.332 inches
- Nominal Operating Condition

	@ T/O	@ Cruise
Supply Air Temp, °F	700	608
Cavity Supply Pressure, psia	120	32
Cavity Exit Pressure, psia	20	6.1
Rotor Speed, rpm	2400	2254

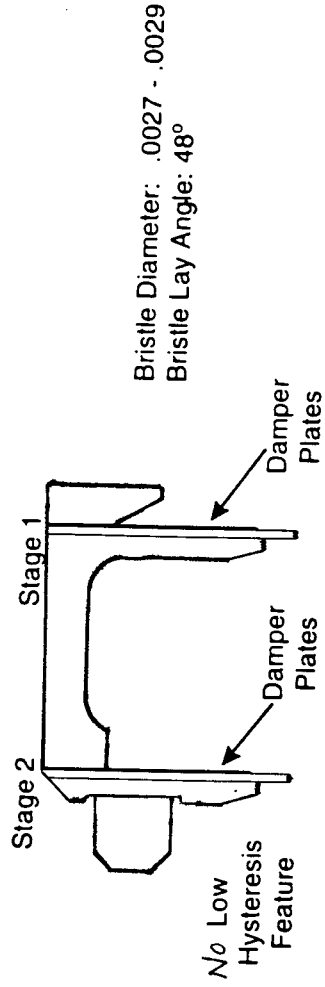


LH Brush Seal

LH Brush Seal Design Features



Current Two Stage Aft Outer Brush Seal



Subscale Verification Tests

- Five Seals Designed and Tested for Final Seal Selection

Feature	Design #1	Design #2	Design #3	Design #4	Design #5
Inner Diameter	8.64"	8.64"	8.64"	8.60"	8.60"
Design Bristle Angle	50°	50°	45°	50°	45°
Actual Bristle Angle	53°	49°	43°	47°	44°
Stiffness, psi/mil	0.72	0.67	1.08	0.80	0.99
Fence Height	0.075"	0.075"	0.075"	0.095"	0.095"

- Verification Tests Consisted of:
 - Bristle Closure
 - High Radial Interference
 - High Radial Offset
 - Cyclic Endurance

Design #2 Was Chosen For GE90 Demo

Engine Test Sequence

- **PHASE I: New 36-inch Single Stage Low Hysteresis Brush Seal Plus used 20-inch Two-stage Brush Seal at the Beginning of Test Program.**

**Test Sequence: Break in → 50 LCF Cycles → One HCF Cycle*
→ 475 LCF Cycles → Test Completed
(TRT: 244 hrs)**

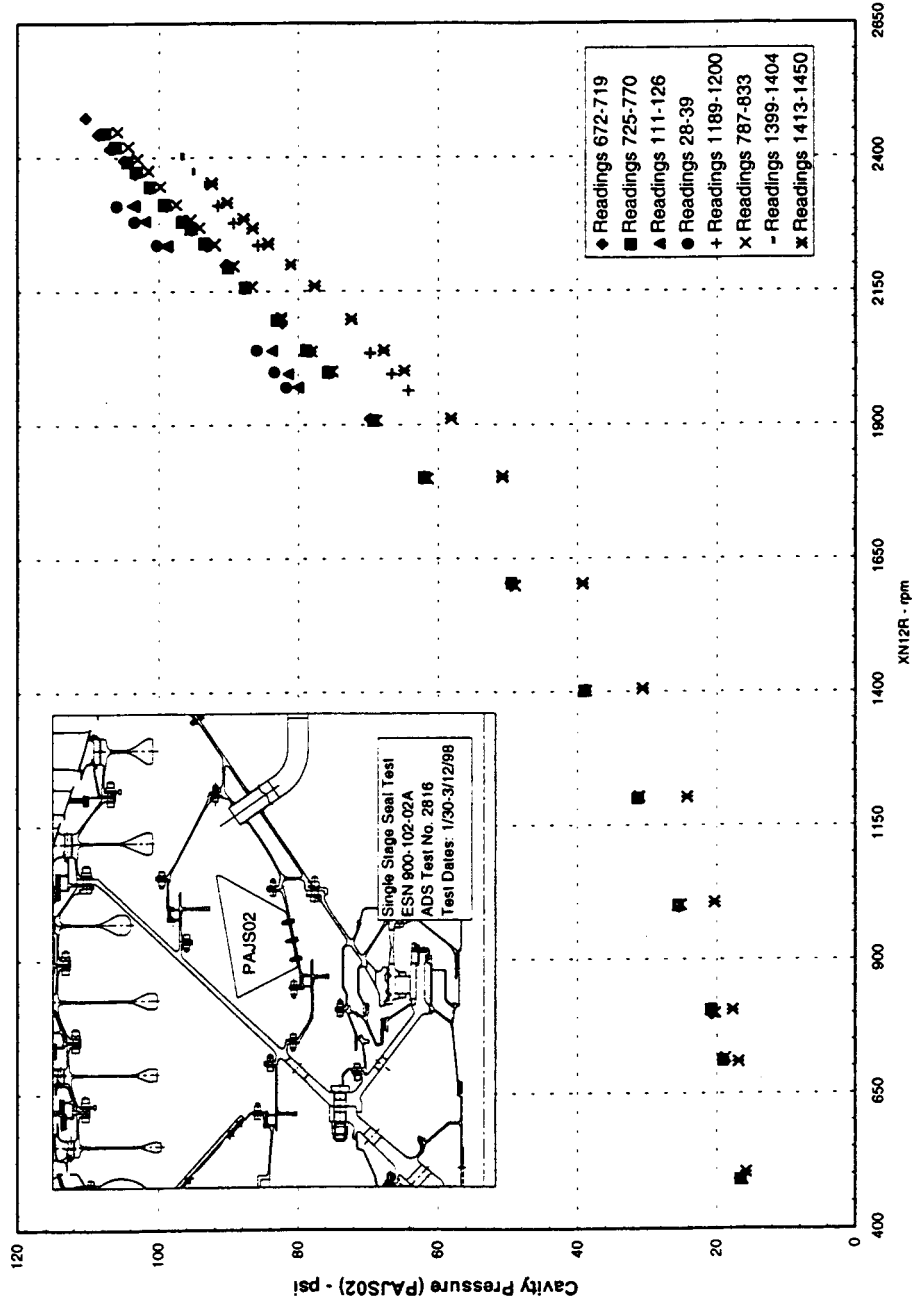
- **PHASE II: Used 36-inch Single Stage Low Hysteresis Brush Seal from Phase I + New 20-inch Two-stage Brush Seal at the Beginning of Test Program.**

**Test Sequence: Ran Additional 774 LCF Cycles
(TRT: 141 hours)**

- * **(92 hours Running Time at Large Fan and Core Unbalance; Max 36-inch Seal/Rotor Closure = 15 Mils)**

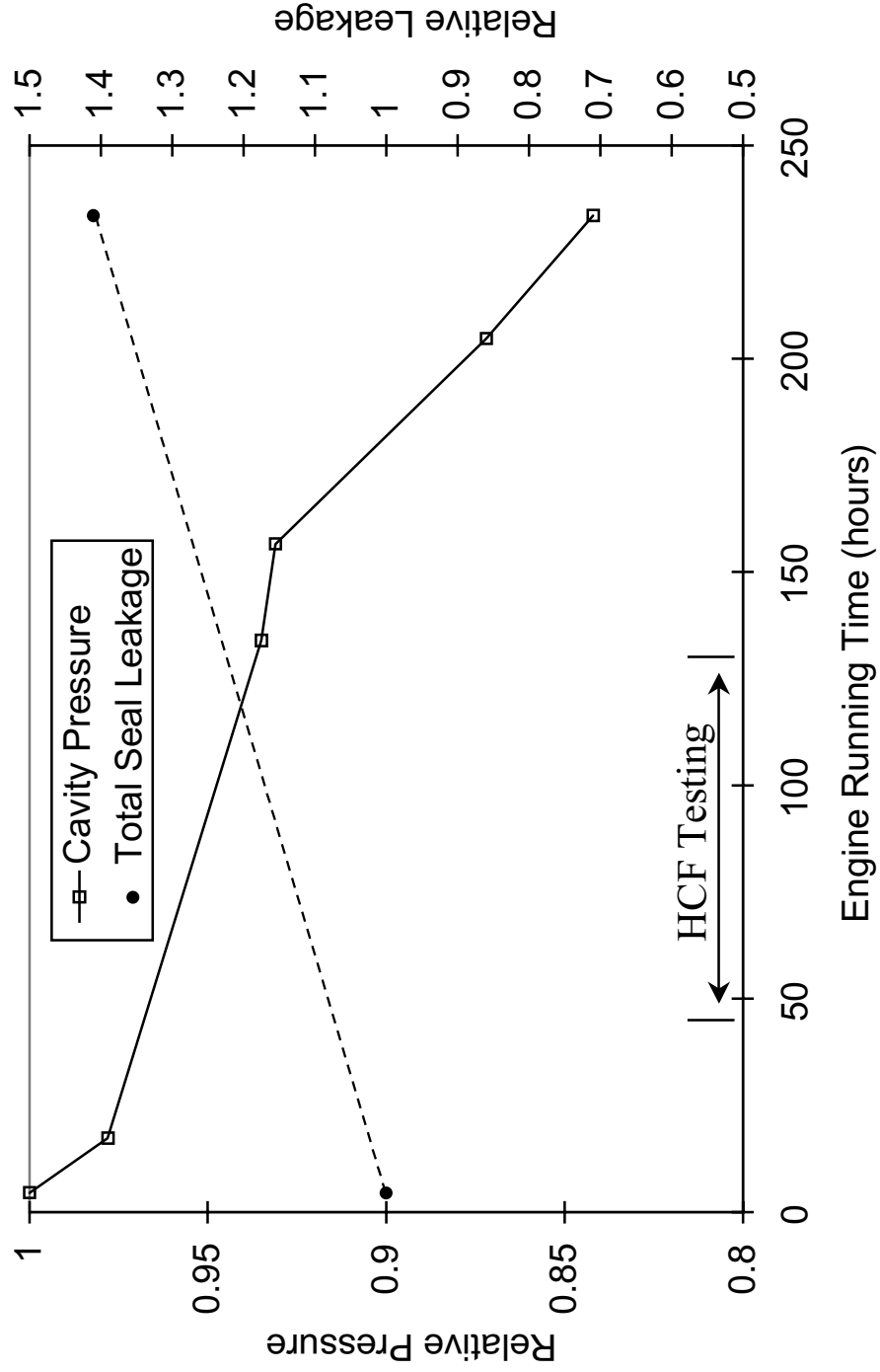
AST Single-Stage Brush Seal Test Results

Thrust Balance Cavity Pressure for Power Cals

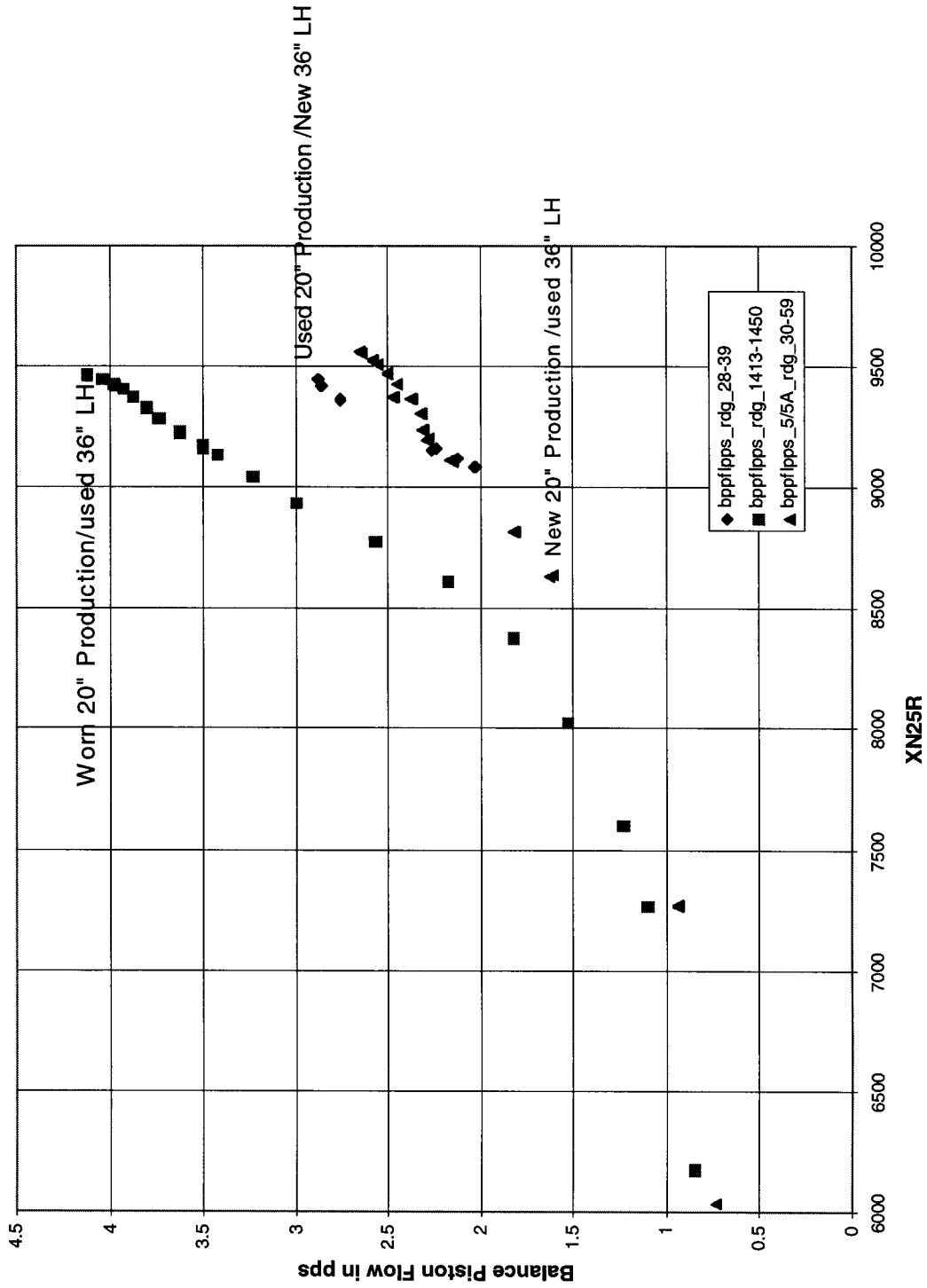


- Cavity Pressures Continue to Drop throughout Testing

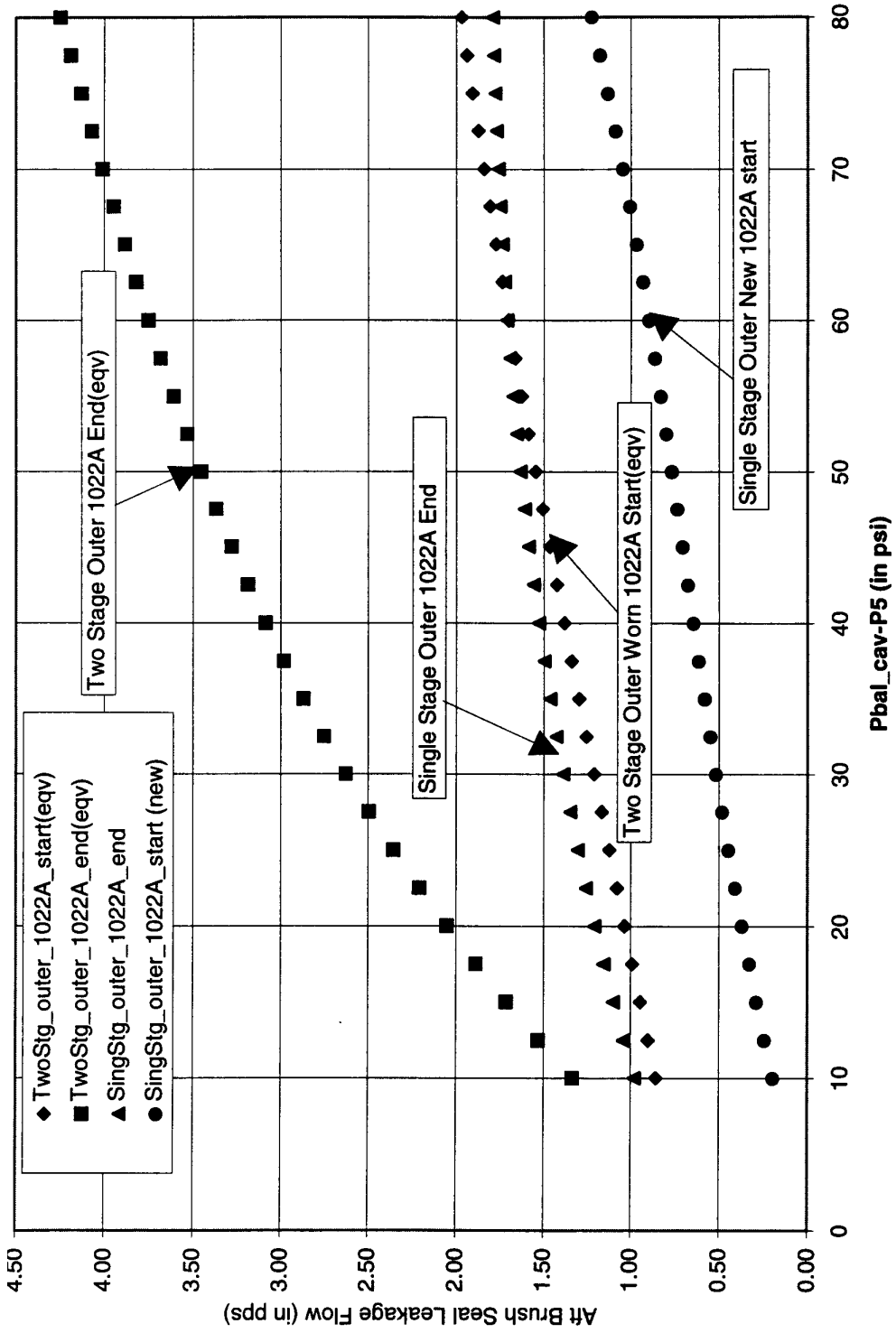
Relative Cavity Pressure and Leakage Versus Time



Balance Piston Flows vs XN25R from ESN 900-102/2A and ESN 900-005/5A



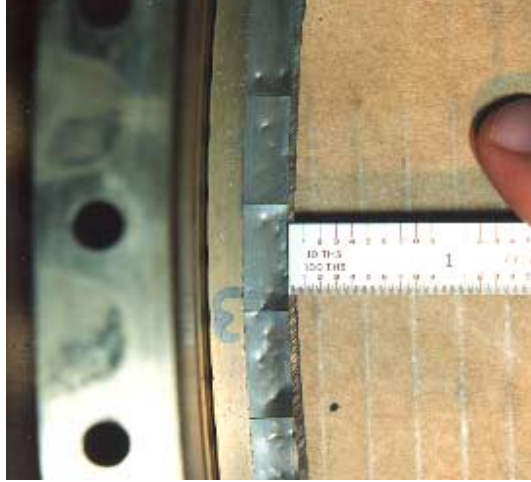
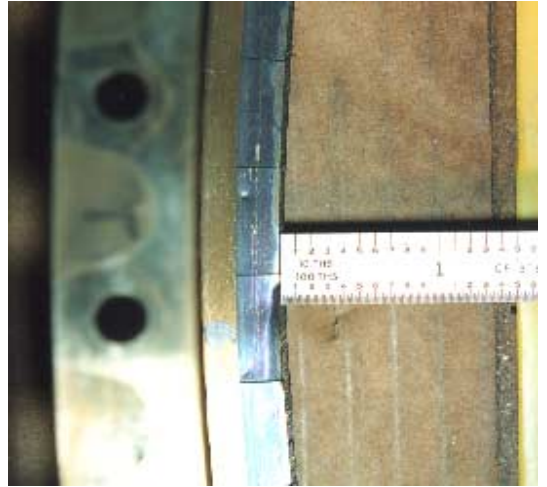
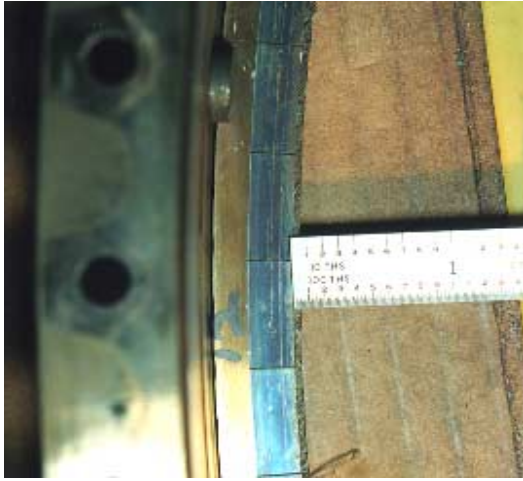
Aft Brush Seal Leakage in ESN 900-102/2A at Start and End of Test Program vs (Pbal_cav-P5)



36-inch Single-Stage Low Hysteresis Brush Seal Condition After Engine Tests



- Damper Plates were Hit by three Metal Pieces resulting from Baffle Cracks



- No Tufting of Bristles
- Smooth Wear

Conclusions

Single Stage Low Hysteresis Brush Seal Meets Performance and Durability Goals and was Validated for GE90 Engine Application

- Leakage of the Deteriorated 36-inch Single Stage Low Hysteresis ≤ 2.1 lb/sec
 - Goal is 2.6 lb/sec
 - More than 30% Leakage Reduction over the Current Two-stage Brush Seal
- No Tufting of Bristles; Wear was Smooth

