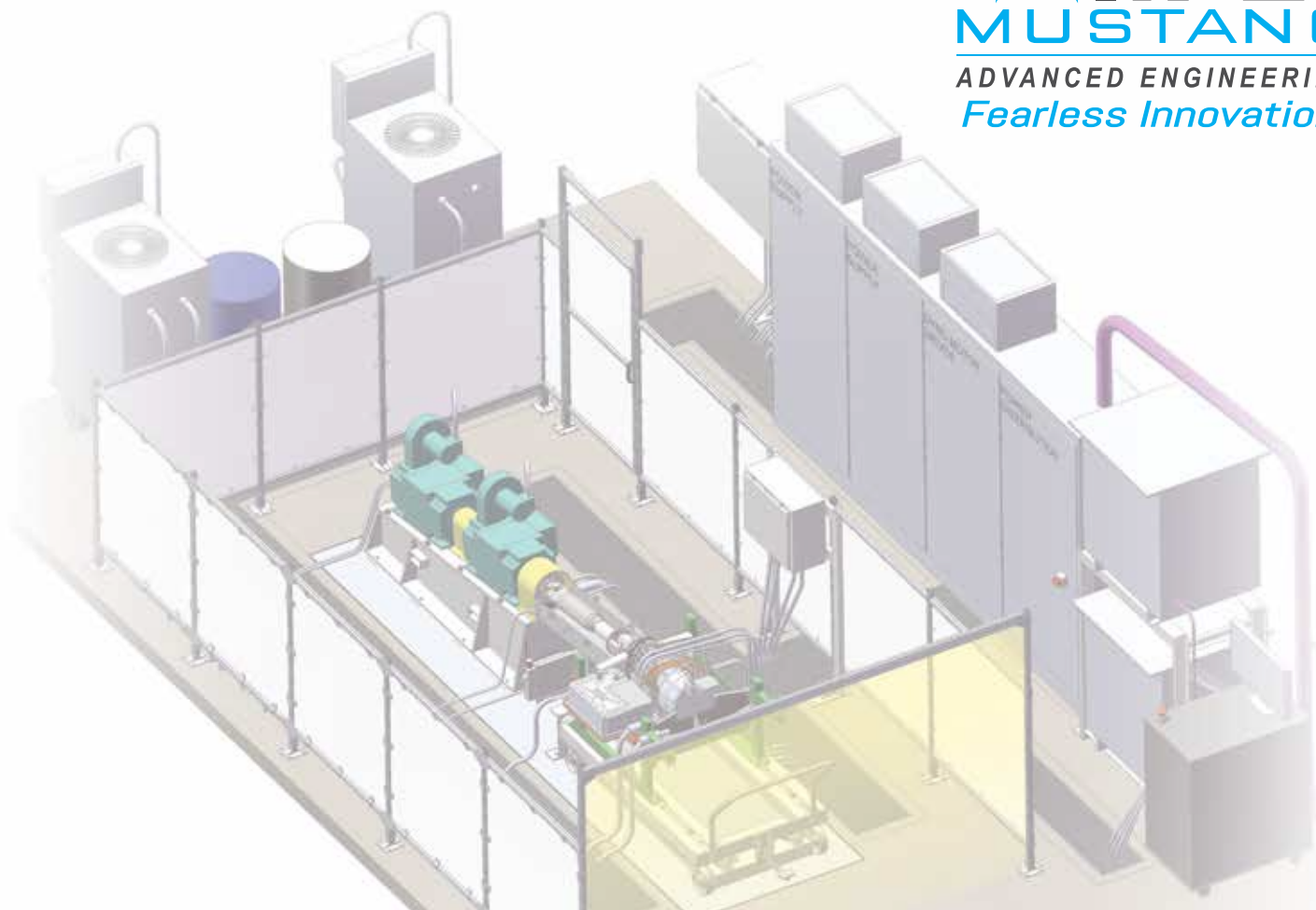


EV & Hybrid - Production Test Cells



Motor Control Unit Testing



Production Software



Electric Motor Testing



Electric Powertrain Testing



Testing Solutions

Global Leaders in Testing

MAE is a test cell system integrator capable of supplying turnkey, fully functional, integrated test cell solutions. MAE draws on more than 35 years of equipment production and test cell integration experience to provide customers the perfect test cell for their requirements. MAE has developed its TESTCell™ product line which leverages existing designs and subsystems integrated with new designs and integrating the latest technology to meet customer requirements efficiently.

MAE was an early adopter of the EV test cell market, integrating the first General Motors EV1 electric powertrain test cell in the 1990's. MAE has delivered many solutions to military, NASA, national testing labs, universities, and commercial entities for a variety of vehicle testing applications. MAE is poised to serve the Electric & Hybrid Vehicle market and its current and future testing needs.

MAE leverages our vast test cell experience and our safety minded engineers to develop test cells that are safe and meet local and national safety requirements. Safety is achieved through physical barriers, electrically lockable access barriers monitored until conditions are safe to unlock, guards, dual hand touch pads, light curtains, electrical lockable doors/covers, pressure pads, lights, lamps and sound. Safety is also designed into the high-power electrical systems with lock-out/tag-out requirements, arc flash analysis and facility interface design.

Test Articles

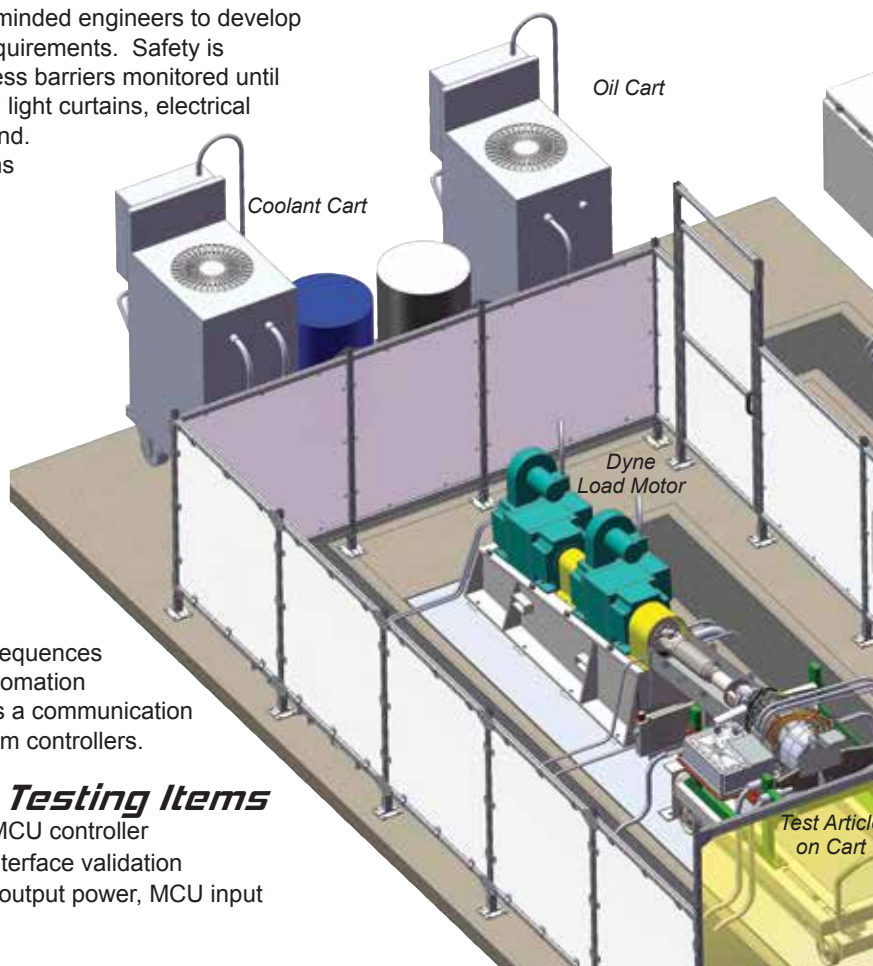
- Electric Powertrain
- Electric Motors
- Electric Motor Control Units
- Electric DC/DC Converters
- Inverters
- Fuel Cell
- Gearboxes
- Batteries

Test Cell Automation Controller

The production automation controller primary function is to sequence the testing procedure and collect data at <1,000Hz. The Automation Controller has chassis mounted signal conditioning and uses a communication backbone to interface with various remote I/O and sub-system controllers.

Common EV & Hybrid Production Testing Items

- MCU communication interface validation and flashing the MCU controller
- MCU LV (12 -48VDC) power consumption, functional I/O interface validation
- Power & Efficiency: Test motor/gearbox shaft power, MCU output power, MCU input power
- Torque and speed regulation at various load points
- Motor regenerative cut off level
- Phase angle, shaft runout and ABS sensor
- Motor phase balance and encoder validation
- Open circuit test: Speed, parasitic torque, voltage, back EMF
- Closed circuit test: Torque, shaft lock and stall
- Insulation Test, HiPot, megger test, winding resistance
- Battery or fuel cell, voltage, loaded current, thermal monitoring
- Dynamic vibration spectral, FFT, order tracking
- Thermal temperature imaging of components
- Coolant and/or oil system heat rejection, pressure differential, leak checks
- Visual & Auditable checks: coolant leaks, cable routing, squeals and knocks



EV Powertrain (Motor, MCU & Gearbox)

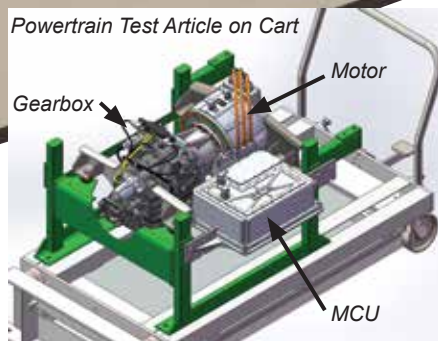
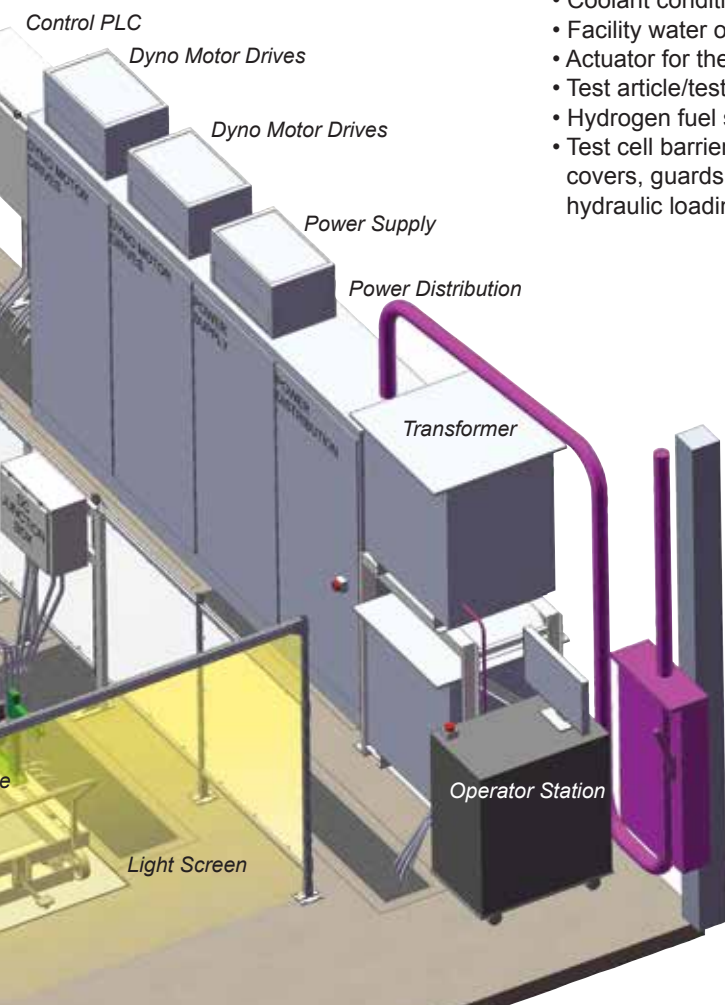


Test Article Mounting Fixturing

Test Cell Components

The EV and Hybrid production product test cell is composed of various test cell building block items as well as custom test article specific items:

- Test cell automation and data acquisition control system (<1,000 Hz)
- High speed data acquisition system (>1,000 Hz to GHz)
- Power analyzer measurement systems (1 - 5MHz)
- MCU & vehicle accessory PS LV (12 - 48 VDC)
- D.C. PS battery simulator/cycler HV (200 - 1,500 VDC)
- Loading motor/dyne controls; AC, DC, eddy current, etc.
- Test bed for test article, loading motor/dyne, fixed, movable, rotatable
- Test article fixturing to test bed, adapter plates, hydraulic clamping systems, lifts and carts
- Various test article interfaces (CAN, CAN FD, ARINC 429, ARINC 825/CAN, Mil-STD-1553)
- Coolant conditioning systems for liquid and gaseous coolant medium
- Facility water or water/glycol, chiller and/or coolant systems
- Actuator for the test article and sub-systems manual control items
- Test article/test cell climate controller interfaces
- Hydrogen fuel supply systems
- Test cell barriers, safety locks, covers, guards, sensors, hydraulic loading units



Components

Coolant/Oil Cart
1kW - 250kW



Battery Simulator
100kW - 2,500kW



Electric Motor Testing

Electric Wheel-end Production Test Stand



Test Cell Components and Integration

Automation Controls System

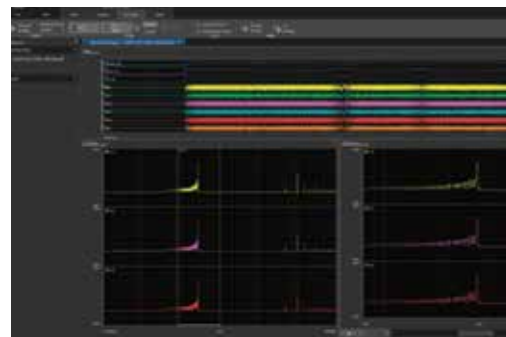
The EV & Hybrid production product test cell operator interface and control software is composed of various MAE developed software modules attached to test cell controllers and interfaced with the operator. MAE routinely uses PLC test cell controllers in the production environment, due to their robust nature and ease of replacement parts.

The Test Cell Controller and sub-system controllers will be configured to sequence the test article through a test script and monitor safety related sensors & items, test cell sensors and test article sensors at < 1,000Hz sampling rates. Should faster sampling rates be required for items such as accelerometers, microphones, MAE will supply our highspeed DAC system which will monitor sensors at rates up to 204,800Hz. Additionally, MAE can supply our Power Analyzer and antennas DAC systems with sample rates > 1MHz to GHz range. Other electrical sensors and sub systems such as insulation HiPot tester can easily be integrated and monitored.

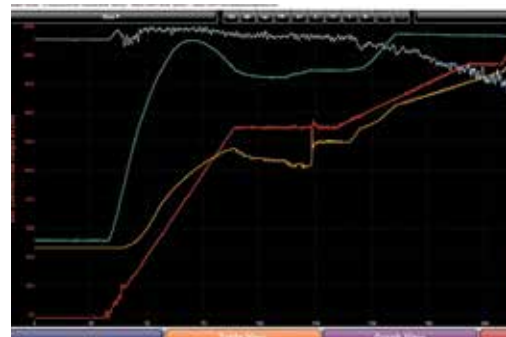
Operator Test Scripts and associated pass/fail criteria can easily be developed and uploaded to the Production Automation Software System. The test stand can be automated to read an RFID tag reader, bar code reader or other means to select the proper test procedure for the presented test article. Additionally, the operator can manually enter the test article or select a test sequence to be perform.



TESTCell™ Automation & DAC System



Software Screens



Automation Controller Screens



Mustang Advanced Engineering

2300 Pinnacle Parkway

Twinsburg, OH 44087

Phone: (330) 963-5400

Fax: (330) 425-3310

Email: Sales@MustangAE.com

MustangAE.com

About MAE

Mustang Advanced Engineering is a leading supplier of advanced, custom engineered testing and measurement systems. Located in Twinsburg, Ohio since 1986, MAE delivers world-class testing solutions, custom design support, technical assistance, backed by a dedicated factory service team, making them a trusted source of expertise for the global industrial market. Visit MustangAE.com for more information. Follow them on Facebook, Twitter, LinkedIn, and Instagram.

