

# Microgravity Emissions Laboratory (MEL)

NASA Glenn Research Center

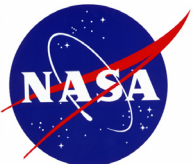
Anne M. McNelis

Prepared for the 7<sup>th</sup> Microgravity  
Environment Interpretation Tutorial

March 2-4, 2004



- **Acronyms**
- **Introduction of Microgravity Emissions Laboratory (MEL)**
- **Example MEL testing data**
  - **Light Microscopy Module (LMM)**
  - **Fluid and Combustion Facility (FCF)**
    - **FIR and CIR components**
    - **ATCU, Exhaust Vent Pump, IOP Fan**
  - **Physics of Colloids in Space (PCS)**
  - **INTEK Zeolite Crystal Growth Experiment (ZCG)**
- **Conclusions**



- **ACRONYMS**
- **MEL – Microgravity Emissions Laboratory**
- **LMM - Light Microscopy Module**
- **FCF - Fluid and Combustion Facility**
- **FIR – Fluids Integrated Rack**
- **CIR – Combustion Integrated Rack**
- **ATCU – Air Thermal Control Unit**
- **EVP - Exhaust Vent Pump**
- **IOP – Input Output Processor**
- **PCS - Physics of Colloids in Space**
- **ZCG - Zeolite Crystal Growth Experiment**



## INTRODUCTION

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

## INTRODUCTION

- **A special test facility is required for conducting microgravity emissions testing.**
- **Isolated from the effects of the surrounding physical environment.**
- **High sensitivity instrumentation for measuring extremely low levels of acceleration.**

## INTRODUCTION

**MEL has been engineered, test calibrated and utilized at the NASA Glenn Research Center (GRC) in Cleveland, Ohio, for the characterization, simulation, and verification of the ISS microgravity environment.**

**Over 30 tests have been conducted since November 1999.**

**Typical test articles have included**

- **operating disk drives,**
- **pumps, motors,**
- **solenoids,**
- **Fans**

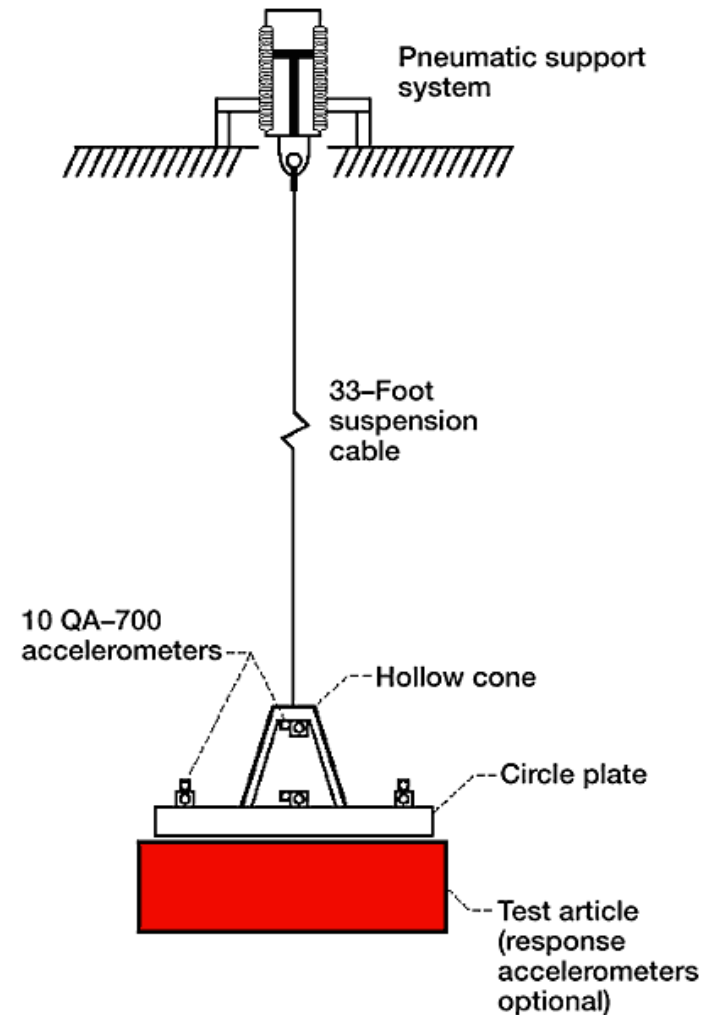
**Main customer FCF**

- **Open to other NASA and commercial customers**



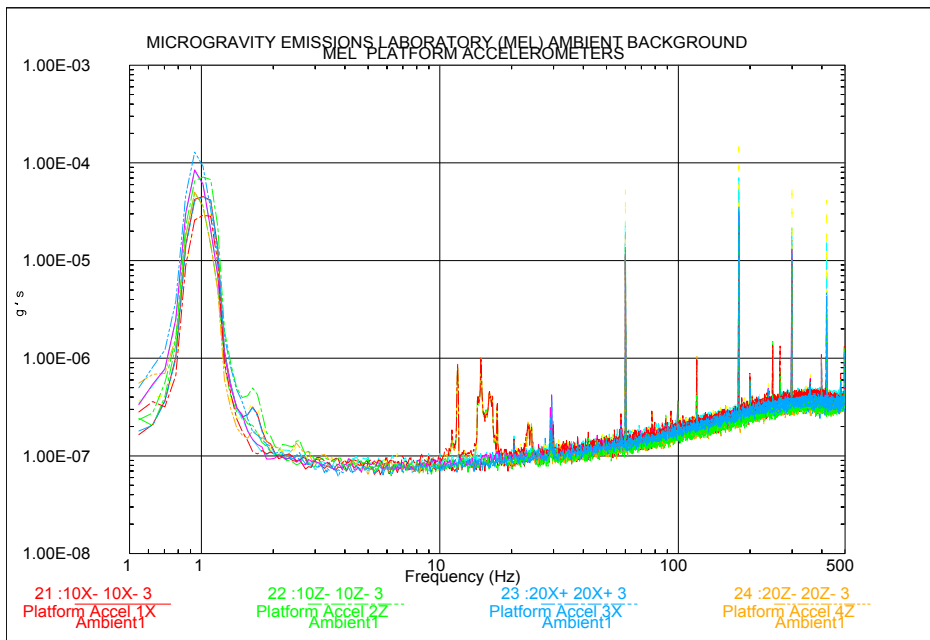
## INTRODUCTION

- 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



## INTRODUCTION

- Measuring within the realm of the ISS vibratory requirements
- 0.10 mg Noisefloor
- 0-315 Hz





## INTRODUCTION

- **MEL measurements are seismic (Force proportional to acceleration).**
- **Frequency range of interest is 0-315 Hz**
- **Main MEL System Components:**
  - **CSA Pneumatic suspension system reduces vertical frequencies to 0.2 Hz.**
  - **Each suspension unit has capacity of 600 or 1200 lbs.**
  - **34 ft pendulum braided vectran cable (1<sup>st</sup> pendulum mode at 0.15 Hz).**
  - **110 lb “mushroom” platform (1st mode at 380 Hz).**
  - **10 QA-700 servo control accelerometers**

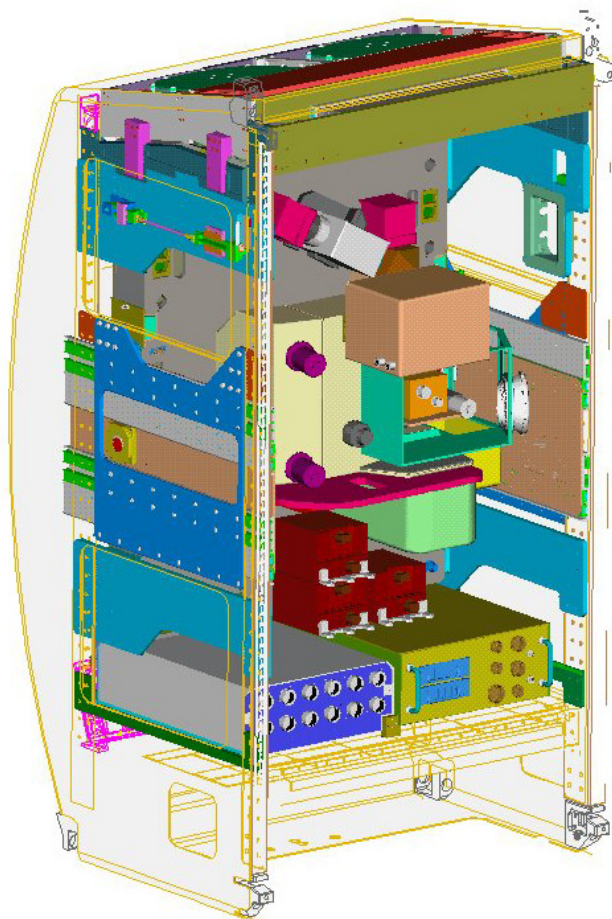
## INTRODUCTION

- **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 in time and frequency domain at CG of test unit or unit's interface upon request.**
  - **Narrowband and 1/3 octave band data**
  - **Ambient/Noise floor documented**
  - **Capability of measuring accelerations at additional response locations**
  - **FRF**
  - **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.**

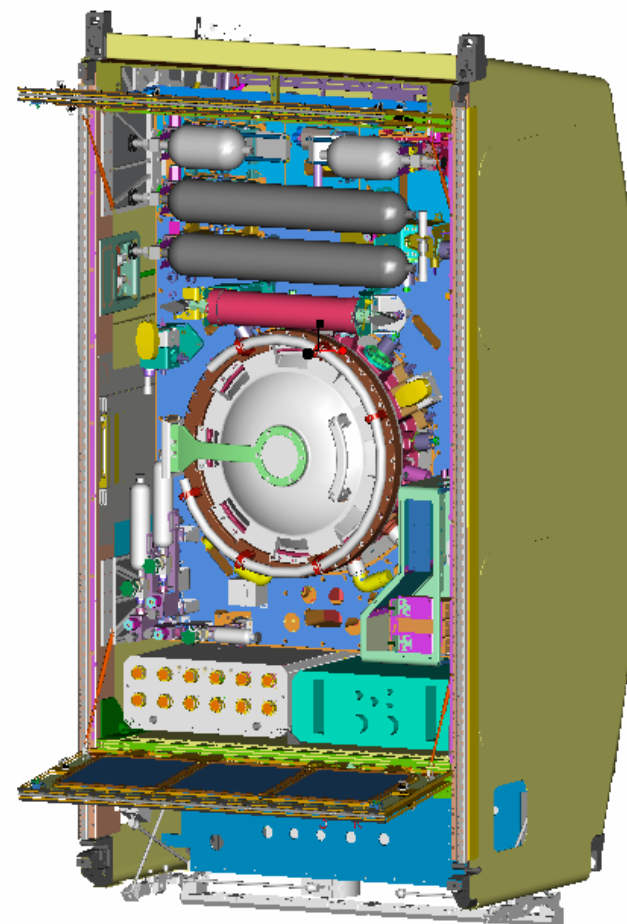
## EXAMPLE MEL TESTING DATA

MEL Main Customer: Fluids and Combustion Facility (FCF)

Fluids Integrated Rack (FIR)



Combustion Integrated Rack (CIR)



## Light Microscopy Module (LMM)

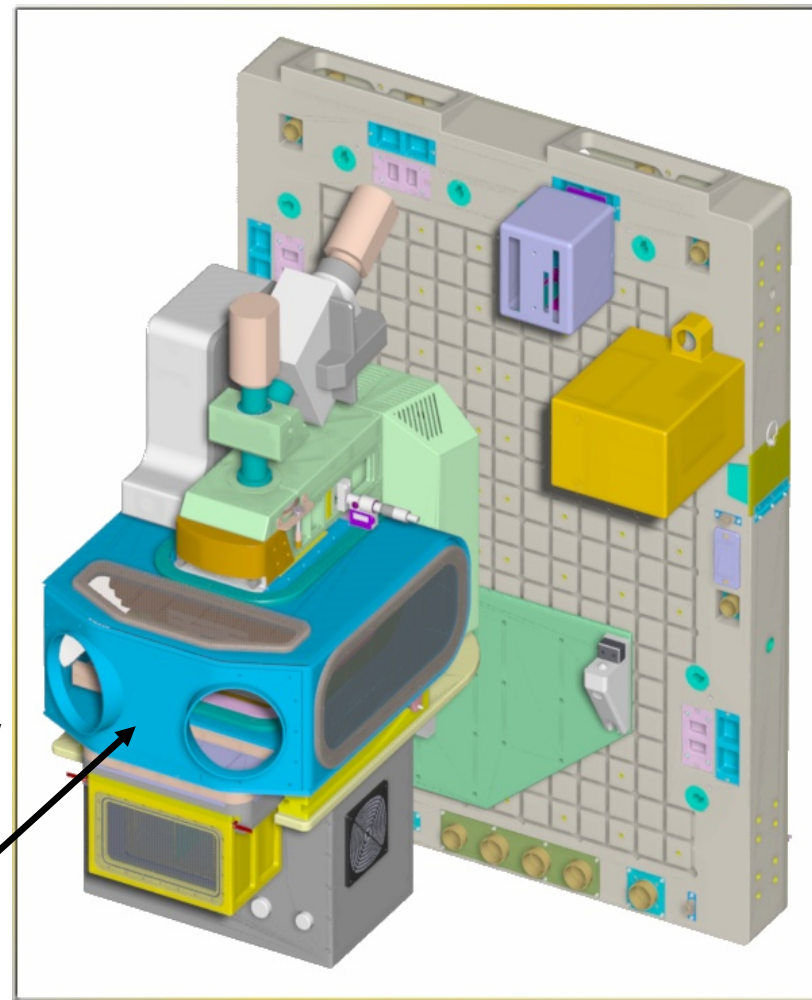
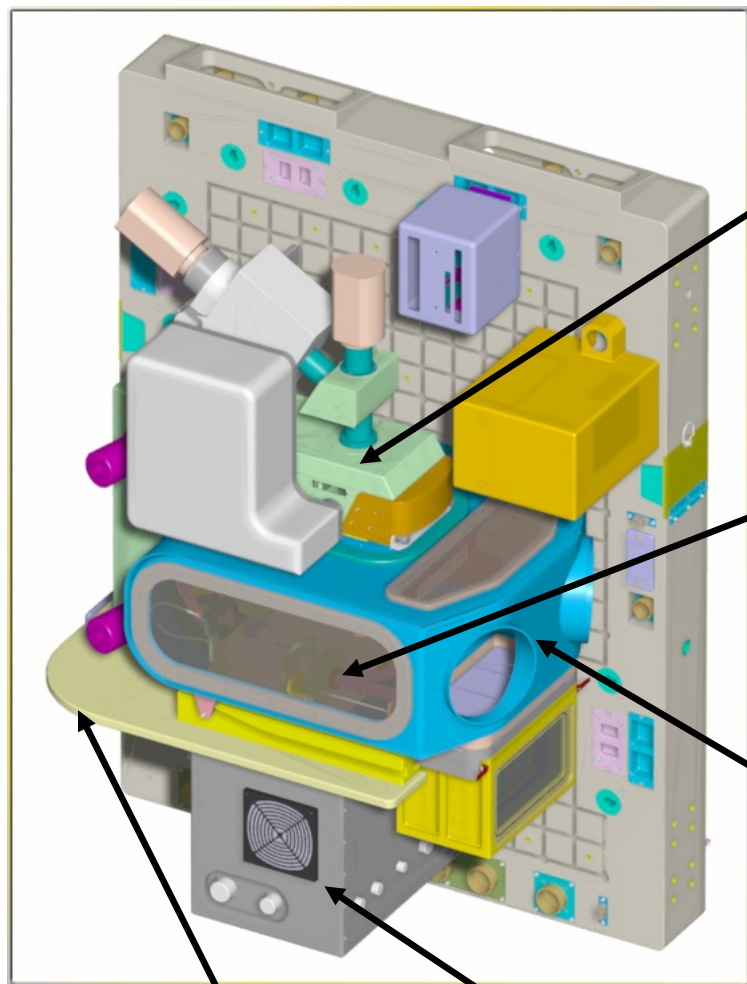
- A Light Microscopy Module (LMM) is being designed and developed at NASA Glenn Research Center (NASA GRC).
- The LMM is planned as a remotely controlled on-orbit microscope sub rack facility.
- The LMM microscope is a modified commercial research imaging light microscope with powerful laser diagnostic hardware and interfaces.
- Features include
  - high resolution color video microscopy
  - phase contrast,
  - spectrophotometry and confocal microscopy
- Laser tweezers are integrated with the diagnostics as a sample manipulation technique.

## Light Microscopy Module (LMM)

- As part of the development of LMM it was necessary to quantify the microgravity disturbances generated by the Control Box Fan (LCB).
- Isolating the LCB was deemed necessary to reduce the fan speed harmonic amplitudes and to eliminate any broadband disturbances across the 40-60 Hz and near 100 Hz frequency ranges. These frequency regions were defined as critical to the ability of the LMM's own camera focusing capability.
- The accelerations generated by a LCB component were measured in the Microgravity Emissions Laboratory (MEL)



### Light Microscopy Module (LMM)



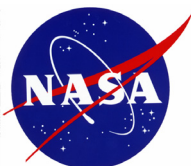
Microscope

Auxiliary  
Fluids  
Container

Light Microscopy  
Module  
Closed  
And Open  
Configurations

Control Box Fan

Spindle Plate

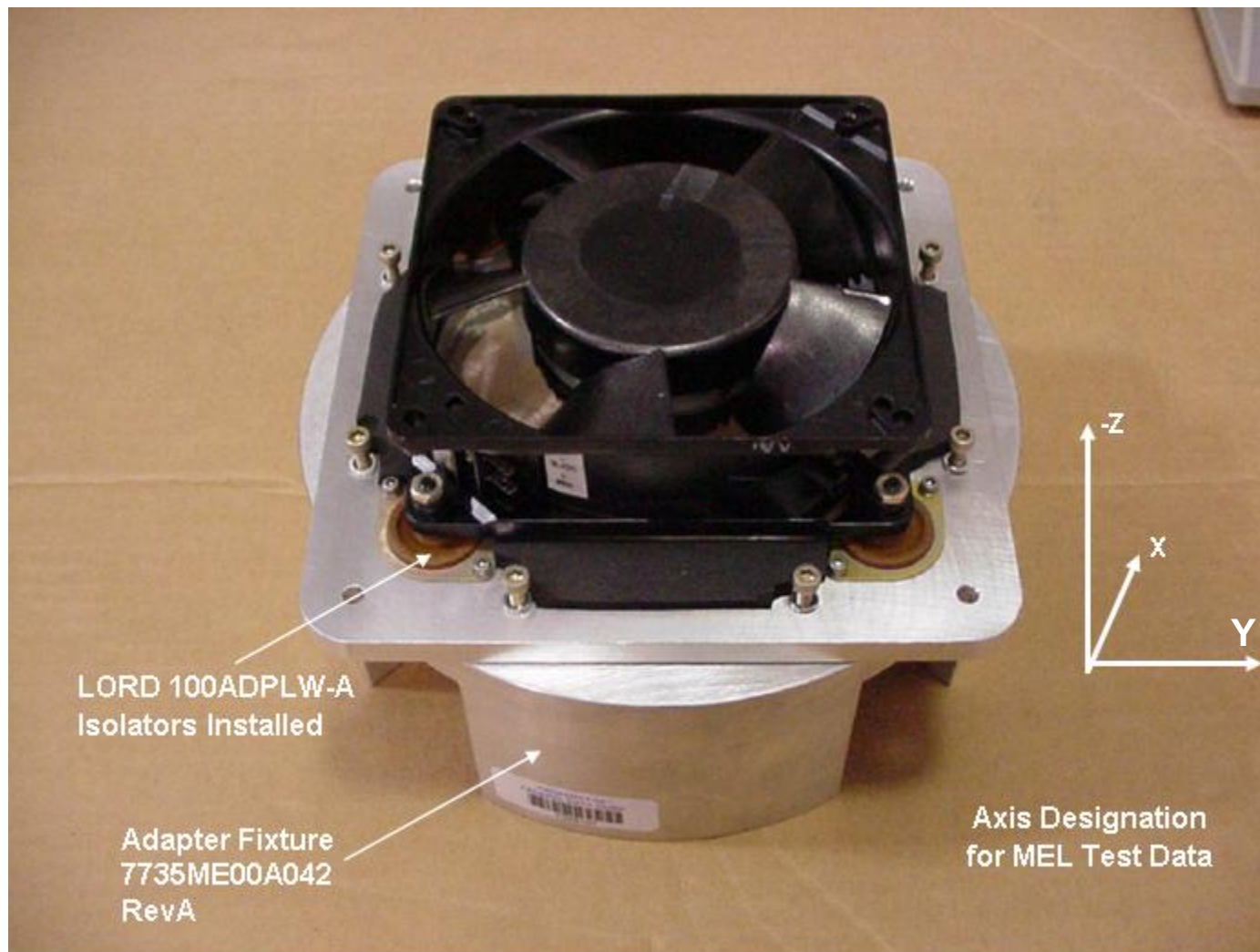


## Light Microscopy Module (LMM)

### June-July 2002 MEL Test

- **LMM Model Comair Rotron GL12B4 Fan Candidate**
- **The fan type tested is part of the LMM Control Box Fan assembly. The fan draws warm air out of the control box and is a continuous disturbance source on orbit.**
- **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.**

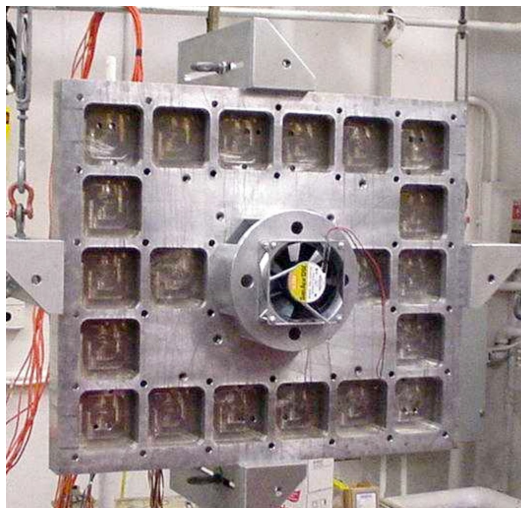
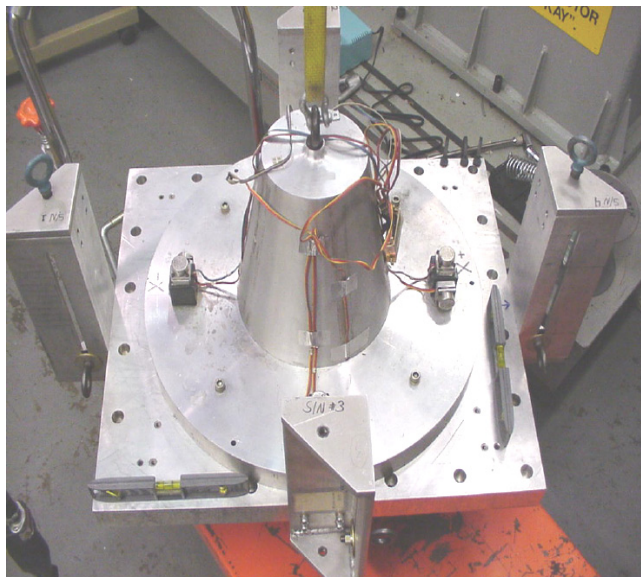
## Light Microscopy Module (LMM) Control Box Fan



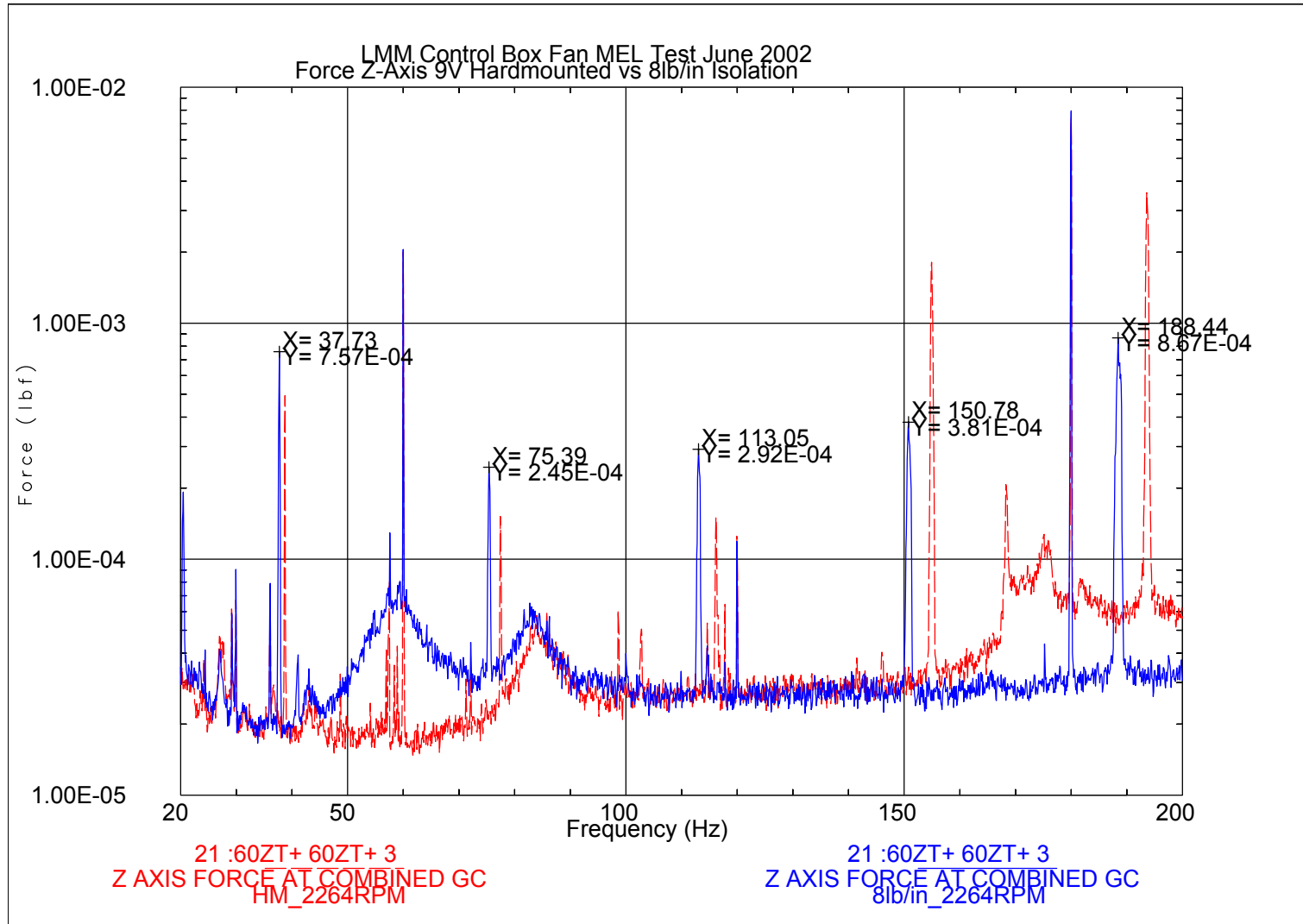


## Light Microscopy Module (LMM) Control Box Fan

MEL Support Cable  
(traced in white).



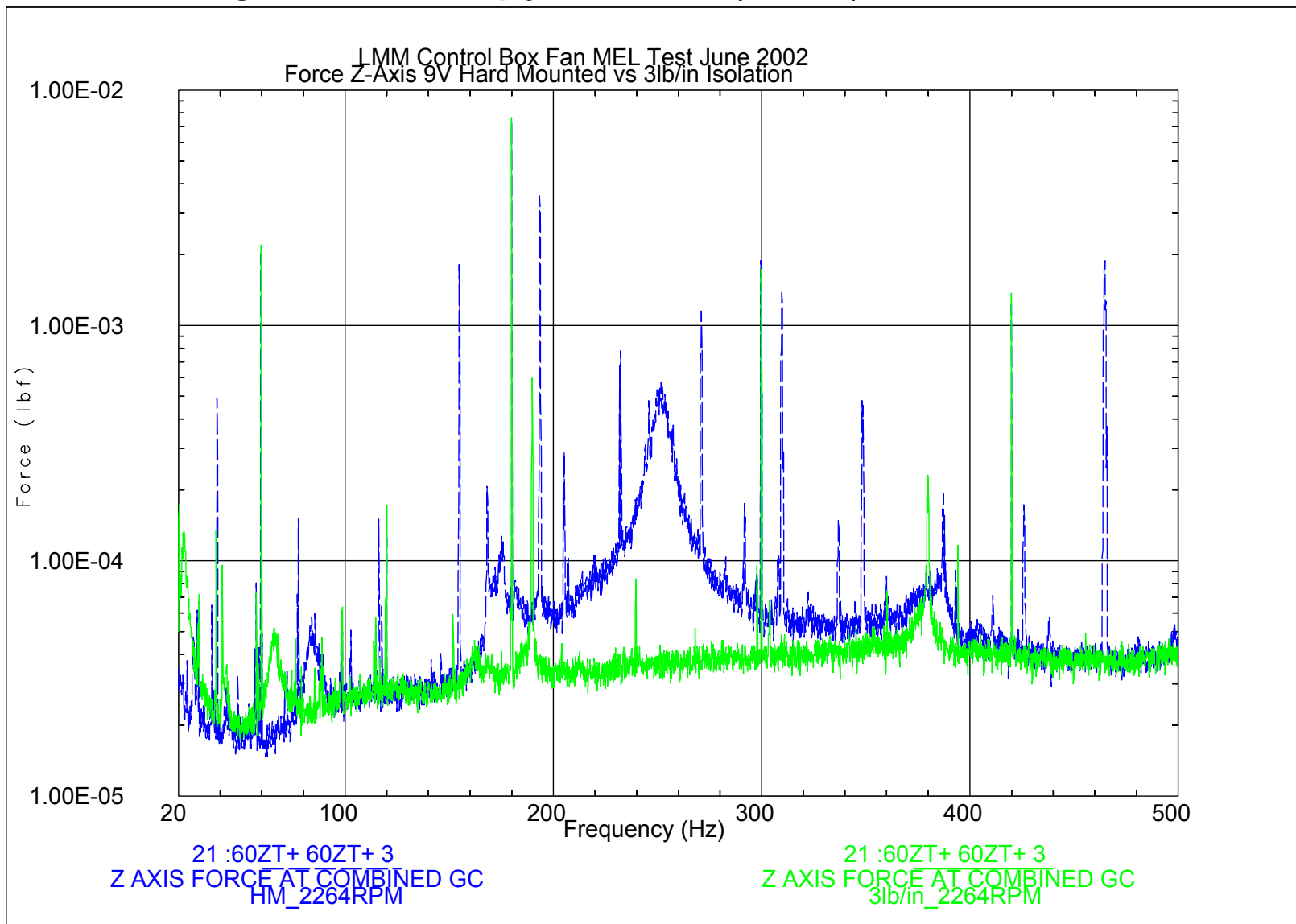
## Light Microscopy Module (LMM) Control Box Fan



Fundamental 37.73 Hz (2264 rpm) and harmonics for the 9 volts supply operation.

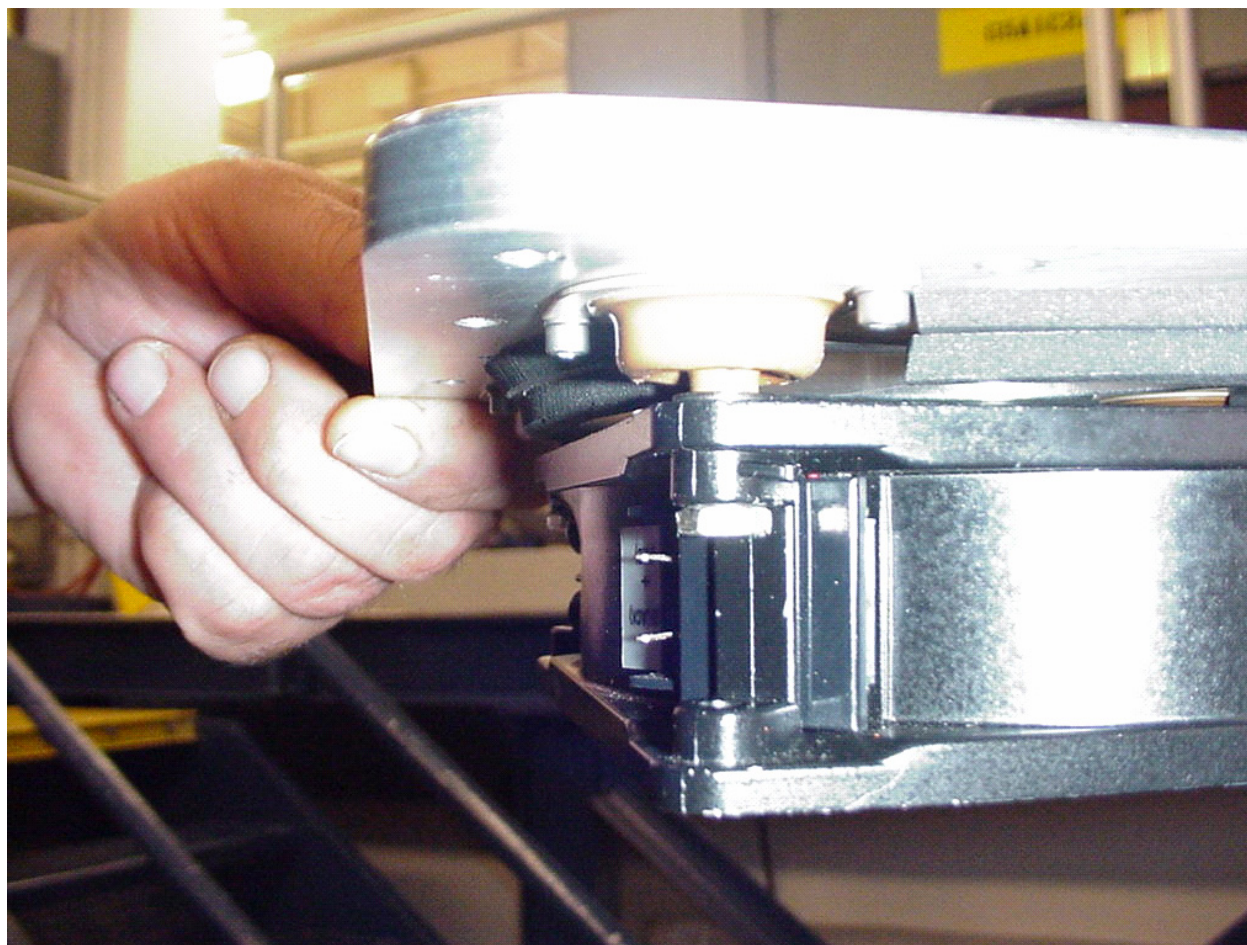


## Light Microscopy Module (LMM) Control Box Fan





## Light Microscopy Module (LMM) Control Box Fan



**3 lb/in Isolators Installed in MEL Test**

## Light Microscopy Module (LMM) Control Box Fan Test Conclusions

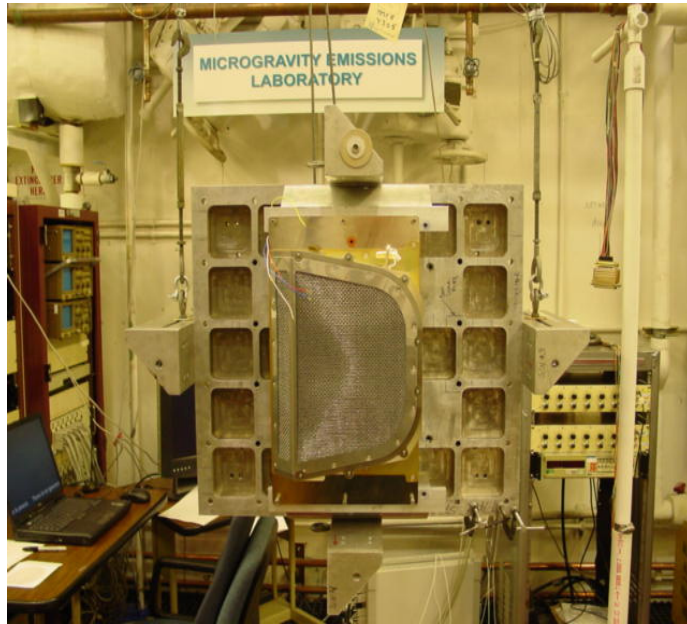
- **The LMM LCB was tested hard mounted and isolated using 1lb/in, 3 lb/in, 5 lb/in, 8 lb/in and 20 lb/in isolators**
- **LMM LCB was operated at 7V (1636 rpm) and 9V (2264 rpm) fan speeds.**
- **The 8 lb/in isolator did not reduce fan speed harmonics in the critical frequency ranges.**
- **The 3 lb/in isolators met the goal of reducing the acceleration amplitudes at 40-60 Hz and around 100 Hz.**
- **MEL test data was used to predict the level of disturbance in the on-orbit rack configuration to compare to ISS requirements.**
- **The LMM continues in development at NASA GRC and will be part of the FCF FIR rack.**

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

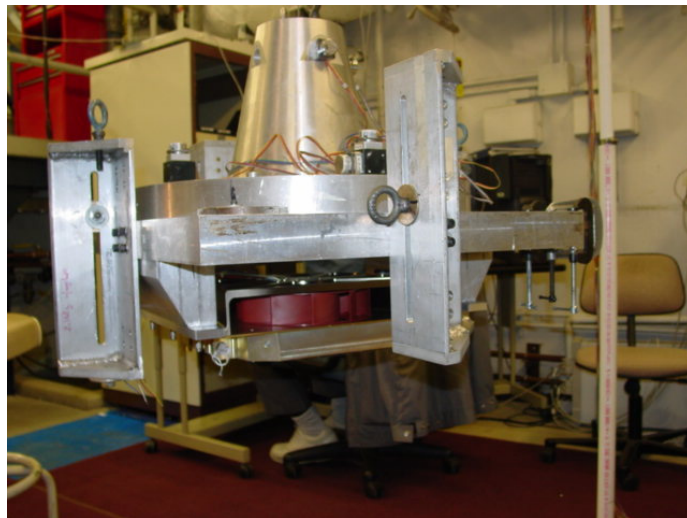
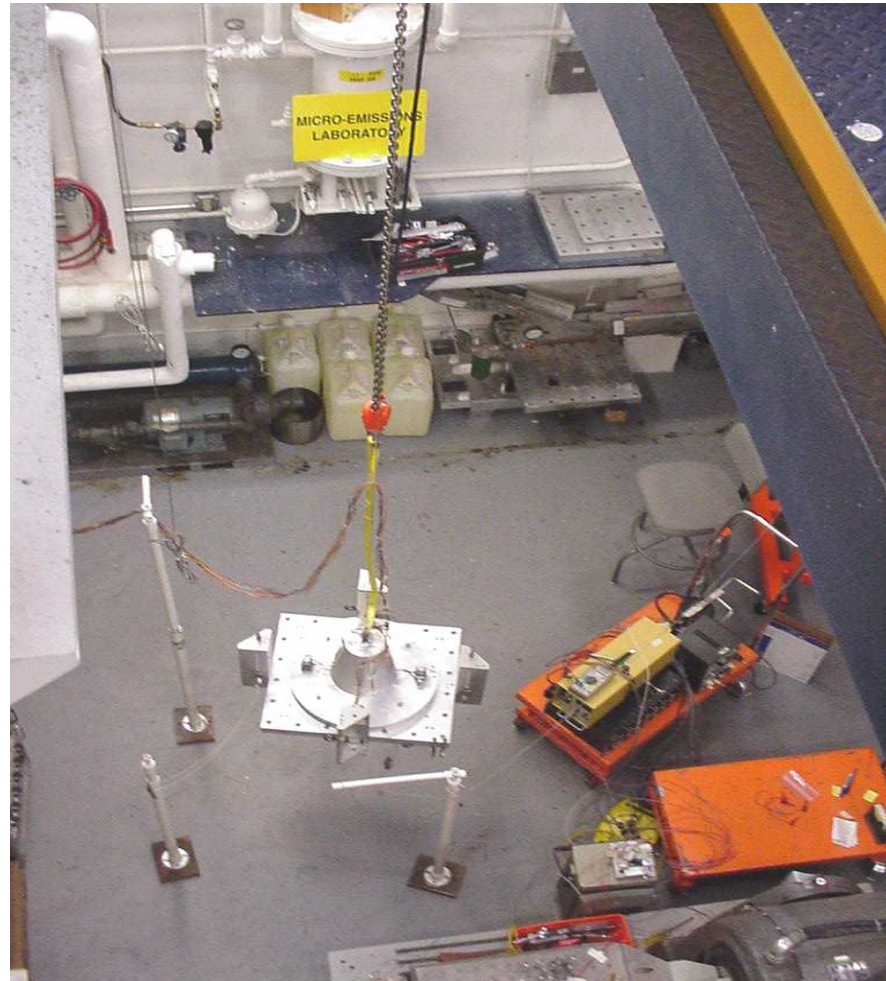
### October 2003 MEL Test

- **EBM model ATCU Fan/Housing in FCF CIR Configuration**
- **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 at various fan speeds from 1600rpm through 2400 rpm.**
- **The disturbances measured by the fan operation are dominated by the rotational fundamental and harmonics produced.**

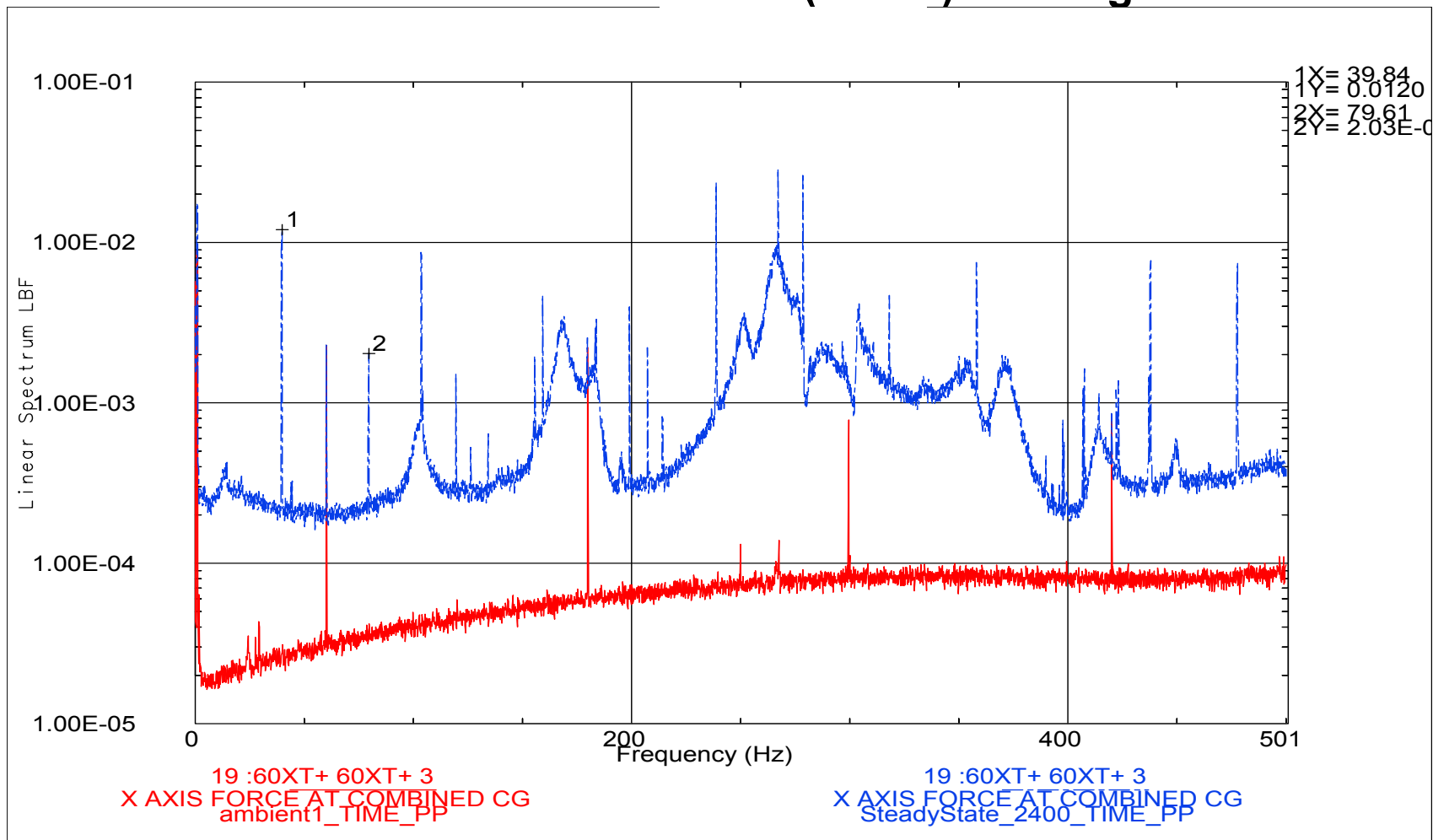




## Fluid and Combustion Facility (FCF) FCF ATCU CIR Fan MEL Testing



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



**Fundamental 39.8 Hz and harmonics for the 2400 rpm steady state run operation.**

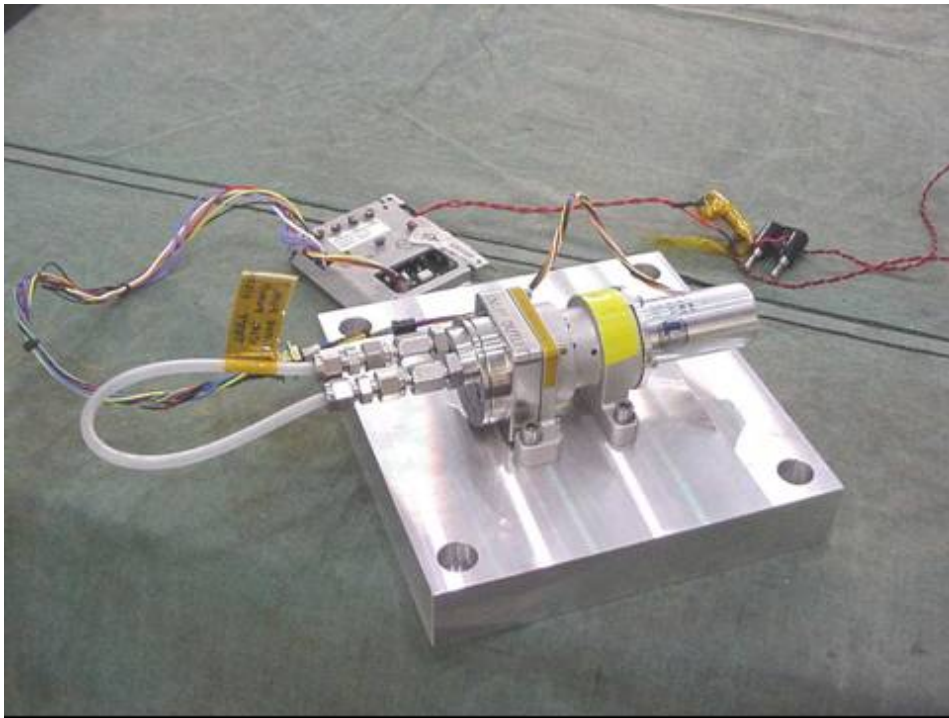


## Fluid Combustion Facility Exhaust Vent Package Recirculate Pump

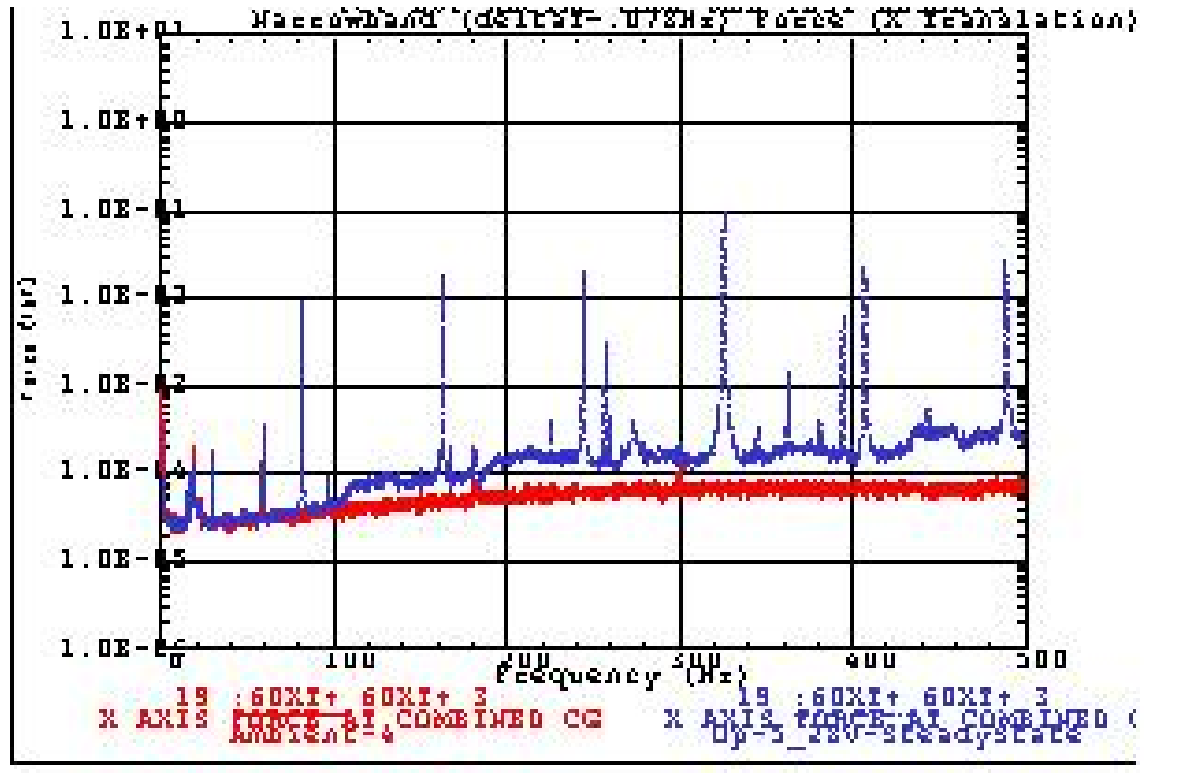
### March 2001 MEL Test

- 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 dependent 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 Recirculate Pump



## Fluid Combustion Facility Exhaust Vent Package Recirculate 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

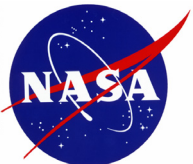


## Fluids and Combustion Facility IOP Fan Candidate Model San Ace 120L

**April 01 MEL Test**

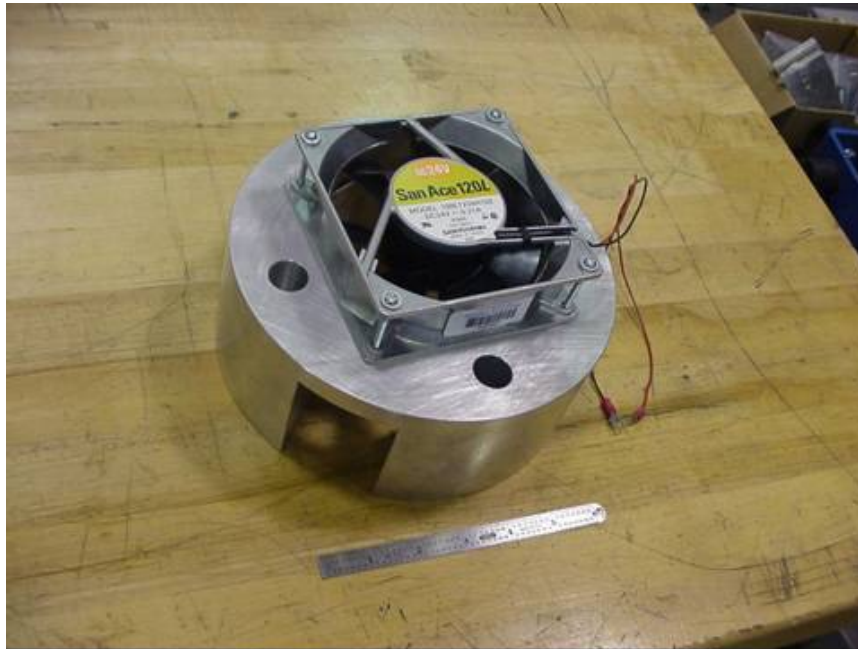
**Manufacturer: San Ace model 120L**

- **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.**

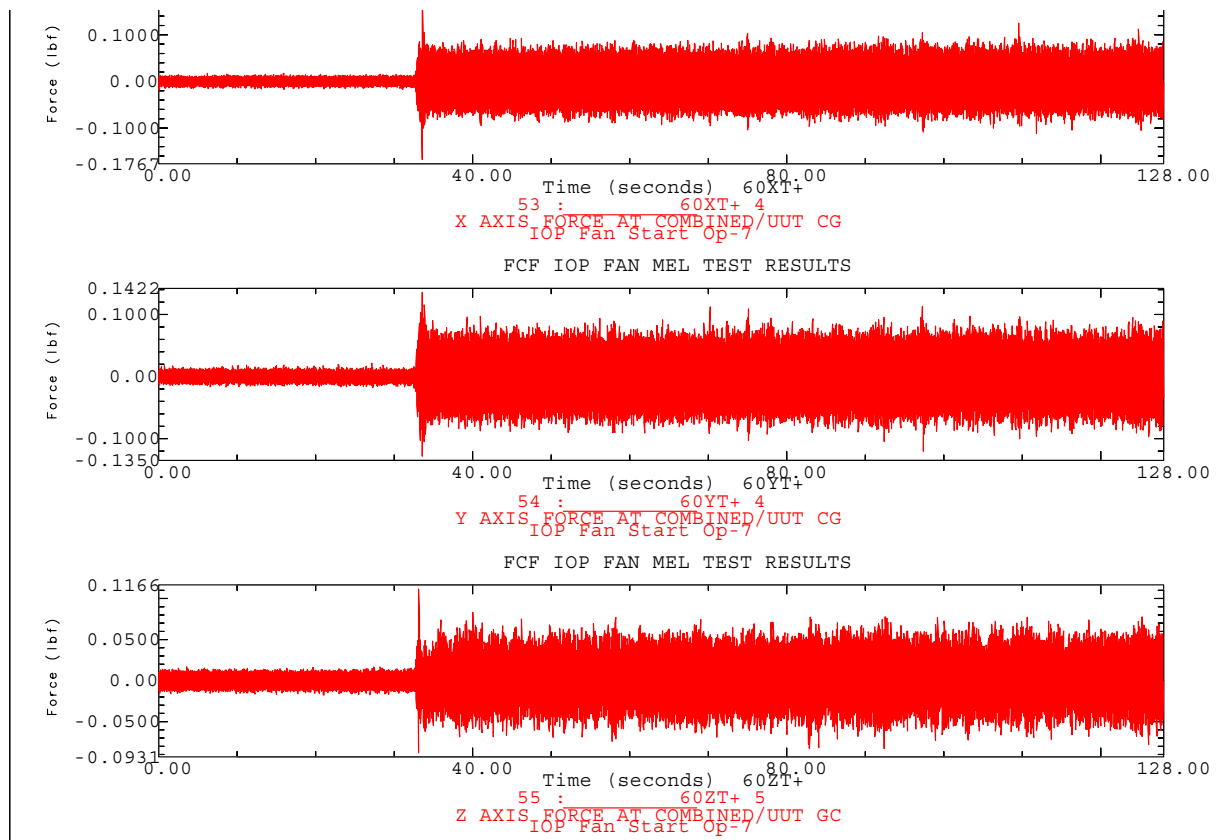




## Fluids and Combustion Facility IOP Fan Candidate Model San Ace 120L



## 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**

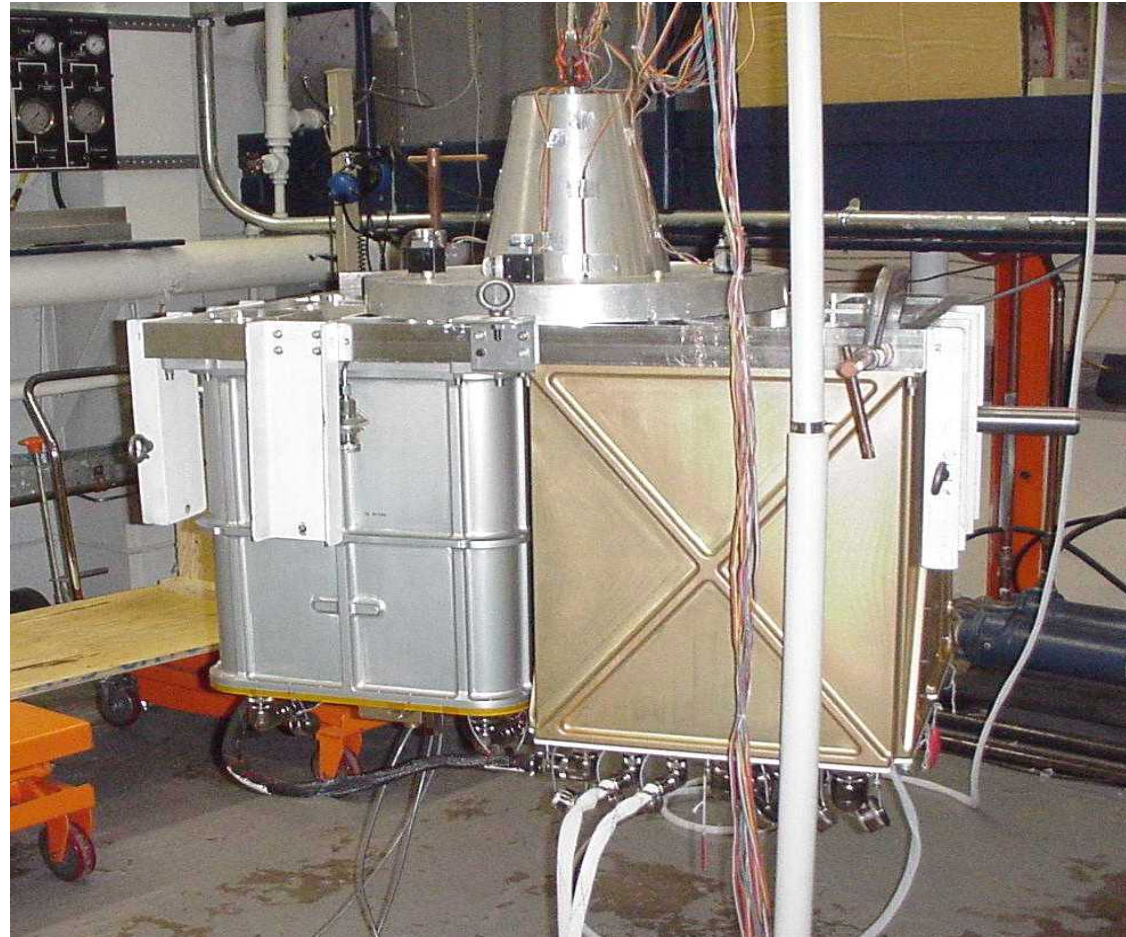


## ***MEL Physics of Colloids in Space (PCS) Testing Express Rack Double Mid-deck Locker Configuration***

### **MEL May 2000 Test**

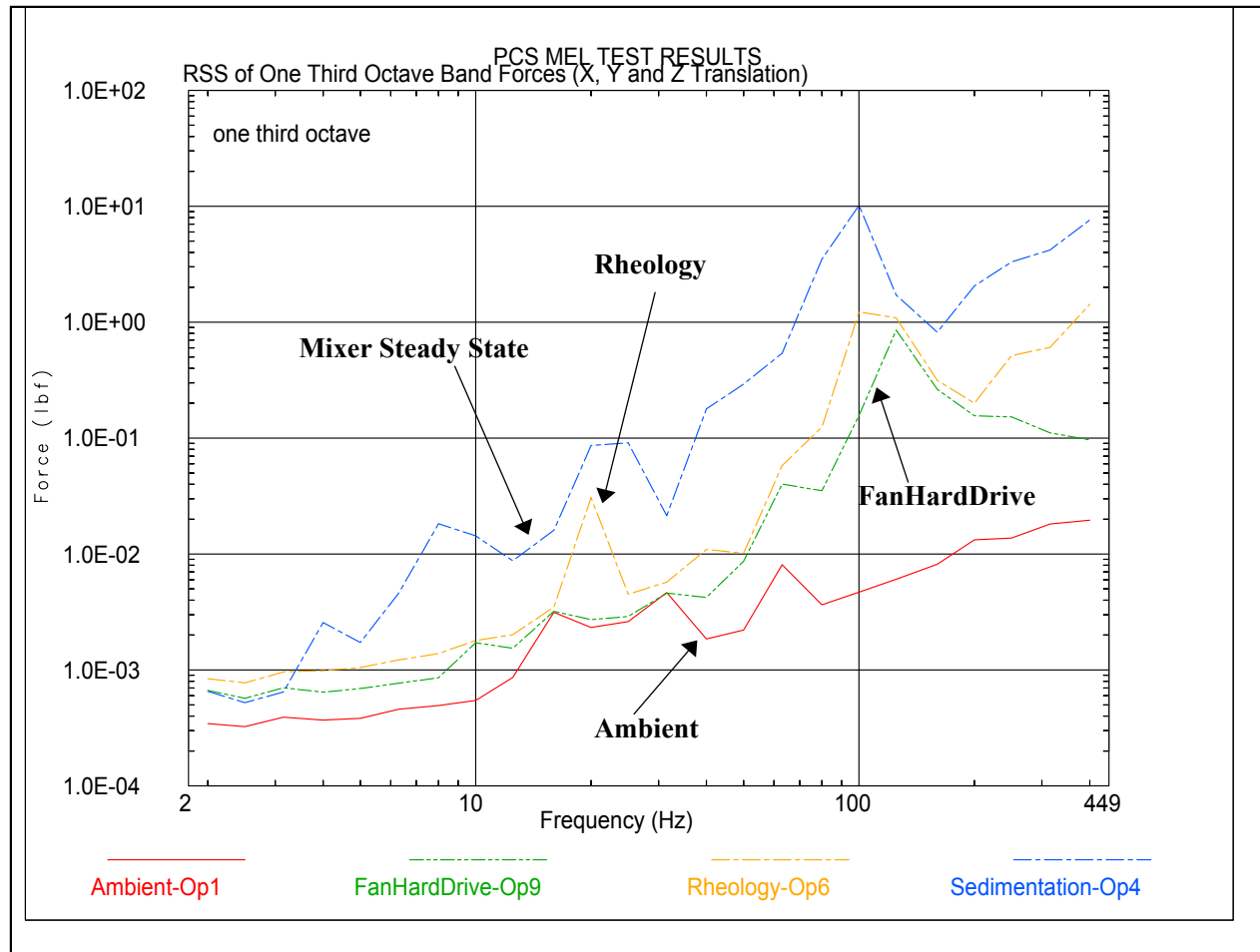
- **Physics of Colloids in Space Experiment (PCS)**
- **The experiment is a double locker configuration and is housed on the ISS in an ARIS controlled EXPRESS-II rack.**
- **Science investigation on sample cells is conducted in the Test section. PCS contains eight different colloid samples. Each sample 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 Physics of Colloids in Space (PCS) Testing Express Rack Double Mid-deck Locker Configuration***

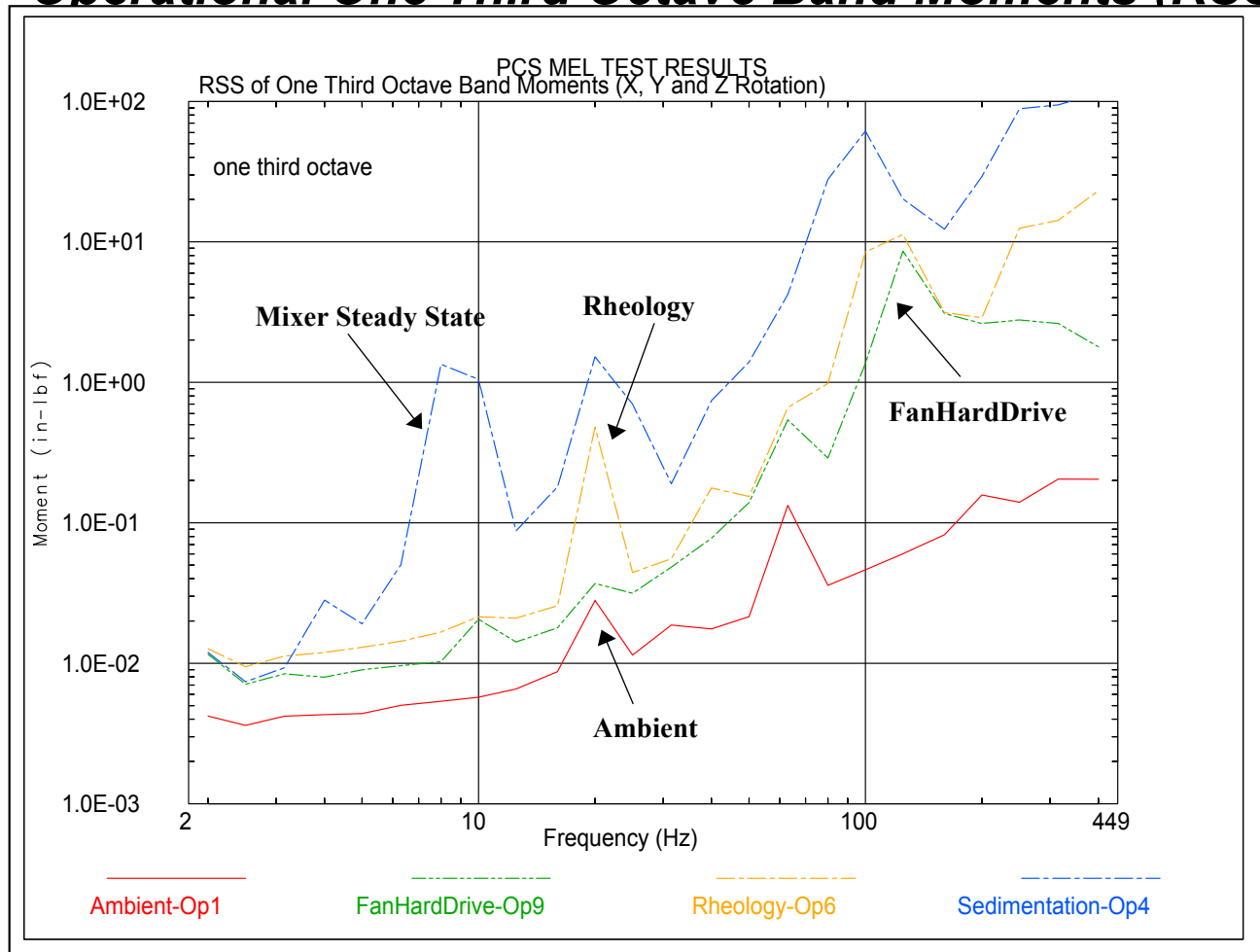




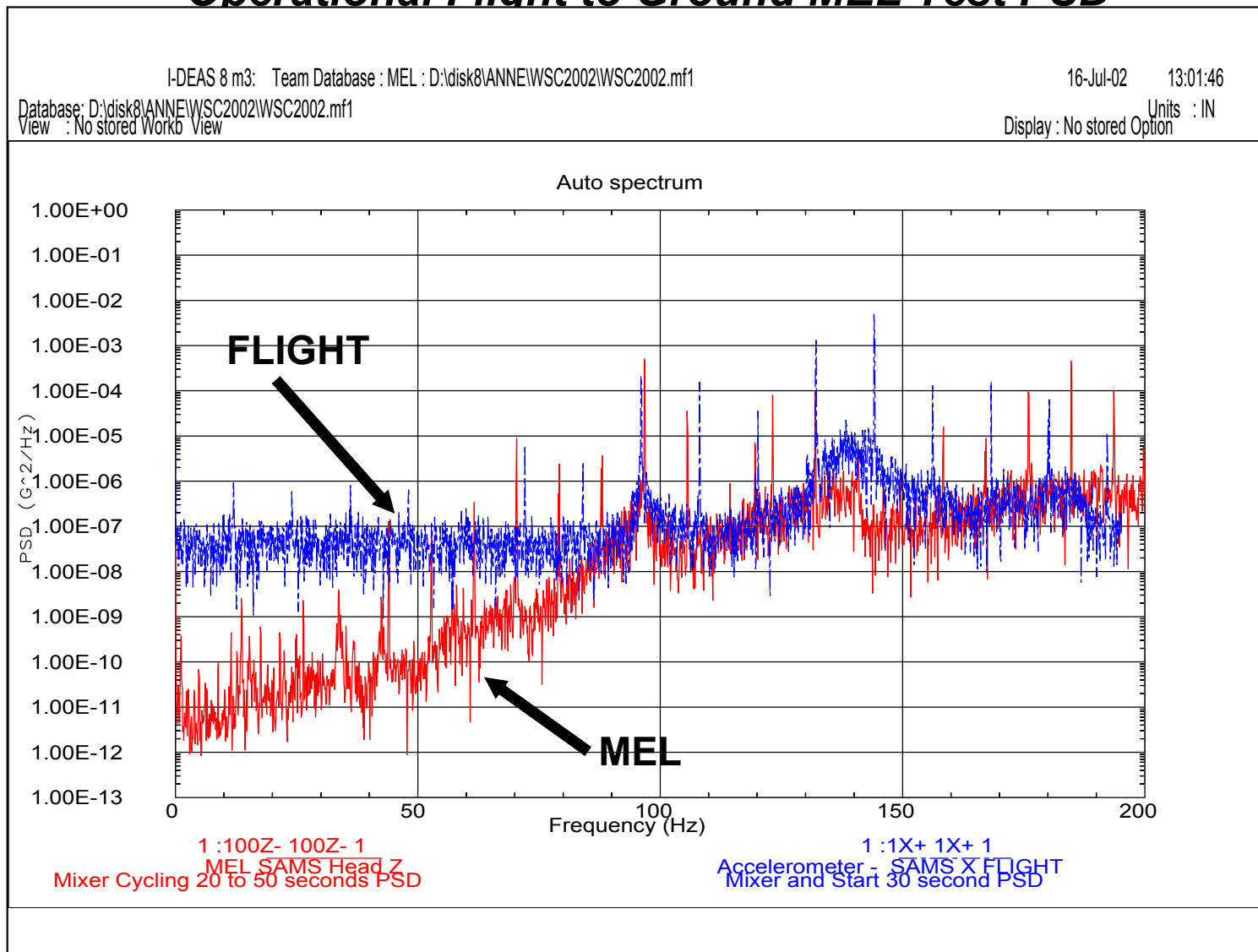
## MEL Physics of Colloids in Space (PCS) Testing Operational One Third Octave Band Forces (RSS)



## MEL Physics of Colloids in Space (PCS) Testing Operational One Third Octave Band Moments (RSS)



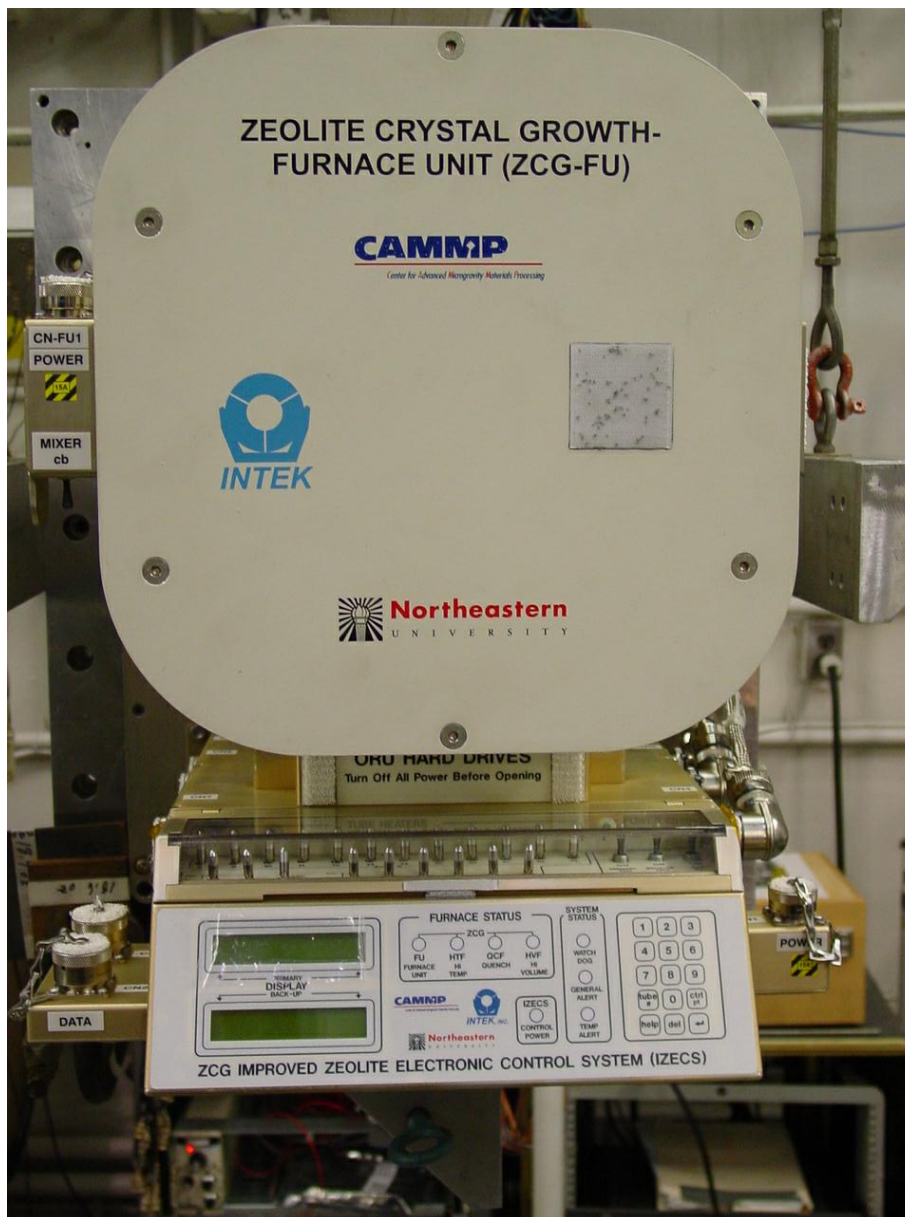
## MEL Physics of Colloids in Space (PCS) Testing Operational Flight to Ground MEL Test PSD



## Zeolite Crystal Growth Experiment (ZCG)

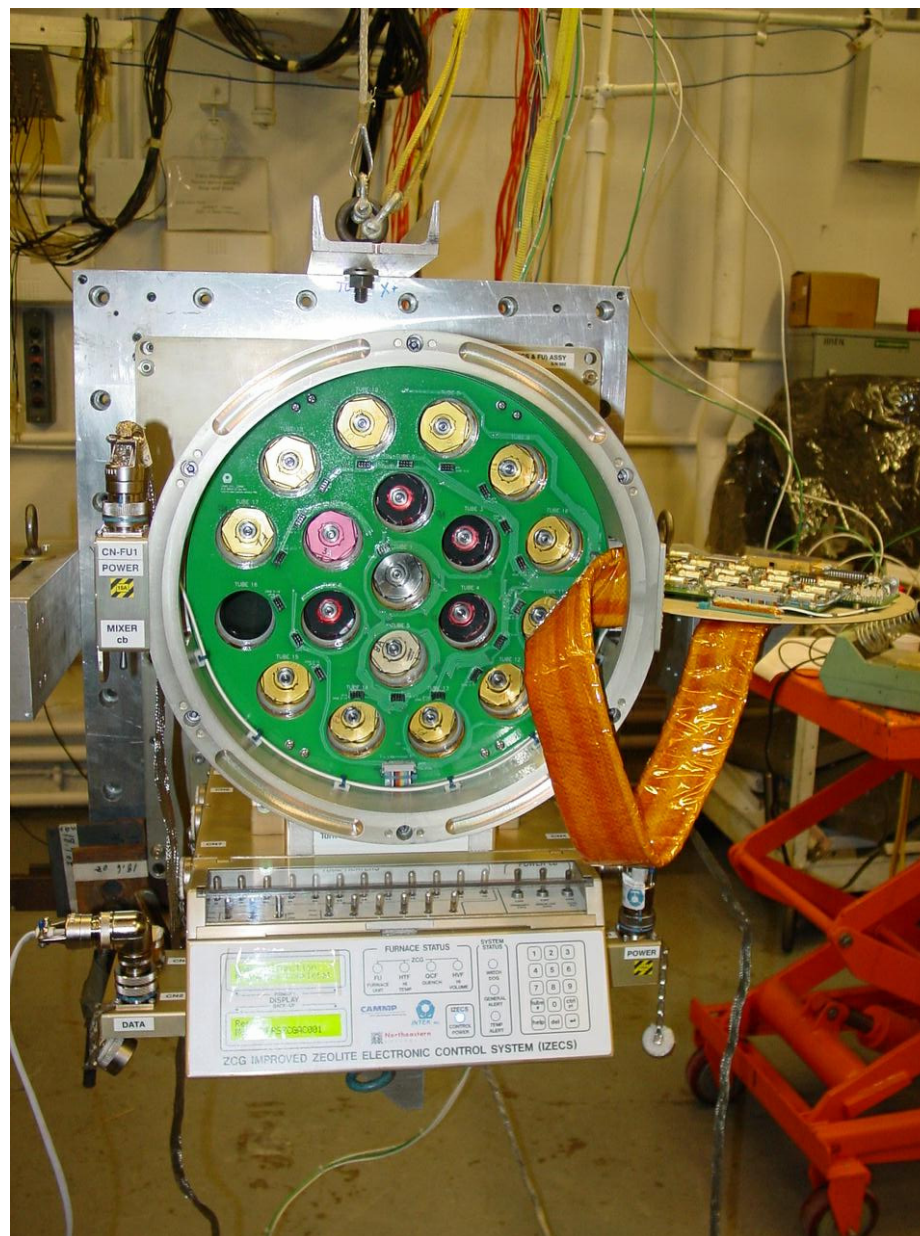
- **The ZCG is a furnace crystal growth experiment that utilizes DC motors to mix the test material within the 19-autoclave cells of the ZCG Furnace.**
- **The primary disturbance sources in the experiment are two cooling fans, hard drive A and B operations, and autoclave motor operation of the furnace experiment section.**

## Zeolite Crystal Growth Experiment (ZCG)





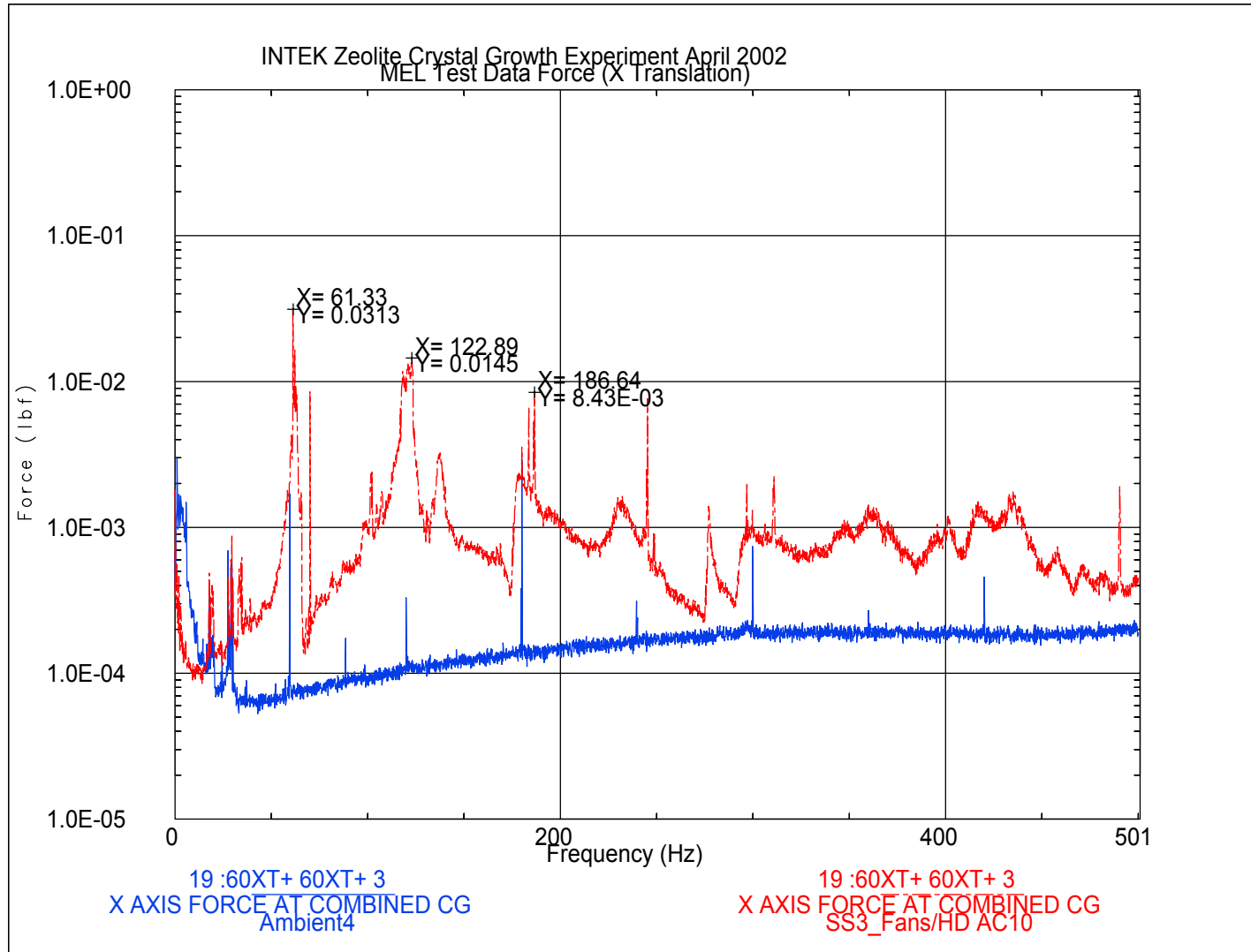
## Zeolite Crystal Growth Experiment (ZCG)



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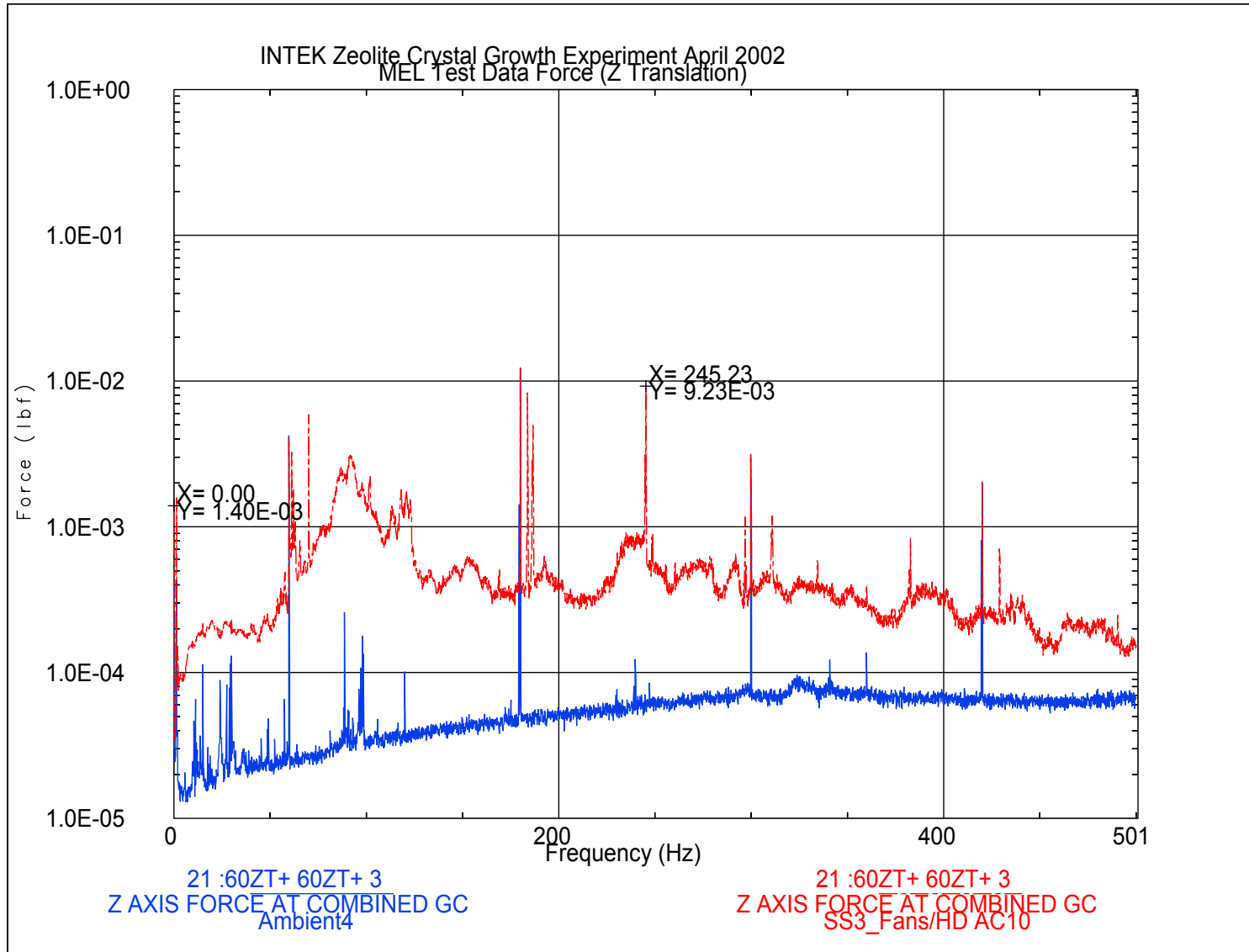


## Zeolite Crystal Growth Experiment (ZCG)





## Zeolite Crystal Growth Experiment (ZCG)



## Zeolite Crystal Growth Experiment (ZCG)

- **By reviewing the narrowband and 1/3 octave band data for the autoclave operation, it is evident that there are response peaks at 61.33 Hz, 122.89, and 186.64 Hz.**
- **These peaks are the tonal characterization of the motorization of the autoclave sample cell mixing activity.**

## CONCLUSIONS

**MEL is a production facility testing various components of GRC's FCF science rack for ISS.**

**Microgravity Emissions Laboratory Testing URL:**

- <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**

