ENERGY SYSTEMS
TEST AREA (ESTA)

Power Systems
Test Facilities

National Aeronautics and
Space Administration
• Isolated from main JSC campus
• Safety provisions to accommodate hard failures and hazardous conditions
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
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
SO URC E

- **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
• **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^-6Torr 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$^\circ C$)
- Some chambers reach $500^\circ F$ (260$^\circ C$)
- 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
**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
• **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
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/materiales lay down.
  - Controlled access.