ENERGY SYSTEMS
TEST AREA (ESTA)

Power Systems
Test Facilities

National Aeronautics and Space Administration

NASA
Isolated from main JSC campus

Safety provisions to accommodate hard failures and hazardous conditions
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
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, ±530 ADC, 125 kW
  - 5 to 120 VDC, ±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
• 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
**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 mAADC, 1200 W
    - Quantity: 1
• **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
**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
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.
**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 (1x10^{-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
• **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
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
• **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 $-300^\circ$F (\(-185^\circ\text{C}\))
  - Some chambers reach $500^\circ$F (260$^\circ\text{C}$)
  - 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
BA TTERY A BUSE C A PA BILITIES

• 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
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
• **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)
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