ENERGY ASSURANCE℠

ENERGY ASSURANCE OVERVIEW

NAATBatt Annual Conference, 7-10 February 2022

J. C. Copeland, Founder & CTO, Energy Assurance LLC

COMPANY TIMELINE

2009

Energy Assurance founded by Cindy Millsaps and John Copeland

2011

First 2,500 sq. ft. facility opened in Buford, GA

2014

Facility expansion to 5,000 sq. ft.

2019

EA moves to current facility location in Gainesville, GA, expanding to 16,000 sq. ft.

2020

Growth investment to expand into medium format received from Renew Partners

2021

20,000 sq. ft. large-format cell performance lab acquired in Hopkinton, MA

OUR TEAM

We have been in the battery industry a long time and all we test are batteries

Team Members (28)

8 Battery Industry Engineers

2 Failure Analysis Engineers

2 Lab Managers

1 Program Manager

9 Seasoned Test Lab Technicians

5 Sales, Marketing & Customer Success

Experience

- Motorola, Google, Lenovo, TÜV SÜD, Intertek, The Home Depot, UL, Energizer, Facebook, Natron Energy, General Parts Company, Bain & Co, A123 Systems.

- Our Staff sits on Multiple technical panels; we are thought leaders in the industry.

- Our engineers and technicians have over 200 years combined experience in battery testing.

SERVICE OFFERINGS

Performance Testing

OEMs test under multiple conditions to understand their impact on battery life and safety. This extends into competitive benchmark testing to understand relative strengths or weaknesses.

Safety/Regulatory Testing

All Lithium-Ion batteries must undergo various tests in order to be legally placed on the market. We work with multiple global compliance providers to obtain the necessary approvals to expand your reach into international markets.

Failure Analysis

Lithium-Ion batteries are inherently dangerous. We offer both proactive and retrospective product analysis to help quantify risks or determine causes of failures in the field.

ELECTRICAL PERFORMANCE TESTING

~3,000 cycler channels and over 200 thermal chambers, ovens, & incubators

Capabilities:

- Capacity verification (at temperature)
- Cycle life/endurance cycling
- Charge-discharge efficiency
- Charge-discharge rate capability
- Charge retention/recovery (residual/recoverable capacity)
- Float charge resilience
- Drive cycle testing/HPPC
- Open-circuit-voltage (OCV) characterization vs. capacity
- Precision dimensional measurement
- Over-voltage / over-current
- Storage at various temperatures
- Fuel gage accuracy
- SMBus / I2C / CANBus
- DC-IR (pulse)
- ACR (1 kHz / LF)
- Electrochemical impedance spectroscopy (EIS)
- Realtime secure cycler data access and advanced analytics through *Voltaiq*®

ABUSE TESTING

A multitude of stress environments, both standards-based and custom

Capabilities:

- Stand-alone containment modules (160 and 320 sq. ft)
- Overcharge
- Short-circuit
- Forced-discharge
- Vibration
- Mechanical shock
- Precision drop to various surfaces
- Impact
- Crush
- Nail penetration
- Bend
- Thermal abuse (up to 300°C)
- Cold temperature storage
- Thermal cycling (-73°C to 177°C)
- Humidity (5% to 95%RH)
- Thermal shock (-73°C to 215°C)
- Low pressure (altitude)
- Over pressure
- Emersion (water ingress)
- Insulation resistance
- Battery swell response (flat plate thickness)
- Fault handling
- Chemical resistance

REGULATORY: OUR ACCREDITATIONS

Our full scope of services cover the US and international safety and performance testing standards

UL

ANAB
ACCREDITED
ISO/IEC 17025
TESTING LABORATORY
AT-1601

TÜV SÜD America

SGS

IEC IECEE™

FAILURE ANALYSIS SERVICES

Proactive

Engineering Analysis (“Safety Review”)

- Possible sources of failure

Thermal Runaway Testing

- Possible effects of failure

Retrospective

Failure Analysis

- What happened
- How did it happen
- Why did it happen

Goal of Both:

Are changes needed to product sourcing/design?

CONTACT US

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APPENDIX

(Atlanta) Gainesville, GA Lab Equipment

Cycling Capabilities

- 1,776 total cycling channels (664 Maccor/1112 Neware)

Brand (Cycler)	Channel Voltage (V)	Channel Current (A)	Notes	Number of Channels
Neware	5	6/12/100/400	Multirange	**1016/40/16/4**
Maccor	5	6.5	EIS Mux (8)	**96**
Neware	6	4	Powerbank (USB)	**16**
Maccor	10/12/15	5	Small Battery	**224/40/40**
Maccor	20	6	Small Battery	**60**
Neware	24	15	Smart Battery (SMBus)	**8**
Maccor	25	10/20	Small Battery	**96/12**
Neware	30	10	Small Battery	**8**
Maccor	30	10	Smart Battery (SMBus)	**48**
Maccor	40/60	25/20	Mid-Format Battery	**12/36**
Neware	150	200	Mid-Format Battery	**4**

Environmental Chambers

- 63 chambers

Chamber Type	Temperature Range (°C)	Volume (Cu Ft)	Number of Chambers
Temp Chamber	-75 to +200	0.7 to 2.3	**19**
Temp/Humidity Chamber	-70 to +180 10 to 98%RH	4.0 to 21.0	**13**
Incubator	0 to 60	0.9 to 58.0	**14**
Oven	(RT+10) to 300	1.5 to 28.0	**14**
Air-Air Thermal Shock	-73 to +215	4.8	**1**
RT Room (not a chamber)	25 ±2	147.5 sq ft	**1**
45C Room (not a chamber)	45 ±2	147.5 sq ft	**1**

APPENDIX

(Boston) Hopkinton, MA Lab Equipment

Cycling Capabilities

- 1,180 total cycling channels

Brand (Cycler)	Channel Voltage (V)	Channel Current (A)	Combinable Max. Current (A)	Number of Channels
Maccor	5	100	200	**128**
Maccor	5	120	240	**220**
Maccor	5	240	480	**550**
Maccor	5	300	2400	**240**
Maccor	5	450	900	**42**

Environmental Chambers

- 148 chambers

Chamber Type	Temperature Range (°C)	Number of Chambers
VWR Incubator	0 – 40	**38**
VWR Oven	25 – 80	**33**
Symphony Incubator	0 – 60	**18**
Tenney	-70 – 150	**4**
Test Equity – Standard	-30 – 175	**22**
Test Equity – Cascade	-70 – 175	**3**
Daihan Incubator	0 – 60	**23**
Canatech Small Chamber	-10 – 60	**2**
Canatech Large Oven	25 – 80	**4**
RT Room (not a chamber)	25 ±2	**1**

AUTOMOTIVE PERFORMANCE TESTING

Large-format cell DV and PV validation test types (ref: USABC, etc.)

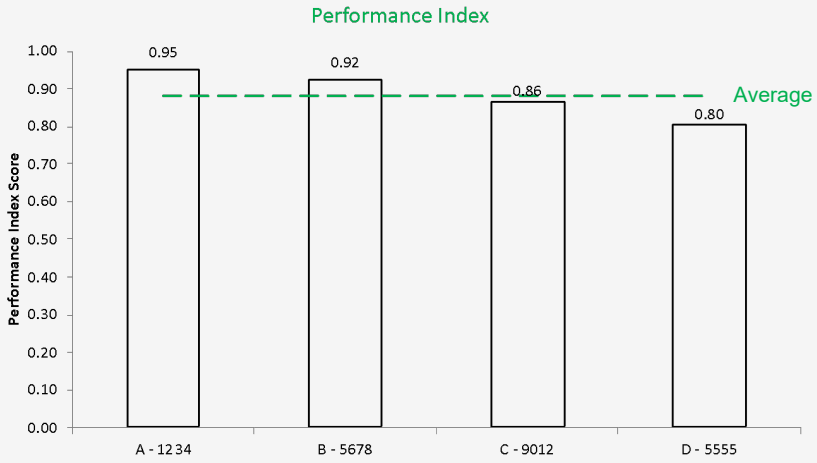
Test Type	Description
State of Health (SOH)	1-2 day test, measures capacity and DCR at 50%, sometimes measure DCR at 20% and 70% as well RPT: Used for storage. Very similar to SOH, but ends at a specific SOC before the cell goes back into storage.
Hybrid Power Pulse Characterization (HPPC)	Discharge/charge pulses at a range of different SOCs to measure DCR
Cycling	Charge/discharge loop to measure capacity fade and cell aging characteristics. Usually has a regular SOH schedule embedded.
Storage	Cell is stored at a certain temperature to measure aging effects. Cell is taken out of storage and runs an RPT at room temperature at regular intervals.
Cold Crank	Low temp test (-25°C or lower) multiple discharge pulses starting at a low SOC. Simulates starting the car at low temp.
Drive Cycle	Similar to cycling but uses an OEM-specific profile to simulate driving requirements. OCV: Slow charge/discharge cycle (~0.1C) with long rest steps at a series of SOC levels. Measures hysteresis and open cell voltage at range of SOCs.
Rate Maps	Series of full charge or full discharge pulses at a range of C-rates. Measures DCR at different amps.

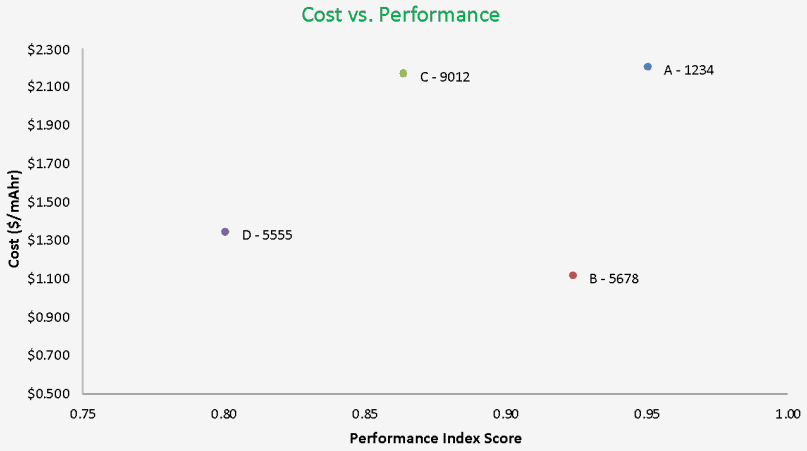
PERFORMANCE & BENCHMARK TESTING

Proprietary scoring methodology

			Capacity Claims		Cycles	Discharge		Charge Time
		Weightings	10%		40%	40%		10%
		Better?	***Higher***	***Higher***	***Higher***	***Higher***	***Higher***	***Lower***
		Sub-weightings	30%	70%	100%	50%	50%	100%
Identifier	**Manufacturer**	**Part #**	**Stated** Ahr	**Acutual** (%)	**Room Temp** (# cycles)	**25A** (min)	**75A** (min)	**Recharge** (min)
A - 1234	A	1234	200	105	834	440	115	340
B - 5678	B	5678	225	110	798	400	110	285
C - 9012	C	9012	180	95	718	375	95	195
D - 5555	D	5555	210	97	587	395	100	255
Average			204	102	734	403	105	269
		Sample Size	*20*	*20*	*5*	*10*	*10*	*25*

= The top performing data point in each test





- Allows for head-to-head performance comparison against competitive products or supplier qualifications
- Output summarizes data in an easy digestible format that can be used as marketing collateral

REGULATORY: TRANSPORTATION TESTING

UN 38.3

Recommendations on the transport of dangerous goods – UN Manual of Tests and Criteria, 7th Revised Edition

IEC 62281

Safety of primary and secondary lithium cells and batteries during transport

REGULATORY: SAFETY TESTING

ANAB

- UN 38.3
- IEC 61960
- ANSI C18.1M
- RTCA DO standards

TÜV SÜD CARAT

- IEC 62133 ed 2
- IEC 62133-1/-2
- IEC 62281
- IEC 60086-4
- UL 1642
- UL 2054
- IEC 62368-1 Annex M
- UL 62133

UL Data Acceptance Program

- UL 1642
- UL 2054
- UL 62368-1 Annex M
- UL/CSA 62133-1/-2
- UL 60086-4

IECEE Certified Body Test Lab (CBTL)

- IEC 62133 ed 2
- IEC 62133-1/-2
- IEC 60086-4
- IEC 62281

SGS Agent Program

- UL 1642, 2054, 2056
- UL 62133-1, 62133-2
- UL 1973, 2271, 8139

SAFETY REVIEW/FAILURE ANALYSIS:

Considerations and Methods

- Verification of regulatory marks (are they real; is it current)
- **Insulation methods**
- Conductor sizing
- Manufacturing issues → latent defect opportunities
- **Protective devices review and functionality**
- Charging circuit review → risk to battery/cell?
- **Cell manufacturer and type / check for counterfeit indications**
- **Internal cell examination (x-ray or CT scans) + (teardown/construction review)**
- Mechanical design review – ability to protect safety critical components
- End user instructions and safety warnings