National Aeronautics and Space Administration

W-8 Acoustic Casing Treatment Test Overview

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NASA Advanced Air Vehicles Program
Advanced Air Transport Technology Project
Aircraft Noise Reduction Subproject

Outline

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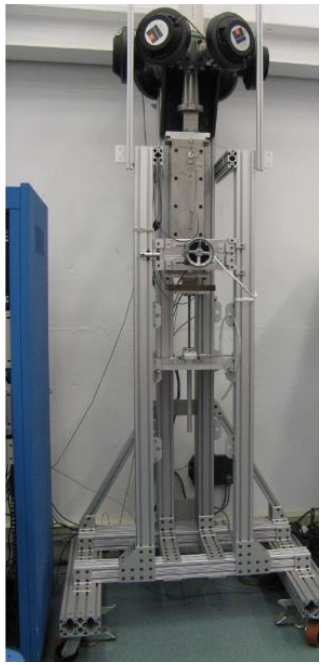
- Summary

Acoustic Casing Treatment Development

Overall Objective: To improve upon acoustic and aerodynamic performance acoustic casing treatments by further understanding their impact in the over-the-rotor environment and incorporating lessons learned from previous tests.

NIT

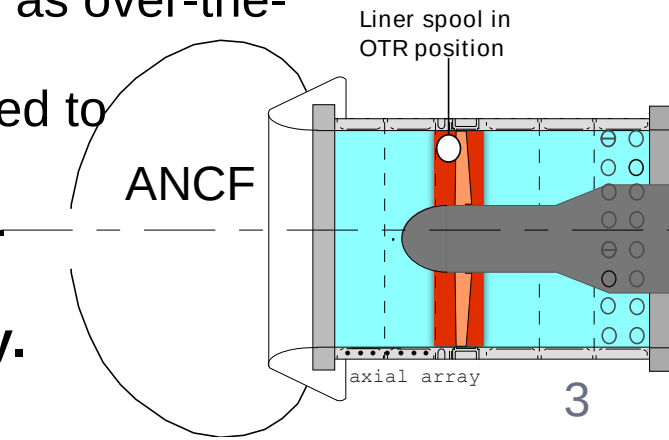


2015: Normal Incidence Tube (NIT) Test

- Traditional impedance measurements to determine liner performance.
- Liner performance with varying sound levels to understand how they scale to sound levels in the over-the-rotor environment.

2016: Advanced Noise Control Fan (ANCF) Test

- Evaluate the acoustic performance of 4 over-the-rotor liners
- Evaluation of the liners installed in the inlet as well as over-the-rotor.
- Both in-duct and far-field microphones were be used to evaluate the acoustic performance.
- Results will be presented at AIAA Aviation in June.



Same treatment geometries tested in each facility.

2017: W-8 Acoustic Casing Treatment Test

Test Objective: to evaluate the potential benefits of acoustic casing treatments installed over a high bypass turbofan rotor at TRL 3.

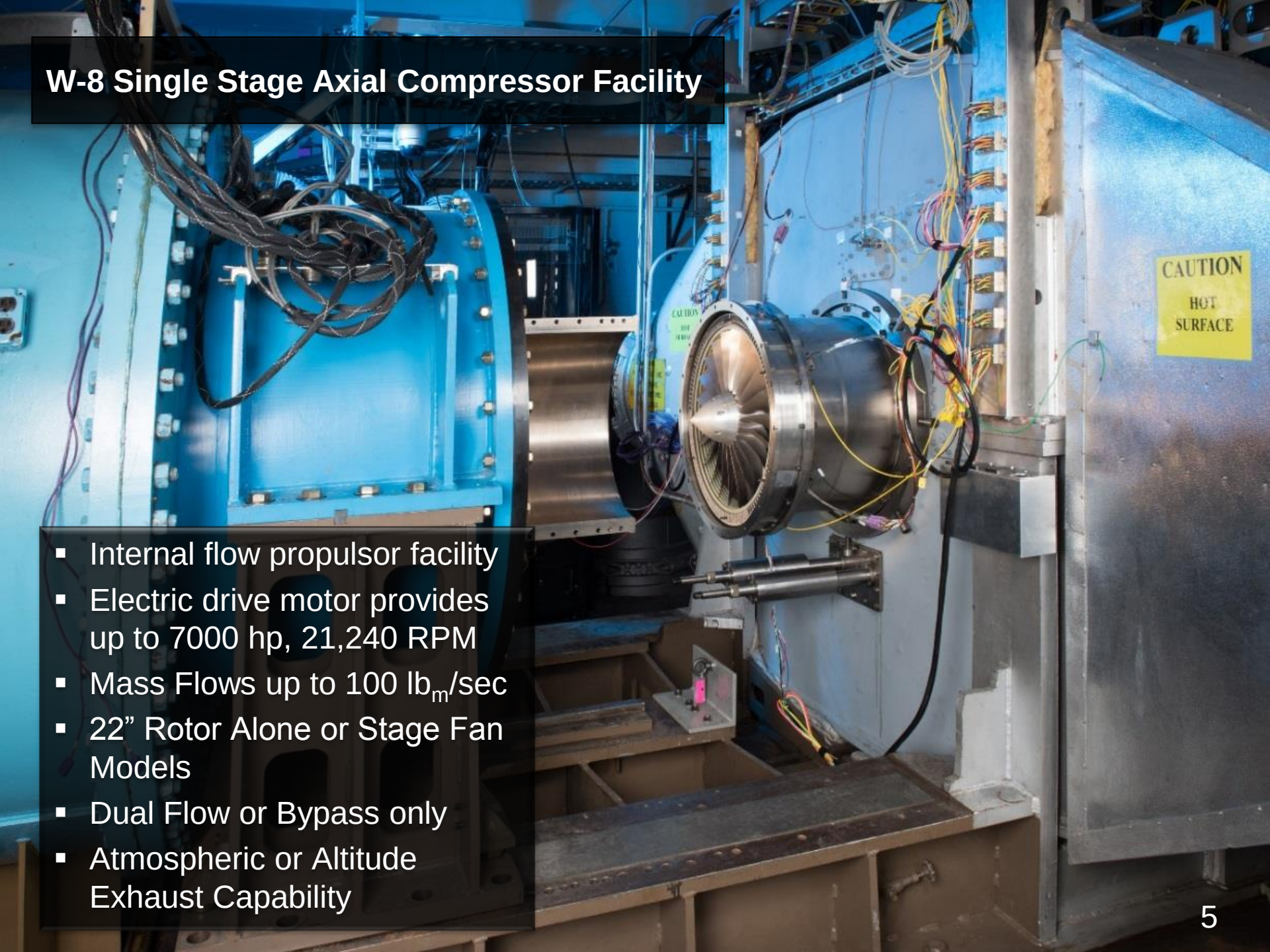
Test Data Acquired:

- Steady Fan Exit Measurements (pressure/temperature)
- Unsteady Fan Exit measurements (hotfilm)
- Inlet In-duct Acoustic Array Measurements

Data Analysis in Progress

- Overall Acoustic Performance
- Overall Aerodynamic Performance

W-8 Single Stage Axial Compressor Facility



- Internal flow propulsor facility
- Electric drive motor provides up to 7000 hp, 21,240 RPM
- Mass Flows up to 100 lb_m/sec
- 22” Rotor Alone or Stage Fan Models
- Dual Flow or Bypass only
- Atmospheric or Altitude Exhaust Capability

SDT/R4 Hardware

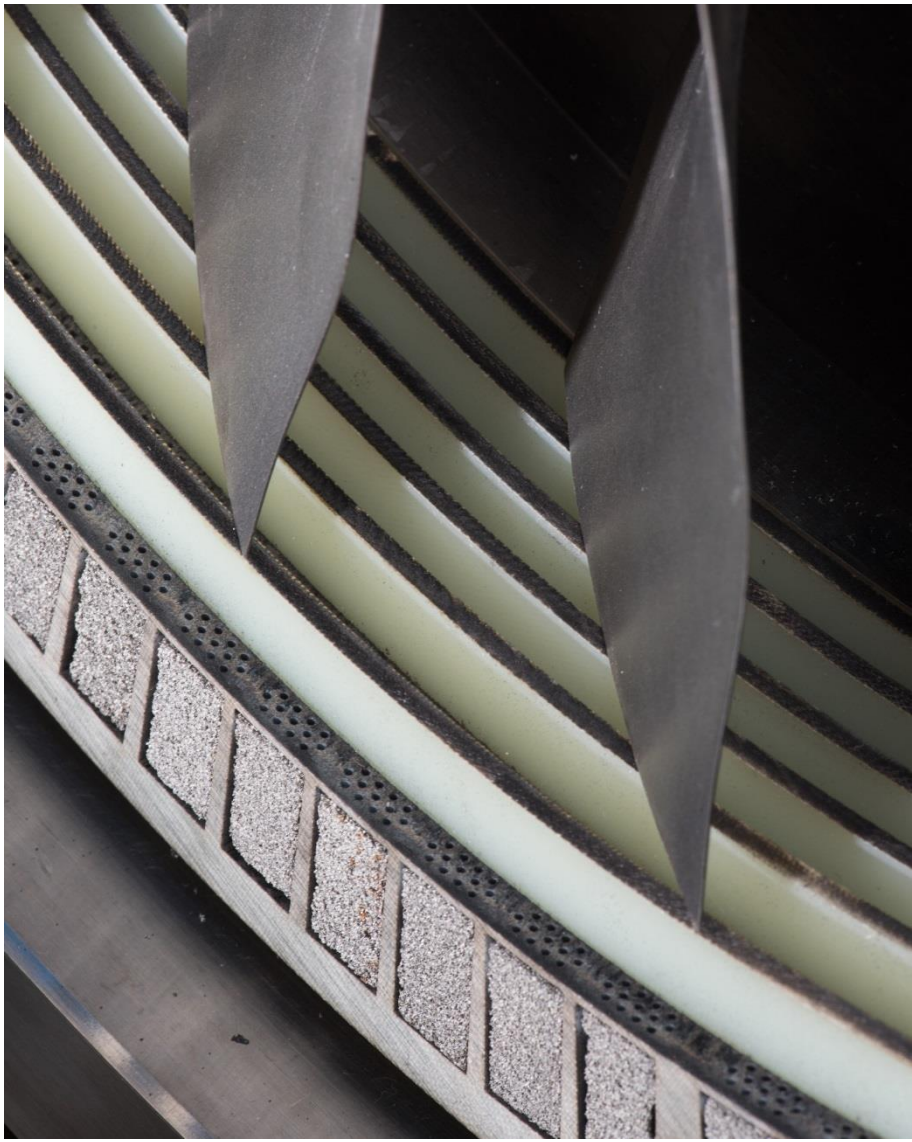
- The Source Diagnostic Test hardware was tested in a rotor alone configuration in the 9x15 wind tunnel[1] and the W-8 Single Stage Axial Compressor Facility[2] in the early 2000's

Parameter	Value
No. of Fan Blades	22
Fan Tip Diameter	22 in. (0.56m)
Hub/tip Ratio	0.30
Corrected Tip Speed	1215 ft/s (370 m/s)
Fan Design Speed, corrected rpm	12,657
Fan Design Pressure Ratio	1.50

[1]Hughes, Christopher E., Jeracki, Robert J., and Miller, Christopher J., "Fan Noise Source Diagnostic Test – Rotor Alone Aerodynamic Performance Results," AIAA 2002-2426 or NASA TM 2005-211681.
[2]Van Zante, Dale E., Podboy, Gary G., Miller, Christopher J., Thorp, Scott A., "Testing and Performance Verification of a High Bypass Ratio Turbofan Rotor in an Internal Flow Component Test Facility," GT2007-27246.

Fan Case Configurations

1. Hardwall
2. Groove Only
3. Empty Chamber
4. Thick Perforate
5. Foam Metal
6. Expansion Chamber



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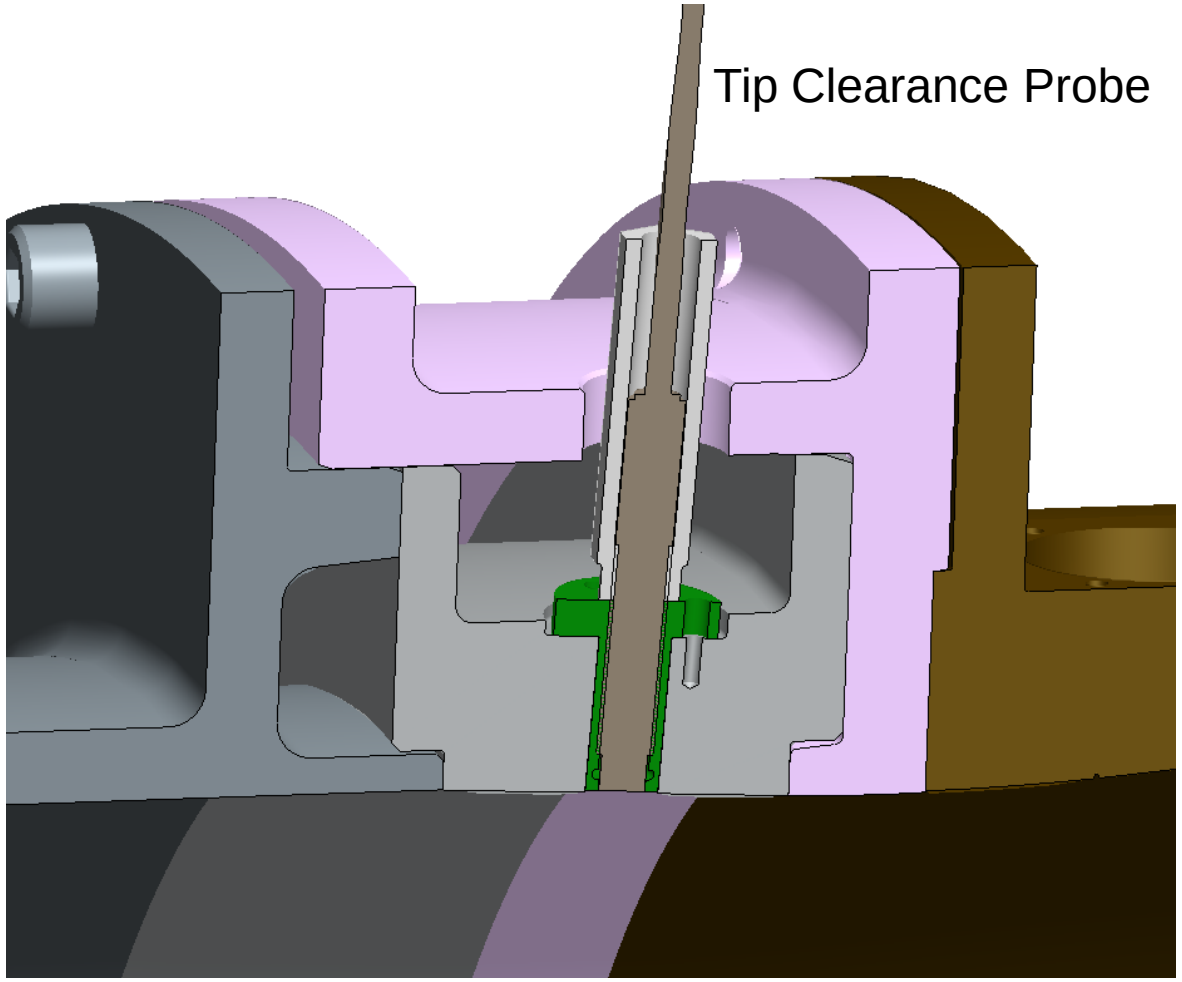

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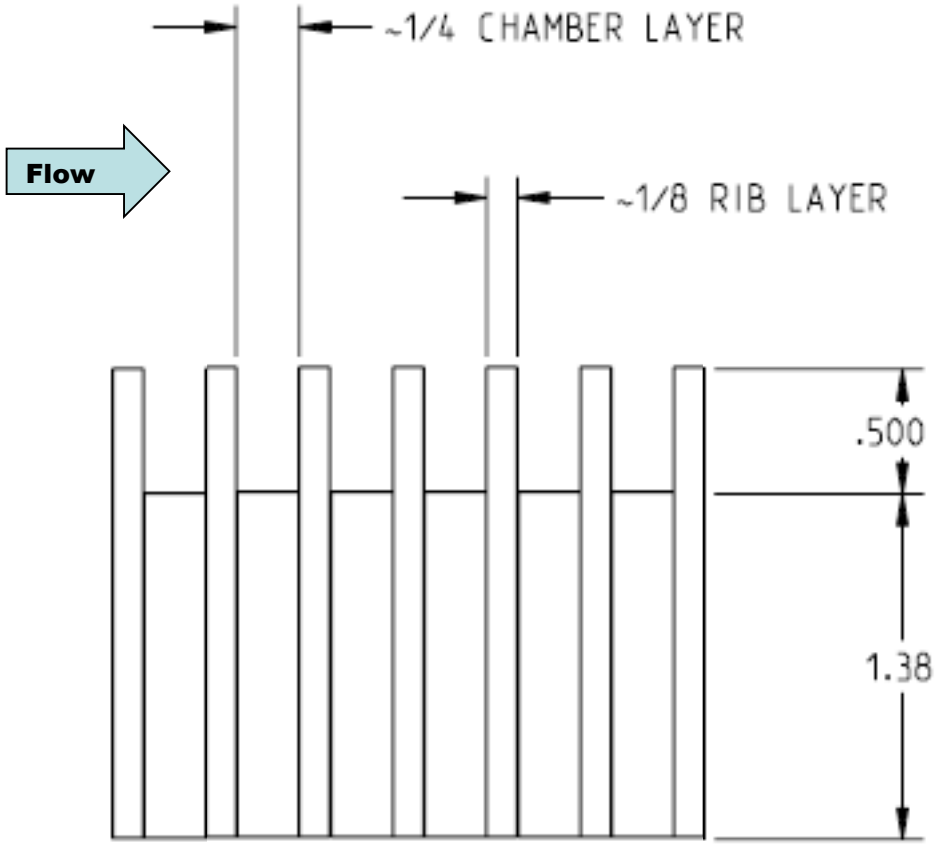

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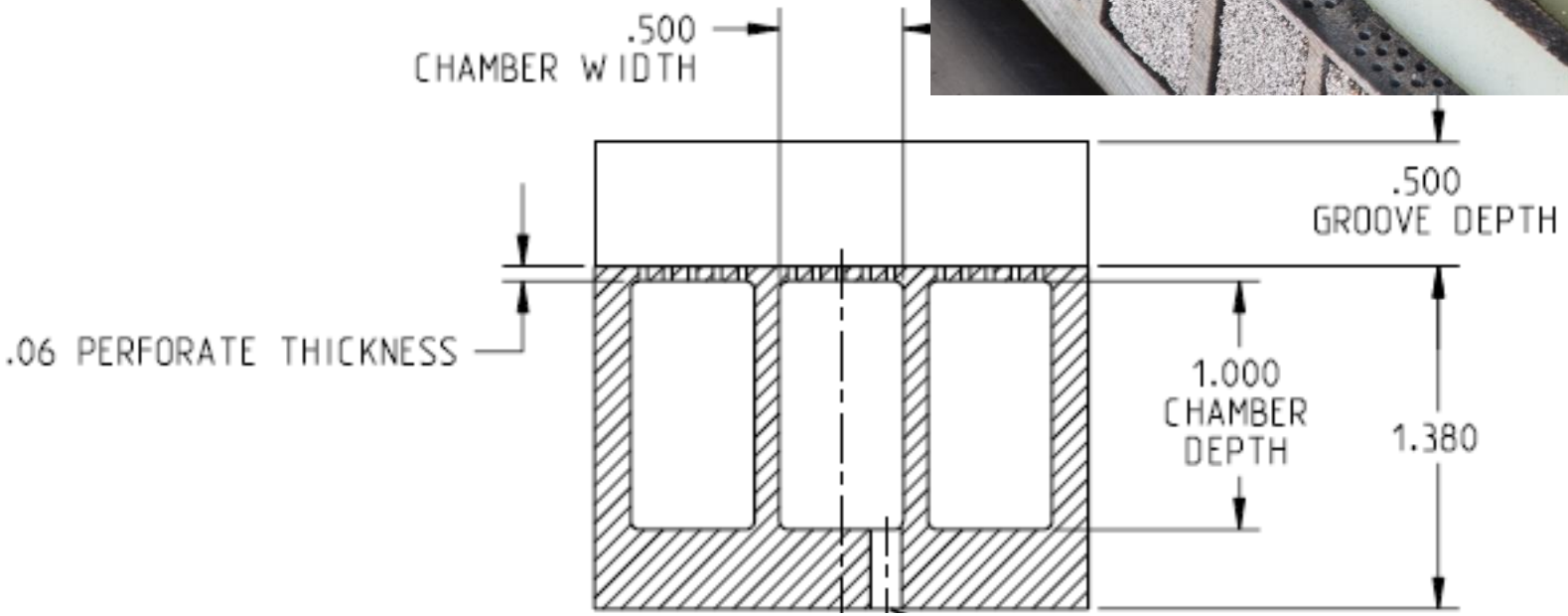

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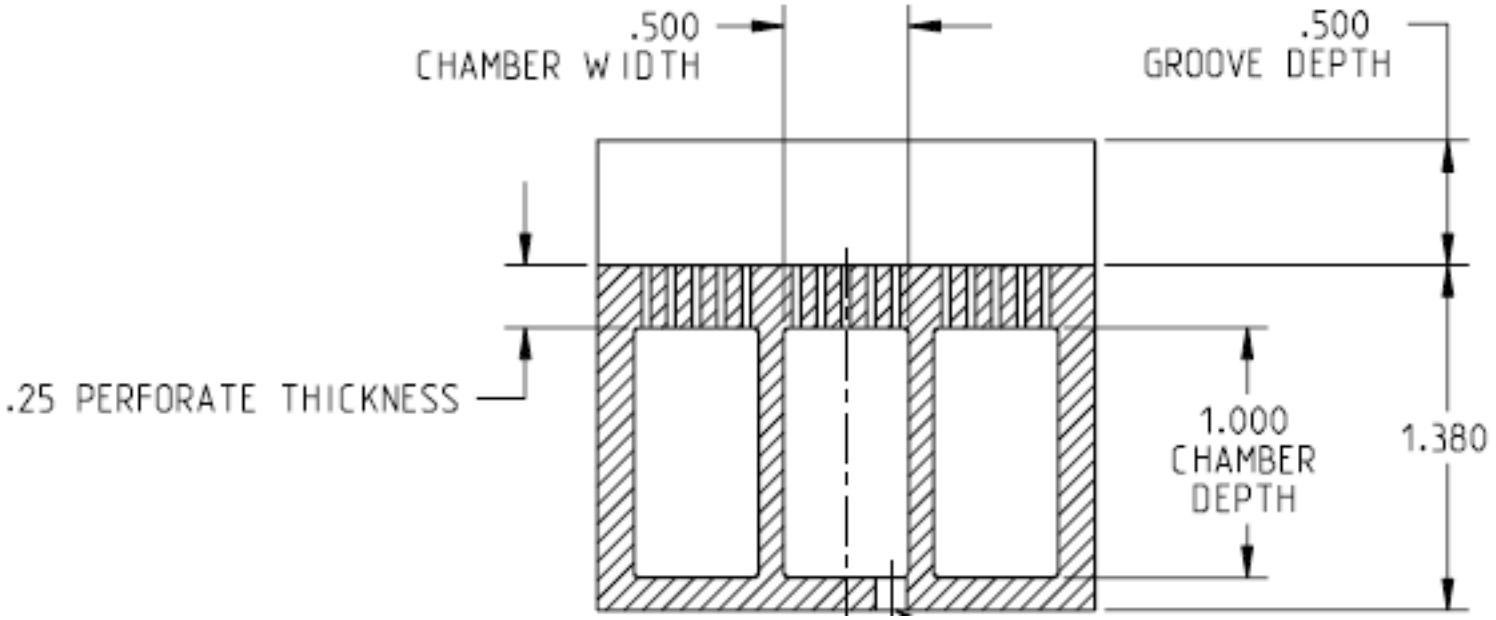

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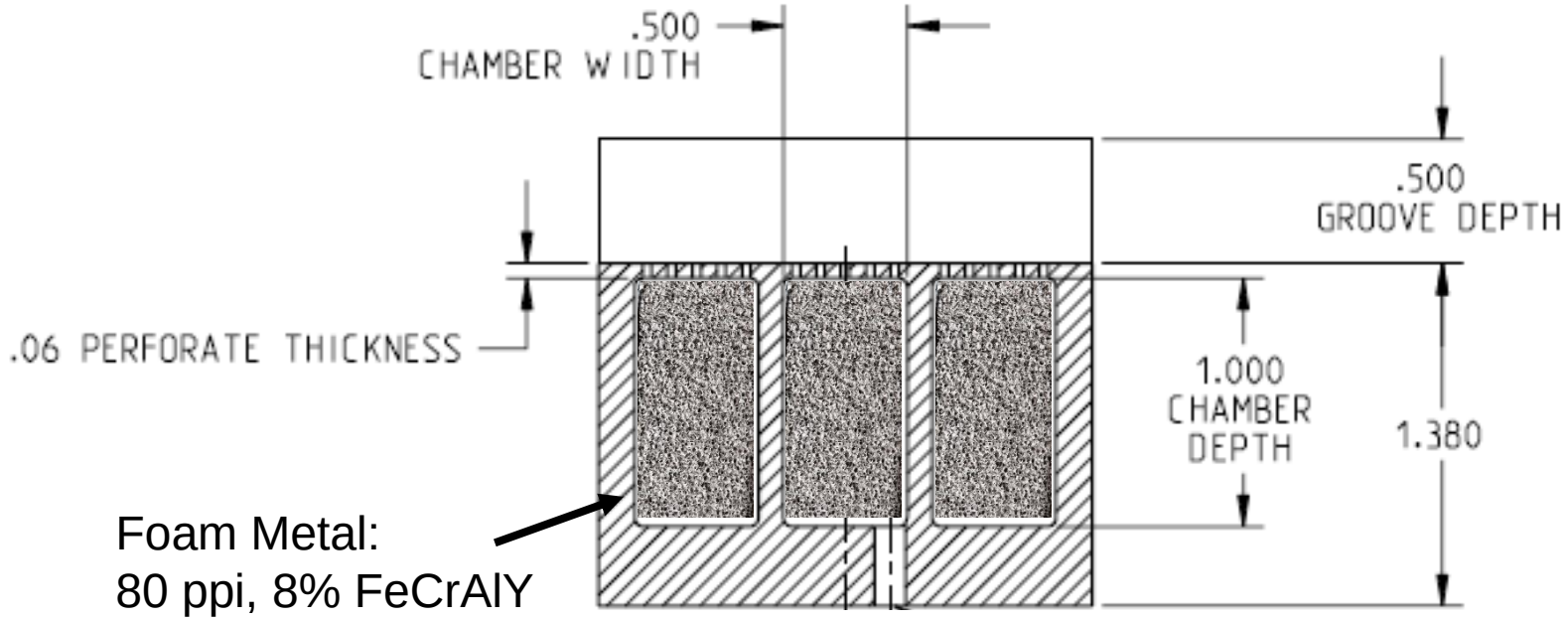

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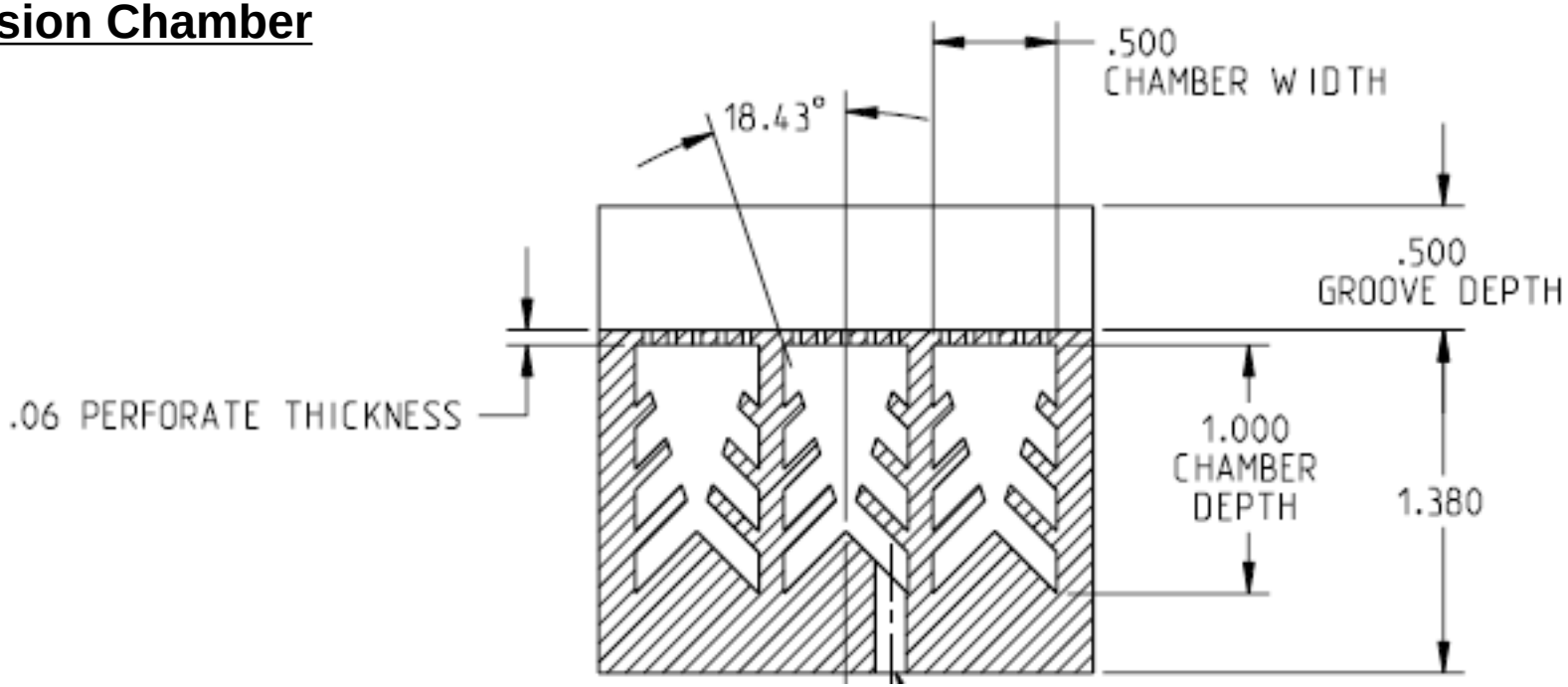


Test Summary and Test Conditions

Steady Aerodynamic Measurements

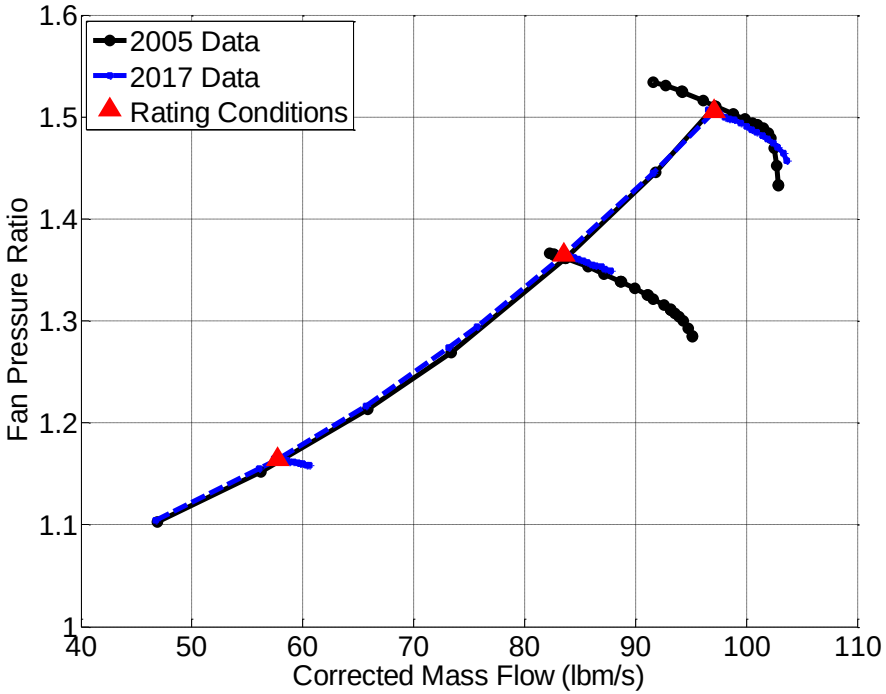
- Fan exit rake measurements on the nominal operating line and speed lines at rating conditions.
- Fan exit pressure-temperature probe surveys at the rating conditions

Unsteady Aerodynamic Measurements

- Fan exit hofilm surveys at the rating conditions

Acoustic Measurements

- Fan exit rakes removed to provide a ‘clean’ acoustic configuration.
- Inlet In-duct Array acoustic measurements on the nominal operating line and speed lines at rating conditions.



Rating Condition	% Design Speed	Corrected Mass Flow
Approach	61.7%	57.8 lb/s
Cutback	87.5%	83.7 lb/s
Takeoff	100%	97.2 lb/s

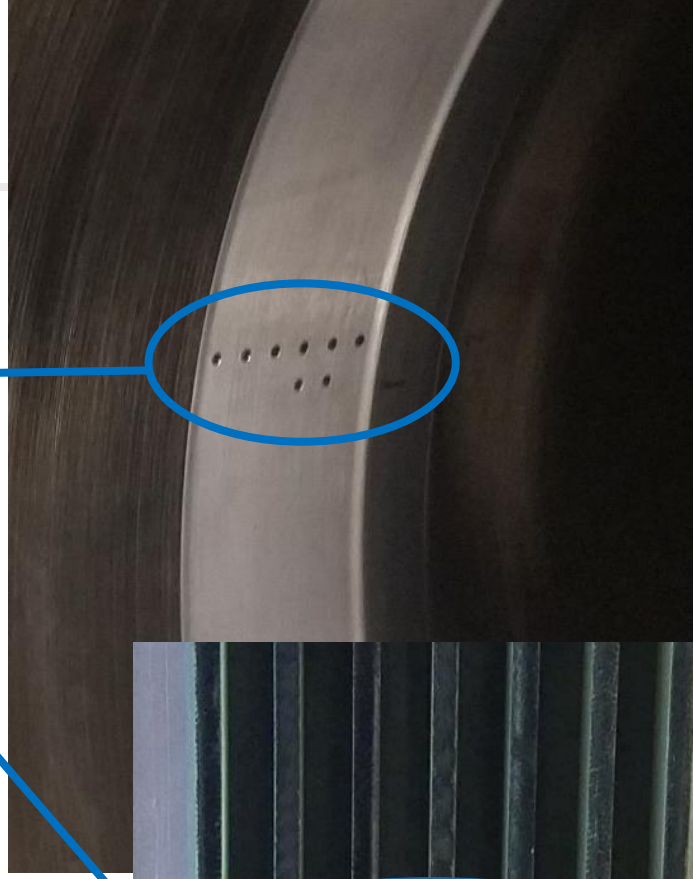
Aerodynamic Performance Instrumentation

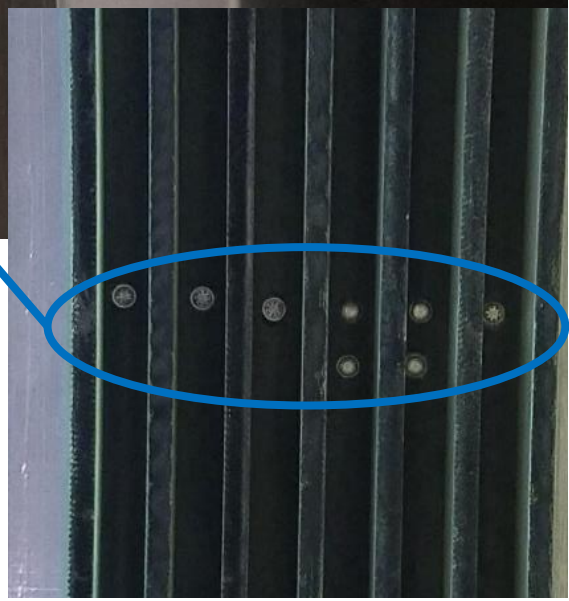
Pressure-Temperature Detailed Surveys
Hotfilm Surveys

3x7 element Pressure Rakes
3x7 element Temperature Rakes

Casing Treatment Instrumentation

8-Over-the-Rotor Kulites® in the Baseline and Circumferentially Grooved Fan Cases

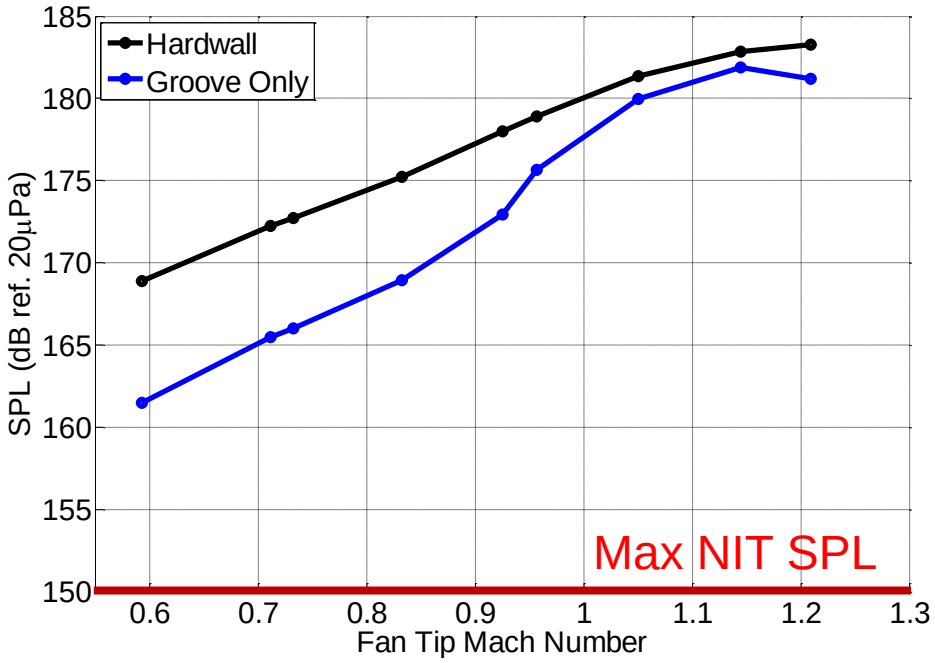




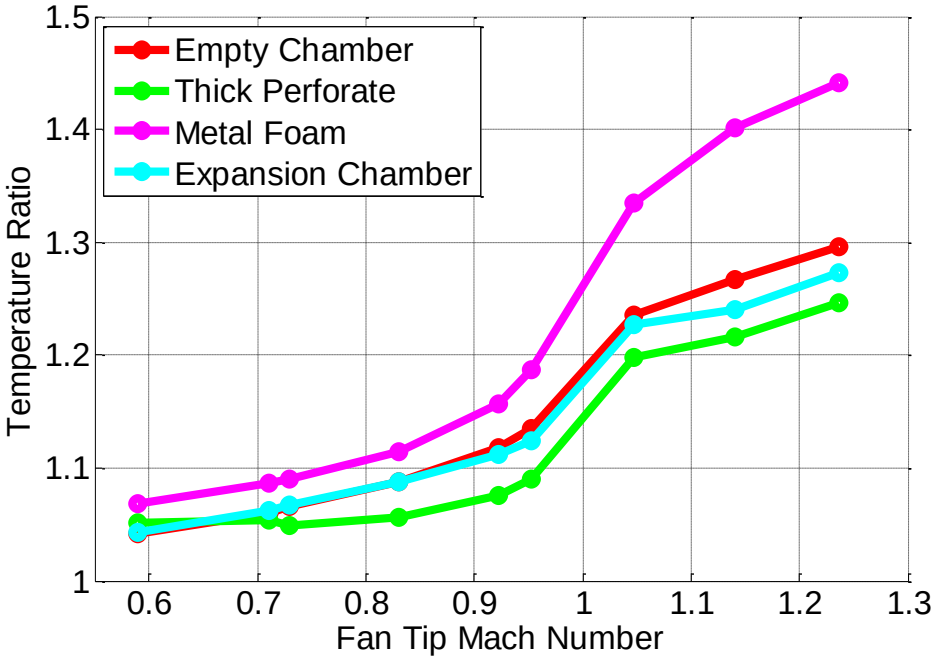
6-Surface thermocouples in each axial row of treatment in each of the 4 treated fan cases

Over-the-Rotor Environment

Dynamic Pressure Level at the Fan Leading Edge

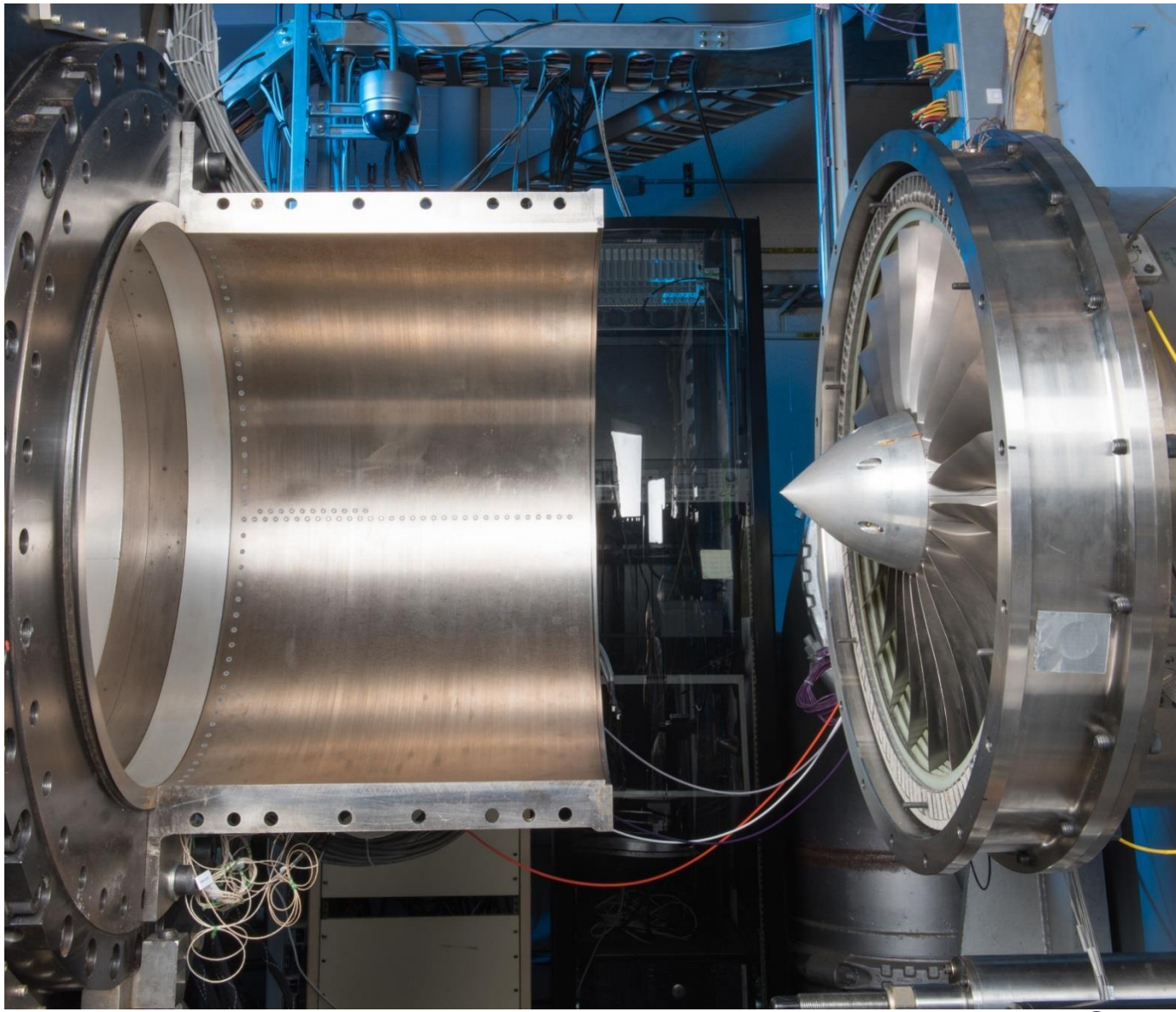


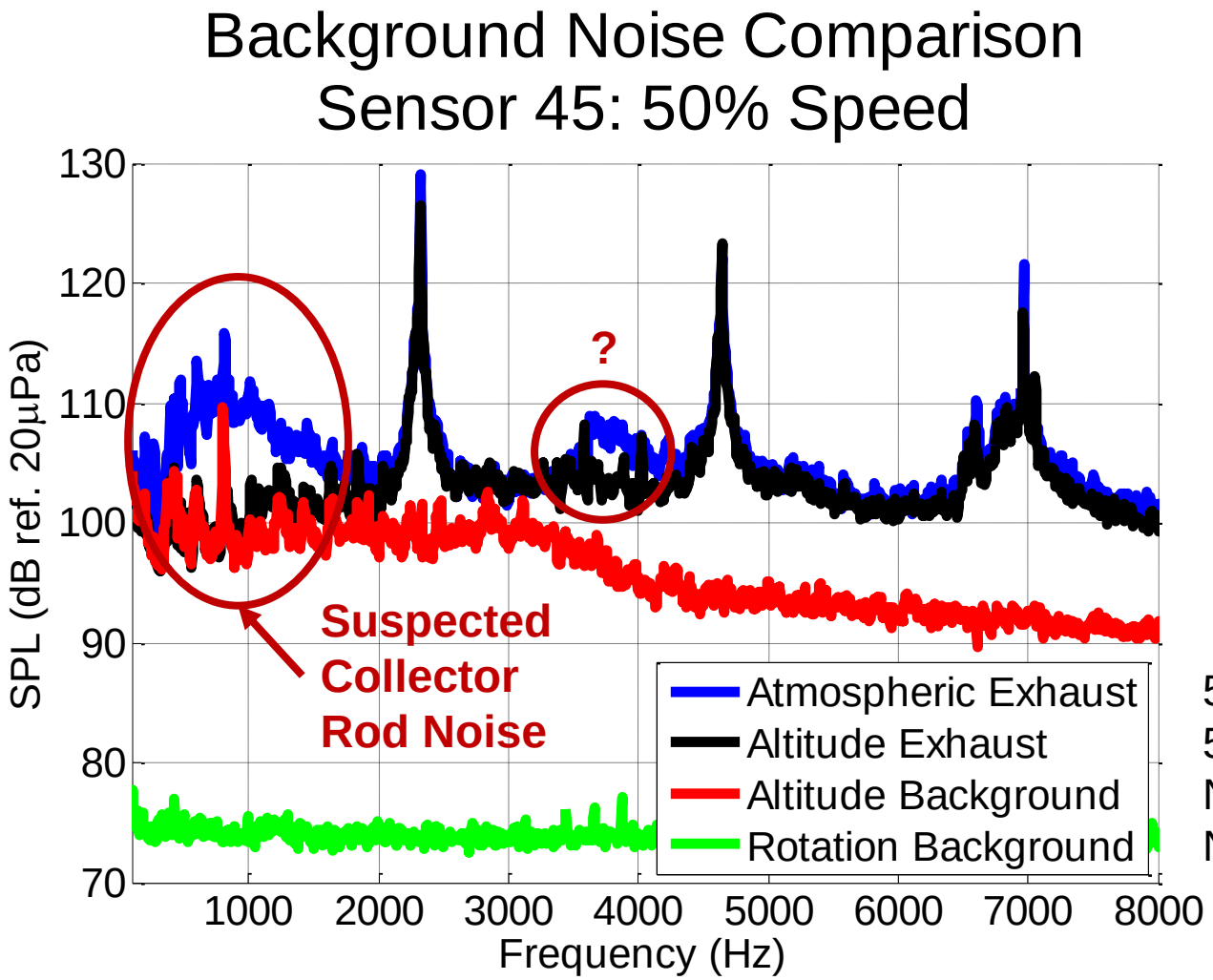
Temperature within the Treatment at the Fan Leading Edge



Inlet In-duct Array Instrumentation

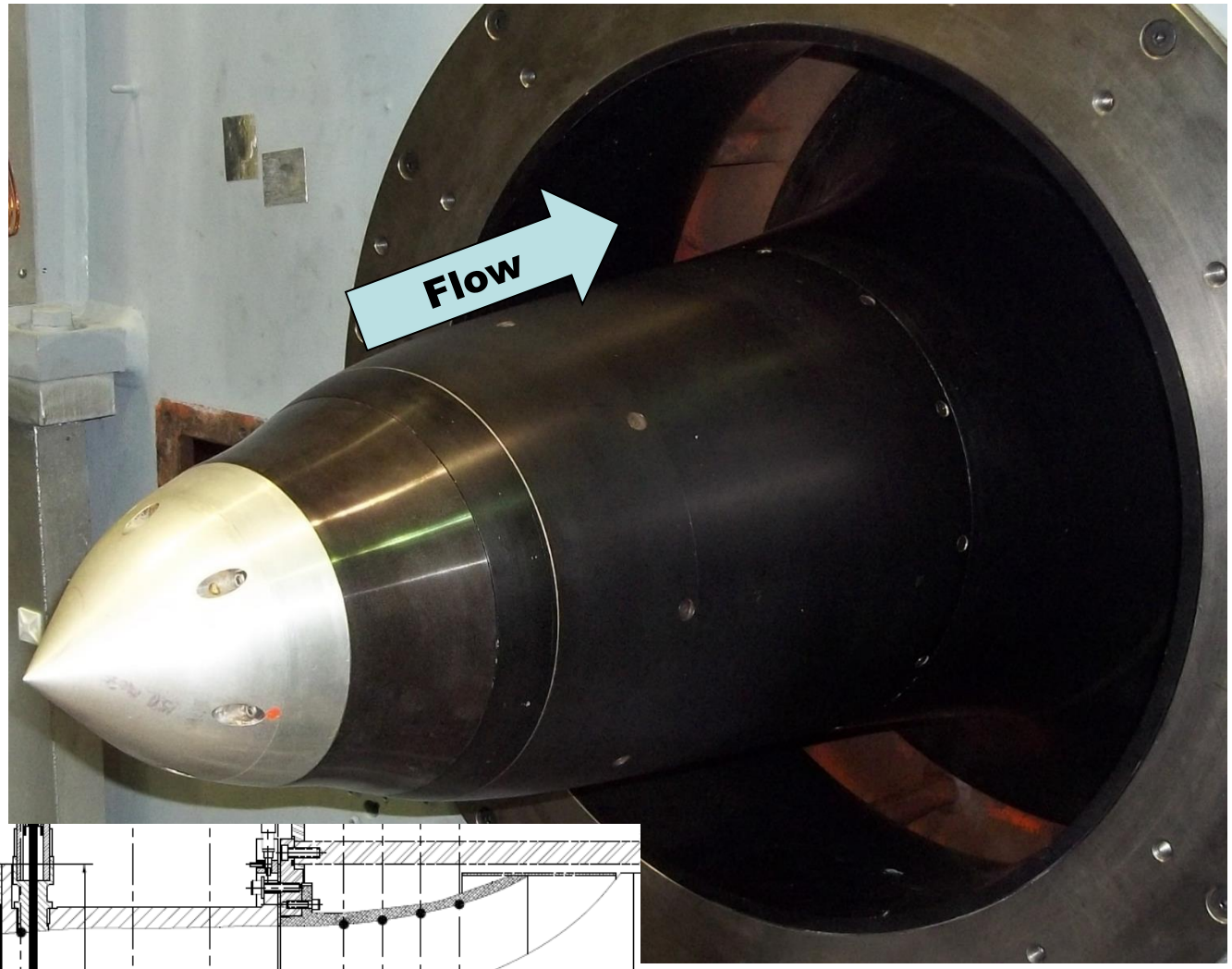
- 22-inch constant area inlet duct
- 85 sensors
  - Kulite® 25PSIA
  - Installed into nylon inserts
- T-Array
  - ½ Circle
  - Long Axial
  - Staggered Short Axial

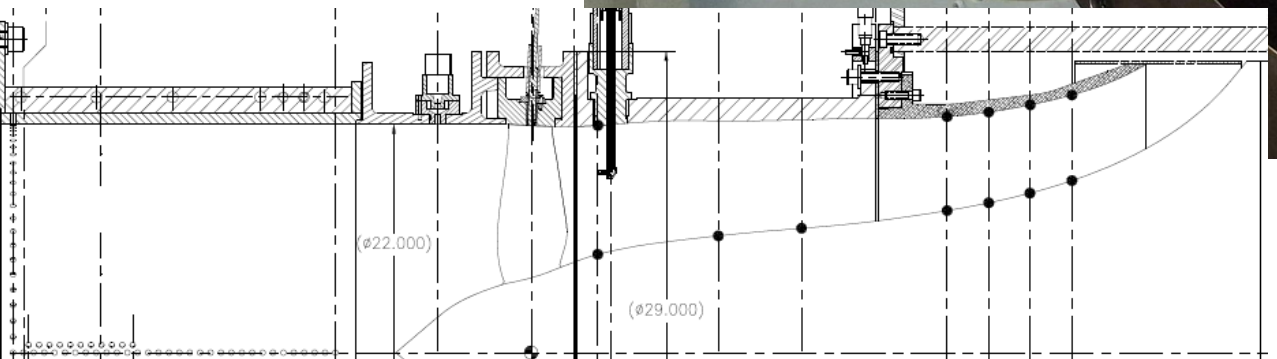




50%: $M_{exhaust}$ = 0.46
50%: $M_{exhaust}$ = 1.39
No fan: Clean Flow
No fan: No Flow

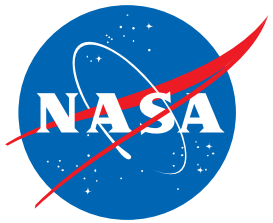
W-8 Exhaust





Summary

- In January and February 2017, aerodynamic performance and acoustic measurements were made to evaluate the potential benefits of acoustic casing treatments installed over a high bypass turbofan rotor.
- Data analysis is in progress to determine the impact of the treatments on the fan exit steady and unsteady flow-field and acoustic performance.
- Over-the-Rotor Environment:
  - The 0.5” groove depth reduces the incident pressure field on an acoustic treatment by up to 6dB.
  - Pressures over-the-rotor are significantly higher than simulated in the Normal Incidence Tube (LaRC).
  - Temperatures can be a concern at sonic fan tip Mach numbers.
- W-8 Background Noise:
  - Gearbox/Bearing/Drive Motor noise is not an issue.
  - Flow background noise is potentially an issue under 1kHz.
  - Low frequency exhaust noise is potentially an issue when atmospheric exhaust is used.
- NASA/TM-2017-219489 “Inlet Acoustic Data from a High Bypass Ratio Turbofan Rotor in an Internal Flow Component Test Facility”
  - Contains in-duct array data with the hardwall fan case for the development of array processing techniques and comparison to 9x15 far-field data.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