ENERGY SYSTEMS TEST AREA (ESTA)

Power Systems Test Facilities

National Aeronautics and Space Administration (NASA)
JOHNSON SPACE CENTER (JSC)

Energy Systems Test Area (ESTA)

- 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

• 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, ±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
SO URCE / LO A D

- **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
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.
• **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°F (-185°C)
  - Some chambers reach 500°F (260°C)
  - Precise humidity control
  - Unattended operation
• 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
• **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