

ENERGY SYSTEMS
TEST AREA (ESTA)

POWER SYSTEMS TEST FACILITIES



National Aeronautics and
Space Administration



POWER SYSTEMS FACILITY

- Located in the Energy Systems Test Area (ESTA) - Bldg 361
 - 1 MVA of facility power
 - 450 kVA of clean, isolated, monitored, power
 - 45 tons of cooling
 - Humidity control
 - Access control



•East Side



•North Side



•South Side

POWER TESTING

- **Flight Testing:**
 - Acceptance testing on hardware before flight
 - Involves independent verification from Quality Control
 - Support Shuttle and Station projects
- **Development Project Support:**
 - Power systems research
 - Power system component and system development and testing



POWER TEST EQUIPMENT CAPABILITIES SUMMARY

- **Sources:**

- 8 to 445 VDC, \pm 530 ADC, 125 kW
- 5 to 120 VDC, \pm 500 ADC, 30 kW
- 300 VDC, 200 ADC, 60 kW
- 50 kVDC, 24 mADC, 1200 W
- Various DC and AC sources

- **Loads:**

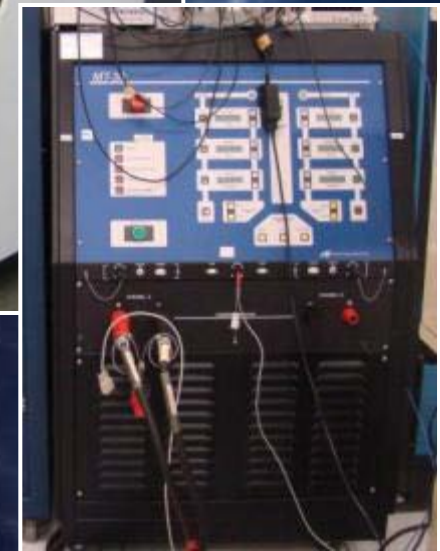
- 24 - 300 VDC, 100 ADC, 30 kW
- 0 - 40 VDC, 360 ADC, 10 kW
- 120 VDC, 1200 ADC, 6000 W
- 150 VDC, 33 ADC, 165 W
- 500 VDC, 150 ADC, 1000 W
- Various DC and AC loads

- **Test Equipment:**

- Calibrators
- Spike Generators
- Scopes
- Digital Multimeters
- Spectrum Analyzers
- Dielectric Analyzers
- High Voltage Switching Units
- Low Voltage Switching Units
- High Speed Data Systems
- Power Amplifiers
- Impedance Analyzers
- Data Acquisition and Control Systems
- Thermal Imagers
- Microscope Camera System
- Chillers

SOURCE / LOAD

- **AeroVironment**
- **Dual Channel Cycling Stations**
- **ABC-150**
 - 8 to 445 VDC, ± 530 ADC, 125 kW
 - Quantity: 2
- **MT-30**
 - 5 to 120 VDC, ± 500 ADC, 30 kW
 - Quantity: 1



SOURCE

- **Lamda EMI Inc**
 - DC Regulated High Power Supplies
 - EMHP300-200D42214
 - 300 VDC, 200 ADC, 60 kW
 - Quantity: 2
 - EMHP150-130D42211
 - 150 VDC, 130 ADC, 20 kW
 - Quantity: 1
 - EMHP40-600D42214
 - 40 VDC, 600 ADC, 30 kW
 - Quantity: 3
- **Spellman High Voltage Co**
 - High Voltage Power Supply
 - SL50PN1200/220
 - 50 kVDC, 24 mADC, 1200 W
 - Quantity: 1



LOAD

- **Resistive Load Banks**

- 24 - 300 VDC, 100 ADC, 30 kW
- Parallelable for higher power levels
- Quantity: 2

- 0 – 40 VDC, 360 ADC, 10 kW
- Parallelable for higher power levels
- Can be modified for higher voltages
- Quantity: 2



LOAD

- **Kikusui Electronic Corp.**

- Multifunctional DC Electronic Load
- PLZ164W
 - 150 VDC, 33 ADC, 165 W
 - Quantity 20
- PLZ1003WH
 - 500 VDC, 150 ADC, 1000 W
 - Quantity 10

- **NH Research Inc.**

- High-Power / High-Current Electronic Load
- 4700-6
 - 120 VDC, 1200 ADC, 6000 W
 - Parallelable for higher power levels.
 - Quantity: 5



BATTERY FACILITIES

Located Primarily in the Energy Systems Test Area – Bldgs 350, 354, & 354P

- Test battery performance (rate capability, cycle life test, thermal cycling and exposure, vacuum, vibration)
- Test battery safety (crush, drop, external short circuit, heat-to-vent, overcharge and overdischarge, vent and burst pressures)
- Provide long-term cold storage
- Associated infrastructure to accomplish the above includes trained, experienced personnel, approved procedures, safety equipment, test chambers, proper facility ventilation.. etc.



BATTERY TEST EQUIPMENT CAPABILITIES SUMMARY

- **Performance Testing:**

- 10 V / 15 A - 36 channels
- 30 V / 30 A - 9 channels
- 15 V / 15 A - 12 channels
- 50 V / 50 A - 4 channels
- 5 V / 10 A - 2 machines with 12 channels
- 80 V / 80 A with 12 channels (needs to be installed)

- **Abuse Testing:**

- 2" and 4" Chamber: 0.1 to 700 psig
- 4" Chamber: 10^{-3} torr to 700 psig
- 2' Chamber currently being installed
- Crush testing (internal short simulator)
- Vent/burst testing (vent tester)
- TCEQ (Texas Commission on Environmental Quality)
- 8Ch 15V / 15A
- 6Ch 40V / 30A

- **Environments:**

- Chambers from 2' to 15'
- Vacuum (1×10^{-6} Torr to 100PSI).
- Thermal (-300°F to 500°F).
- Humidity control from 5% to 95%

- **Test Equipment:**

- Calibrators
- Scopes
- Digital Multimeters
- High Speed Data Systems
- Data Acquisition and Control Systems
- Thermal Imagers
- Microscope Camera System

BATTERY TESTING

- **Flight Testing:**

- Acceptance testing on hardware before flight
- Involves independent verification from Quality Control
- Support many Shuttle and Station projects

- **Performance testing:**

- Long and Short Term Cycling
- Determine capacity of batteries
- Determine optimal charge/discharge rates
- Capacities at different thermal environments
- Vacuum tolerance

- **Safety/Abuse Testing**

(We do everything the label tells you not to):

- Overcharge / Over discharge
- Short Circuit
- Thermal/Heat-to-Vent
- Drop Test
- Crush Test
- Vibration
- Vent/Burst



PERFORMANCE TEST EQUIPMENT

- **Automated Battery Test Stands**

- 12 Systems ranging from 5 V to 500 V and 10 A to 600 A
- Off-the-shelf units (Arbin, Maccor, PEC)
- NASA constructed units (Labview)
- Each channel is independent of the other
- Can record voltage, current, and temperature
- Constant voltage, current, and power modes



BATTERY TEST ENVIRONMENTS

- **Bell Jar Vacuum Chamber**

- 10^{-4} torr
- Pyrex see-thru design
- Protective blast barrier
- 16" diameter x 24" high

(pressures and rates of depress and repress are programmable)

- **Vacuum Environments**

- 10^{-6} torr
- 8ft and 15ft (Thermal Vacuum)

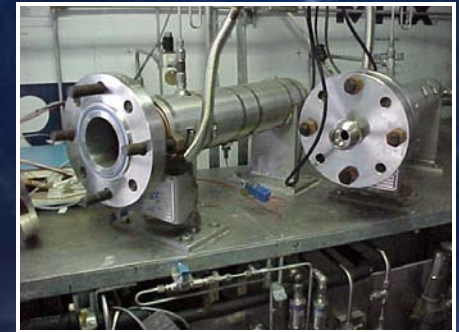
- **Thermal Chambers**

- Various sizes ranging from 2ft to 8ft
- Some have cryogenic capabilities of -300°F (-185°C)
- Some chambers reach 500°F (260°C)
- Precise humidity control
- Unattended operation



BATTERY ABUSE CHAMBERS

- 2" and 4" Chamber: 0.1 to 700 psig
- 4" Chamber: 10^{-3} torr to 700 psig
- 2' Chamber currently being installed
- TCEQ (Texas Commission on Environmental Quality)
 - approved purge of battery vent products
- Connected to:
 - Arbin 8Ch 15V /15A;
 - Labview 6Ch 40V / 30A



BATTERY ABUSE CAPABILITIES

- **Drop Test Stand**

- Trap door operated by solenoid valve connected to a remote switch behind blast wall.
- 6" long x 7" wide trap door
- Adjustable drop height of 0' to 8'
- Video camera capability



BATTERY ABUSE CAPABILITIES

- **Crush Test Stand**

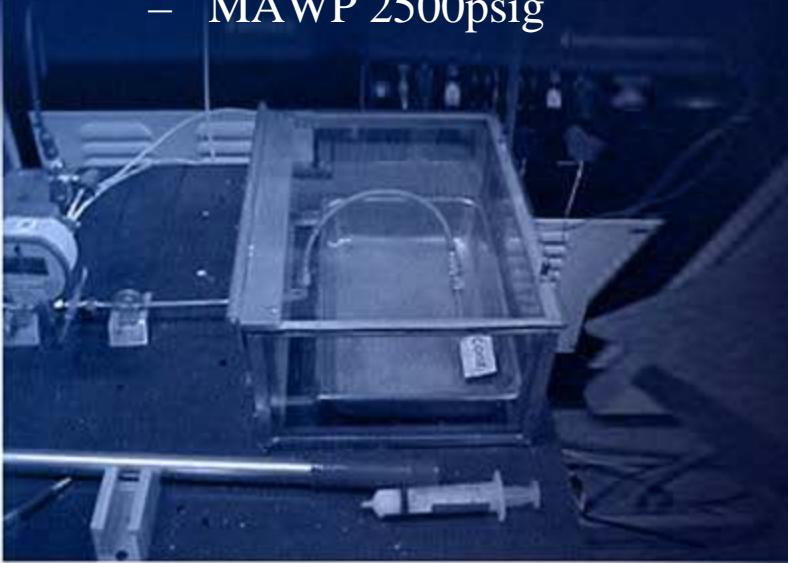
- Operator protected by a blast wall
- Simulates an internal short
- Cause deformation without penetration
- Can measure pressure of hydraulic system and calculate force
- Monitor OCV and temperature
- Video camera capability



BATTERY ABUSE CAPABILITIES

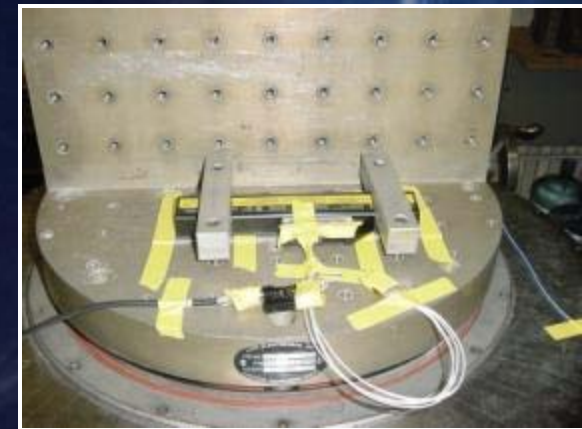
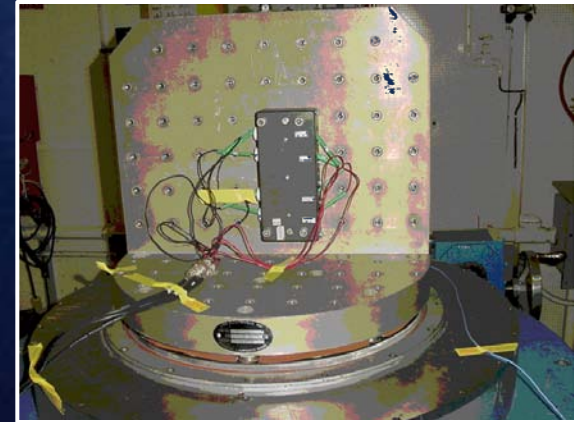
- **Vent/Burst Test Stand**

- Can apply water pressure to battery and measure the pressure the battery vents.
- Can block vent hole and measure the pressure the battery bursts
- MAWP 2500psig



BATTERY ABUSE CAPABILITIES

- **Vibration**
 - Poorly constructed battery prone to internal shorts
 - Vibrate in the x, y and z axes to a defined spectrum
 - Cells and batteries undergo charge & discharge cycling before and after testing
- **Shock testing is also performed**



BATTERY TEST AREA RESOURCES

- **Walk-In Freezer**

- Temperature range: -4°F to 80°F (-20°C to 27°C)
- Usable envelope:
 - 40' long x 9.5' height x 8' width
 - 8' entrance with 2 swing doors
- Temperature data recording
- Alarm
- Fire Protection System



- **Other Resources**

- Spot welding (tabs onto cells for battery build-up)
- (for flight or just ground test)
- Wet and Dry Chemistry Labs (GCs, IR, UV, HPLC,
- Glove Box, Programmable oven, venthood,
- microcalorimeter)



SUMMARY

- **What Do We Have To Offer:**

- **40+ years of power and battery systems design, development and test expertise.**
- **Facilities and resources designed to support power and battery systems development and testing.**
- **Proven processes for the development and testing of all power system components.**
- **Use of all resources from entire Energy Systems Test Area:**
 - **Local machine shop.**
 - **Local welding shop.**
 - **Local chemical analysis lab.**
 - **Local clean processing area.**
 - **Local in place calibration.**
 - **Land for buildups/materials lay down.**
 - **Controlled access**