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LINER ENVIRONMENT EFFECTS STUDY

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Estimation of the heat flux to the combustor liner is a key step in the design of aircraft engine combustion systems. This forms the basis for determining the amount of cooling air and the method of introducing it. Currently, this is largely an empirical effort. Future design constraints such as higher pressures and temperatures, shorter combustor lengths and tolerance to poorer quality fuels, however, accentuate the need for a firmer basis for the heat transfer calculations. In particular, it becomes necessary to account for the radiation contributions from the flame gases (in spectral bands) and soot particles (continuum) over a wide range of combustor operating conditions. Analytical efforts to model the liner heat transfer reflecting the above complexities are hampered by the lack of sufficient experimental data for model verification.

The Liner Environment Effects Study Program described here is designed to address this need. It is aimed at establishing a broad heat transfer data base under controlled experimental conditions by quantifying the effects of the combustion system conditions on the combustor liner thermal loading and on the flame radiation characteristics.

Five liner concepts spanning the spectrum of liner design technology from the very simple to the most advanced concepts will be investigated. These concepts comprise an uncooled liner, a conventional film cooled liner, an impingement/film cooled liner, a laser drilled liner approaching the concept of a porous wall and a siliconized silicon carbide ceramic liner. The liners will be accommodated in a simple test rig housing a three-inch diameter combustor.

Effect of fuel type will be covered by using fuels containing 11.8, 12.8, and 14% hydrogen. Tests at 100, 200, and 300 psia will provide a basis for evaluating the effect of pressure on the heat transfer. The effects of the atomization quality and spray characteristics will be examined by varying the fuel spray Sauter mean diameter and the spray angle. Additional parameters to be varied include reference velocity, a wide range of equivalence ratio, cooling flow rate, coolant temperature and the velocity of the coolant stream on the backside of the liner.

Both spectral and total radiation measurements will be made in addition to obtaining extensive liner metal and film temperature data.

<u>Reference</u>:

Claus, RW: Spectral Flame Radiance from a Tubular-Can Combustor, NASA TP-1722, 1981.

Liner Environment Effects Study Objectives

Establish Broad Data Base on the Effects of Combustion System Environment on Combustor Liner Temperatures and Flame Radiation Characteristics for a Variety of Liner Concepts and Fuel Properties.

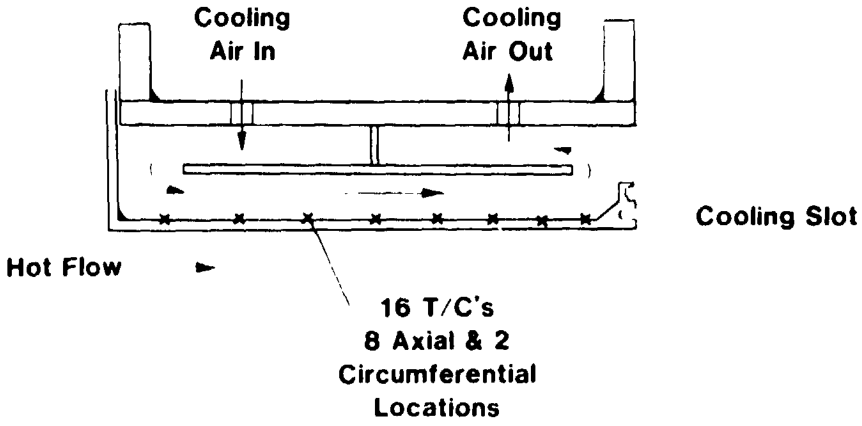
Data Will Provide Basis for

- Detailed Combustor Modeling, and
- Combustor Design

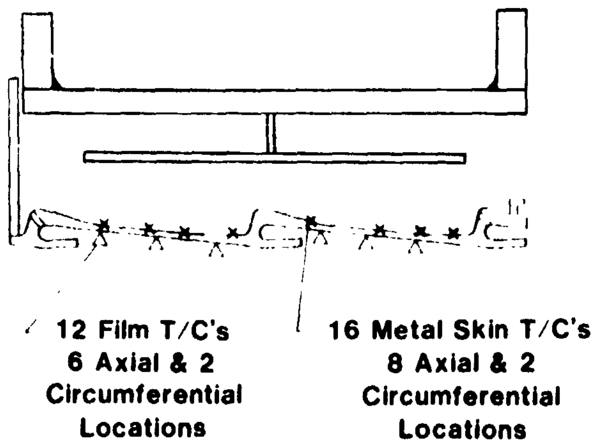
Liner Cooling Designs

- Uncooled
- Film Cooled
- Impingement & Film Cooled
- Ceramic Liner
- Multi-Hole Liner

Uncooled & Convectively Cooled Liner



Film Cooled Liner



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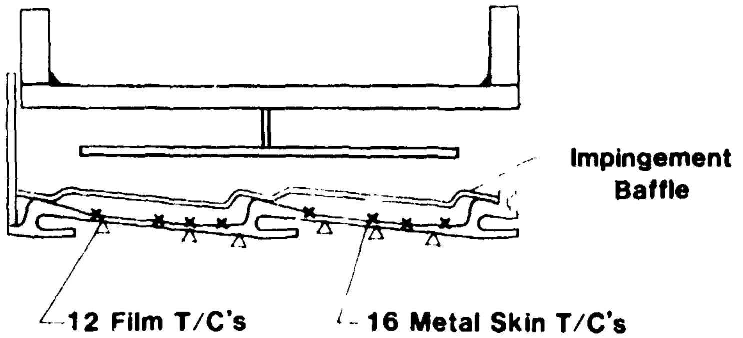
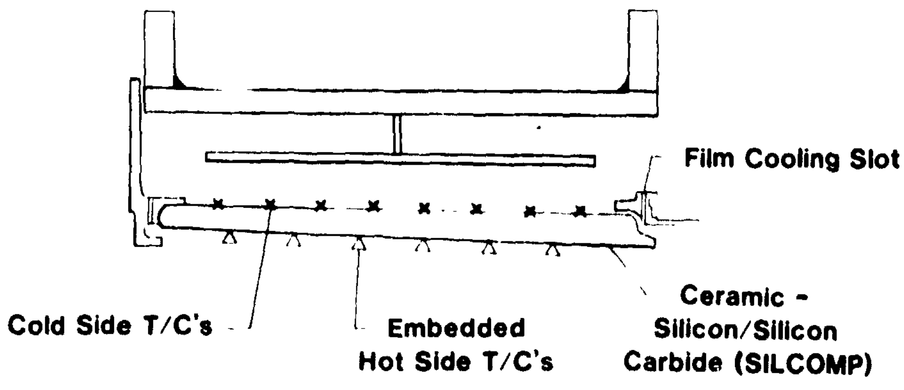
Impingement/Film Cooled Liner



Ceramic Liner



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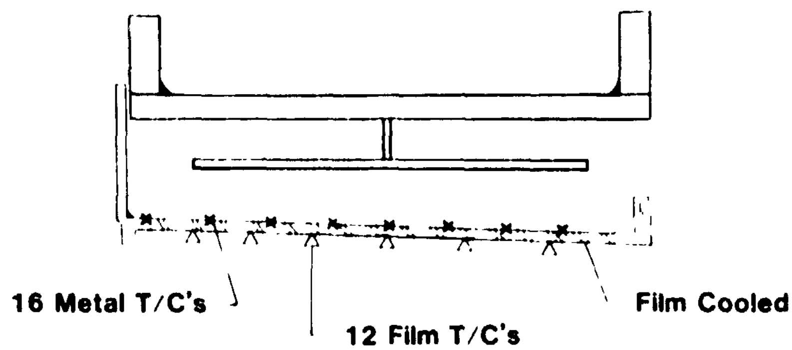
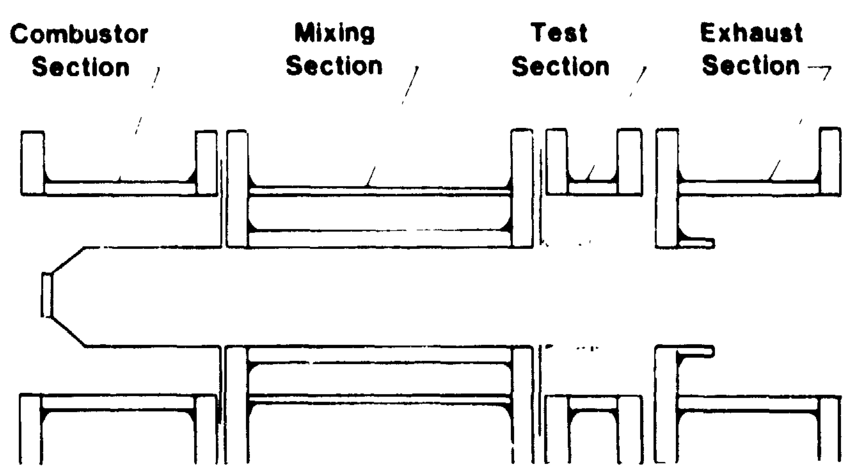
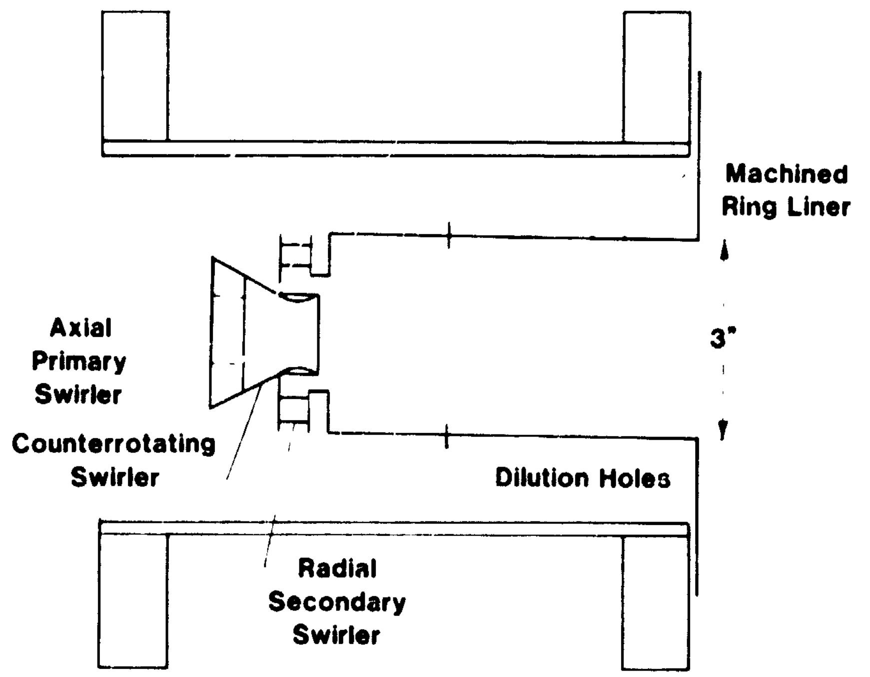
Multi-Hole Liner



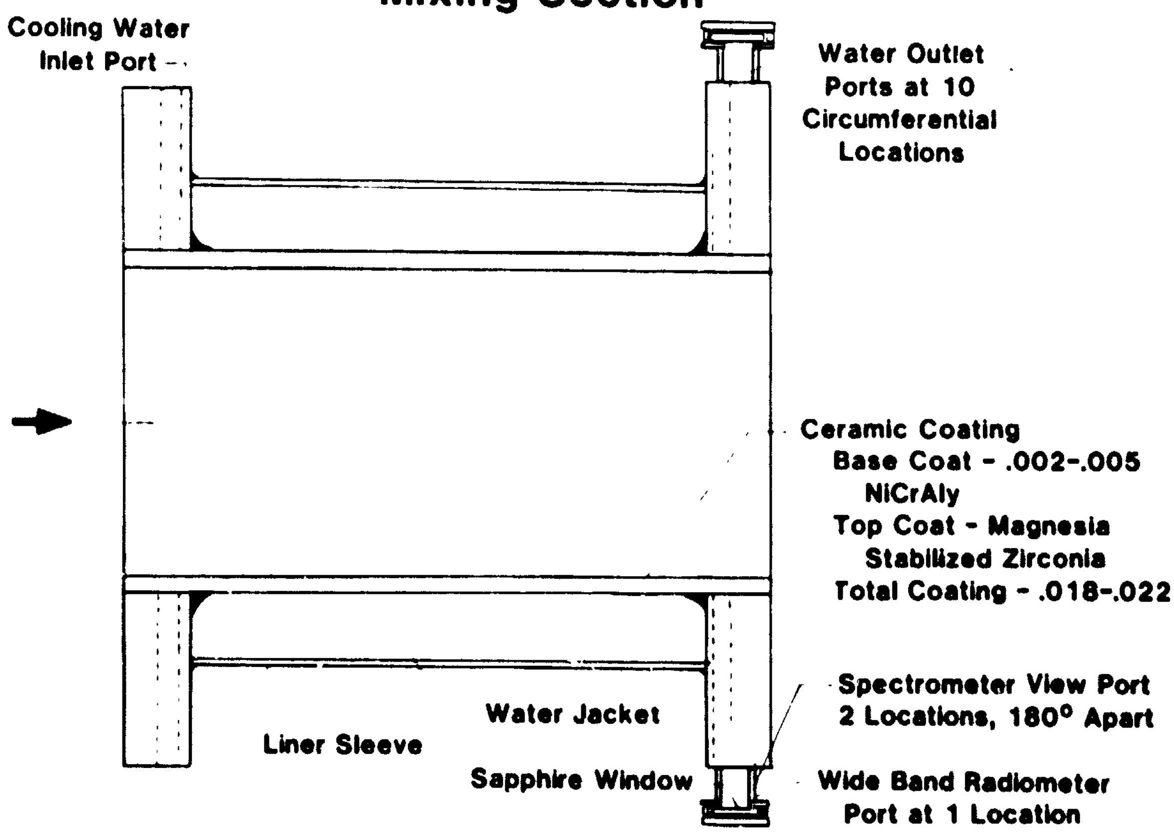
Test Rig Assembly



Combustor Section



Mixing Section



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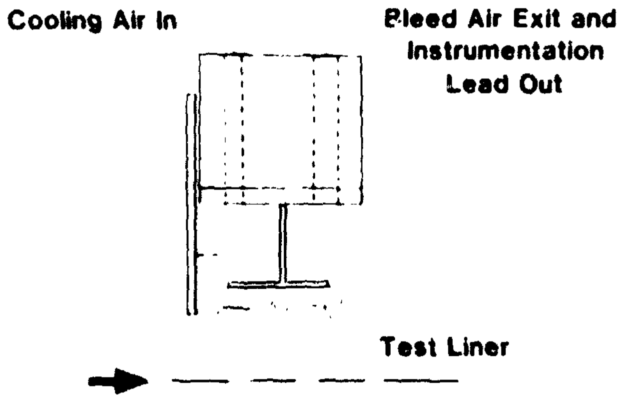
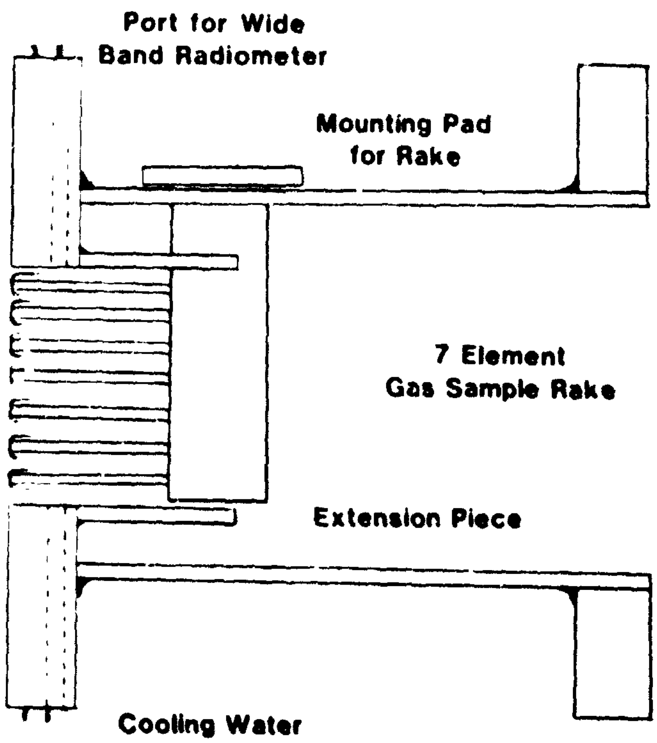
Test Section



Exhaust Section



Test Variables

Parameters	Values
Liner	5 Concepts
Fuel Hydrogen , Wt. %	14.0, 12.8, 11.8
Fuel Nozzle Spray Angle, Deg	45, 100
Fuel Nozzle Spray, Sauter Mean Diameter, Microns	75, 150
Equivalence Ratio	0.3, 0.5, 0.8, 1.2, 1.3
Cooling Flow Rates (at 2.1 MPa), kg/s	0.14, 0.23, 0.32
Cooling Flow Temperature, K	589, 700, 811, 1000
Internal Reference Velocity, m/s	9.1, 18.3, 30.0, 41.0
Bleed Flow Rates(at 2.1 MPa), kg/s	0.18, 0.32, 0.45
Pressure, MPa	0.7, 1.4, 2.1

Test Instrumentation

Temperatures

- Burner Air Inlet
- Cooling Air Inlet
- Bleed Air
- Air Baffle
- Cooling Air Passage
- Liner Metal (16)
- Liner Film (12)

Radiation

- Total (Wide Band) - 2
- Spectral - Infrared Fourier Transform Radiometer

Humidity

- Inlet

Flows

- Burner Air
- Cooling Air
- Bleed Air
- Fuel

Gas Sample

- Exit (7 Element Probe)

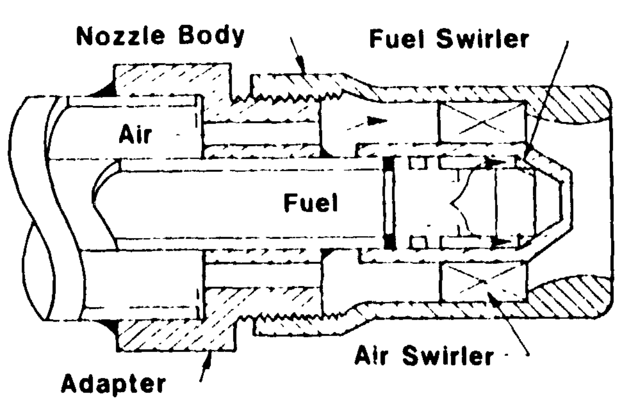
Pressures

- Burner Inlet (Pt and P3)
- Cooling Air Passage
- Inner Impingement Plate
- Exit

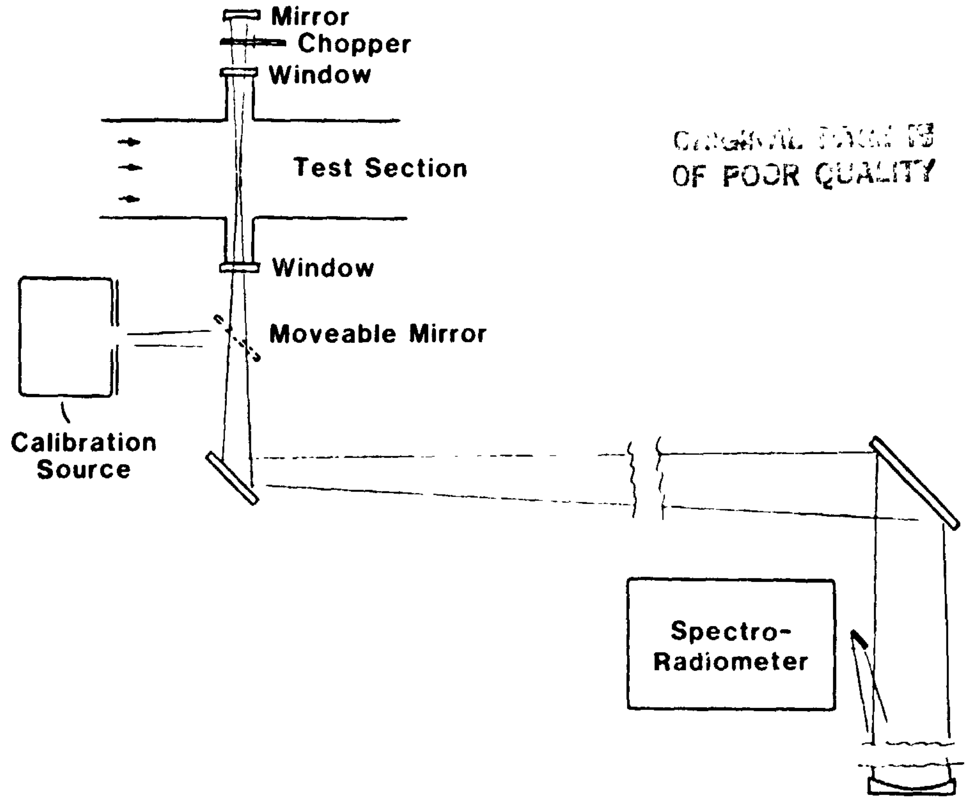
Droplet Size Measurement

- Tests will be Conducted with the In-House Droplet Measurement Devices at 1 atm
- Air-Assist Fuel Nozzle with Several Combinations of Swirlers and Simplex Tips
- Establish Air Flow Requirements to Achieve Desired SMD's - Operational Considerations Likely to Require Compromise

Air-Assist Fuel Nozzle



Spectral Radiation Measurement Scheme



Control and Data Aquisition Spectral Radiation Measurements