

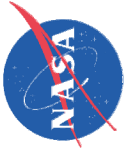
## “Forming a Turbomachinery Seals Working Group – An Overview and Discussion”

By

Margaret P. Proctor

### **Abstract**

A proposal to form a Turbomachinery Seals Working Group is discussed. Survey responses regarding the purpose, membership, and meeting frequency are presented as well as the areas of expertise and experience of the respondents. The types of seals used, designed, or sold, current work, and technical challenges of turbomachinery seals, their materials, analysis, geometry, manufacturing, maintenance, testing, and incorporation into engine systems are also presented.

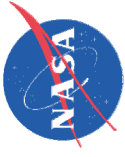


# Forming a Turbomachinery Seals Working Group An Overview and Discussion

By  
Margaret P. Proctor

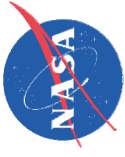
Seals Team of the Mechanical Components Branch  
Materials and Structures Division  
NASA Glenn Research Center

Presented at the  
2006 NASA Seal/Secondary Air System Workshop  
November 14-15, 2006  
Cleveland, OH



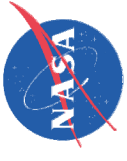
## Purposes

- Identify technical challenges to improving turbomachinery seal leakage and wear performance, reliability and cost effectiveness
- Develop a coordinated effort to resolve foundational issues for turbomachinery seal technologies
- Identify and foster opportunities for collaboration
- Advocate for funding



## Membership

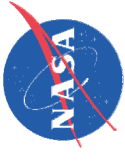
- Open to industry, academia, and government
- Ideally there would be representation from:
  - NASA
  - Other government agencies (DOD, DOE)
  - Engine companies –both aero and space
  - Seal companies
  - University researchers
- **Questions:**
  - U.S. only or open to foreign interests?
  - How many people does a working group need to be viable and functional?



## Survey Response

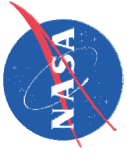
- Number of responses: 6 as of 10/31/06

	Interest?	
	<u>Yes</u>	<u>No</u>
– Industry:	5	5
• No. Engine companies	2	2
• No. Seal Companies		
• Other		
– Government:	1	1
– Academia:		



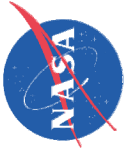
## Survey Response - Purpose

Ways to serve community	Yes	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>
Identify Technical Challenges to improving turbomachinery seal leakage and wear performance, reliability, and cost effectiveness	6	5	1	
Develop coordinated effort to resolve foundational issues for turbomachinery seal technologies	5		2	2
Identify & foster opportunities for collaboration	5		1	1
Serve as agent to coordinate technical investment in seal technology across government agencies with vested interest in turbomachinery	4	1		1
Serve as a catalyst for technical discussions	5		2	1
Advocate for funding	3			1



## Survey Response – Meeting Frequency

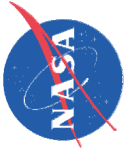
Annually	1
Semi-annually	4
Quarterly	
Biennially	1
Never	
Other	



## Survey Response – Areas of Experience & Expertise

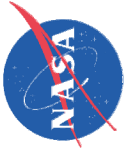
- Submarine Design
- Machinery Operation & Maintenance
- High temperature/high pressure rotor-stator sealing
- Fluid-dynamics & heat transfer in rotating systems (jet engines – internal air; turbogenerators)
- Experimental methods in fluid dynamics & heat transfer
- Two-phase (air/oil) flow & heat transfer
- Air systems, seals, heat transfer, gas turbine design
- Development & application of labyrinth, brush, carbon, & rope seals
- Cryogenic and high temperature shaft seals – brush, finger, non-contacting film riding concepts





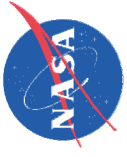
## Survey Responses – Currently working on

- Seals for centrifugal compressors in O & G industry
- High pressure ratio seals in rotating cavities
- Labyrinth seals
- Brush seals
- Carbon face seals
- Advanced sealing, DOE High Hydrogen Turbine Program
- Large industrial gas turbines
- Low leakage, non-contacting finger seals
- Sealing in dusty lunar environment



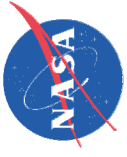
## Survey Responses – Types of seals you use, design, or sell

- Labyrinth - 5
- Brush - 4
- Carbon Face
- Cloth seals for many static applications
- Finger
- New concepts



## Survey Responses – Your Biggest Technical Challenges related to turbomachinery seals

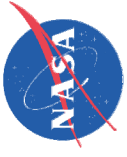
- Sealing pressure; dry gas seal failures
- Durability
- Low leakage, durable, long life, low cost, easily installed seals
- Reduced heat up while reducing leakage
- Wear of brush seals
- Achieving low leakage and long life seals at high temperature and high speed



## Survey Response – technical challenges related to

### Analysis

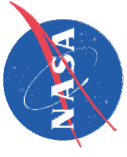
- Acoustic stability
- Dynamic tracking
- Validation of physics-based models for performance and durability
- Predicting wear
- Fluid-structure interactions particularly for compliant, non-contacting designs



## Survey Response – technical challenges related to

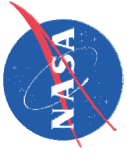
### **Materials**

- Creep resistance of high strength alloys
- Temperature limitations on carbons & metals rub tolerance
- Scaling of capabilities
- High temperature applications
- Lack of material property data
- High temperature materials
- Friction coefficient data



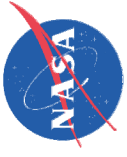
## Survey Response – technical challenges related to Geometry

- Size of mechanical seal assemblies
- Scaling of seal assemblies
- Controlling leakage at circumferential splits in seal
- Scaling up from prototypes to actual hardware



## Survey Response – technical challenges related to **Manufacturing**

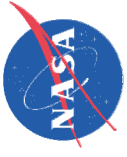
- Cost -2
- Repairability
- Low cost, reliable techniques



## Survey Response – technical challenges related to Maintenance

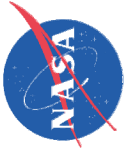
- Wear
- Cost
- Excessive wear of rub damage





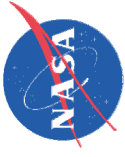
## Survey Response – technical challenges related to Testing

- Realistic subscale testing
- Rotordynamics testing
- Full-scale prototype testing
- Cost of engine testing
- Dynamic testing
- Off-design conditions i.e. demo of durability during system failure modes
- Lack of facility for testing large, near full-scale parts
- Resources for test articles



## Survey Response – technical challenges related to Incorporation into Engine System

- Understanding closure between rotor and stator during start and shutdown transients
- Access to engine systems



## Where do we go from here?

- Accept additional survey responses until November 30, 2006.
  - Blank copies can be found at the registration table
- Decide if sufficient interest exists to establish the working group.
- Respondents to survey will receive a summary of results via e-mail as well as notification of future plans.