Composites Engineering Research Laboratory

Equipment, Capability, and Facility Presentation

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CERL Mission Statement

To provide to the broad spectrum of New England Composites Industries:

- 1. Applied engineering expertise for manufacturing, process development and optimization
- 2. Complete, advanced analytical services
- 3. Focused educational training
- 4. Prototype manufacturing

This broad spectrum of services all within one industry owned organization, fulfills CERL's charter to facilitate the needs of our industry as it strives to compete in the global marketplace.

Targeted Sectors For Engineering and Analytical Support

Marine	Construction	Alternative Energy	Avionics / Aerospace	Consumer
 Engineering FRP Hand layup Vacuum Infusion Unsat. polyesters Gel Coats 	 Filament Winding Pultrusion Chemical Resistant Products Infrastructure Unsat. Vinyl esters 	 Windblade manufacture and repair Hydro-kinetics 	 Advanced FRP Carbon fiber TS Epoxies Carbon fiber TP PEEK, PS Elevated Temperature Molding 	 Sheet and bulk molding compounds Electronics composites TP thermo- forming TP composites Decorative Laminates Solid Surfacing

CERL Services Scope

- The directive of the laboratory is to partner with Regional Composite Companies to address their engineering and applied research needs to allow them to be more productive and competitive in the global composites marketplace
- The scope of the laboratory can be sub-divided into 3 levels of support:
 - Level 1 Quality Control Testing: Once test methods are developed, this testing would be for routine or repetitive data collection.
 - Level 2 Methods Development and Unknown Sample Testing: This testing would require methods development and engineering interpretation of results. The fee structure would relate to the two components of this testing
 - Level 3 Product Development / Process Optimization: This support would incorporate both significant engineering support as well as, as needed analytical testing support. The fee structure can be hourly / instrument time, or per project

ANALYTICAL CAPABILITY OF CERL

Shimadzu AGX – 300kN Frame / 100kN Load Cell, Accessories include– Tensile and Flexural Configurations



Tensile Testing Configuration

- 100 kN Load Cell Capability is equal to roughly 22,500 pounds of force.
- 300kN Frame can withstand roughly 67,000 pounds of force.

Application and Uses

- Mechanical testing of materials
 - Tensile
 - Compression
 - Flexural
 - Cove Bend
- Data capture rate to 0.1msec

TA Instruments Q800 Dynamic Mechanical Analyzer (DMA)



Testing Fixtures / Modes Include:

- 3 point bend
- Single or Dual Cantilever
- "Rock and Roll" Clamps
- Tensile Clamp

Applications and Uses

- Dynamic and Static flexural modes
- Most sensitive technique for Tg determination in Composites
- Advanced predictive modeling TTS
- Used as a micro-UTM
- Fatigue capabilities
- High temperature applications

TA Instruments AR2000 Ex Parallel Plate Rheometer with Electrically Heated Plates



Fixtures include both liquid and solid state sample configuration testing

Applications and Uses

- Extremely powerful analytical technique
- Measures in both dynamic and static shear modes
- Characterizes flow behavior of materials as a function of: time, shear rate, amplitude, frequency, temperature, and normal force.
- Exceptional method for characterizing the effects of processing conditions on the behavior of the material.
- Quantifies cure, viscosity, process induced flow and recovery behaviors, and is overall the most informative tool in the lab for behavior characterization

TA Instruments Q400 Thermo-Mechanical Analyzer (TMA) with Mechanical Cooling Accessory





Mechanical Cooling Accessory capable of controlled cooling to -70°C

Applications and Uses

- Coefficient of expansion and contraction measurements
- Softening characterization
- Dimensional changes as function of temperature, force, and time

Probe set includes: Expansion, Penetration, and Knife Edge Flexural Testing Capabilities

Q2000 & 2920 Differential Scanning Calorimeters



Q2000 T Zero DSC sub-ambient to -90C

Applications and Uses

- Technique measures heat flow through a sample as a function of: time, temperature, and environment (air Vs. nitrogen)
- Used for cure kinetics modeling, Tg determination, melt, crystallization, and all thermal enthalpic events



2920 DSC

Q500 Thermogravimetric Analyzer



Q500 TGA ambient to 1200°C

- Run in Inert (Nitrogen) or Oxidative (Air) Atmosphere
- Balance sensitive to 0.1µg

Applications and Uses

- The primary application of this instrument is to measure weight loss as a function of: time, temperature, and environment
- Used for accurately determining organic Vs. inorganic composition, volatile content, thermal stability temperatures
- Decomposition fingerprinting of organic materials

Keyence VR-3200 MacroScope





12x to 160x Optical Imaging, Non-Contact characterization of surfaces up to 4 inches by 8 inches with automatic stitching capability <u>Applications and Uses</u>

- Roughness and Waviness Measurements
- Defect analysis and automatic counting, labeling, and quantifying
- Surface and defect depth and size analysis
- Automatic report generation
- Image and data output in excel and solidworks

Nicolet iS10 Fourier Transform Infrared Spectrometer (FTIR)



Applications and Uses

- Primarily used for organic structural analysis. Using the ATR technique, any material that can be placed in intimate contact with the crystal can be characterized and identified
- Tremendous tool for reverse engineering, materials identification, contaminate identification, and material change due to processing or environmental exposure

Configured with ZnSe Attenuated Total Reflectance (ATR) chamber

Forcipol 2v and Forcimat Automated Grinder/Polisher



With Forcimat specimen handling Accessory

- Automated Grinding / Polishing unit for precision surface preparation.
- When combined with crosssectioning and potting encapsulation of samples, can be analyzed with the Ergolux High power microscope or the Keyence VR-3200 3D Macroscope optical viewer mode.
- Extremely valuable for optical characterization and documentation of material interfaces and process validation

Reme-Hart Goniometer for Surface Tension / Contact Angle Measurements, and LECO M-400-H2 Micro-Hardness Tester



Goniometer set up to syringe dispense Sample onto various substrates, for the Measurement of surface tension through Contact angle determination



Micro-hardness tester used by the Semiconductor and Composites Industries

Bausch & Lomb Stereoscope and Ergolux High Power Stereoscope



15x Optical Magnification with a 2.0Megapixel camera for magnified image capture.



Up to 1000x Optical Magnification

High Powered Digital Microscopy and 3D Printing System



Nikon High Powered Digital Microscope



Formlabs – Form 1+ SLA 3D Printing System

4.9" x 4.9" x 6.5" Maximum Build Volume

Analytical Balance and Granite Table



Mettler H80 Analytical Balance



2 foot by 3 foot granite table

Non-Destructive Imaging with the FLIR Advanced 655SC Thermography Camera and Software



FLIR 655SC Advanced Scientific Thermal Imaging System



Advanced Thermography Testing of Composite Substrate with 1000W Halogen Lamp and the 655SC Camera with ResearchIR Computer Interface

Non-Destructive Testing – Thermography FLIR E60 Camera and Research IR Interface Software



FLIR E60 Mobile Stand Alone Thermal Imaging System – and in testing mode with ResearchIR



Non-Destructive Testing Using Advanced Ultrasonic A,B, and C Scan Imaging



NOTE: Presently In the process of being purchased

Olympus OmniScan SX PA Ultrasonic Control Unit, with Phased Array Sensing Probe for Composite Flaw Detection

MANUFACTURING CAPABILITY OF CERL

Support Equipment – Blue M Clean Room Oven, and National Appliance Vacuum Purge Oven



Blue M model DCC-256E controlled gas Clean room oven capable to 250°C



1.5 ft³ Chamber. Max Temperature of 225°C, Vacuum Range (-1) Atmosphere (-14.7PSI)

Manufacturing Facility





1HP Rotary Vacuum Pump - 14.1 CFM Allows for in-shop Vacuum Infusion Processing. Pump is fit with a manifold to allow for a quick swap between full and half vacuum SAS Carbon Filter Self Contained Fume Hood and Ohaus Model 1502 Analytical Balance

Muffle Furnace and Clean Dry Compressed Air



Thermolyne Benchtop Muffle Furnace capable of 1100°C.



California Air Systems high pressure And low noise, clean, dry, oil-free air compressors

Bladder Assist Vacuum Forming System



Chemical Storage and Dust Collection



Separate Chemical Storage for Flammable Vs. Hazardous Materials



JET Model DC-650 self contained Dust Collection system

Manufacturing Facility



10' x 12' Fabric Cutting Table with clamp and guided electric cutter makes trimming glass to precise dimensions much easier.



3' x 5' Glass Infusion Table with Simultaneous Top and Bottom Video capability allows for characterization of infusion materials and/or processes.

Additional Mobile Hepa Filter Exhaust Hood, and MITS Glass Table



4' x 4' Mobile Infusion Technology System (MITS) with Simultaneous Top and Bottom Digital Imaging.



Mobile Hepa Filter Exhaust Hood

Commercialized MITS Tables at the New NREL Composites Center – Boulder CO.



MITS 4 ft. by 4 ft. Table with Heated Glass surface capable of temperatures Up to 140C. Digital imaging Top and Bottom Surfaces

MITS 4 ft. by 6 ft. Non-heated Table With Digital Imaging Top and Bottom Surfaces

Manufacturing Facility



SAS Portable Carbon Filter Organic Fume Ventilation. Allows safe use of chemicals without the need for a fixed ventilation system.



Temperature Controlled Molding Surface. Water heated or cooled from ambient to 94°C (200°F) for elevated temperature infusions/processing

Bridgeport EZ Trak 2 DX Milling Machine



- 2 Axis Computer Numerical Control
- 3 Axis Digital Position Readout
- Table Size 9" x 48"

- Small Scale Prototyping
- Thermal & Mechanical Sample Machining

Office Furnishings





Additional Equipment and Materials

- In addition to the equipment listed separately in this presentation, CERL has:
 - Thousands of dollars in hand tools, meters, temperature sensing equipment, voltage regulators, and a various assortment of vacuum infusion manufacturing tools, carts, and mobile handling capabilities.
 - A significant amount of roll stock raw materials for FRP manufacturing.
 - Laboratory stools, tables, and other laboratory and office furnishings