Section 11

Microgravity Emissions Laboratory Facility Overview

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Microgravity Emissions Laboratory (MEL) Facility Overview

- The acceleration emissions generated by various operating components of the ISS, if too large, could hinder the science performed on ISS by disturbing the microgravity environment.

- In June of 2002, the International Space Station (ISS) Program approved a Preliminary/Proposed Interface Revision Notice (PIRN)-110H microgravity allocation plan to be incorporated into the Space Station Program (SSP)-57000 payload integration requirements document. This change formally established microgravity requirements for ISS payloads and defines the rack acceleration and force limit conditions conducive for microgravity experiment operations. These requirements will apply to all NASA developed payloads and to any International Partner (IP) developed payloads that will be located in the United States Laboratory (USL). The duration, low frequency vibrational and transient nature of the acceleration environment is defined in these requirements. Hardware, which will remain on-orbit after Utilization Flight 3 (UF-3), will need to be verified to the vibratory requirements prior to launch.

- These levels are typically 1.0E-2 to 1.0E-6 times the normal 1-g environment of the Earth's gravitational acceleration level.

Microgravity Emissions Laboratory (MEL) Facility Overview

- A special test facility is required for such tests to be conducted in an environment, which isolates effects from the surrounding dynamic influences and has instrumentation of sufficient precision and accuracy for the measurements. Such a facility has been engineered, test calibrated and utilized at the NASA Glenn Research Center (GRC) in Cleveland, Ohio. The Microgravity Emissions Laboratory (MEL) was developed for the characterization, simulation, and verification of the ISS microgravity environment. Over 30 tests have been conducted since November 1999.

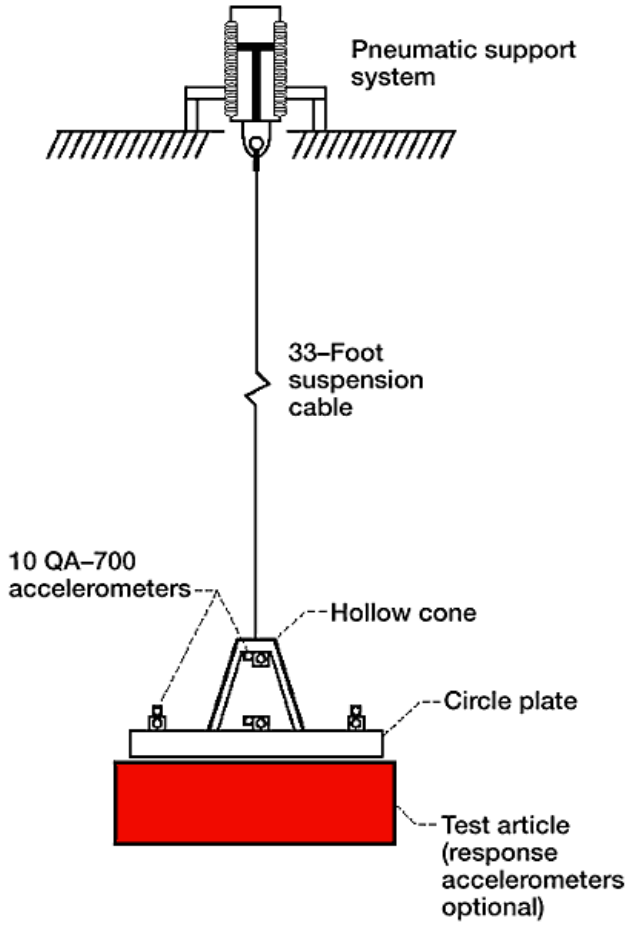
- Typical test components have included operating disk drives, pumps, motors, solenoids, fans, and cameras. Other MEL test articles have included spacecraft onboard electric power systems, optical measurement systems, and crystal growth experiment assemblies.

- The MEL laboratory uses a pendulous system to obtain operating equipment inertial acceleration and mass property measurements. Inertial forcing functions at the center of gravity of the test unit are obtained through post processing of MEL test data with the mass properties of the test setup. Applying the 6 degree-of-freedom (DOF) forces and moments to Finite Elements Analysis (FEM) and Statistical Energy Analysis (SEA) models allow payload developers a way of evaluating test component compliance to ISS microgravity requirements.

Microgravity Emissions Laboratory (MEL) Facility Overview

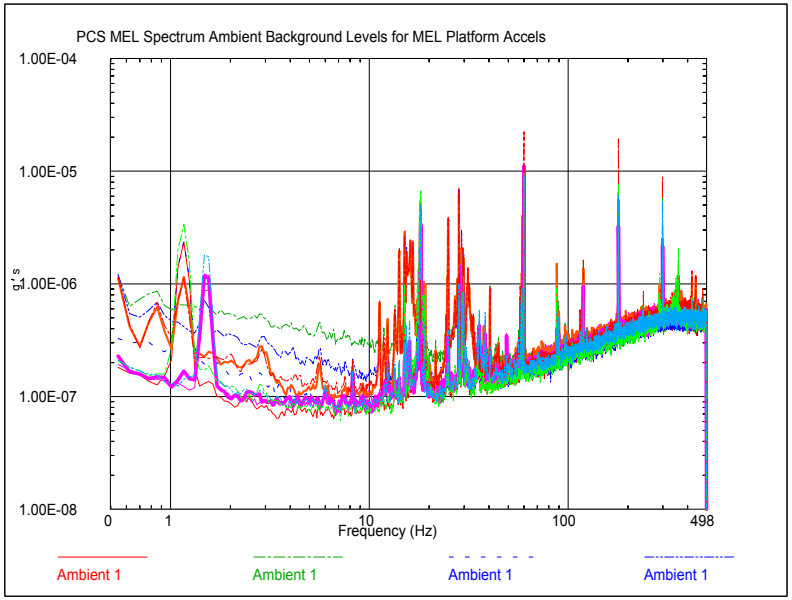
- Pendulous based system developed at NASA to simulate and characterize the ISS on-orbit microgravity environment through ground based testing

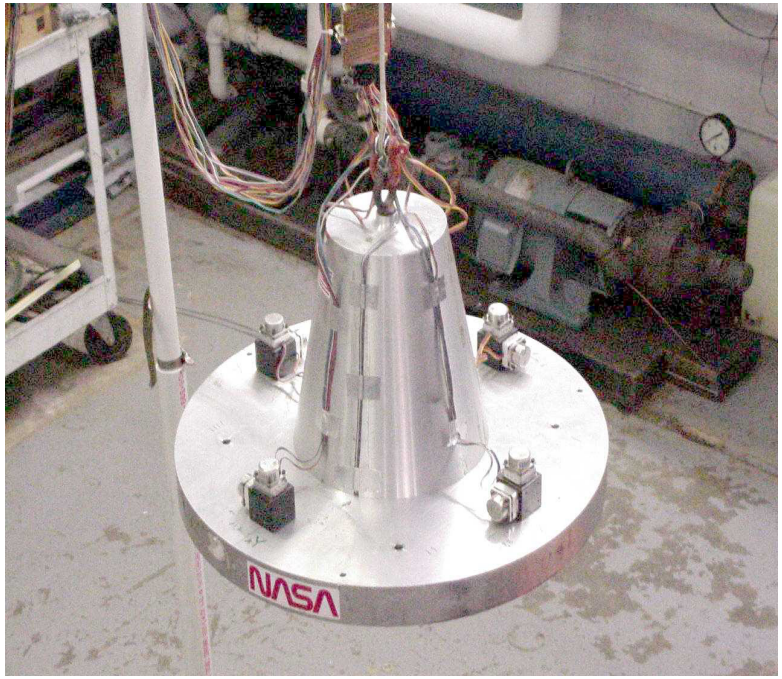
- Provides 6 degree of freedom inertial force characterization for operating ISS or Aerospace components



Microgravity Emissions Laboratory Capabilities

- Measuring within the realm of the ISS vibratory requirements
- 0.10 μg Noise floor
- 0-315 Hz





Microgravity Emissions Laboratory (MEL) Facility Overview

- The Microgravity Emissions Laboratory utilizes a 6 DOF inertial measurement system, capable of characterizing disturbances (down to 0.1 μg's) of the on-orbit science environment by space-flight hardware.

- Test unit operational emissions (accelerations) measured are combined with the system mass matrix to define the forces and moments at the CG of the test unit.

- Applying the 6 DOF forces and moments to SEA and FEM models allow payload developers a way of evaluating test component compliance to ISS requirements.

Microgravity Emissions Laboratory (MEL) Facility Overview

- MEL measurements are seismic (Force proportional to acceleration).
- Frequency range of interest is 0-315 Hz
- Main MEL System Components:
  - CSA Pneumatic suspension system that reduces vertical frequencies to 0.3 Hz.
  - 34 ft pendulum braided vectran cable that reduces lateral frequencies to 0.15 Hz.
  - 110 lb “mushroom” platform for attachment to test unit (1st natural frequency of 380 Hz).
  - 10 QA-700 servo control accelerometers (3 measurements in X direction, 3 in Y direction and 4 in Z direction)
  - Each suspension unit has capacity of 750 or 1200 lbs.

General Products of MEL Test Reporting

MEL Test Products to date including:

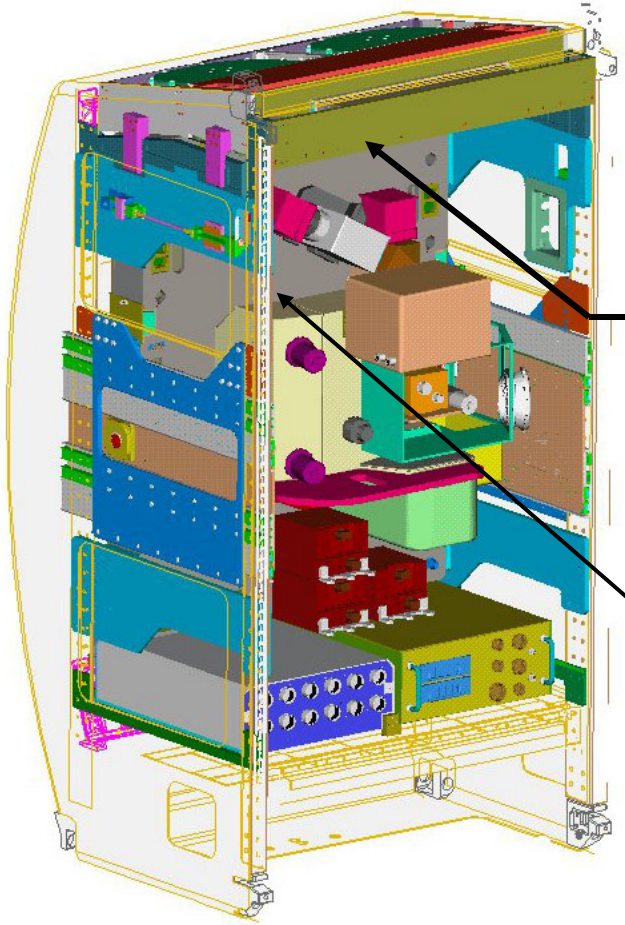
- Mass of unit under test
- Mass moment of inertia in 3 axes for combined test article
- Force and Moment at CG of test unit or unit's interface upon request.
  - Narrowband and 1/3 octave
- PSDs at CG of test unit upon request
  - Narrowband and 1/3 octave
  - Force and Moment Time history format at CG of test unit
- Response acceleration spectral characteristics as requested
- Ambient/Noise floor documented

Microgravity Emissions Laboratory (MEL) Facility Overview

- Location
  - Component testing currently is accomplished in Structural Dynamics Laboratory at NASA Glenn Research Center (GRC)
    - 3 ton roof reinforcement
    - Isolated roof top mechanical room
    - Nominal 34 foot cable length
    - Full operational control
    - 24 hour lockdown capability
- Full TID Support & outside EDAD services
- Manufacturing
  - Developing suite of standard fixtures
  - Leveraging commonality with vibration fixtures
  - Ability to obtain fixtures with in/out house fab
- Customers are both internal and external to GRC
- MEL mounting fixtures must be rigid at least to 315 Hz.

MEL Main Customer: Fluids and Combustion Facility (FCF)

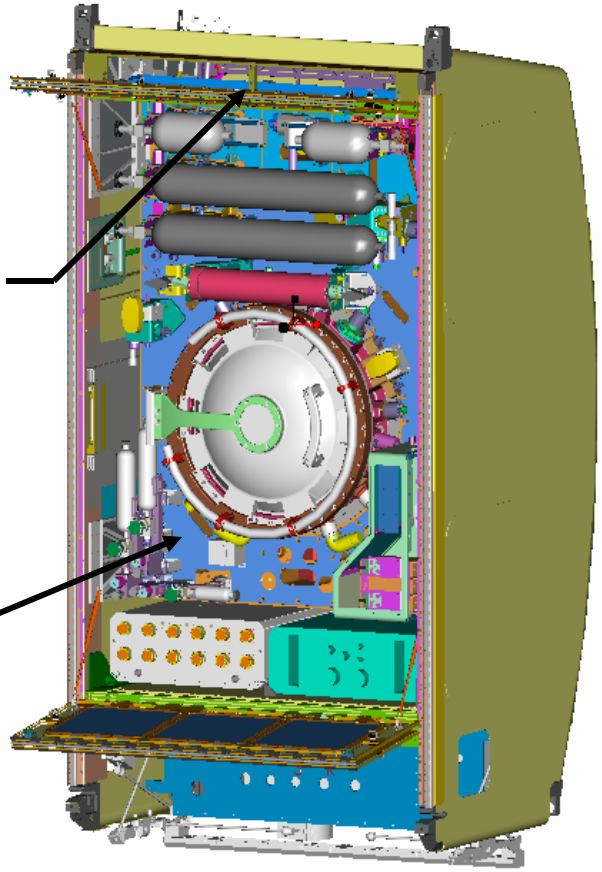
Fluid Integrated Rack (FIR)



Environmental Control Unit
(i.e., **ATCU**)
Behind Panel

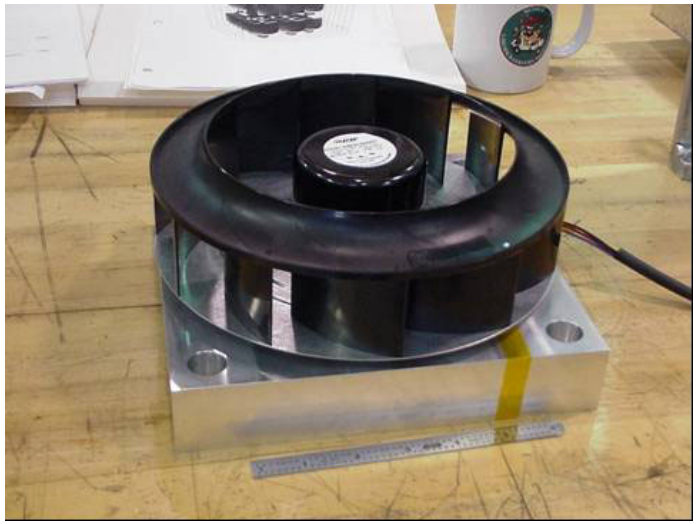
Optics Bench

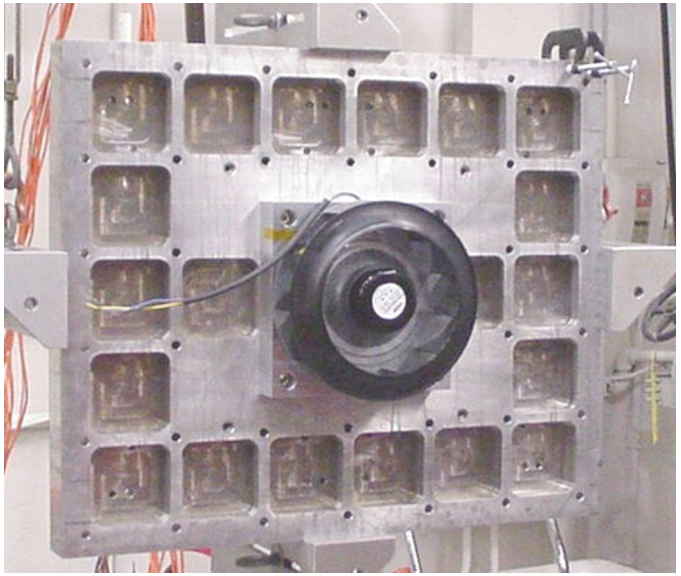
Combustion Integrated Rack (CIR)



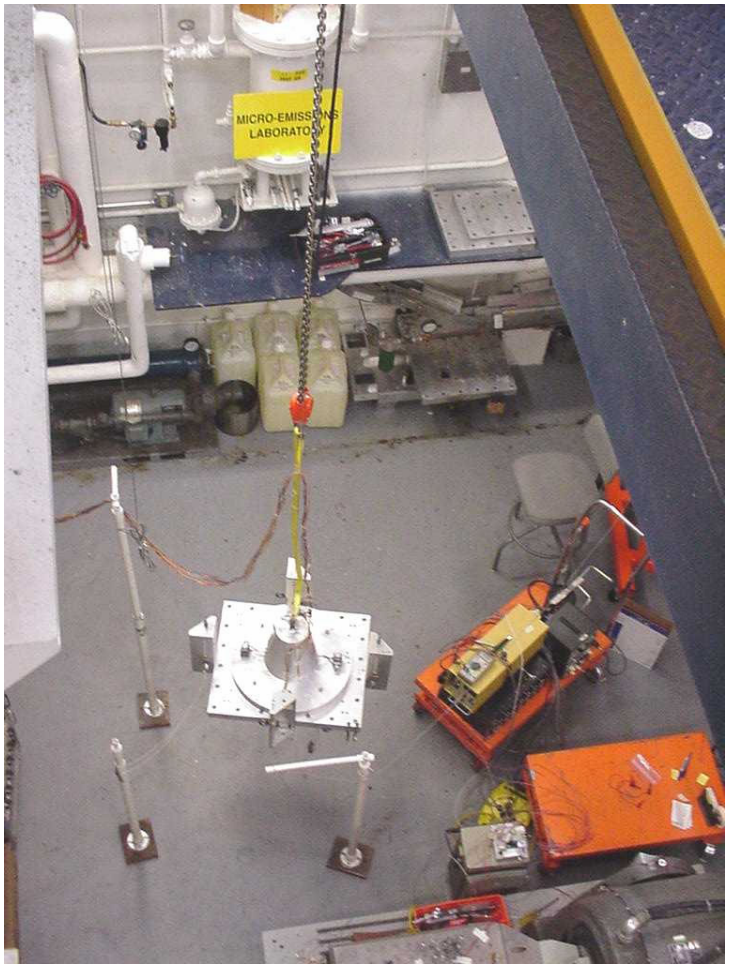
Fluid Combustion Facility
Air Thermal Control Unit (ATCU) Cooling Fan

- August 2001 MEL Test
- McLean model DB824-2425S3 ATCU Fan Candidate
- The fan type tested is one of two identical fans that are part of the Air Thermal Control Unit assembly. One ATCU assembly is installed at the top of each FCF rack. The fans draw warm air from the rear of the rack and force it through a filter and heat exchanger, exhausting cool air to atmosphere.
- The potential disturbance sources from the fan operation are those generated mechanically due to the fan and motor rotation.
- The disturbances measured by the fan operation are dominated by the rotational fundamental and harmonics produced.

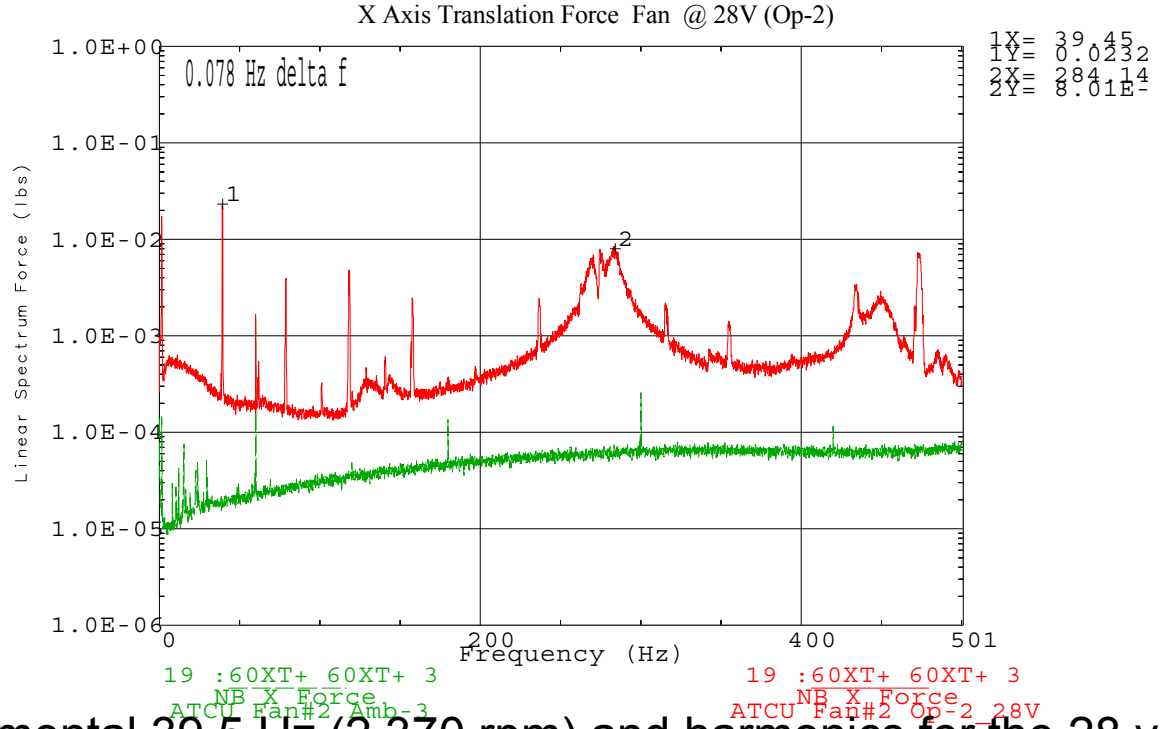




FCF ATCU Fan Candidate MEL Testing



Fluid Combustion Facility
Air Thermal Control Unit (ATCU) Cooling Fan

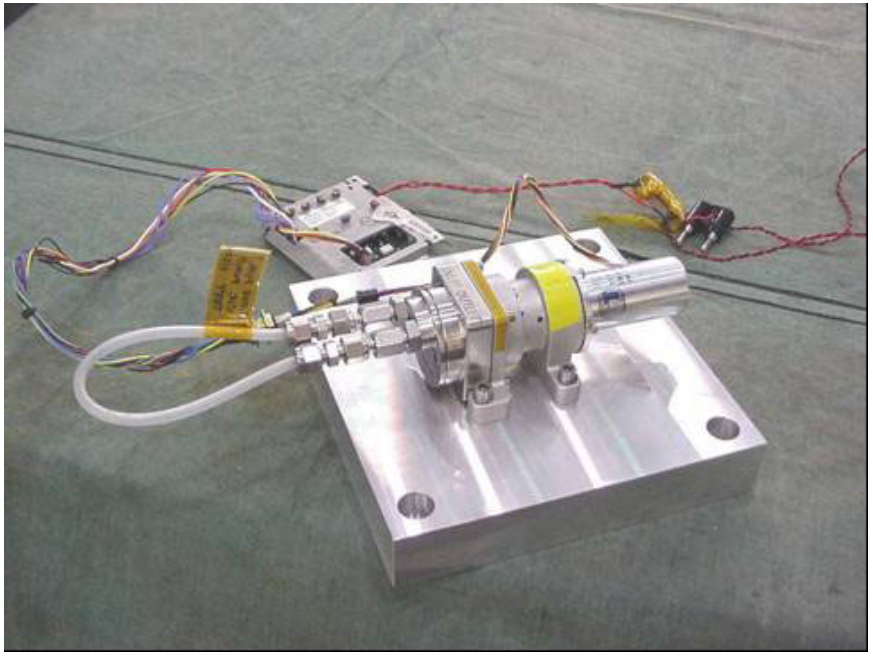


- Fundamental 39.5 Hz (2,370 rpm) and harmonics for the 28 volts supply operation.
- The broadband content around the tonals most likely can be attributed to aerodynamic forces around fan.

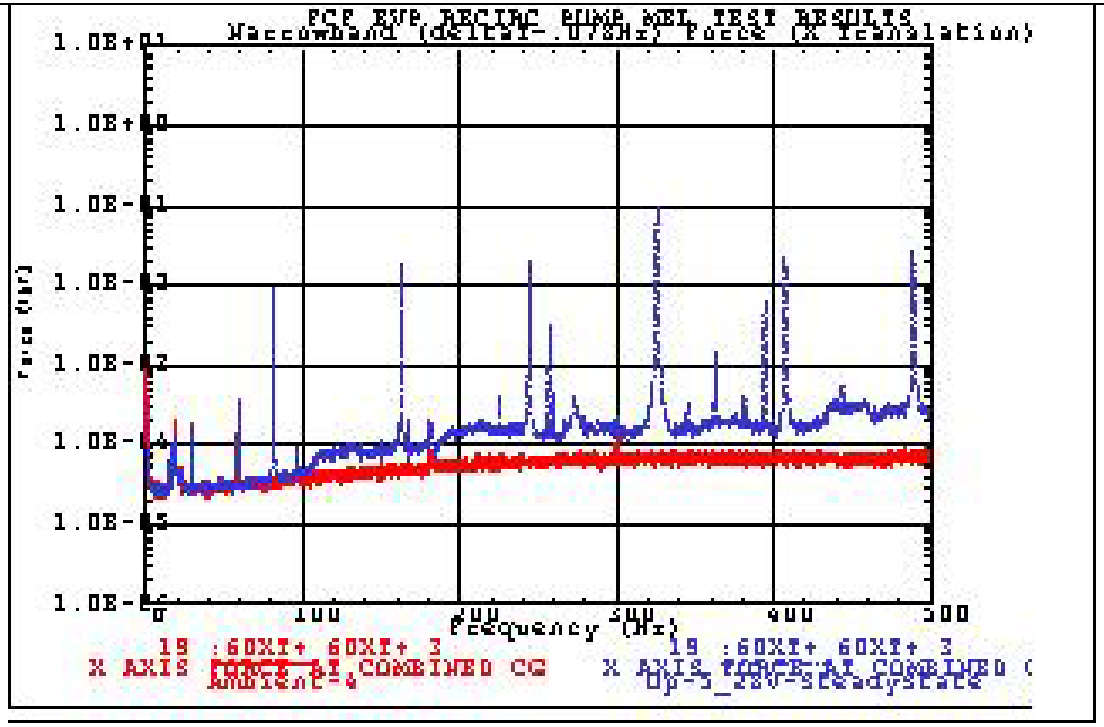
Fluid Combustion Facility
Exhaust Vent Package Recirculation Pump

- March 2001 MEL Test
- Exhaust Vent Package Pump
- Two EVP Recirculation Pumps are mounted on the back of the FCF Combustion Chamber and are used to circulate the gas atmosphere from the chamber into the absorber cartridge.
- The two pumps operate simultaneously during recirculation of the chamber air. The operation will be intermittent and dependant on the experiments need to filter the atmosphere inside the chamber.
- The potential disturbance sources from the Pump operation are those generated mechanically due to the pump and motor rotation.

Fluid Combustion Facility
Exhaust Vent Package Recirculation Pump



Fluid Combustion Facility
Exhaust Vent Package Recirculation Pump

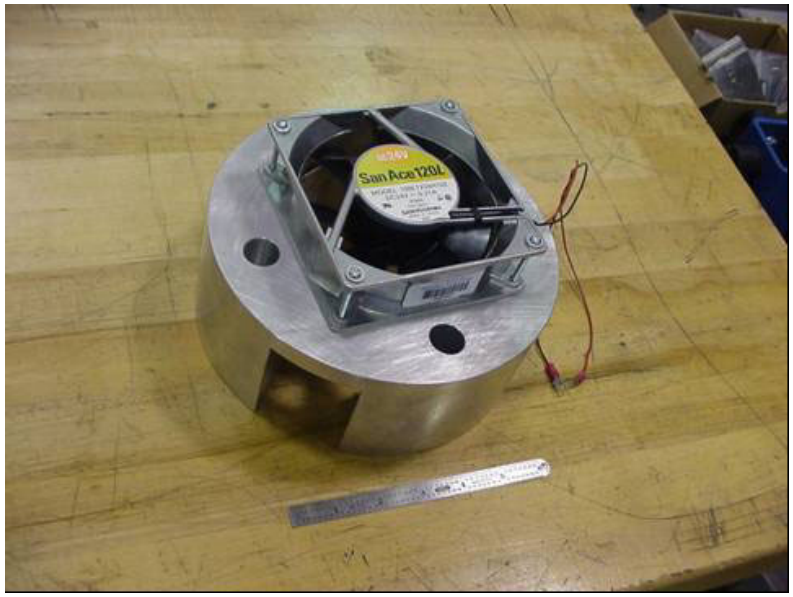


- The Evac Pump operational disturbances are dominated by the rotational fundamental at 83.3 Hz (5,000 rpm) and its harmonics.
- The forcing functions were barely above the measurement background outside these discrete frequencies

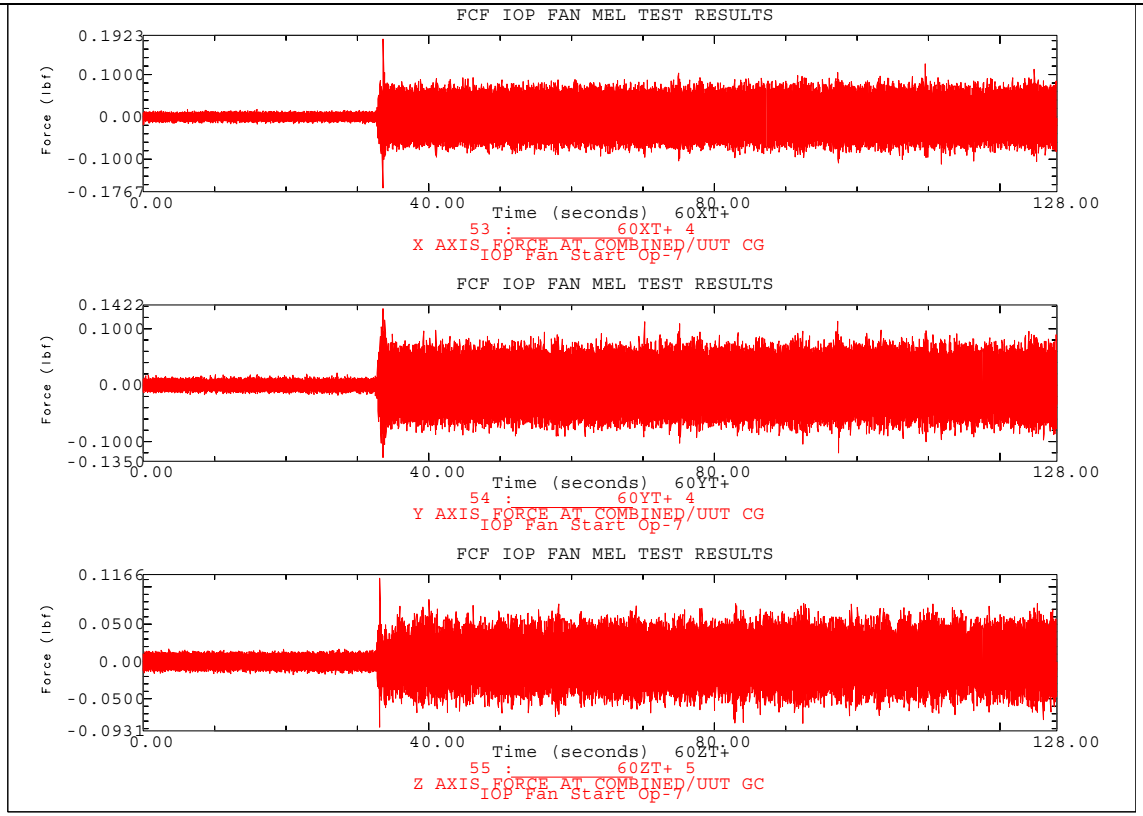
Fluids and Combustion Facility
IOP Fan Candidate Model San Ace 120L

- **April 01 MEL Test**
- Manufacturer: San Ace model 120L
- The Input/Output Processor (IOP) fan supplies a constant air flow over the components of the IOP which include the removable Hard Drives, electrical connections, converters, etc. The air is drawn in from the front of the IOP and exhausted through the back of the IOP.
- The IOP is located toward the bottom of the FCF rack. The fan will operate constantly when the rack is powered.
- The potential disturbance sources from the fan operation are those generated mechanically due to the fan and motor rotation; and possibly aerodynamic forces generated from the flow of air through the assembly.

Fluids and Combustion Facility
IOP Fan Candidate Model San Ace 120L



Fluids and Combustion Facility
IOP Fan Candidate Model San Ace 120L

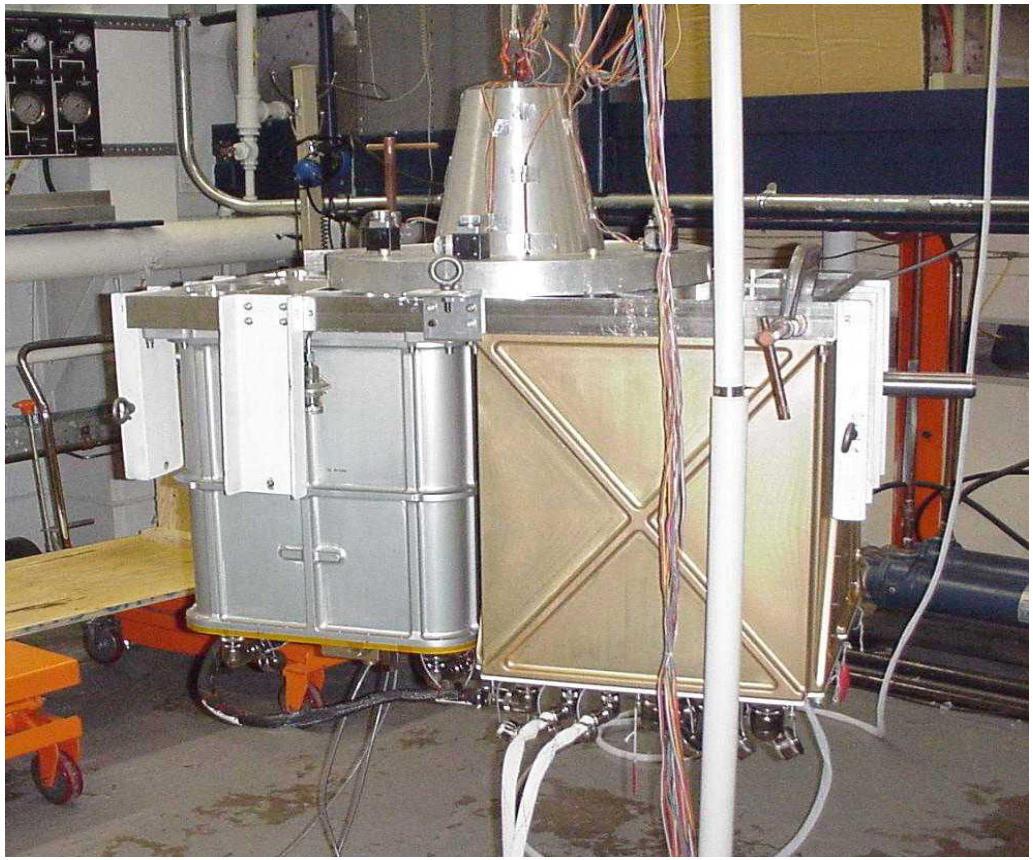


- Transient Measurement of the startup of the FCF IOP Fan
- Forces in X, Y and Z
- Peak force measurement of 0.19 lbf

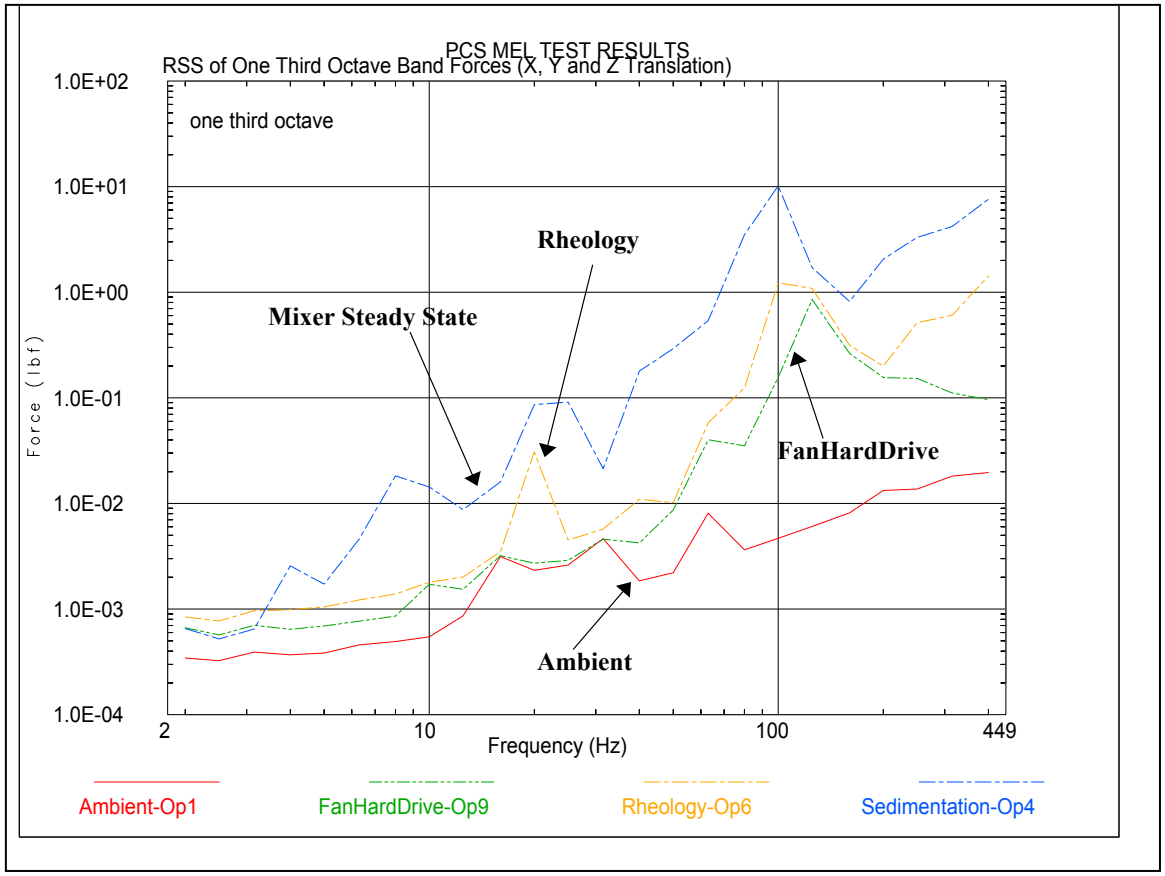
MEL PCS Testing
Express Rack Double
Mid-deck Locker Configuration

- **MEL May 2000 Test**
- **Physics of Colloids in Space Experiment (PCS)**
- **The experiment is a double locker configuration and is housed on the ISS in an ARIS controlled EXPRESS-II rack.**
- Science investigation on sample cells is conducted in the Test section. PCS contains eight different colloid samples. Each sample consists of a fluid and solid particle mixture.
- The Test section is designed to contain the individual sample cells for mixing, testing, and optical analysis.
- The primary disturbance source in this assembly is the sample cell handling and operation mechanisms.

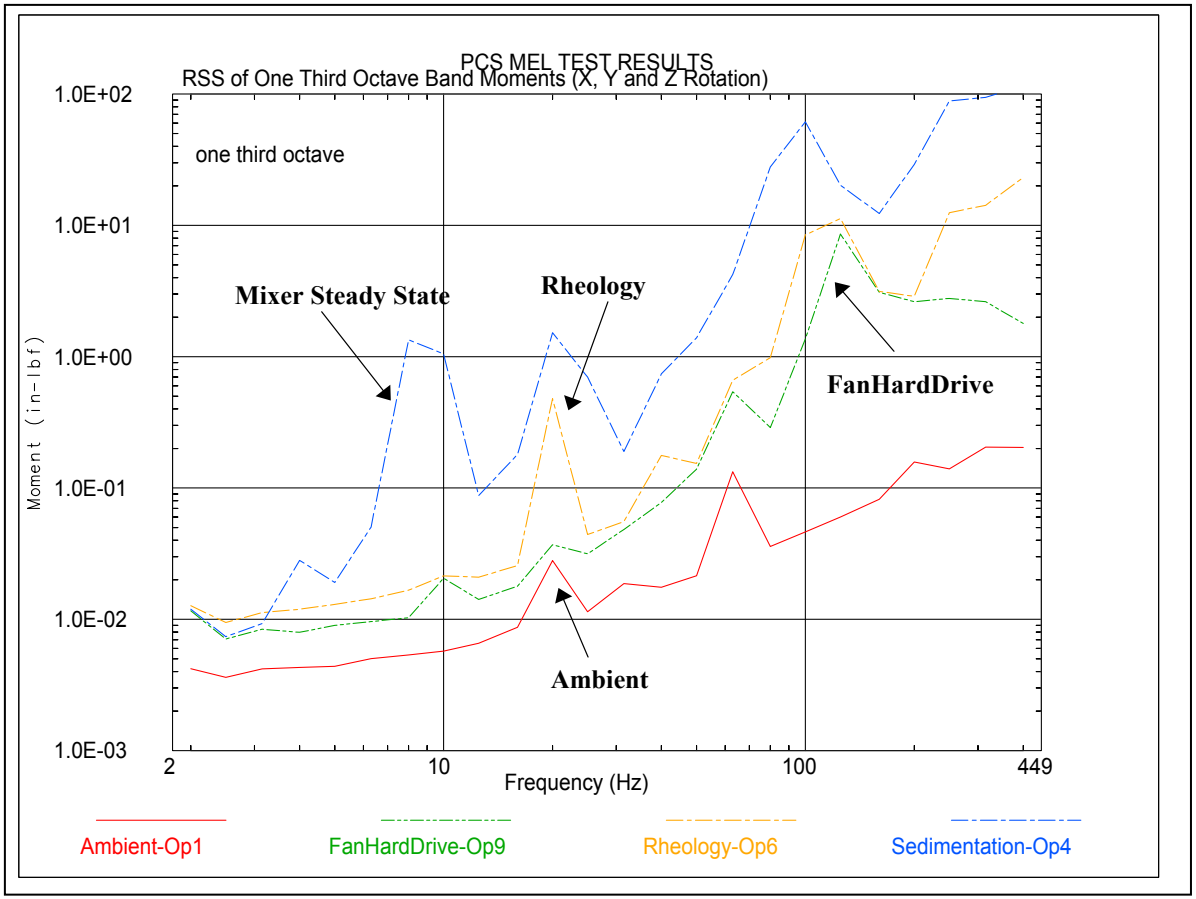
MEL PCS Testing
Express Rack Double
Mid-deck Locker Configuration



MEL Testing PCS Operational One Third Octave Band Forces (RSS)



MEL Testing PCS Operational One Third Octave Band Moments (RSS)



MEL PCS Testing
Express Rack Double
Mid-deck Locker Configuration

- Mixer Steady State operating condition is the maximum microgravity disturber with an RSS peak of 10 lbf at 100 Hz. The Hard Drive Fan operation is the minimum disturber and has a peak RSS value at 125 Hz of 1.1 lbf. Rheology operation peaks at 100 Hz with 1.2 lbf.

- The Mixer Steady State operation RSS levels are consistently well above the ambient background levels over all 1/3-octave band levels.

- The Hard Drive Fan and Rheology operations essentially meet the ambient background conditions between 2 and 15 Hz.

- The Rheology operating condition continues to remain in the background levels through approximately 50 Hz.

Summary of MEL Tests to Date

- **Completed MEL Tests**
  - FCF Single Fan/Housing (ATCU) (Nov 99).
    - Fan steady state and shutdown.
  - FCF Optics Bench (Jan-Feb 00)
    - Air flow pressure through optics bench, steady state fan.
  - FCF Optics Bench Pseudo Package (Mar 00)
    - Fan steady state, computer hard drive write/read, computer fan operations.
  - Microgravity Separation of Energetic Grains (μgSEG) (Feb 00)
    - Steady state operation of motorized track of aluminum spheres, startup and shutdown.

Summary of MEL Tests to Date

- **Completed MEL Tests (continued)**
  - Physics of Colloids in Space (May 00)
    - Avionics and test sedimentation mixer operation, startup, shutdown, rheology, carousel rotation, fan power up, steady state sequences, and fiber cell.
  - SAMS RTS Drawer (Sep 00)
    - SE download of data to external laptop, power up, manual fan switch, power supply shutdown
  - SAMD ICU (Sep 00)
    - Hard drive activity, power up, PCB fan steady state
  - MAMS (Oct -Nov 00)
    - Steady state fan, power up, OSS telemetry, BCTA gimble traversing 180^{o}.
  - SAMS Tape Drive (Dec 99, Apr 00)
    - Tape drive operational write/eject/read

Summary of MEL Tests to Date

- **Completed MEL Tests (continued)**

  – FCF Electrical Power and Control Unit (Dec 00)
    - Maximum and minimum chilled water flow, transient relay switching
  – Stirling Convertor (Jan 01)
    - Steady State convertors at design operating condition with chiller on and flowing, Repeat with convertor offset, repeat with centerline offset, repeat with variation in bracket frequency

  - INTEK (ZCG) Zeolite Crystal Growth Experiment (Jan 01)
    - Cooling Fans, Hard Drive Fans, autoclave motor operations, transient switch and switch cover removal, furnace cover removal, autoclave removal

  - FCF ATCU and IOP Fans (Feb 01)
    - Steady State Fan Operation, Startup and Shutdown Transient

Summary of MEL Tests to Date

- **Completed MEL Tests (continued)**
  - FCF Exhaust Vacuum Assembly Pump (Mar 01)
    - Transient Startup and Shutdown of Pump, Steady State Operation
  - FCF IOP Hard drive Candidates (73 and 50 GB) (Mar 01)
    - Startup, Shutdown, Steady State Operation (Read/Write)
  - IPP/IPSU Hard Drive (18 GB) (Mar 01)
    - Startup, shutdown, Steady State Operation (Read/Write)
  - CSLM-2 (Apr 2001)
    - Fans and Hard drive Steady State; Manual switch activation on ECU, Steady State Heating mode; Quench Operation (solenoid then disk rupture)
  - FCF Gas Chromatograph Pump (Aug 01)
  - FCF ATCU Standalone Fans (Aug 2001)
  - FCF ARIS Integration (Sept 01)
  - FCF Single ATCU/Housing/Isolators (Nov 01)
  - FCF ATCU Complete Assembly (double fans/isolators) (Dec 01)

Summary of MEL Tests to Date

- **Completed MEL Tests (continued)**
  - FCF ATCU Complete Assembly (Jan 02)
  - INTEK Zeolite Crystal Growth Experiment Backup Flight Hardware (Apr 02)
  - Light Microscopy Module (LMM) Control Box Fan Isolator Selection (Jun 02)
  - Light Microscopy Module (LMM) Control Box Fan (Jul 02)
  - FCF FSAP (Aug 02)
  - FCF ATCU Single Fan/Housing (Sept 02)
  - FCF IOP Assembly (Sept 02)
  - FCF Solenoid Valve (Dec 02)

Future Work

- Fluid Combustion Facility (FCF) CIR and FIR
  - Flight hardware for Evacuation Pumps, ATCU Fans, Common IPSU Hard Drives, and etc.
- Light Microscopy Module (LMM)
  - Microscope Motorization Translation Stage
- Developing a database of previous MEL test component disturbance forcing functions
- Facility Improvements
  - Reducing the pendulum frequency
  - Redesign MEL accelerometer Platform
  - Improved method for obtaining Mass Moment of Inertia

MEL Facility Web Presence

- Microgravity Emissions Laboratory Testing URL:

  http://www.grc.nasa.gov/WWW/MEL
  http://facilities.grc.nasa.gov/mel/

  - Web site test request form
  - Testing schedule for MEL
  - Lab Manager, Anne M. McNelis 216-433-8880
  - Email: Anne.M.McNelis@nasa.gov

- NASA Technical Memorandum:
  - Includes flight to ground measurement comparison NASA/TM 2002-211901