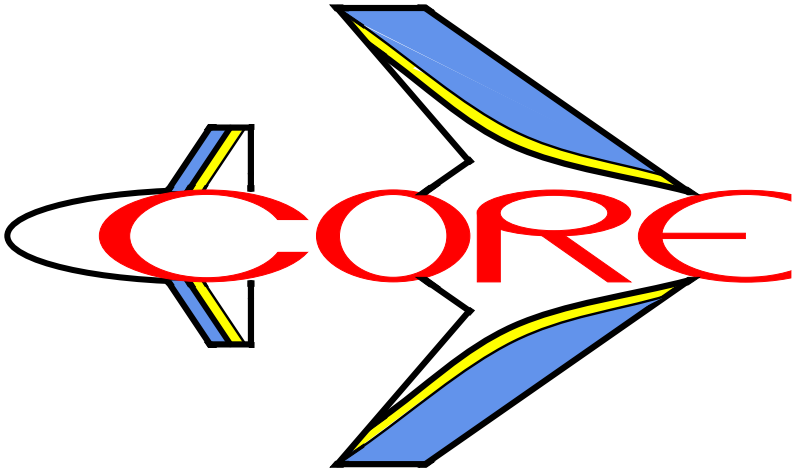
Operating Procedures for the Composites Research Laboratory



Off-Campus Researchers

July 1, 2002

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1. Description

The Composites Research Laboratory (CORE) at the University of Maryland, College Park provides an environment for education, research, and development activity in composite materials and structures. The goals of the laboratory are to promote the understanding and the use of composite materials, to maintain up-to-date manufacturing and testing facilities to conduct basic research, and to provide an accessible knowledge and technology base.

The academic departments with major participation in the composite materials program are the Departments of Aerospace Engineering, Mechanical Engineering Department, the Materials and Nuclear Engineering, and the Fire Protection Engineering Department.

CORE is comprised of facilities that allow the full spectrum of specimen manufacture, preparation, inspection, and testing. The manufacture of composite components and specimens can be done in either an autoclave or a vacuum hot press. A layup facility allows the fabrication of flat laminates with arbitrary stacking sequences. This facility includes the necessary templates to accurately cut preimpregnated tape, and four-section cure assemblies with caul plates and aluminum dams. This facility has been used to manufacture thin laminates, thick (0.5 in) composite sections, open and closed section shell beams, and tapered laminates.

Additional manufacturing capabilities include a filament winder. The filament winder is mechanically controlled and has two axes of freedom, the spindle and the carriage. Simple constant cross section geometries can be fabricated with the winder. The winder is capable of making components 1-ft in diameter and up to 5-ft long.

Composite specimens and components are manufactured with the aid of a micro-processor-controlled Baron autoclave. The controller is linked to a computer that allows for easy development and execution of cure recipes. The autoclave is capable of maintaining and controlling temperatures up to a maximum of 750 °F and pressures up to a maximum of 250 psi and has a test section of 3-ft in diameter and 4-ft in length. Currently, up to seven of the twelve available thermocouple ports can be sampled and stored by the controlling computer. Pressure ports allow the application of total or partial vacuums to six separate cure assemblies. The autoclave capabilities allow for a range of materials to be used including thermoplastics.

Alternately, specimens and components can be made with the vacuum hot press. The press has the capacity of 200 tons over a 3-ft by 3-ft platen. This is equivalent to 300 psi if the full platen area is used. The press can operate up to 1000 °F and is fully programmable. The vacuum hot press represents a more economical cure cycle than the autoclave with additional capabilities. Moreover, the cycle is fully programmable and thus can be quickly altered during the cure cycle.

The cured composite can then be fabricated with the aid of a specially-equipped milling machine. A standard Bridgeport milling machine with automatic feed in the longitudinal direction was adapted for composite manufacturing by placing an aluminum subtable on top of the milling table. This allows cutting of composite parts with diamond-grit tooling and water irrigation. The milling machine is equipped with a horizontal adapter so that

both vertical and horizontal spindles are available. Numerical readouts in all three directions aid the user in fabrication. Diamond-grit circular saws, drills, and reamers are available.

Inspection capabilities within the laboratory include optic and radiography. There is a stereoscopic microscope with high-resolution eyepieces, a light source, and a camera adapter to allow for visual inspection and photographic recording of composite components to a maximum magnification of 340x. The laboratory has an X-ray machine to nondestructively inspect composite specimens. The X-ray machine has adjustable power ratings to allow for the proper exposure of different materials and is capable of penetrating up to 6 in of aluminum. The machine is also equipped with a fluoroscope and a manipulator to allow for real time inspection. The X-ray machine is helpful in determining location and amounts of damage. An inspection capability, in the form of a precision scale, also exists in the laboratory. A Mettler scale capable of 209 g total load and a resolution of 0.0001 g allows for the precise mass measurement of specimens. The laboratory also has a 3-axis Numerex Coordinate Measuring Machine (CMM) capable of measuring a 24x28x16 in cube to an accuracy of 0.0003 inch volumetrically. The CMM is composed of a base machine with a granite surface plate. A software package QC5000 along with many combinations of probes allow the dimensional verification of complex parts.

The testing facility of CORE includes two MTS 810 series uniaxial testing machines (220 kip and 55 kip). The machines can apply axial tension or compression loads under static or cyclic conditions. The larger test frame has hydraulic grips with an area of 4-in-wide, 2-in-thick, and 6-in-deep, and the maximum grip pressure is 5000 psi. The machine has an 8 in stroke to allow for extensive buckling and postbuckling testing. Self-aligning compression platens (220 kip rated) are available. The smaller test frame has side-loading hydraulic grips with a maximum grip pressure of 10,000 psi. For low load resolution, a 5000 lb load cell can be placed in the 55 kip machine with an available calibrated range of 500 lbs. A variable gage length extensometer (0.5 in to 2.0 in) is available for strain measurement of flat and round specimens. Available test fixtures include IITRI compression, IOSIPESCU shear, flat-wise tensile, flat-wise shear (compression and tension), climbing drum, rolling drum, split-disk tensile, and 3- or 4-point flexure. A digital controller and a computer interface with 16 channels of analog to digital conversion is used for modern data acquisition. Software has been developed to allow for different computer-controlled tests, data acquisition, data reduction, and graphical output.

An annular furnace allows exposure of specimens to temperatures of up to 2100 °F while under load. Water-cooled wedge grips (for the 55 kip machine) allow for sustained specimen temperatures. A cold cell capable of liquid Nitrogen temperatures (77 K) is available for static and fatigue loading. The laboratory also has a conditioning chamber that allows the exposure of composite specimens under controlled heat, ambient plus 5 °F to 300 °F, and relative humidity, ambient to 95%.

Other facilities that exist at the university, such as a scanning electron microscope, continuous ultrasonic scanning, thermal analysis equipment may be accessed and

scheduled through the laboratory.

2. Definitions

The following definitions are used throughout this guide:

1. **Member:** A laboratory member is any faculty member of the University of Maryland, College Park who by area of expertise is interested in composite materials or composite structures. Members must have on file a current resume, report all activity within the laboratory to the Director, provide a listing of all funding and publications associated with the laboratory for inclusion in annual reports, and attend laboratory meetings on a regular basis.
2. **Affiliated Researcher:** Faculty or associate staff affiliated with the University of Maryland, College Park who use the laboratory but are not laboratory members are called affiliated researchers.
3. **Off-Campus Researcher:** An employee of a non University of Maryland, College Park entity (private individual, company, or government agency) who is not affiliated via a research contract with a member or an affiliated researcher is considered to be an off-campus researcher. Sponsored research by an off-campus entity is considered to be an in-house activity and is granted whatever additional privileges of the principal investigator. Activity, which involves an off-campus entity, is usually the performance of a task to meet the requirements of that entity.
4. **Student Researcher:** Both undergraduate and graduate students working in the laboratory. These students may be performing funded or unfunded research. Each student must have an associated faculty advisor who is either a laboratory member or an affiliated researcher.
5. **User:** Any individual within any of the above groups.
6. **Director:** The director of the laboratory is Dr. Anthony J. Vizzini, Manufacturing Building, Rm 1101 & Engineering Classroom Building, Rm 3179D, (301) 405-1123; FAX (301) 314-9775, e-mail: vizzini@eng.umd.edu.
7. **Research Engineer:** The research engineer of the laboratory is Mr. Matt Fox, Manufacturing Building, Rm 1105 (301) 405-1930; FAX (301) 314-9775, e-mail: mfox@eng.umd.edu.
8. **Laboratory Assistant:** Undergraduate or graduate students employed on an hourly basis to assist with tasks in the laboratory.

While these definitions are not complete, they try to differentiate between the many groups of people who work within the laboratory. In all cases the Director of the laboratory determines the status of all users within the laboratory.

3. Scheduling

One of the more difficult aspects of managing resources is scheduling. Often research projects and tasks require a specific sequence of events to take place at proper times. Unforeseen circumstances can arise which will alter the schedule. Priorities may be

changed based on the relative importance of a given task.

The equipment within the laboratory is maintained and scheduled by the Research Engineer. The following rules will help to maintain an equal opportunity among all users.

1. The equipment that can be scheduled include the following:

   a. Baron Autoclave
   b. Accudyne Vacuum Hot Press
   c. Two-Axis Filament Winder
   d. Specialized Milling Machine
   e. Numerex Coordinate Measuring Machine
   f. X-Ray Machine
   g. Hot/Wet Humidity Chamber
   h. MTS Uniaxial Testing Machine (55 kip or 220 kip)

   Other smaller equipment in the laboratory can be used as well, but scheduling is usually not necessary. Space within the laboratory can also be reserved to guarantee its availability.

2. The normal available hours of the equipment are from 8:30 AM until 4:30 PM, Monday through Friday except on University of Maryland official holidays and snow cancellation days. Any use of the equipment outside of this time can be scheduled provided that the necessary supervision or operators within the laboratory are available.

3. The Research Engineer shall schedule a given week of activity on the preceding Monday. All initial requests for equipment use shall be made to the Research Engineer by Monday at 10:00 AM. At that time he will schedule the equipment based on all requests received. Any conflicts will be resolved by the current priority rating as established by the Director.

4. Additional requests after the initial weekly scheduling can be made to the Research Engineer and are on a first-come first-served basis. Requests made after the initial scheduling are filled independently of the priority rating. All scheduled machine time must be made at least 24 hours in advance.

5. Any cancellation of a scheduled use must occur no later than 48 hours prior to use. Failure to do so constitutes a no-show.

6. Any no-show for a scheduled time should be avoided. Off-campus researchers may be charged for no-shows.

4. Storage

The storage facilities of the laboratory are quite limited. Freezer space for temperature sensitive materials is available as are small lockers, cabinets, and shelves. Such space will be provided as available if needed.

5. Use of Facilities

Certain pieces of equipment require safety precautions. At no time are the MTS testing

machines to be used by one person; this is always a two-person operation. The milling machine also requires a second person's presence. During normal working hours there is usually someone in the Manufacturing Building who can provide this presence. During hours other than normal working hours, a second person must accompany the user of the milling machine.

Off-campus researchers will not be allowed unsupervised access to the equipment. However, after sufficient training, supervision will be minimal.

The Research Engineer or the Director may veto any operation within the laboratory. This may occur when a given activity may be unsafe to personnel or machine. The user may appeal this decision to the Director. If the action compromises safety within the laboratory, alternative courses of action may be provided.

Off-campus researchers must supply a written work order before any operation in the laboratory. The work order must provide a detailed description of the work to be performed. A point of contact and phone number(s) must be included. If there are any objections to the procedure, the Research Engineer will add these comments to the work order. The point of contact will be notified, and any change in the work order will be recorded on the work order.)

All users of the laboratory are responsible for maintaining a clean and safe environment. Cleanup is to be preformed by the user. At the end of each working day, the equipment is to be restored to its original state by the user. Users may leave equipment set to a given configuration for a span of time provided that the Research Engineer has been notified and no other users need to use the equipment in the interim.

6. Use of Laboratory Personnel

The personnel of the laboratory consist of the Director, the Research Engineer, and laboratory assistants. For off-campus researchers, personnel will be applied as requested or as required to perform the tasks. In this case, the appropriate charge will be assessed.

7. Training & Certification

A user must be trained and certified to use the following equipment:

1. Baron Autoclave
2. Accudyne Vacuum Hot Press
3. Two-Axis Filament Winder
4. Milling Machine
5. Numerex Coordinate Measuring Machine
6. Hot/Wet Humidity Chamber
7. Annular Furnace
8. MTS Uniaxial Testing Machines (55 kip or 220 kip)

Training is required for the safety of the operator as well as the safety of the equipment. All use of the X-Ray machine must comply with the state safety laws. Currently only the Research Engineer or the Director may operate this machine. Training on a specific machine is provided through the Research Engineer or the Director. Such training will

result in the certification of an individual user on a given piece of equipment. The amount of training per individual will be determined on a case-by-case basis. In some cases, training will include an apprenticeship. Certification indicates that the user has sufficient knowledge to operate the equipment without immediate supervision; however, responsible personnel (the Director, Research Engineer, or their designee) must be on hand to accommodate any emergency event specifically for the autoclave, vacuum hot press, and the testing machines. All certifications are recommended by the Research Engineer and granted by the Director. Note that certification on a given machine does not exempt the user from normal scheduling procedures.

8. Laboratory Fees

All users will be charged for equipment use, material, and labor. Financial arrangements must be made with the Director prior to any activity. For off-campus researchers, an executed purchase order is required. The Director can provide estimates for work to be conducted within the laboratory. The Director will invoice quarterly and at the completion of a project. Any variation to these guidelines must be agreed upon prior to the commencement of activity.

Several rules apply to charges.

1. There is a two-hour minimum labor charge per day for supervised work within the laboratory.
2. The MTS testing machines, the Baron autoclave, the Accudyne vacuum hot press, and the milling machine each have a one-hour minimum use charge per day.
3. The rate for fatigue testing on the MTS 55 kip or 220 kip testing machines is based on a daily rate. The daily rate charged for the MTS machines is equivalent to eight (8) hours of machine time. This rate is charged for any fraction of a day.
4. Any activity conducted by an off-campus researcher must be cleaned up. If the cleanup is insufficient, cleanup will be performed by laboratory personnel, and the off-campus researcher will be charged accordingly.

9. General Behavior

The laboratory attracts many users from different departments and off-campus entities. In general, common courtesy shall always prevail. In the event that a conflict arises, the Research Engineer will mediate. If this action is not acceptable to all parties the Director should be informed.

The equipment within the laboratory reflects the efforts of the university to acquire the necessary tools to manufacture and test composite materials and structures. Care should always be taken to avoid damage to the equipment.

In the case of an equipment failure, malfunction or unusual response, the Research Engineer or the Director must be contacted immediately. Emergencies such as fire, accident or injury requiring medical attention should immediately be reported to Campus Emergency Services at extension 5-3333.

Failure to comply with these guidelines may result in the suspension of privileges in the

laboratory.

A. Supplements

Use, Labor, and Materials Rates

Type	Item	Off-Campus Researcher Rate
Equipment	Autoclave	80.00/hr
	Vacuum Hot Press	60.00/hr
	Milling Machine	20.00/hr
	MTS 55 kip Testing Machine	100.00/hr
	MTS 220 kip Testing Machine	100.00/hr
	Coordinate Measuring Machine	100.00/hr
	X-Ray Machine	40.00/hr
	Conditioning Chamber[1]	10.00/day
	Annular Furnace	30.00/hr
Labor	Research Engineer	50.00/hr
	Laboratory Assistant	16.00/hr
Materials	Standard Cure Yard Goods	100.00/cure
	Pressurization Charge[2]	12.00/unit
	IM7/8552 Graphite/Epoxy	8.00/ft^2
	FM 123 Film Adhesive	5.00/ft^2
	Tab Material (0.125”)	15.00/ft^2
	Std Small Strain Gage, Wire, & Chemicals	9.00/gage
	Std Large Strain Gage, Wire, & Chemicals	8.00/gage

[1] In addition, material costs are $100.00 per 2 months of use or any fraction for humidity conditioning

[2] A unit of pressurization is equivalent to 100 psi-hr

Rates are effective July 1, 2002 through June 30, 2003 and are subject to change.

Sample Calculation – 6-ply Tensile Coupon

Procedure	Use	Cost	Total Cost per Specimen
Layup Autoclave Curing Cleanup Postcure (20 specimens/cure)	Full Cure Materials 5 Nitrogen 6 Autoclave 1 Technician 14 Laboratory Asst 50 Graphite/Epoxy	100.00 60.00 480.00 50.00 224.00 400.00	65.70
Machining Laminates Tabs	0.5 Laboratory Asst 0.5 Milling Machine 0.167 Glass Tabs	8.00 10.00 2.50	20.50
Prep Tab Bond Cleanup (20 specimens/cure)	Bond Cure Materials 1 Nitrogen 2 Autoclave 1 Technician 5 Laboratory Asst 3.33 Film Adhesive	60.00 12.00 160.00 50.00 80.00 16.67	18.93
Measurement & Instrumentation	2 Gages + wires 0.77 Laboratory Asst	16.00 12.32	28.32
Testing	0.30 Testing Machine 0.30 Technician 0.30 Laboratory Asst	30.00 15.00 4.80	49.80
Totals	Laboratory Asst Technician Materials Equipment	40.32 20.00 50.93 72.00	183.25

Composites Research Laboratory Work Request

Composites Research Laboratory Work Request

Requestor:		Date/Time:	
Phone #:		Authorization:	
Group:		FAS Account #:	
Project:		Date Needed By:	
CORE USE ONLY		Request is for:	☐ Estimate ☐ Performance of Work

Description	Qty.	Unit Cost	Total Cost
		GRAND TOTAL	

☐ Delivered To: _____ Date: _____

☐ Picked Up By:

All rates are based upon the most recent labor/material charges and policies listed in the Operating Procedures for the Composites Research Laboratory. For more information, please contact Dr. Anthony Vizzini (301-405-1123) or Matt Fox (301-405-1930).