



Battery Engineering and Test Services

BET Services Inc., Battery Engineering and Test Services
7400 Pacific Circle, Mississauga, Ontario L5T 2A4 - Tel (905) 564 6411, Fax (905) 564 6355



BATTERY ENGINEERING AND TEST SERVICES
Pure Electric and Hybrid Systems

BET HELPS TO PUT THE PIECES TOGETHER



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MISSION STATEMENT

To provide professional, cost effective engineering and test services to companies or public agencies seeking to reduce or eliminate exhaust emissions

ACTIVITIES

- ❖ **Application Relevant Battery Cycling**
 - ◆ controlled environmental chambers (temperature and humidity)
 - ◆ batteries for EV, HEV or static applications
 - ◆ 8 V to 600 V systems

- ❖ **Development of Application Relevant Test Machinery**
 - ◆ battery cycling (batteries for EV, HEV or static applications)
 - ◆ cyclic loading of fuel cells (up to 1,100 V and 500 kW)
 - ◆ emulating power train sub-systems for R&D

- ❖ **System Integration (EV, HEV or static)**
 - ◆ low voltage, low power (12 V - 50 V, < 10 kW)
 - ◆ medium voltage, medium power (100 V - 300 V, < 100 kW)
 - ◆ high voltage, high power (600 V, > 100 kW)



COMPANY EXPERIENCE

- ❖ **DIFFERENT BATTERY TECHNOLOGIES**
- ❖ Purpose Design of Test Machines for Battery and Fuel Cell work
- ❖ EV and HEV System Integration

BATTERY TECHNOLOGIES

- ❖ NaS Traction (320 V, 37 kWh, 55 kW)
 - ♦ Ford Ecostar, BMW, VW and Mercedes prototypes
- ❖ Flooded Lead Acid Traction (up to 212 V, 70 kWh)
 - ♦ FLT, Milk Floats (UK), G Van, buses in Santa Barbara
- ❖ Lead Acid SLI and standby
- ❖ VRLA Traction (300 V, 22 kWh, 70 kW)
 - ♦ Ford Ranger
- ❖ NiMH Traction (300 V, 30 kWh, 60 kW)
 - ♦ air cooled NiMH Ford Ranger
 - ♦ water cooled NiMH Chrysler Van
 - ♦ other prototype air and water cooled NiMH
- ❖ NiMH Hybrid (air cooled) (300 V, 1.6 kWh, > 25 kW)
- ❖ NaNiCl (ZEBRA), (18 kWh - 100 kWh, 30 kW to > 100 kW)
 - ♦ traction in cars (e.g. Mercedes Vito, Mercedes A class, BMW prototypes)
 - ♦ hybrid in buses (OCC 28 ft multi-mode hybrid bus, other European buses)
- ❖ Li Ion Exploratory work
- ❖ NiCd in various vehicles



COMPANY EXPERIENCE

- ❖ Different Battery Technologies
- ❖ **PURPOSE DESIGN OF TEST MACHINES FOR BATTERY AND FUEL CELL WORK**
- ❖ EV and HEV System Integration

APPLICATION RELEVANT TEST STATIONS

- ❖ Tests can be conducted in Environmental Chambers
 - ◆ -40°C to +50°C, and variable humidity
- ❖ Controlled Resistive Loads (air cooled)
 - ◆ low voltage (< 50 V), low power (< 25 kW) for modules (batteries or fuel cells)
- ❖ Thyristor based Battery Cyclers
 - ◆ electrical distribution system source and sink
 - ◆ wide voltage and power range, 0 V - 500 V, 350 A cont., (up to 700 A pulses)
 - ◆ fuel cell load (sink only)
- ❖ IGBT Inverters (50 msec response)
 - ◆ electrical distribution system source and sink
 - ◆ waveforms similar to vehicle drives or static power converters
 - ◆ low cost designs based on industrial drives, (minimum voltage at present 75 V DC, lower voltage systems under development)
- ❖ IGBT Inverter Battery Cyclers, 75 V - 645 V, up to 1,000 A
- ❖ IGBT Inverter Fuel Cell Loads, 75 V - 1,075 V up to 500 A
- ❖ IGBT Inverter UPS power converter (from batteries or fuel cells)
- ❖ IGBT Inverter EV or HEV power train sub-system emulators
 - ◆ emulates fuel cells, batteries, electrical drive train, generator load, etc. for power train development work, etc.



COMPANY EXPERIENCE

- ❖ Different Battery Technologies
- ❖ Purpose Design of Test Machines for Battery and Fuel Cell work
- ❖ **EV AND HEV SYSTEM INTEGRATION**

EV AND HEV SYSTEM INTEGRATION

- ❖ EV and HEV Vehicle Systems
 - ♦ complete road-worthy vehicles using batteries of various technologies
 - ♦ pick-up truck with electric drive (320 V NaS battery, 37 kWh, 55 kW)
 - ♦ 28 ft bus with a multi-mode hybrid power train (557 V parallel connected ZEBRA batteries, Siemens traction set and all-electric auxiliaries)
- ❖ **BET** Test Stations Emulate Vehicle EV and HEV Systems
 - ♦ battery management systems, charge algorithms
 - ♦ drive cycle emulation, variable power control (0.1 s commands)
 - ♦ CAN, SCP or analogue communications to control the drive cycle and the thermal chamber (e.g. for diurnal or seasonal variation)
 - ♦ multi-channel data acquisition
 - ♦ safety systems, cooling systems, etc.
 - ♦ operates without supervision 24 hours/day, 7 days/week, 52 weeks/year
 - ♦ 200 kW motor shaft dynamometer can be integrated with the test station for hybrid test rigs (variable load but no regeneration)
 - ♦ test motor driving a regenerative electric dynamometer
dynamometer: rotating electric machine connected via a double inverter to the grid providing fast changing loads and regeneration



TEST STATIONS

- ❖ EV or HEV Battery Cyclers
- ❖ Fuel Cell Loads
- ❖ Environmental Chambers
- ❖ Dynamometers (motor shaft)
- ❖ Vehicle Hoists

EQUIPMENT OVERVIEW

	Quantity
❖ EV or HEV Battery Cyclers (also used as fuel cell loads)	
♦ resistive loads (48 V DC maximum),	300 A, 500 A, 8
♦ thyristor bi-directional (18 V DC),	4 channel, 50 A 1
♦ thyristor bi-directional machines (500 V DC maximum) continuous current rating	100 A 5 180 A 1 350 A 16
♦ IGBT bi-directional inverters (680 V DC maximum), kVA rating for 380 V AC supply	185 kVA 9 225 kVA 1 265 kVA 5 630 kVA 1
(ratings as cyclers or loads depends on minimum DC voltage)	
Total number of machines	47
❖ Environmental Chambers (pack or vehicle size)	8
❖ Motor shaft dynamometers (200 kW)	2
❖ Vehicle Hoists	
♦ cars/vans (4 tonne capacity)	1
♦ larger vehicles (4 wheel tower, 12 tonnes)	1



TEST STATIONS

- ❖ **RESISTIVE LOADS**
- ❖ Thyristor bi-directional Machines
- ❖ IGBT bi-directional Inverters
- ❖ Environmental Chambers

RESISTIVE LOADS

- ❖ **Characteristics**
 - ♦ low voltage (< 48 V), low power (< 25 kW)
 - ♦ current rating 300 A or 500 A (2 models)
 - ♦ MOSFET control (0.2 s reponse)
 - ♦ low ripple
 - ♦ drive cycle control for module R&D
 - ♦ charge algorithms can be programmed
 - ♦ current control to 0.5 A
 - ♦ discharge energy converted to heat - air cooled
 - ♦ fan noise and waste heat are issues
 - ♦ high cost, energy inefficient

- ❖ **Machines at *BET***
 - ♦ 4 x 300 A machines
 - ♦ 4 x 500 A machines



TEST STATIONS

- ❖ Resistive Loads
- ❖ **THYRISTOR BI-DIRECTIONAL MACHINES**
- ❖ IGBT bi-directional Inverters
- ❖ Environmental Chambers

THYRISTOR BI-DIRECTIONAL MACHINES

- ❖ Characteristics
 - ◆ low cost, energy efficient
 - ◆ 3 phase, 60 Hz thyristor bridge control, source and sink, drive cycle control
 - ◆ wide dynamic range 0 V - 500 V, 0.5 A - 350 A (pulses up to 700 A)
 - ◆ current or power control, 100 ms response
 - ◆ low voltage ripple, current ripple (360 Hz, can be filtered)
 - ◆ use for battery cycling (source and sink)
 - ◆ use for fuel cell load (sink only)
 - ◆ discharge (sink) energy dumped into electrical distribution system (very energy efficient but can result in low power factor)
 - ◆ very little waste heat or noise (user friendly)



TEST STATIONS

- ❖ Resistive Loads
- ❖ Thyristor bi-directional Machines
- ❖ **IGBT BI-DIRECTIONAL INVERTERS**
- ❖ Environmental Chambers

IGBT BI-DIRECTIONAL INVERTERS

- ❖ Characteristics
 - ◆ medium cost, low ripple, energy efficient, very little waste heat
 - ◆ low acoustic noise, low electronic noise
 - ◆ 50 ms response time, current or power control
 - ◆ application relevant waveforms in source and sink
(vehicles and power converters use inverters to interface with battery or fuel cell)
 - ◆ discharge (sink) energy dumped into electrical distribution system
(very energy efficient)
 - ◆ high power factor
 - ◆ uses
 - EV and HEV battery cycling (source and sink)
 - fuel cell loads (sink only)
 - electric power train sub-system emulation
(can emulate fuel cell, battery, drive train, etc.)
 - ◆ **BET** machines operate in range 75 V DC - 680 V DC currents from 0.5 A to 1,000 A



TEST STATIONS

- ❖ Resistive Loads
- ❖ Thyristor bi-directional Machines
- ❖ IGBT bi-directional Inverters
- ❖ **ENVIRONMENTAL CHAMBERS**

ENVIRONMENTAL CHAMBERS OVERVIEW

- ❖ **Characteristics**
 - ♦ chambers at **BET** are sized for full battery packs (EV or HEV, in singles or multiples)
 - ♦ 2 chambers could take a mid-size vehicle or quite large fuel cell systems
 - ♦ temperature control in range -40°C to +60°C
 - ♦ humidity control available on 2 chambers
 - ♦ test station control for cycling etc. can also be arranged to control the chamber temperature for special tests e.g. diurnal cycles or battery temperature investigation
- ❖ **Chambers at BET**
 - ♦ 8 pack or vehicle-size chambers available
 - ♦ larger chambers are in a fixed location, smaller chambers can be moved to different test locations



TEST STATIONS

- ❖ Resistive Loads
- ❖ Thyristor bi-directional Machines
- ❖ IGBT bi-directional Inverters
- ❖ **ENVIRONMENTAL CHAMBERS**

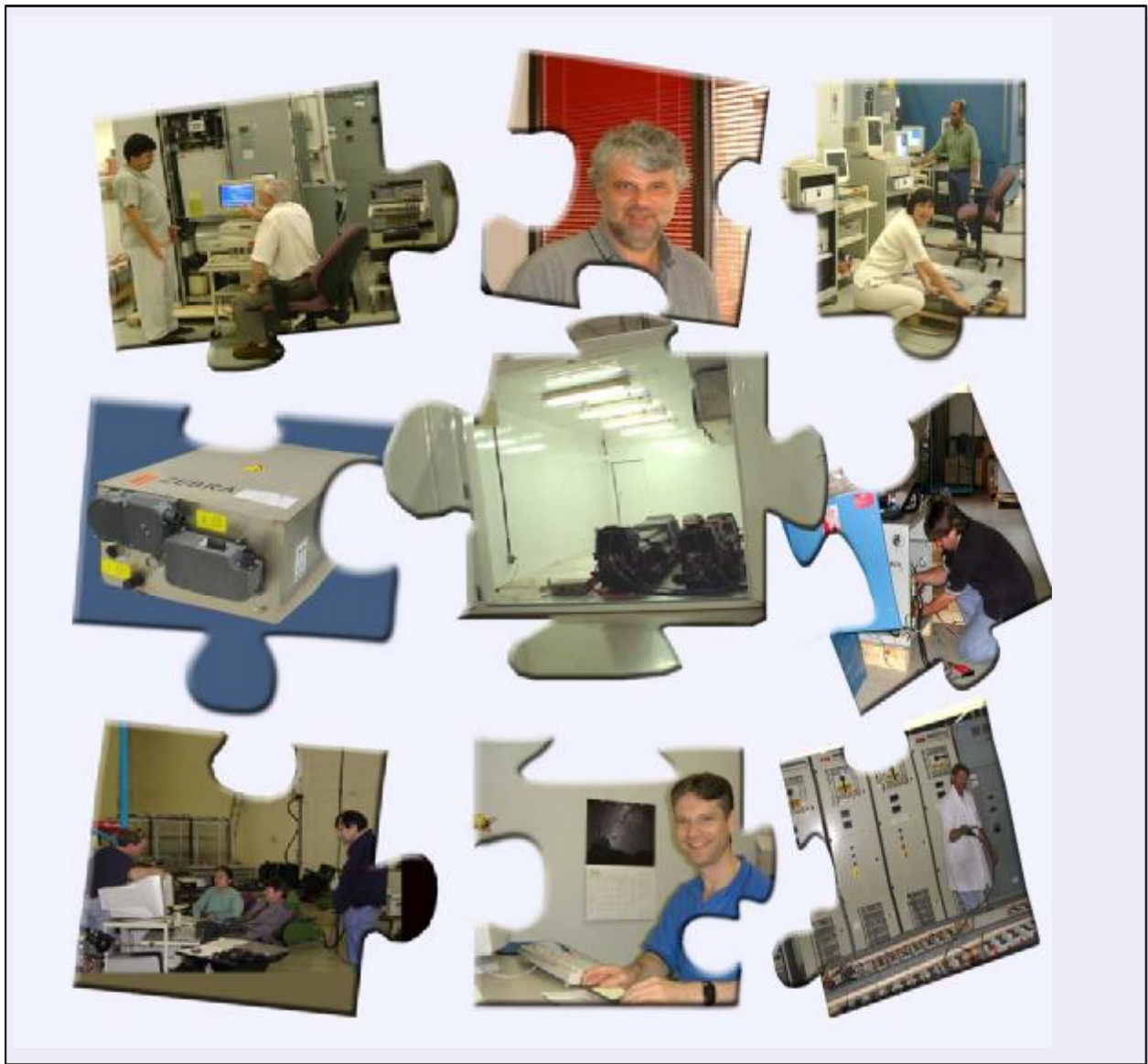
ENVIRONMENTAL CHAMBERS DETAILS

Thermal Chamber	Usable Space approx (W x L x H)	Temperature Range
RH Pack Chamber	9 ft x 13 ft x 8 ft	-30°C to +50°C
RH Vehicle Chamber	13 ft x 20 ft x 8 ft	-40°C to +50°C
Thermotron Chamber (F)	14 ft x 9 ft x 8 ft	-50°C to +85°C
Envirotronic Chamber #1 (F)	7 ft x 9 ft x 8 ft	-50°C to +65°C
Envirotronic Chamber #2 mobile	5 ft x 4 ft x 4 ft	-30°C to +150°C
Envirotronic Chamber #3 mobile	5 ft x 4 ft x 4 ft	-30°C to +150°C
Envirotronic Chamber #4 mobile	6 ft x 5 ft x 7 ft	-40°C to +65°C (also humidity)
SEXTON	8 ft x 14 ft x 12 ft	-55°C to +55°C (also humidity)
Time for Pull Down		1°C/2 min 5°C/min (SEXTON)
2 Chilled Bays - Roller Shutter	10 ft x 12 ft x 15 ft	5°C to ambient
2 Bays - Roller Shutter	10 ft x 12 ft x 15 ft	ambient (security room)
Class II Room - Roller Shutter	9 ft x 20 ft x 12 ft	ambient (security room)
Forced Ventilated Room - Steel/Glass Doors	8 ft x 17 ft x 12 ft	ambient (special tests)



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