NASA HIGH TEMPERATURE TURBINE SEAL RIG DEVELOPMENT

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Turbomachinery Seal Development Ojectives

- Evaluate feasibility of advanced seal concepts and materials of meeting next generation engine speed and temperature requirements.
- Complete fabrication/installation of state-of-the-art turbomachinery seal test rig capable of testing seals under known/anticipated design conditions.
- Work with industry to assess/demonstrate performance of their seals prior to test in engine.

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High Temperature Turbomachinery Seal Test Rig

Test rig designed to test at speeds and temperatures envisioned for next generation commercial and military turbine engines.

Test rig is one-of-a-kind. More capable than any known test rig in existence at either engine manufacturers or seal vendors.

- **Temperature** — **Room Temperature thru 1500 °F**
- **Surface Speed** — **1500 fps at 40,455 RPM, 1600 fps at 43,140 RPM**
- **Seal Diameter** — **8.5" design; other near sizes possible**
- **Seal Type:** — **Air Seals: brush, finger, labyrinth, film riding rim seal**
- **Seal Pressure** — **70 psi @ 1500 °F: Current**
  150 psi @ 1445 °F: with Hydrotest qualification of heater
- **Motor Drive** — **60 HP (60,000 RPM) Barbour Stockwell Air Turbine with advanced digital control for high accuracy/control**

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Test Parameters

- Seal flow vs. pressure, speed, temperature
  (Both test rig and test seal are heavily instrumented)
- Seal performance vs. simulated ramp cycles using new digital air turbine speed controller.
  Multiple speed step mission profile capabilities.
- Seal durability vs. once-per-rev rotor runout condition
- Seal durability for prescribed seal offset condition (e.g. 3 mil seal offset)
- Accelerated life tests
- Seal and coating wear

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Highlights of Engineering Calculations

- MAR M-247 (Ni Co) cast rotor and seal holder meet LCF and creep life goals at 1500 °F, 1500 fps
- Tri-hub burst containment: Pressure vessel contains disc failure thru operating and overspeed conditions
- Pressure vessel sized and to be hydrotested to ASME pressure vessel code
- Squeeze film dampers damp anticipated inbalance.
  Less than 0.001 in. run-out for anticipated inbalance.
- Relative seal-holder to test-rotor thermal growths acceptable thru 1500 °F operating range
- Rotor windage heating: > 150 °F at 1500 fps
- Critical fits: rotor, bearing, bearing nuts, etc., stay "tight" during maximum speed and temperature conditions

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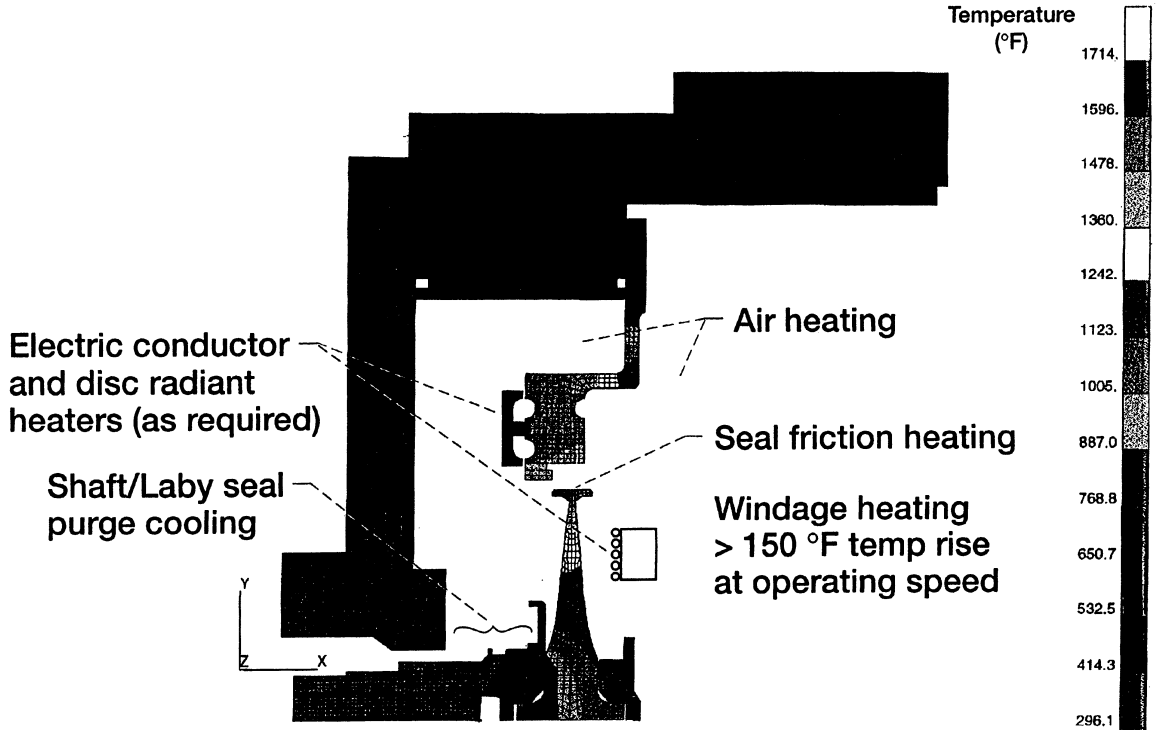
Seal Rig Global Thermal Analysis



Global thermal analysis with windage heating provides input to component stress and displacement analysis

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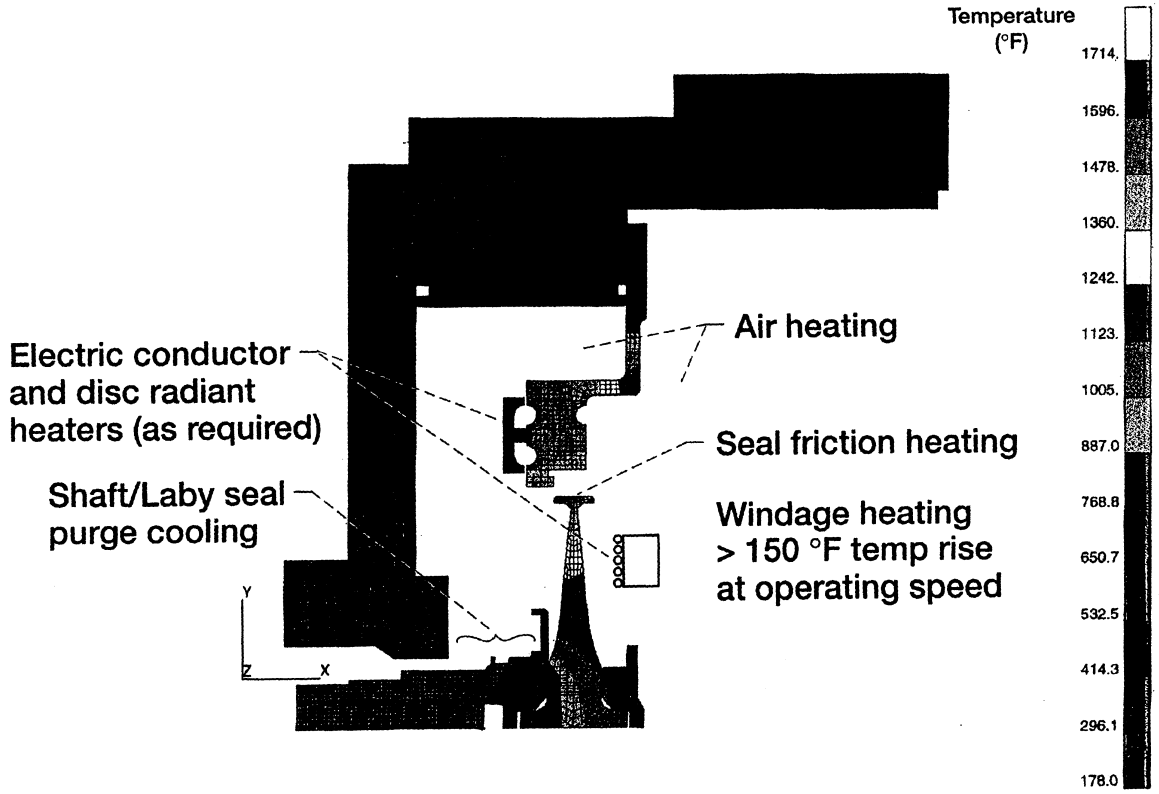
Seal Rig Global Thermal Analysis



Global thermal analysis with windage heating provides input to component stress and displacement analysis

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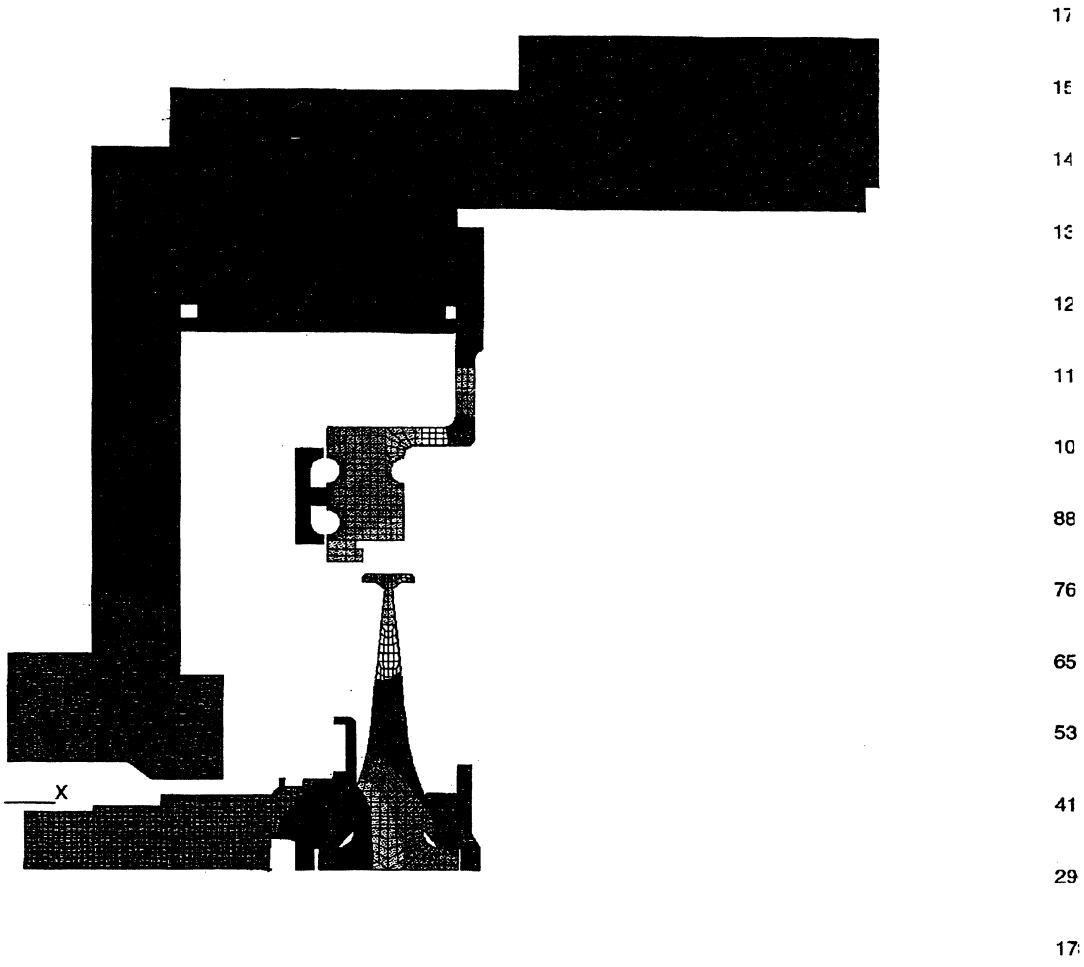
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Test Rig Status

- **Engineering Calculations:** **Complete**
  - **— Rig capable of 1500 +fps/1500 °F operation**
- **Detailed Drawings:** **Complete June, '97**
- **Facility/Test Cell Preparation:** **Ongoing**
  - **— High temperature valves/instrumentation ordered**
- **Complete Rig Fabrication** **4thQ FY98 Est.**
- **Test rig ready for test** **2ndQ FY99 Est.**

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Summary

- Test rig heated by multiple conduction heaters, radiant heater and air heater to overcome significant metal heat loss permitting 1500 °F operation.
- Squeeze film dampers designed to provide smooth operation over operating range.
- MAR M-247 (Ni Co) cast alloy used for rotor and seal holder meet rotor and seal holder creep and LCF life goals.
- Test facility designed to meet anticipated IHPTET, HSR, AST seal test requirements: significant asset for the U.S. engine/seal community.

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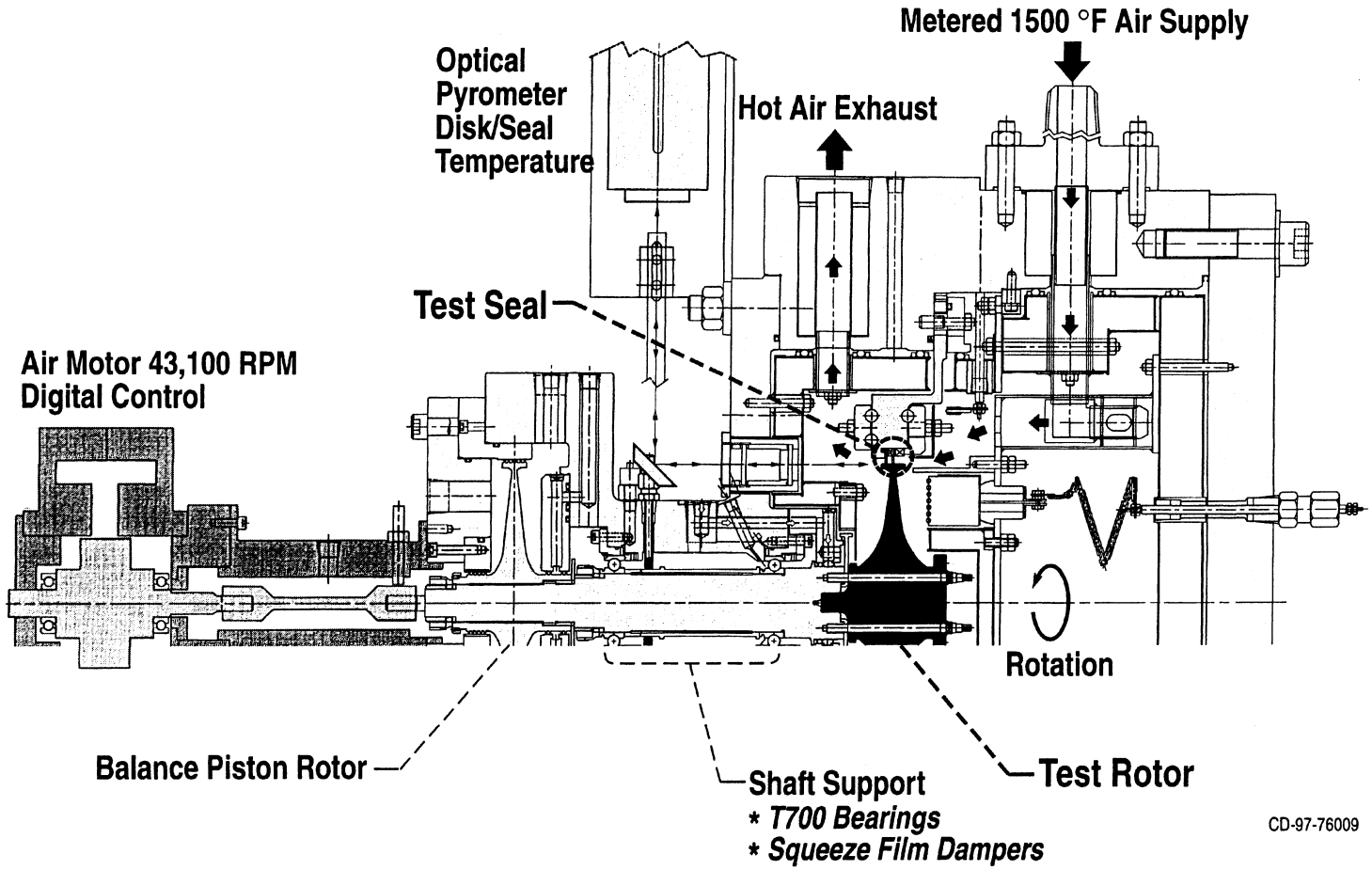
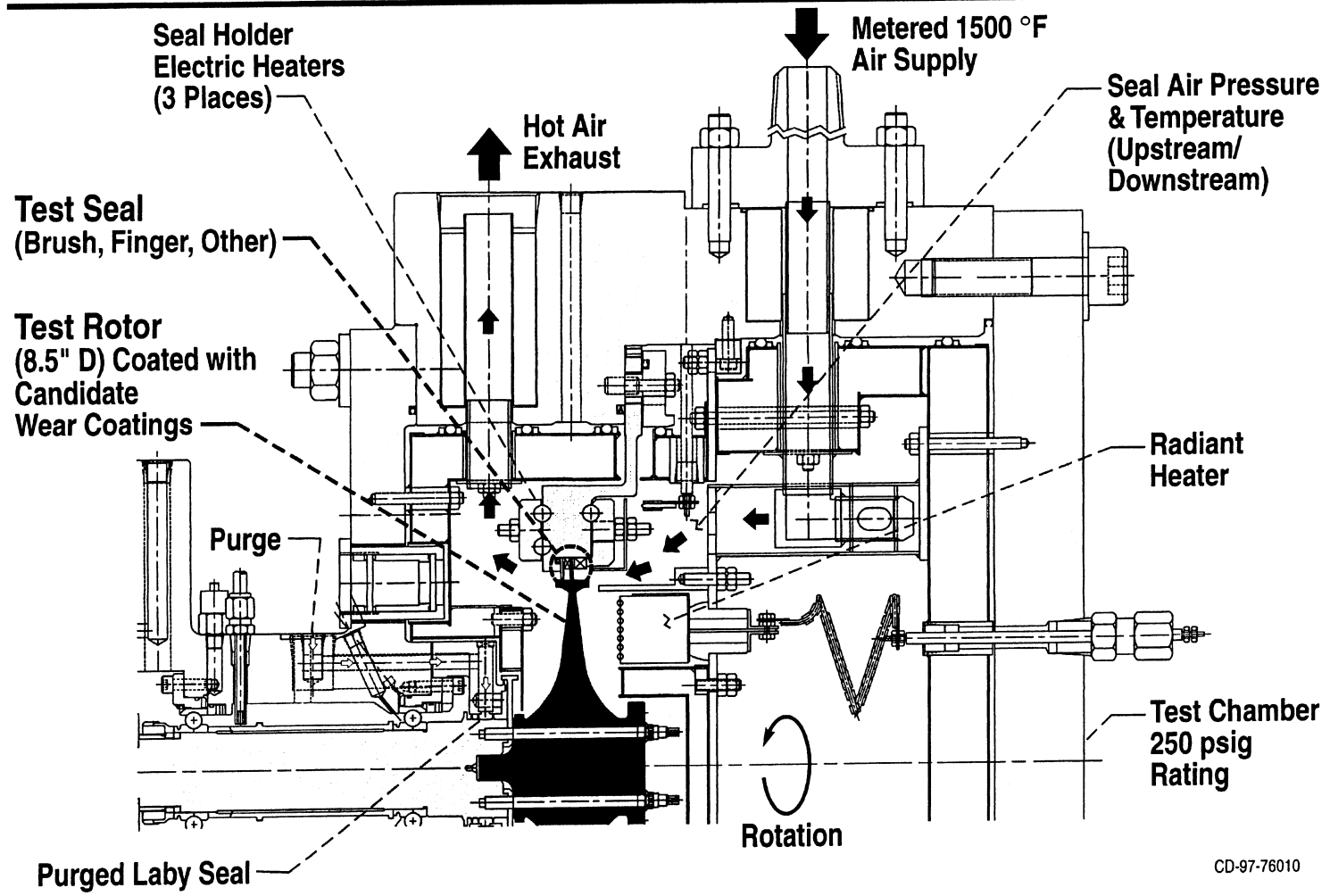
Seal Rig Schematic



Test Chamber Enlarged View



Rig Features Unique Measurement Systems