ADVANCED SEALS AT GE RESEARCH AND DEVELOPMENT CENTER

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Advanced Seals at
GE Research & Development Center

Objective:

Advanced Seals Development, Approach, Methodology, Activities

Overview:

Briefly GE - CRD

Sealing Types Being Developed

Application Areas

Development Approach

DFSS Methodology

Analytical Modeling

Experimental Modeling

Field Validation

GE CRD Advanced Seals Team

- **Saim Dinc**
- **Norm Turnquist**
- **George Reluzco**
- **Ming Zhou**
- **Mahmut Aksit**
- **Ray Chupp**
- **Hong Dai**
- **Jason Mortzhaim**
- **Hamid Sarshar**
- **Chuck Wolfe**
- **Wei-Ming Chi**

Presenters

- **Saim Dinc**
- **Norm Turnquist**
- **Ray Chupp**

Advanced Seals at

GE Research & Development Center

Type of Seals

Static Seals

- Cloth Seals
- Abradable Seals
- ST Static Seals

Dynamic Seals

- Brush Seals
- Aspirating Seals
- Labby Seals
- Honeycomb Seals

Static Seal Testing

Brush & Cloth Seals
1000 psi
1000F

Dynamic Seal Testing

Brush, Aspirating, HC Seals
36 & 50 in. Dia.
800 ft/sec
100 psi

Dynamic Seal Testing

Brush Seals
1200 psi
1000 F Air & Steam
800 ft/sec

Applications

Gas Turbines

Compressor &

Turbine Seals

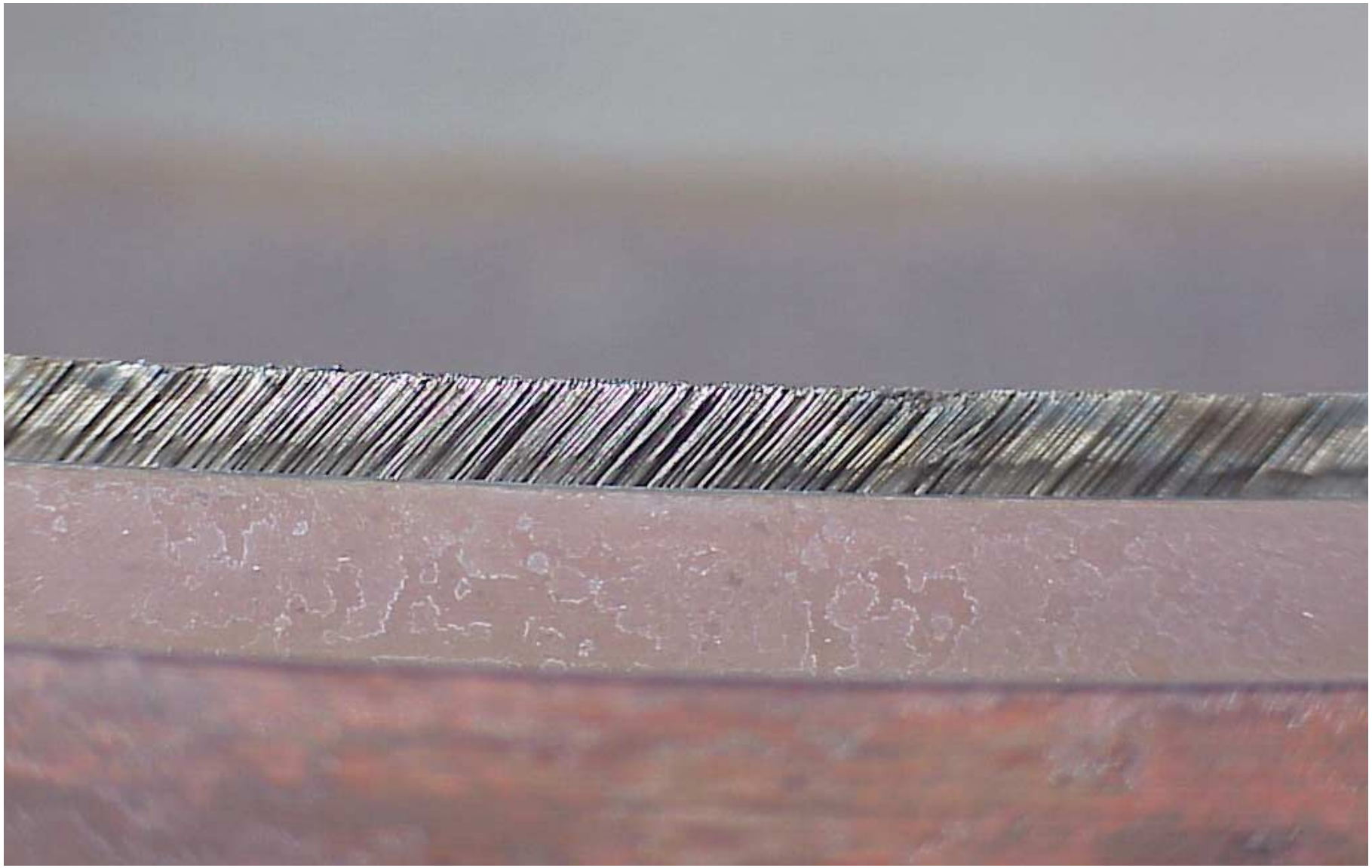
Steam Turbines

Generators

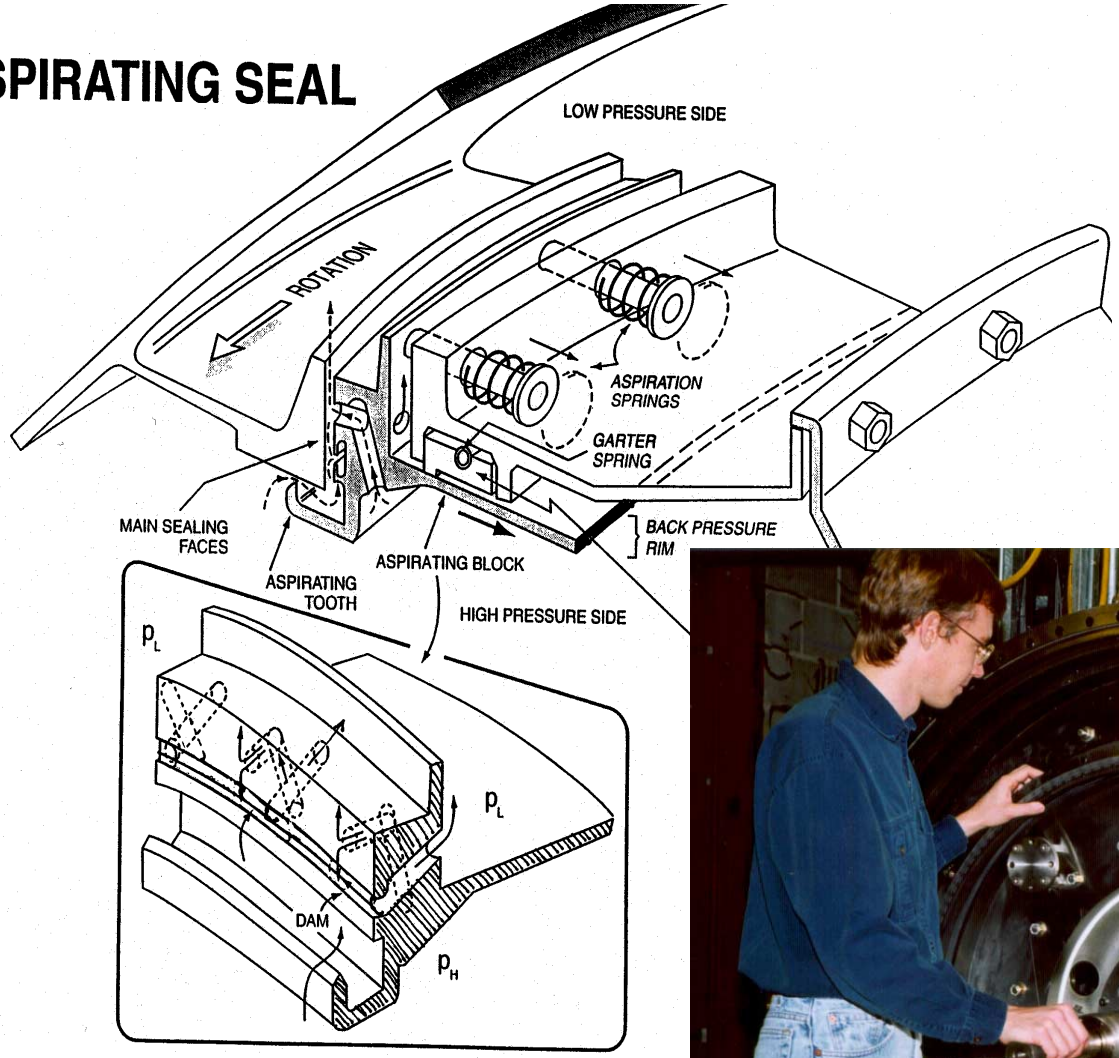
Compressors

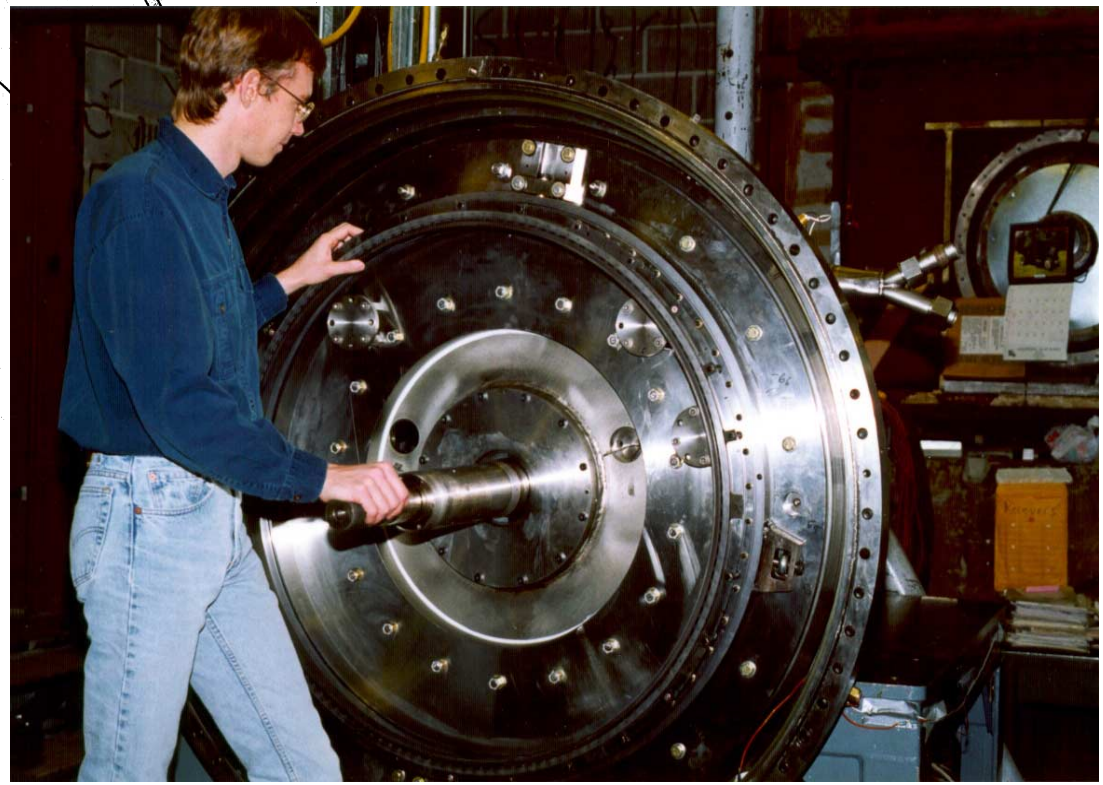
Aircraft Engines

Gas Turbine Brush Seals: After 3 Years of Service



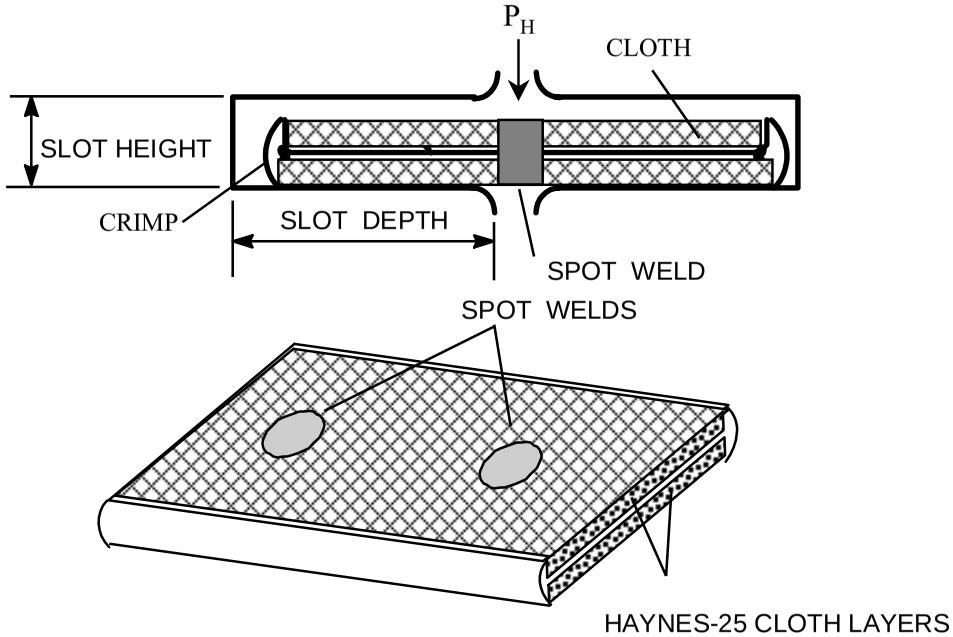
ASPIRATING SEAL



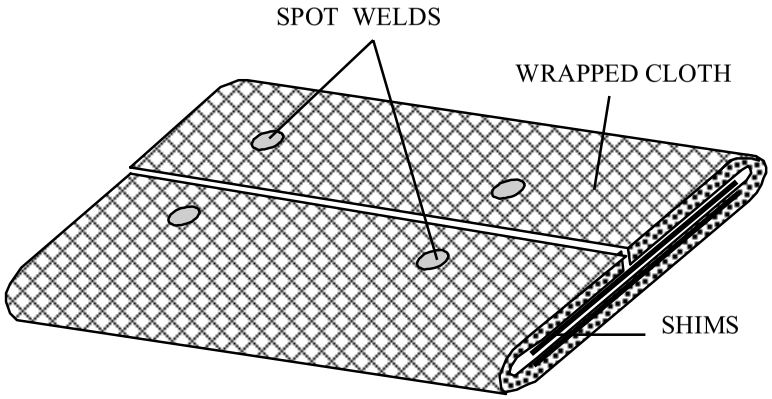


Stationary Seal Applications:

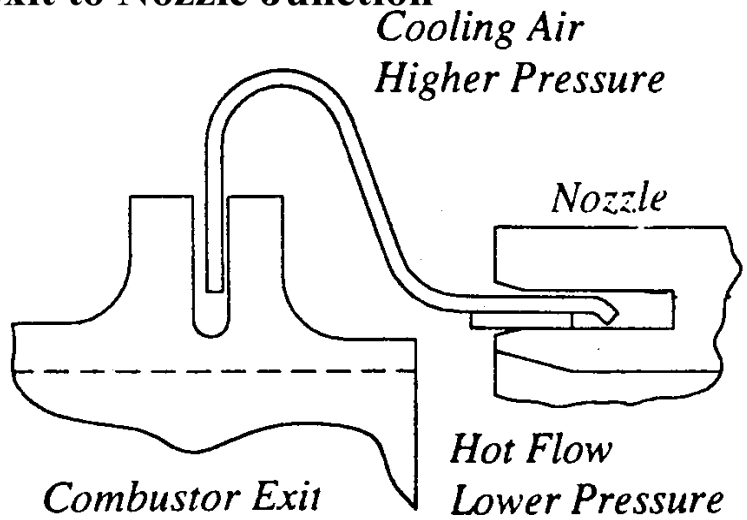
Cloth Seals at Turbine Section Hot Gas Path



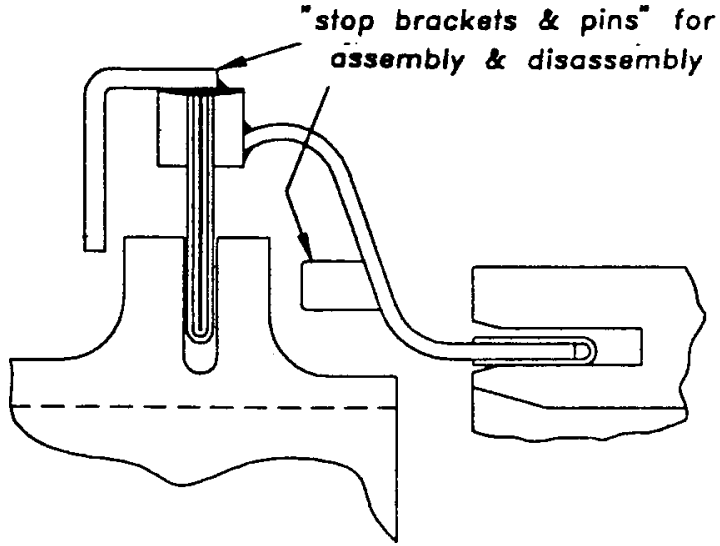
WRAPPED CLOTH SEAL



Cloth Seals at Combustor Exit to Nozzle Junction



(a) Previous sealing arrangement

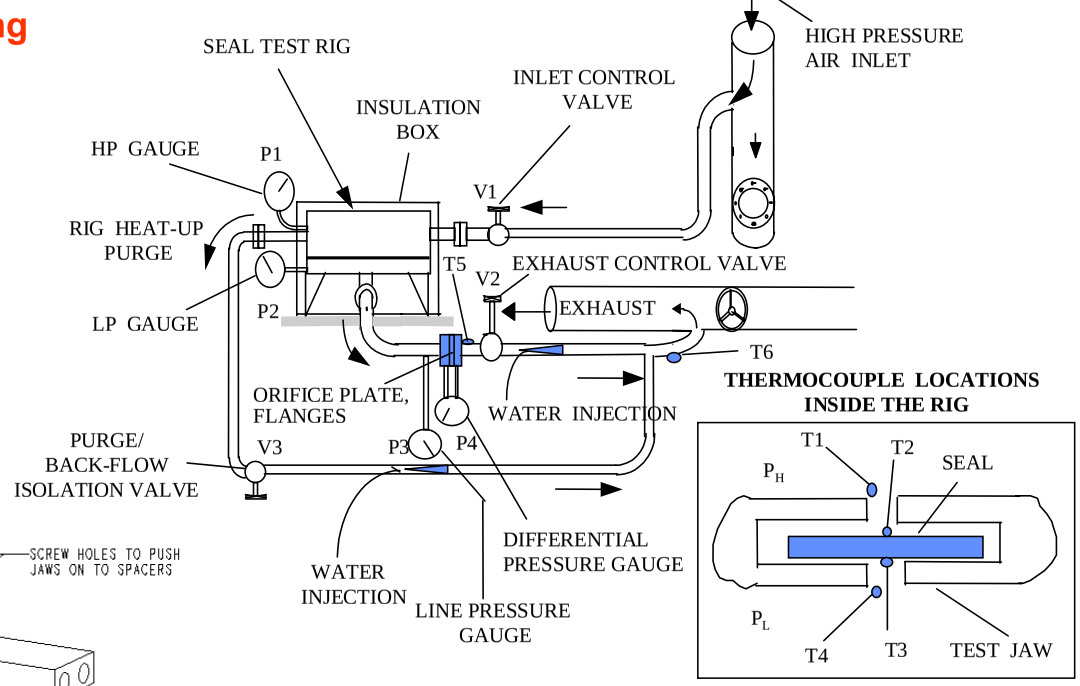


(b) Sealing arrangement with cloth seals

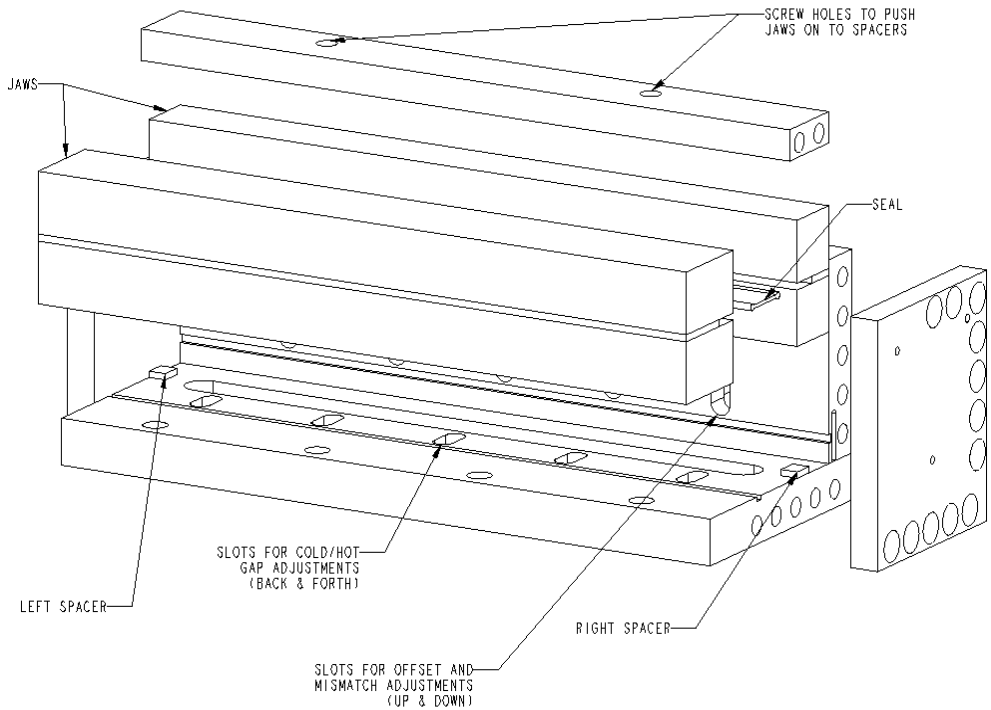
Cloth Seals Leakage Performance Testing

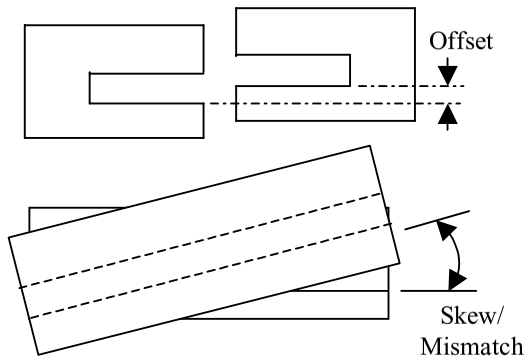
- **Seal samples are tested under different machine conditions.**
- **Leakage performance is measured for various slot offset, skew, pressure ratio and temperatures.**

System layout of the test rig.

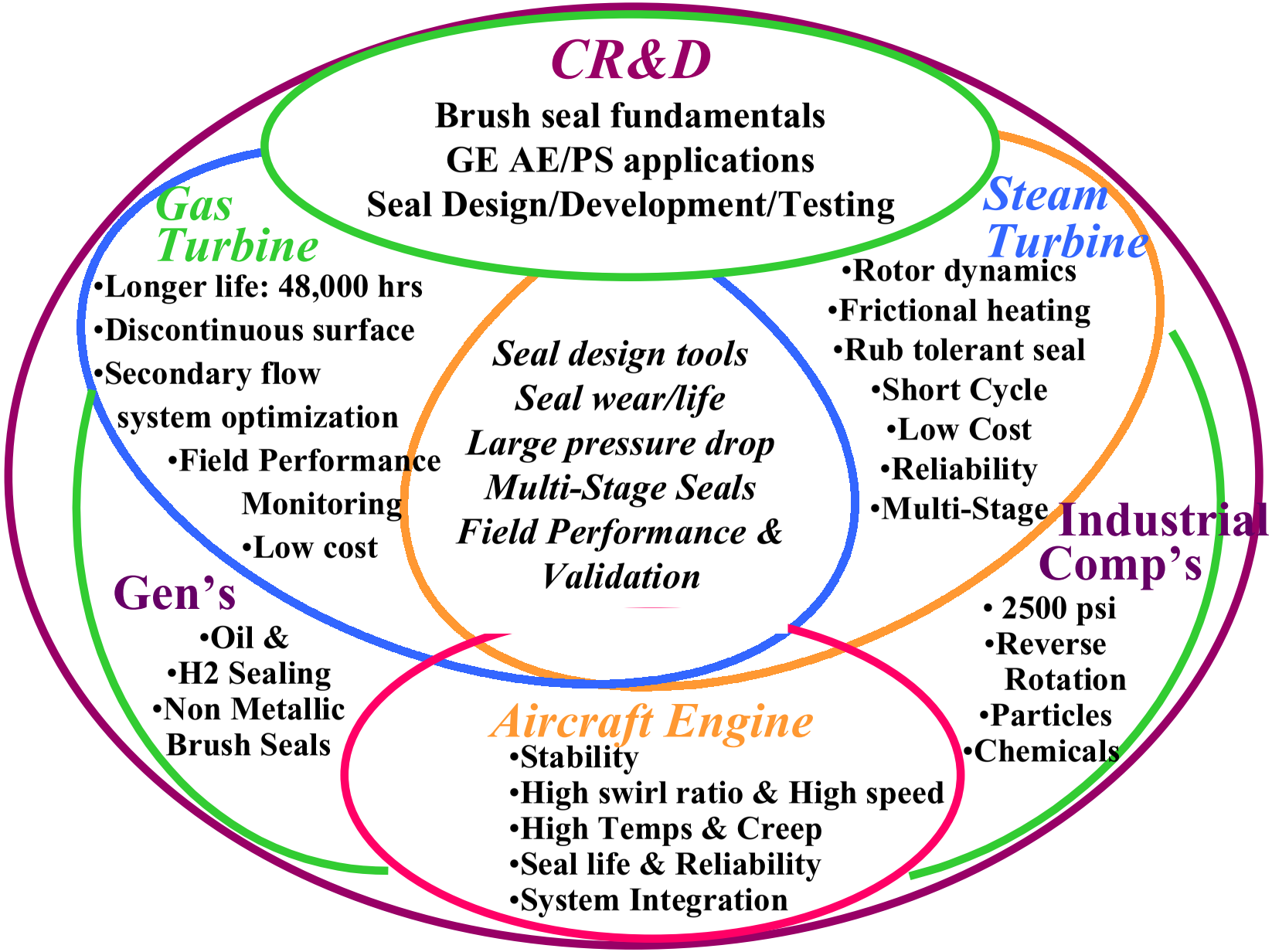


Test sample assembly

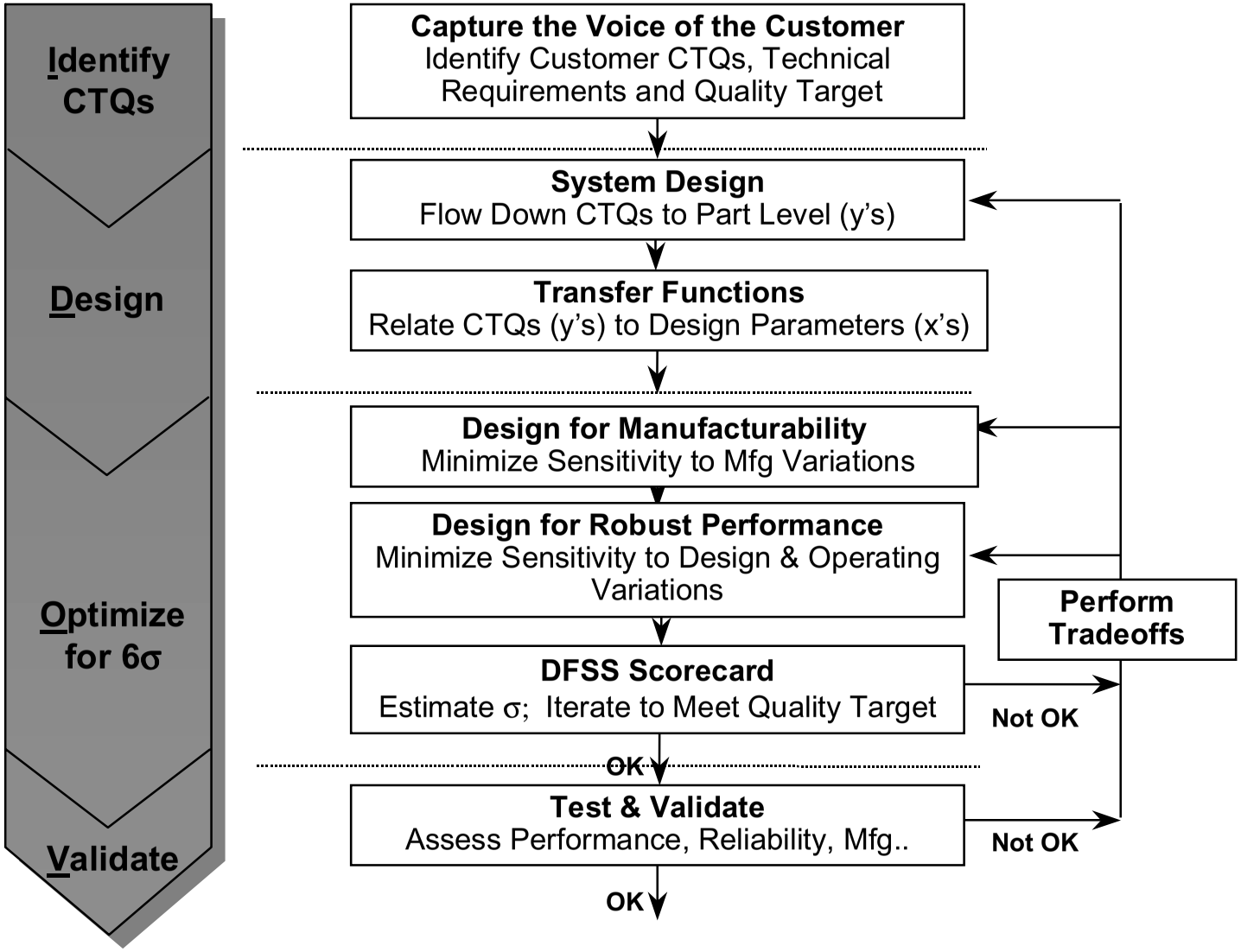




GE - CRD Brush Seal Technology Development



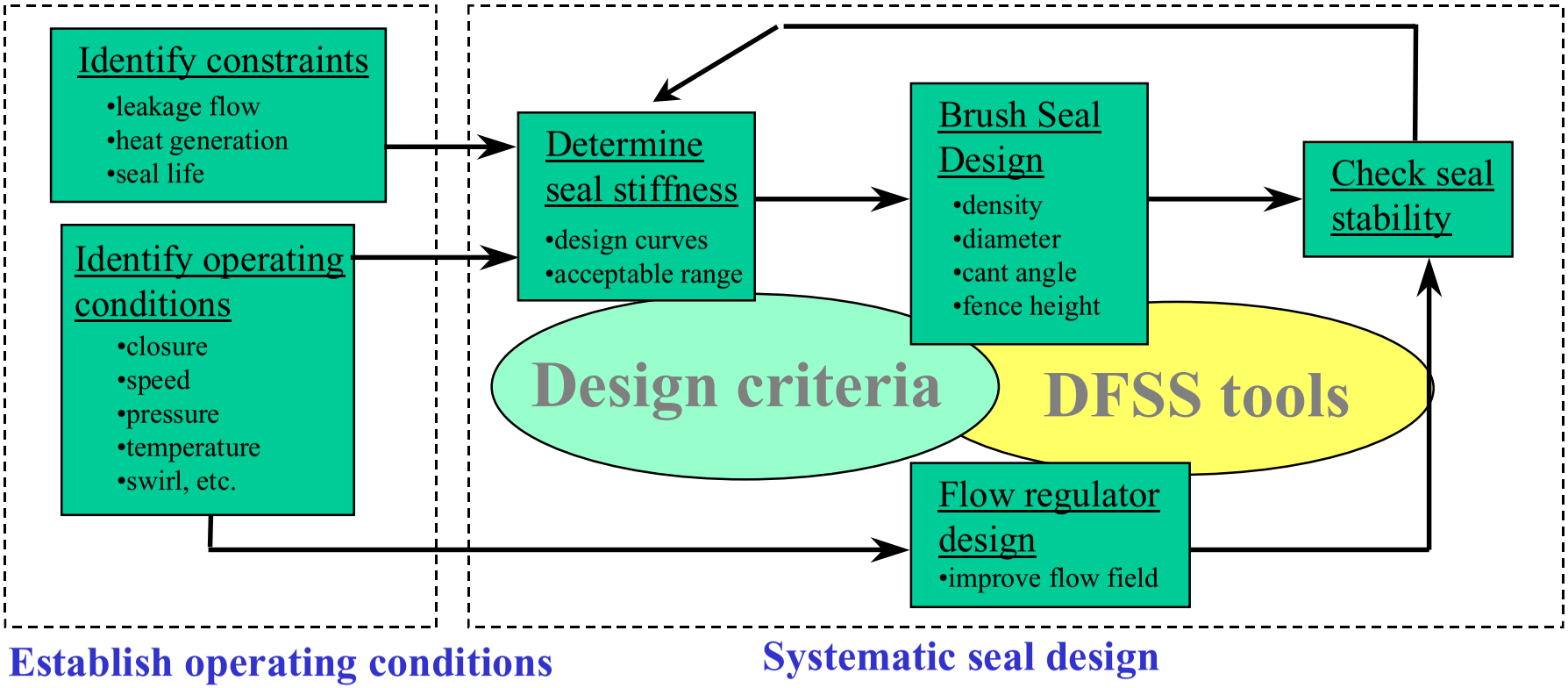
GE's DFSS Design Process



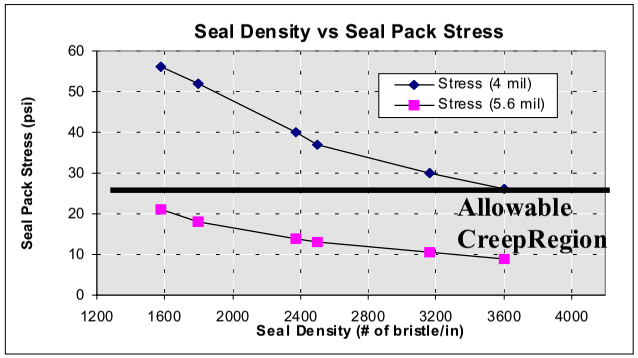
Predictive, statistical design, to achieve 6σ during product development

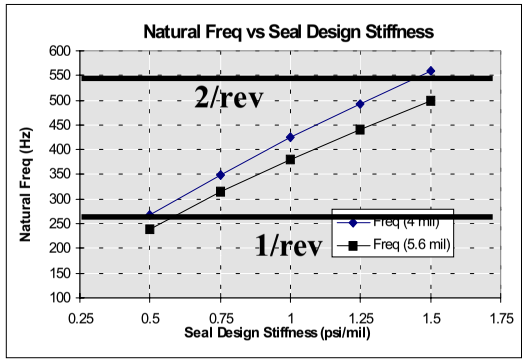
GE Proprietary Information

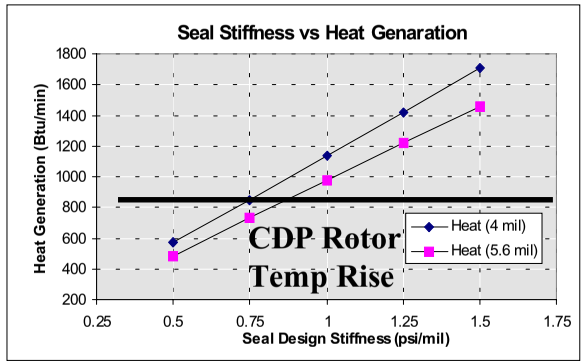
Brush Seal Design Process/Methodology



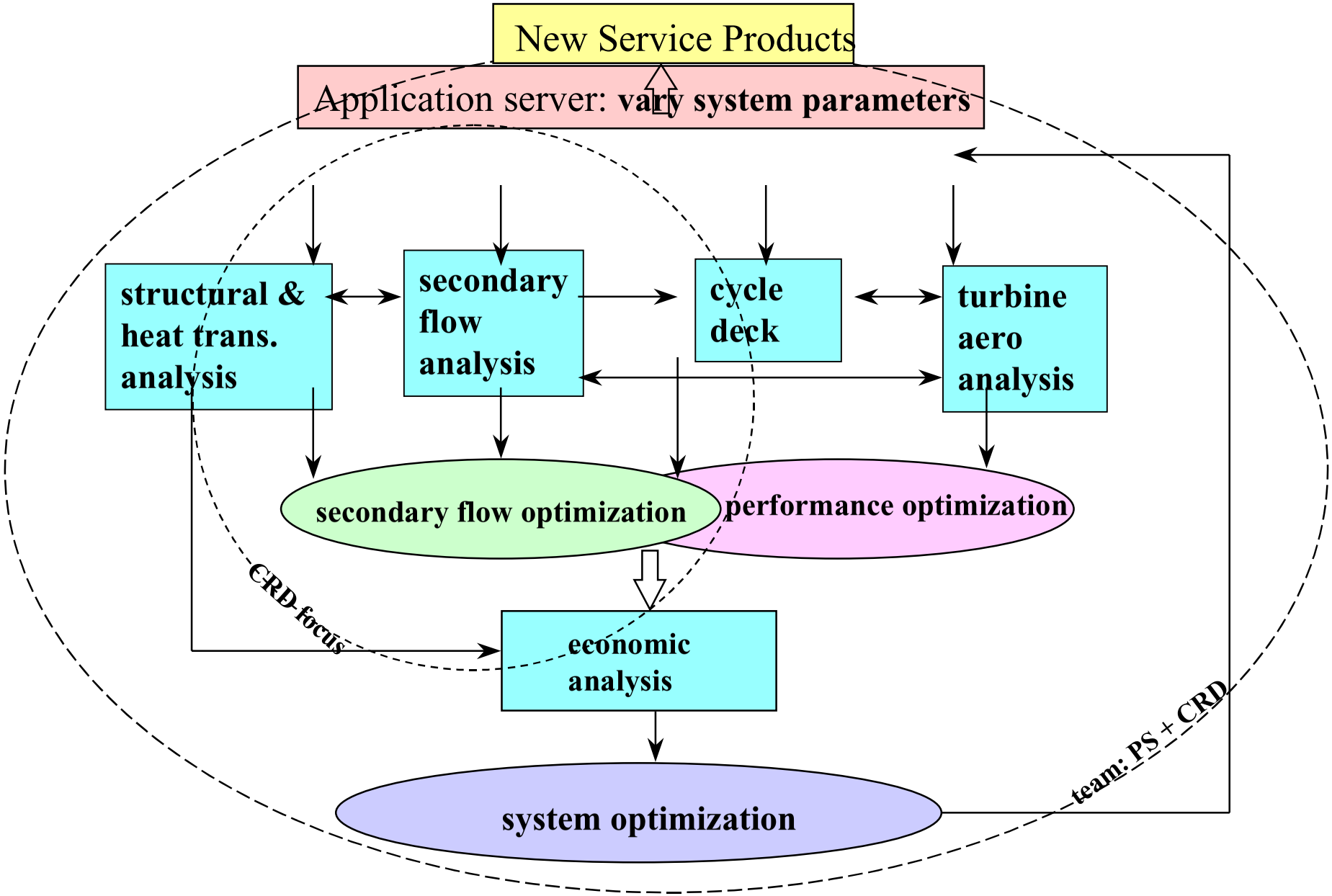
Brush Seal Design Tools:







Gas Turbine System Level Secondary Flow/Performance Analysis

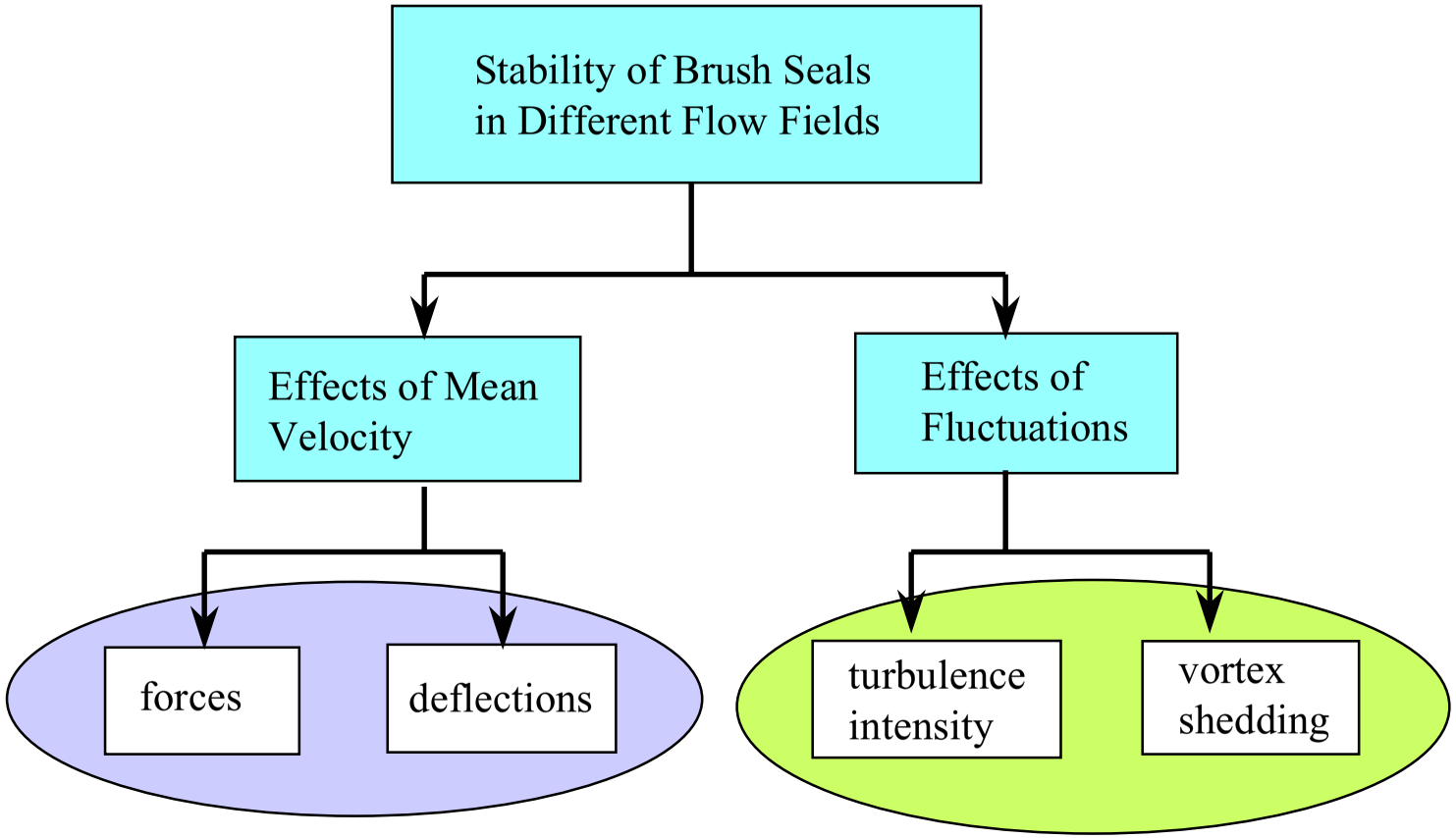


NASA/CP—2000-210472/VOL1

The Approach for Brush Seals Development

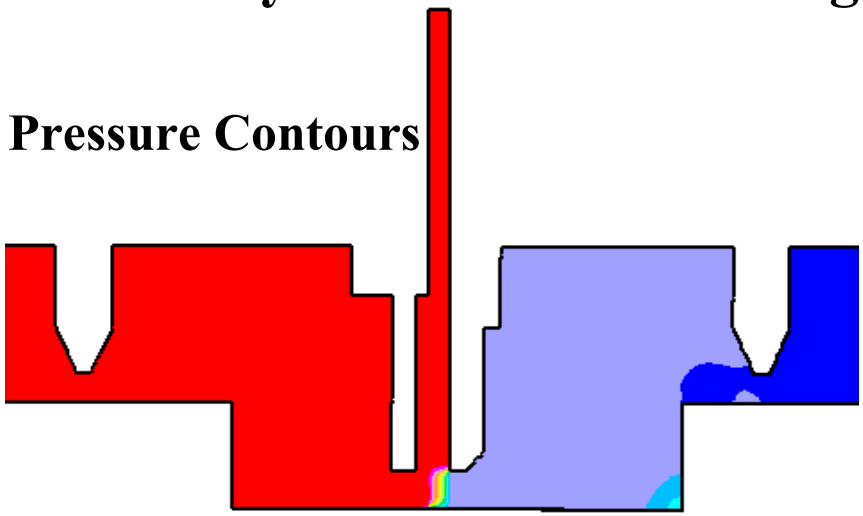
- **Operating Conditions**
- **Preliminary Seal Design**
- **Seal Stress Analysis**
- **Seal Frequency Analysis**
- **Seal Leakage Characterization**
- **Seal Stiffness**
- **Seal Blow-down/Seal Hysterisis**
- **Seal Material Characterization/creep/oxidation**
- **Seal Heat Generation/rotor Dynamics**
- **Seal Stability**
- **Seal Wear**
- **Seal Life/performance Degradation/seal Design for Reliability**
- **Seal Component & Sub-scale Testing**
- **Seal Engine Assembly**
- **Field Performance Test/secondary Flow Optimization**
- **Design Tools Validation/field Data Integration**

Brush Seal Stability Road Map

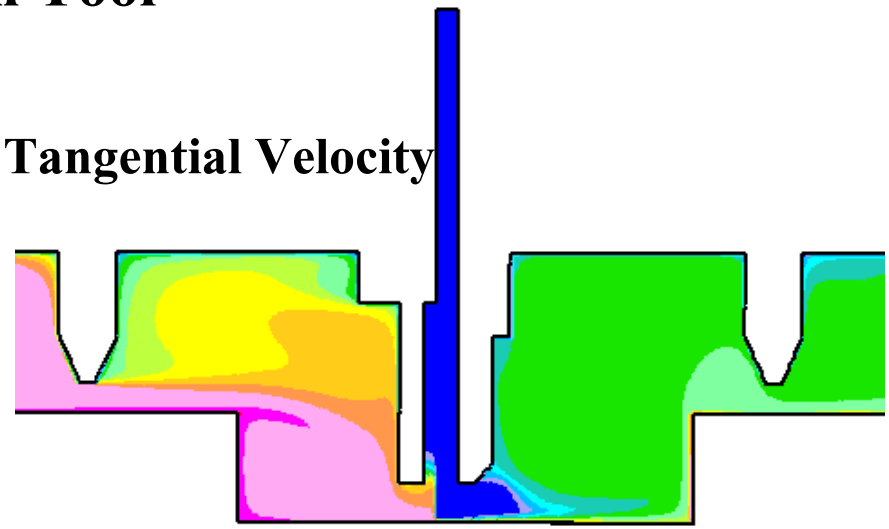


CFD Analysis Is Used As a Design Tool

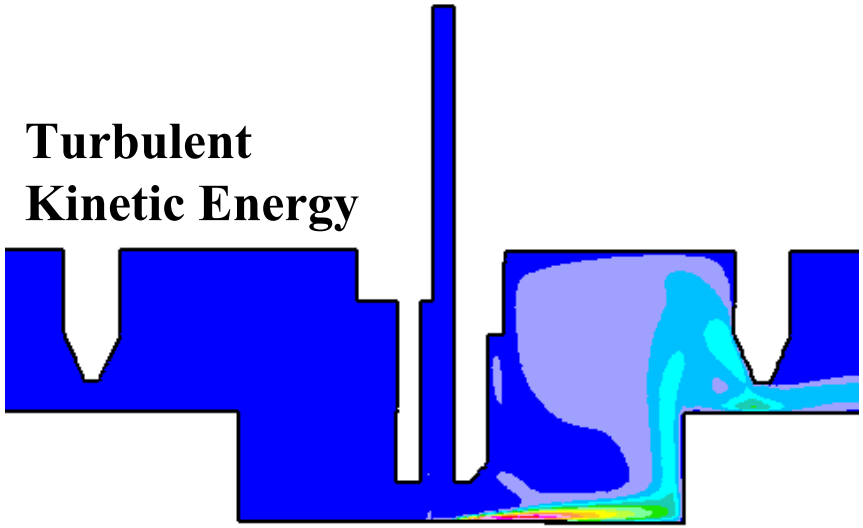
Pressure Contours

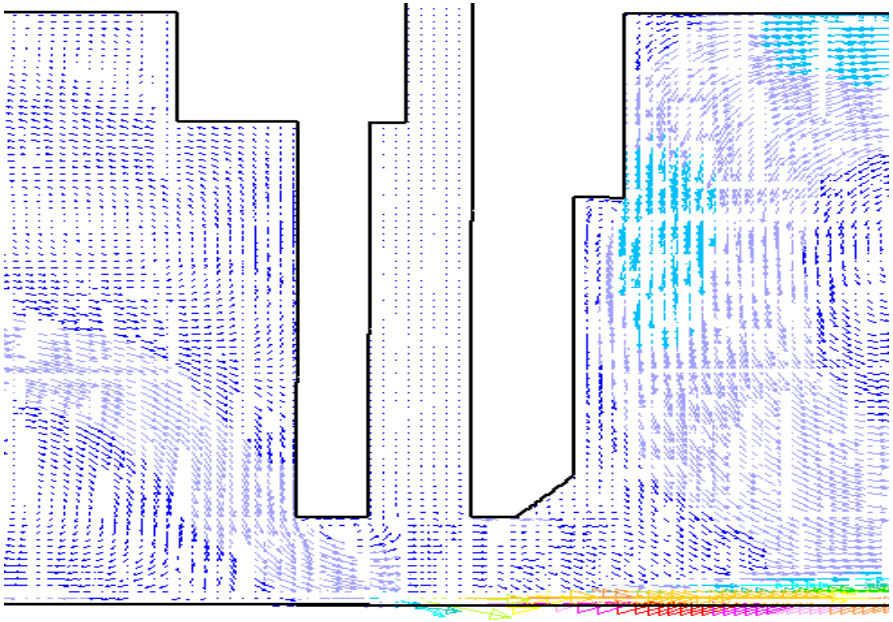


Tangential Velocity

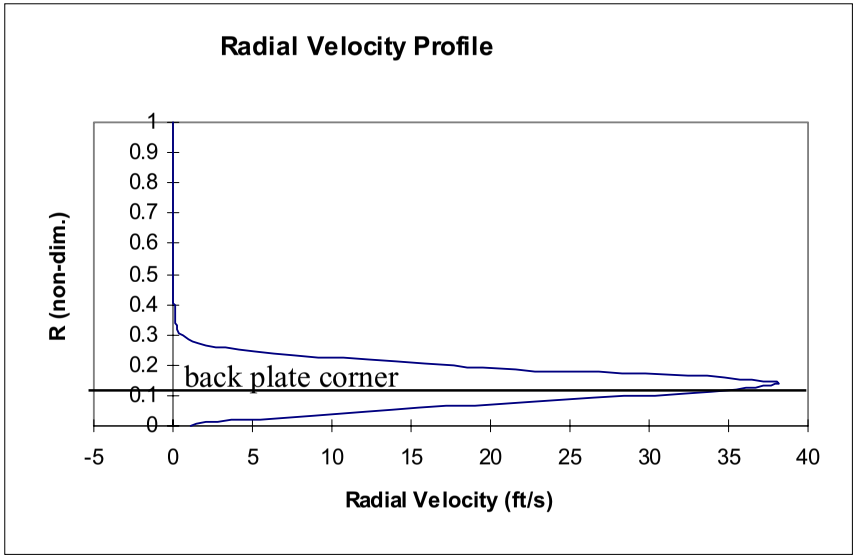


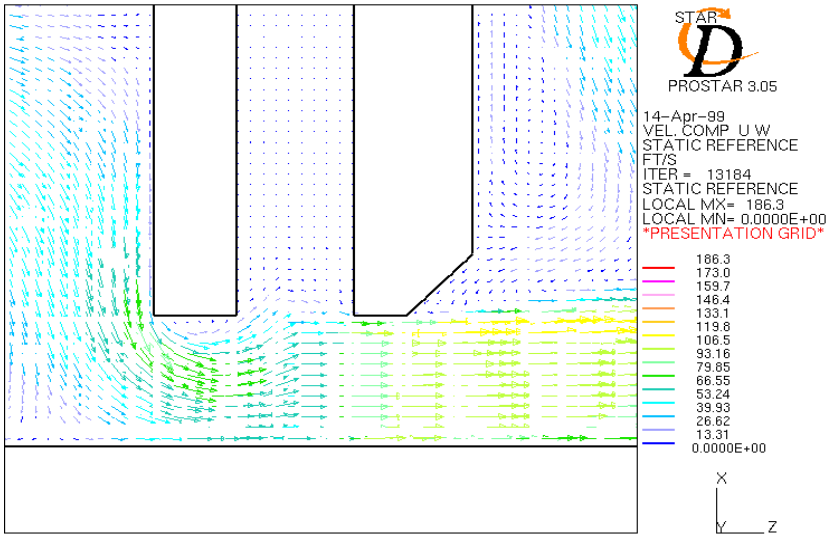
Turbulent Kinetic Energy

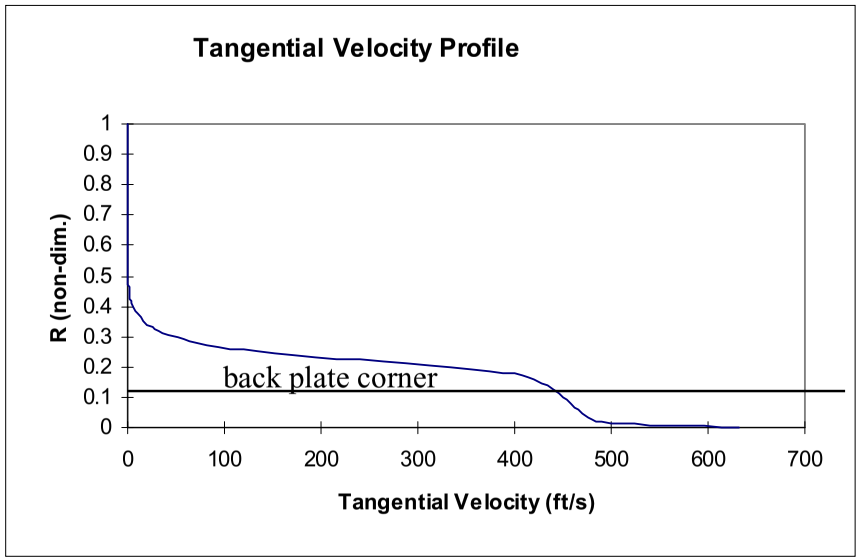


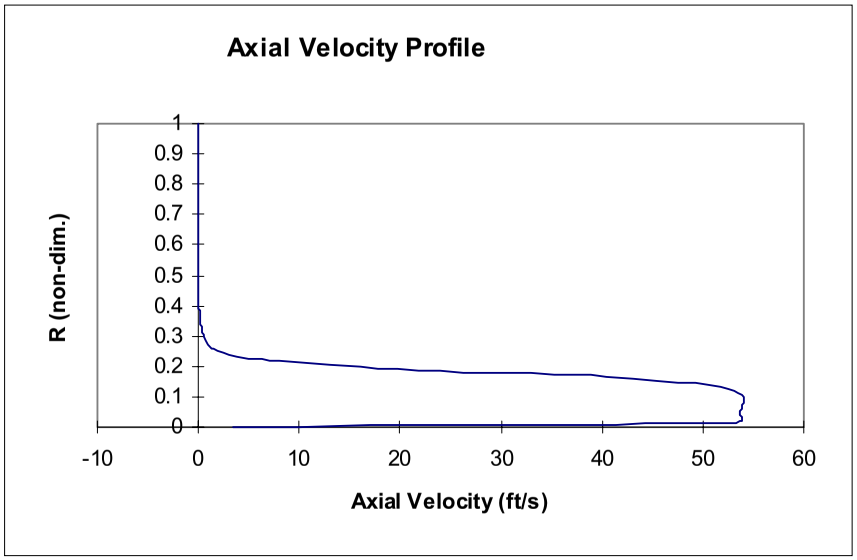


Current Brush seal w/Line-to-line in S-S Conditions
Velocity profiles from the Rotor surface towards bristle pinch point

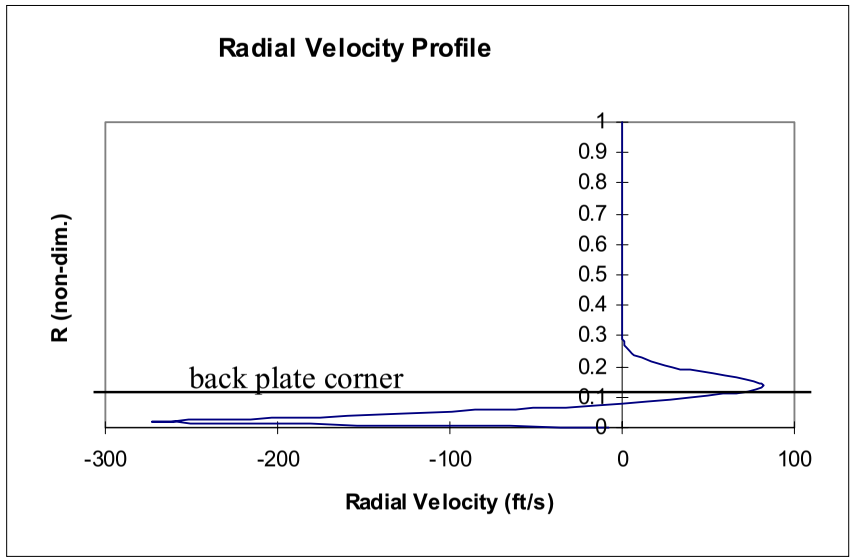


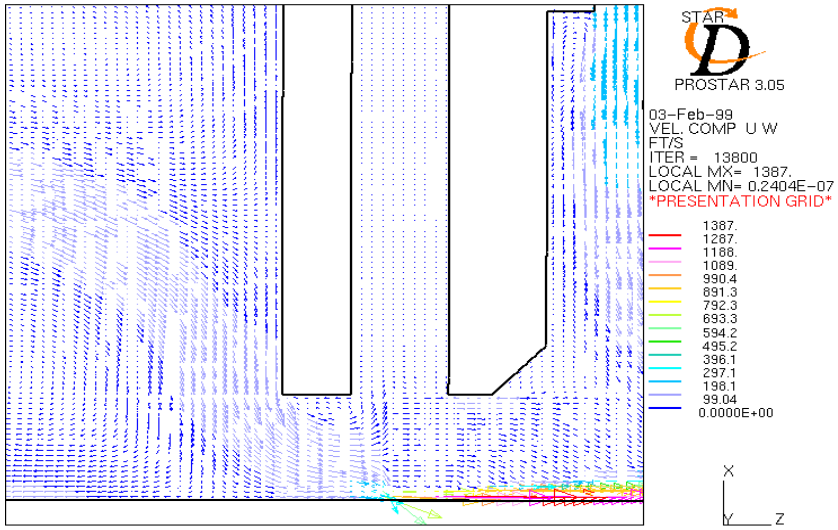


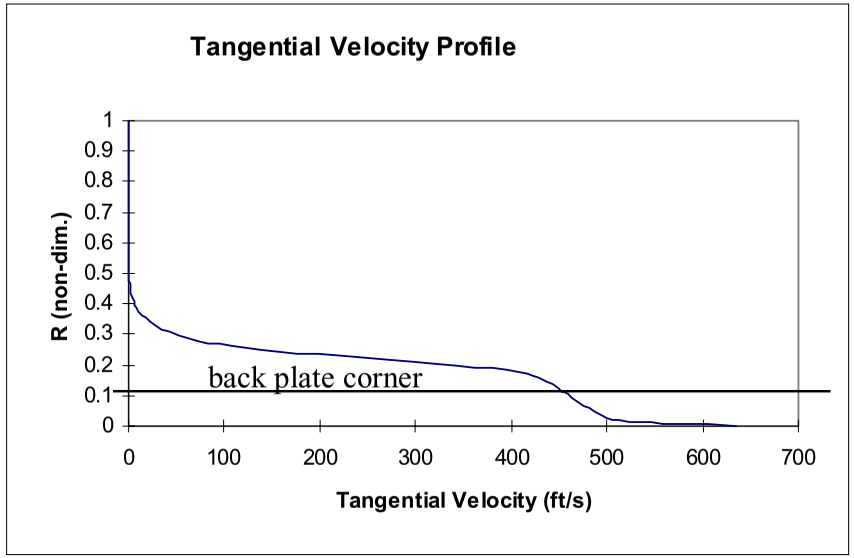


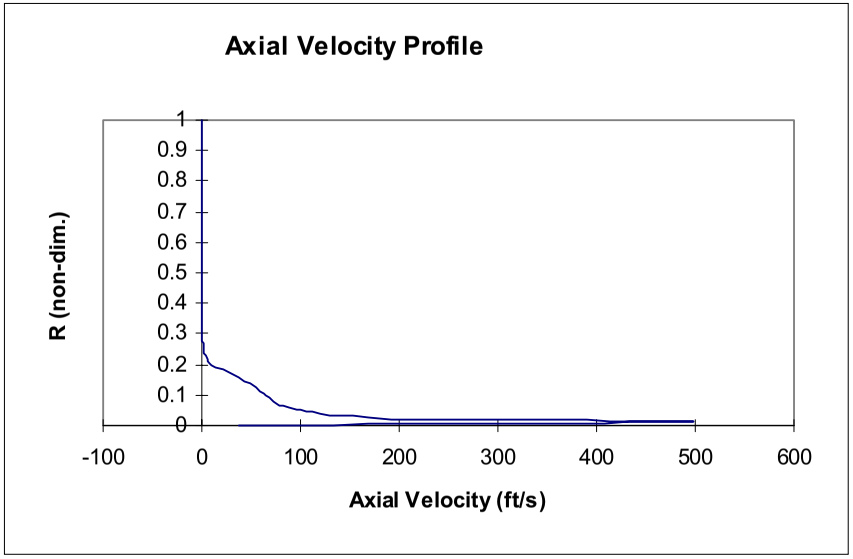


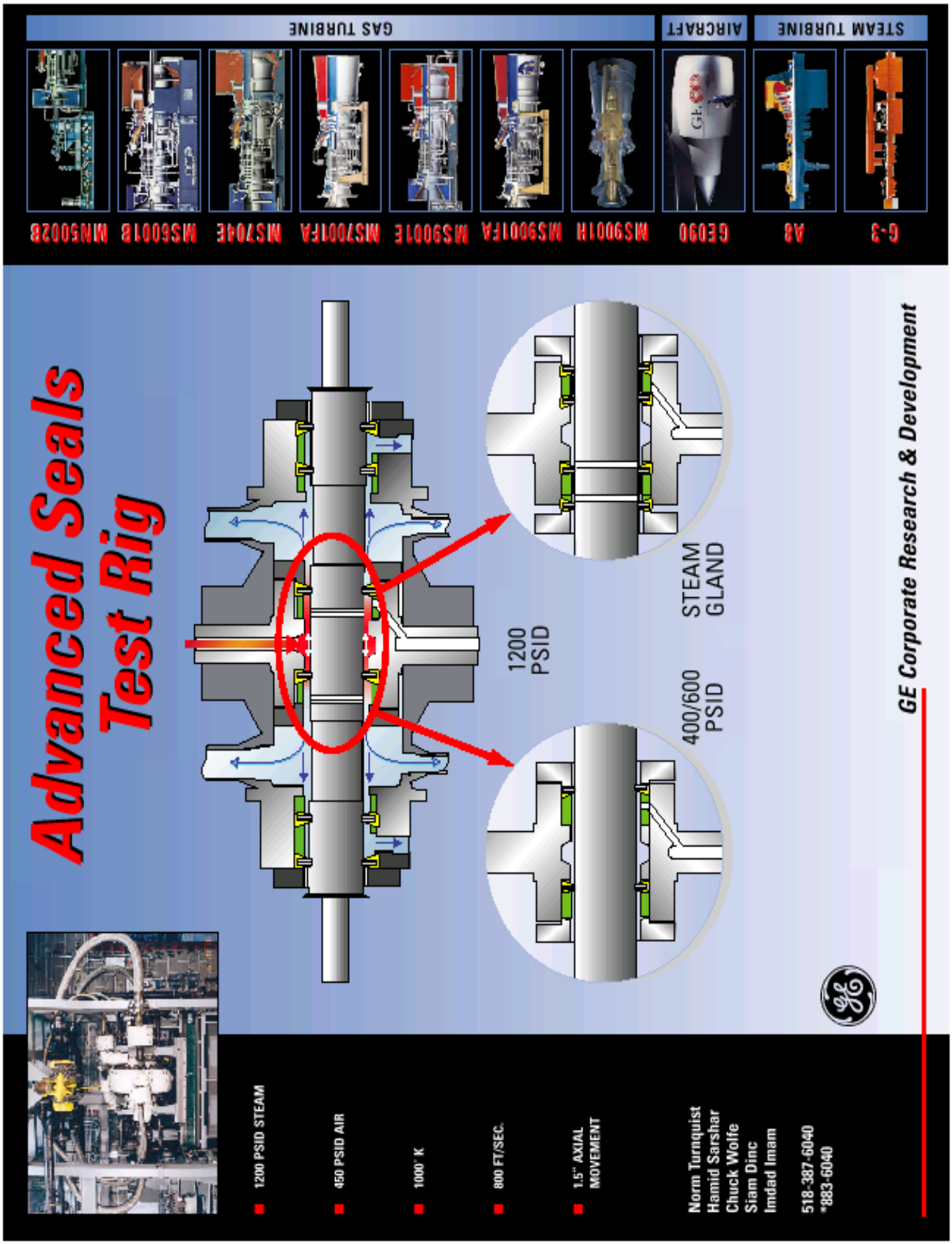
Current Brush seal w/0.010” Clearance Seal in S-S Conditions
Velocity profiles from the Rotor surface towards bristle pinch point










Advanced Seals
Test Rig
1200 PSID STEAM
450 PSID AIR
1000° K
800 FT/SEC.
1.5" AXIAL MOVEMENT
Norm Turnquist
Hamid Sarshar
Chuck Wolfe
Siam Dinc
Imdad Imam
518-387-6040
*883-6040
1200 PSID
400/600 PSID
STEAM GLAND
GE Corporate Research & Development
GAS TURBINE
AIRCRAFT
STEAM TURBINE
MS5002B
MS6001B
MS7041E
MS7001FA
MS9001E
MS9001FA
MS9001H
GE90
A8
G-3

Technology Status/Milestones:

- **Transient Capability/Stable Brush Seals**
  - From current seals to 3-5 times dynamically more aggressive engine seals
- **High Surface Speed**
  - From 400 f/s of AE seals to 800 f/s of GT seals
  - From 800 f/s to 1600 f/s surface speed
- **High Pressure Loading**
  - From 100 psi two stg seals to 400 psi single stage seal design
  - Moving to high delp multi-stage seal designs
- **High Swirl Flow Field**
  - Swirl ratios of current applications are 0.3 moving to 0.6 - 0.9 region
- **Air Temperature**
  - From 700 F to 1200 - 1800F temperatures
- **Seal Life and Durability**
  - GT fleet leader w/35,000 field hrs w/minimum degradation
  - ST fleet leader 15,000 hrs w/minimum degradation
- **Rotor Surface**
  - Ceramic coated AE rotors to uncoated GT and ST applications
  - Interrupted surface at ST bucket tip seals
- **Rotor Dynamics/Rub Tolerant Soft Seal Design**
  - Moving towards “Rub Tolerant Soft Seals”

36 Publications, Patents Activity: 65 Total; 15 issued, 20 Pending, 30 Additional New Dockets