US ARMY RDECOM

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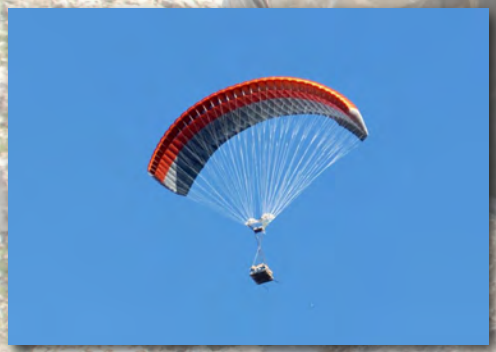
US ARMY NATICK SOLDIER RD&E CENTER

*TECHNOLOGY DRIVEN.* ***WARFIGHTER FOCUSED.***

# *US ARMY NATICK SOLDIER RD&E CENTER*

# ***TESTING FACILITIES and EQUIPMENT***



The **Natick Soldier RD&E Center (NSRDEC)** is located at the U.S. Army Natick Soldier Systems Center in Natick, Massachusetts.

We have the dedicated mission to maximize the Warrior's survivability, sustainability, mobility, combat effectiveness and quality of life by treating the Soldier as a System.

This booklet is provided to industry, academia and government agencies to show the testing facilities and capabilities that can be made available for use on a fee-for-service basis.

If you require the use of facilities and associated testing services for your testing requirements we may be able to assist with those needs.

Please call us at (508) 233-4184 for more information.

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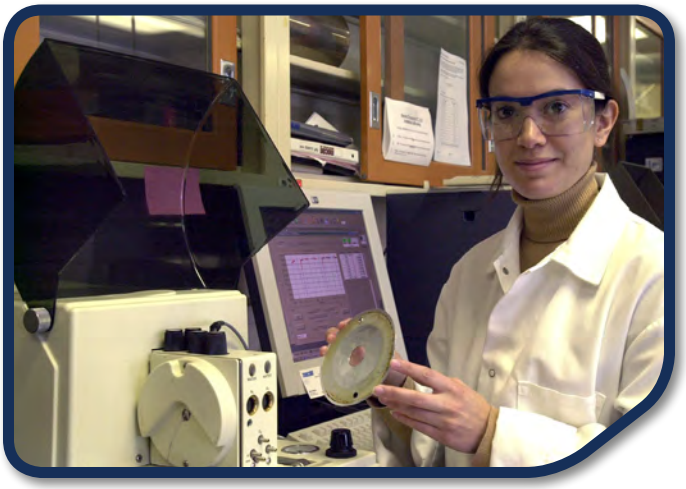


## INTRODUCTION:

The U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) in Natick, MA is a Federal research and development (R&D) laboratory charged with maximizing the Warfighter's survivability, sustainability, mobility, combat effectiveness ,and field quality of life. Successful pursuit of these objectives requires extensive testing and evaluation capabilities, many of which can be made available to the private sector under a Testing Services Agreement or TSA.

A TSA is a means by which a Federal laboratory can exercise the statutory authority to perform fee-for-service test and evaluation activities for private industry, academic institutions, and individuals. The fee is equivalent to the Government's cost for performing the test service. Materials, processes, equipment, models, devices, computer software, etc., may all be tested.

Unlike collaborative agreements the TSA does not include a research or development component, and all data belongs to the TSA partner. TSAs typically involve some unique Government capability or a more common capability that is not available due to geographic or scheduling constraints to ensure there is no "undue competition" with private industry. A TSA consists of several pages and a cover letter, requires minimal effort to execute, and can be enacted in a reasonably short period of time.

## AVAILABLE RESOURCES:

- Unique testing facilities
- Highly rated and experienced staff
- State-of-the-art equipment

Please Note: All available resources including design, engineering and fabrication facilities are available in conjunction with a testing or evaluation activity.

You can be confident with the results you receive from our testing professionals. We know from experience the value of obtaining reliable data, with the welfare of America's sons and daughters serving in our Armed Forces depending on it. That same care goes into all testing procedures regardless of the recipient.

## POINT OF CONTACT:

For additional information please visit our website at nsrdec.natick.army.mil or call the NSRDEC Business Development Office at (508) 233-5667 / (508) 233-4184, or send an e-mail to nati-amsrd-nsc-ad-b@conus.army.mil.

## DORIOT CLIMATIC CHAMBERS

The Doriot Climatic Chambers reproduce environmental conditions occurring anywhere around the world. They provide an invaluable service by significantly reducing the need to conduct actual field testing. In fact, critical human and equipment testing often require very controlled conditions that cannot be achieved in the field, or anywhere else. The Chambers can simulate temperature, humidity, wind, rainfall, and solar radiation. These conditions can be set up separately or run concurrently. The size and configuration of the chambers provide great flexibility. The dual chambers allow for simultaneous testing in both tropic and arctic environments:

- Two 10' H × 15' W × 60' L wind tunnels make it ideal for testing large equipment. Tents, heaters, parachutes, airbeams, medical devices, and windmills have all been tested in the wind tunnels.
  - The Tropic Wind Tunnel has the ability to create temperatures ranging from 0° F to 165° F with 10 to 90% relative humidity. Rain can be simulated at up to 4" per hr with wind up to 40 mph. Solar load can be simulated with a system consisting of six rows of 250-W light bulbs.
  - The Arctic Wind Tunnel has the ability to create temperatures ranging from -70° F to +120° F with 10 to 90% relative humidity. Rain can also be simulated at rates up to 4" per hr with wind speeds reaching up to 40 mph. The desired conditions of temperature with wind and relative humidity are constantly controlled to within plus or minus 1° F.
- Two five-person treadmills can run up to 15 mph at a 12% grade in each wind tunnel. There is an external observation area to watch and monitor the testing within the chamber.
- An in-house kitchen can be used to prepare meals for Soldiers testing or to assess the effects of nutrition on physical performance. The Chambers also contain a dormitory for sleep studies and dressing rooms with showers and laundering facilities.

## THREE-DIMENSIONAL ANTHROPOMETRIC LABORATORY

This laboratory is a Cyberware laser-based optical digitizing system that records the three-dimensional (3-D) surface coordinates of the head and face, and a Cyberware 3-D anthropometric scanning system collects whole body data on approximately 95% of a subject's body.

There are various methods of obtaining accurate 3-D data describing human shapes. Applying these data in the areas of computerized design and evaluation will provide faster and more cost effective tools for developing military/non-military clothing and equipment systems.

## COGNITIVE PERFORMANCE LABORATORY

This laboratory conducts basic and applied human research studies to characterize cognitive performance as influenced by militarily-relevant contextual and physical stressors. It includes seated computerized testing stations, an immersive virtual reality system based on open source and leading video gaming technologies, and ambulatory eye-tracking:

**Virtual Reality (N-CAVE):**

- Full view (two 12ft W × 9ft H) projection displays
- Any environment (MOUT, mountains, desert), with full surround sound
- User interface via wide area motion tracking with weapon simulation
- Locomotion interface via self-propelled treadmill synchronized with a VR system

**Mobile Cognitive Assessment Platform (MoCAP):**

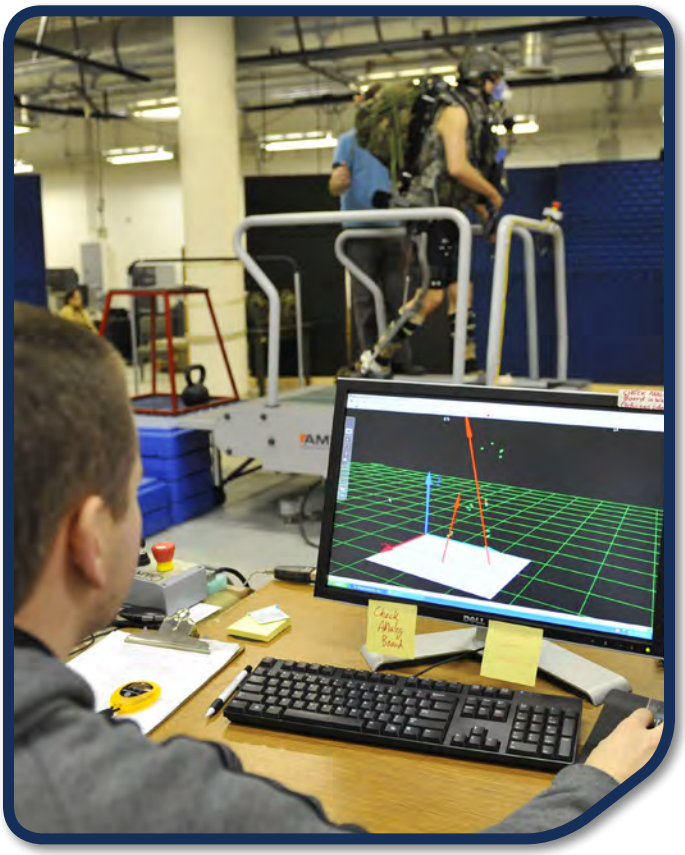
- Head-mounted instrumented display, headset/microphone, and wrist keyboard
- M4, GPS tracking in outdoor environments, ruggedized PDA, laptop computer carried in custom harness
- Subject-worn laptop and PDA synchronized with an experimenter base station via wireless peer-to-peer and VoIP
- Physiological monitoring, gait analysis
- Custom software for experimental design and data acquisition
- Real-time eye tracking for indoor or outdoor use

## THE CENTER FOR MILITARY BIOMECHANICS RESEARCH

The Center for Military Biomechanics Research is a 7,500 ft$^2$ dedicated laboratory outfitted with state-of-the-art equipment for 3-D analysis of movement, measurement of external forces on the body, monitoring of muscle activity, determining oxygen consumption, and real-time mapping of pressure patterns.

Equipment includes:

- Motion Capture Systems (Qualisys, Peak Motus, Dartfish)
- Force Platforms (AMTI)
- Force Plate Treadmill (AMTI)
- Surface Electromyography (EMG) Systems (Delsys)
- Moment of Inertia Instrument (Space Electronics Inc. XR 250)
- Custom-Built Balance Perturbation System
- Stationary and Portable Metabolic Test Equipment (ParvoMedics TrueMax 2400, COSMED K4B2 Cardio-Pulmonary Exercise Test Equipment)
- Data Acquisition and Analysis Workstations (Qualisys Track Manager, C-Motion Visual3D Professional, LabVIEW, MATLAB)
- Custom-Designed Indoor and Outdoor Obstacle Courses
- Custom-Built Repetitive Box Lift Station



## CLOTHING AND INDIVIDUAL EQUIPMENT FIGHTABILITY COURSE

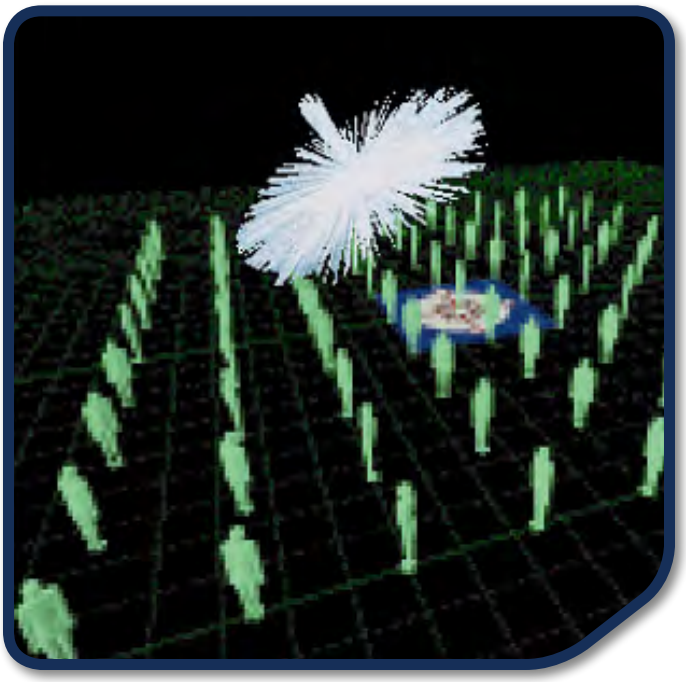
This is an obstacle course that is designed to measure the effects of equipment on a Soldier's mobility, agility, and speed in a combat environment. The course includes nine outdoor obstacles and a two-story building with stairs, doorways, windows, and halls for evaluation of Military Operations in Urban Terrain (MOUT). Each obstacle is equipped with electronic timing devices for measuring Soldier performance.

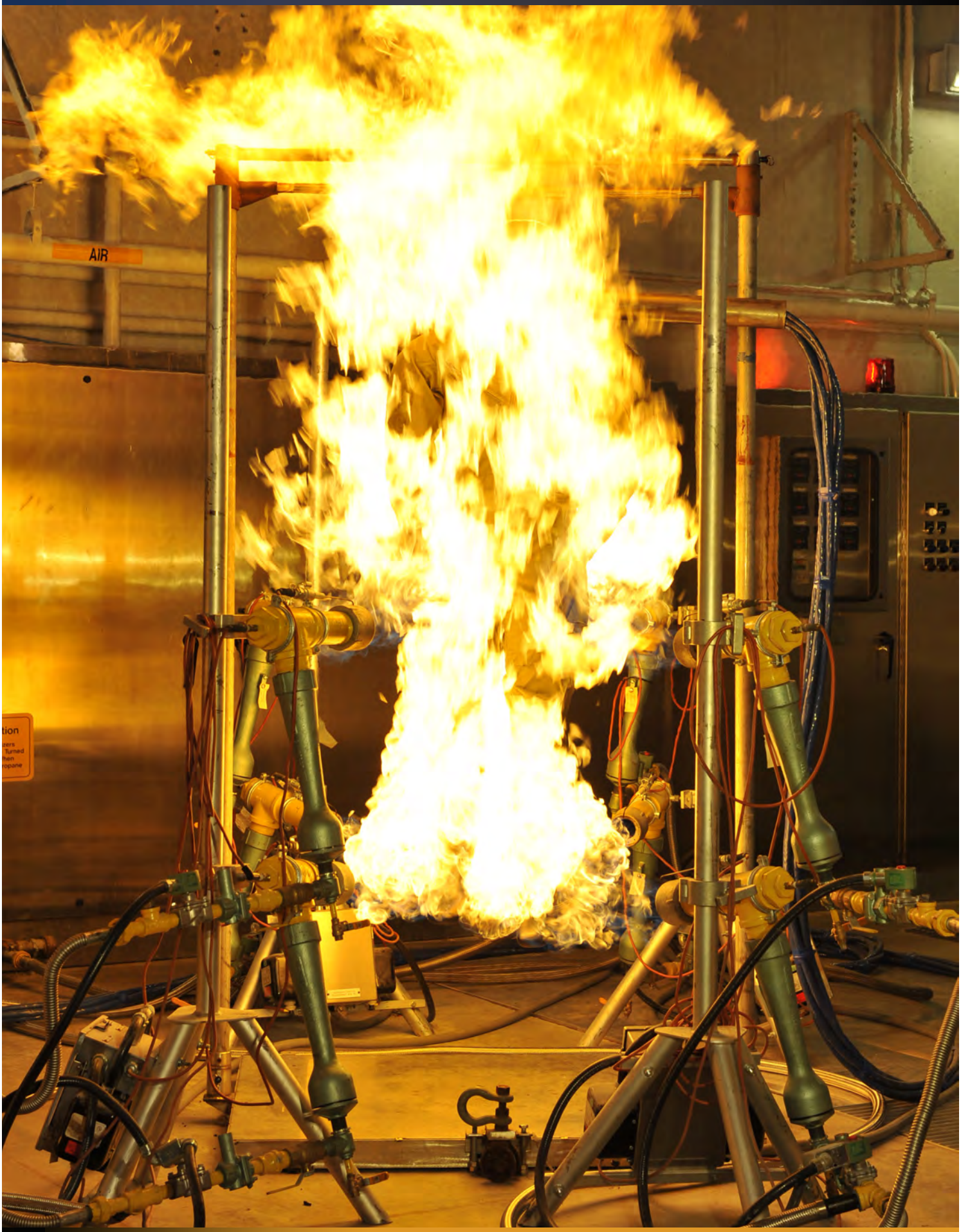
## SOLDIER SYSTEMS INTEGRATION LABORATORY (SSIL)

Provides ability to integrate, demonstrate, and assess Soldier domain technologies in simulated environment to explore efficacy when subjected to operationally relevant employments. Evaluates components/sub-systems hardware/software technologies and team interactions, and supports Soldier and Small Combat Unit assessments of operational concepts, network architectures, and C2 information systems through human in-the-loop virtual/live/constructive simulations. Provides controlled and configurable environment, day and night operations and robotic and sensor simulations including UAV/UGV/UGS simulations.

## MODELING AND ANALYSIS (M&A) CENTER

The M&A Center supports decision makers through the development and exercise of constructive models to perform critical acquisition life cycle analyses. Application of Simulation and Modeling for Acquisition, Requirements, and Training (SMART) and Simulation-Based Acquisition (SBA), provides customers with reduced program risk, cost, and schedule, while enabling improved system performance. The primary models utilized include: Infantry Warrior Simulation (IWARS), One Semi-Automated Force (OneSAF), Integrated Casualty Estimation Model (ICEM), Combat XXI, and Close Action Environment (CAEn).

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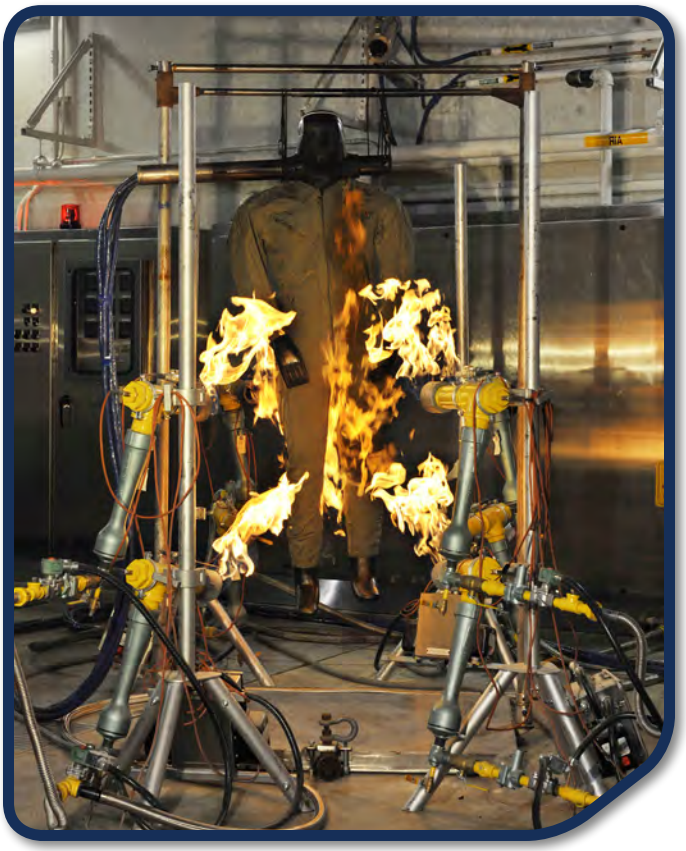


NSRDEC is the primary facility within DoD for the development of clothing and individual equipment for the protection of the Warfighter. NSRDEC provides scientists and engineers with unprecedented research evaluation capabilities for flame and thermal protective materials, clothing, and equipment.

## OUELLETTE THERMAL TEST FACILITY

The Thermal Test Facility is a joint Army/Navy state-of-the-art facility (8,100 $ft^2$) that was designed to:

- Evaluate and characterize the effect of flame and thermal threats on materials, ranging in size from research quantities (milligrams) to full-scale systems, under defined flame and thermal conditions
- Assist in the development of improved materials in clothing and individual equipment for the protection of the individual Soldier
- Evaluate and analyze the thermal processes and combustion by-products of fuel burning equipment (i.e., tent heaters, water heaters, kitchen burners, etc.) to provide optimum performance of equipment to improve the Warfighter's quality of life.

The facility houses a large propane fuel cell and four laboratories:

**Propane Fuel Cell (Full-Scale Testing)**
Is used to evaluate the combustion and thermal characteristics /bury injury predictions of full-scale systems under defined thermal threats. It houses a control room and four major test systems.

- **Control Room** – Controls and monitors all tests and building systems (i.e., propane delivery system, data acquisition system, wet scrubber system, underground storage tank, exhaust systems, heating units, fire alarm system, deluge system, temperature and gas monitoring systems, close-circuit television, and video teleconferencing).
- **Stationary Instrumented Manikin**– Is instrumented with 123 thermal sensors and dressed in full size clothing is exposed to a controlled heat flux for a designated time period. Heat transferred through the test clothing during and after exposure is measured and run through a burn injury prediction model. The test will predict locations on the manikin where a second and third-degree burn are received, as well as the total percentage of body burn.

  There are only eight other known manikin systems of this type in operation world-wide (three in North America, three in Europe, and two in Japan).
- **Fire Room and Traversing Manikin (NCTRF)** – Is suspended on an integrated motorized traversing mechanism, allowing passage of the

manikin through a room with eight propane sand burners on the floor. (The burners can be positioned to simulate different fire scenarios.) It is the same instrumented manikin (with 123 thermal sensors) as is used for the "stationary manikin". As is the case with the stationary manikin, the heat transferred through the test clothing of the traversing manikin during and after exposure is measured and recorded using a data acquisition system. These data are then input in a burn injury prediction model and are used to the predict and locate areas of the manikin receiving second-degree burns and third-degree burns and to predict the total percentage of body burn.

- **Thermal Oven (NCTRF)** – Involves placement of an instrumented manikin inside a thermal oven and sensors on the manikin are used to assess the convective heat transfer through clothing systems. Heat lamps can also be used in the oven to assess both the convective and radiant heat transfer through clothing systems. The maximum oven temperature is 650ºF.
- **Propane Burn Pit (8ft×12ft) (NSRDEC)** – Is designed to simulate a controlled open field fire and measure its effect on different test specimens such as tent structures. It has a propane delivery system consisting of nine 7ft ribbon burners located approximately 6 inches below floor level and is covered by a grate. Programmed control of the burners allows for operation of one or more burners, individual adjustable timed sequencing of burner ignitions, individual adjustable burner heights, and individual adjustable durations. Burners are capable of producing a continuous flame, at least 18 inches above the burn pit grate (approximately 24 inches above the ribbon burner). The minimum total capacity of the burn pit is 28.5 million BTU/h (11,400 scfh of propane vapor).

### Flammability Testing Laboratory (Swatch Level Testing)

Provides swatch level testing to evaluate the flammability characteristics (i.e., the fabric's propensity to ignite and continue to burn after exposure to an ignition source) and potential for burn injury (i.e., the ability of a fabric or layered fabric configuration to prevent thermal and/or radiant heat transfer that could cause the onset of a second-degree burn) of materials under defined flame and thermal conditions.

The tests most commonly performed in this laboratory are:

- **Vertical Flame Test**
- **Horizontal Vertical Flame Test**
- **Limiting Oxygen Index (LOI)**
- **Thermal Protective Performance (TPP)**
- **Radiant Heat Resistance**
- **45° Flame**
- **Thermal Barrier** — Uses a bench-scale thermal barrier test apparatus (TBTA) to provide data similar to that provided by the instrumented manikin on fabric swatches. Single or multiple layers of materials (5×7 inches) are exposed to a radiant heat source at a designated heat flux for a specific exposure time. The amount of heat transferred through the tested material during and after exposure is measured and recorded using a data acquisition system, and the data are input in burn injury prediction models and used to predict the degree of burn received. The thermal barrier test differs from the TTP test in heat source (radiant only vs. convective and radiant in the TTP test) and in sample orientation (variable vs. horizontal only).

### Materials Analysis Laboratory (Research Level Testing)

Provides the capability of assessing and predicting the flame and thermal properties of small quantities of materials (milligrams/grams – solid or liquid). Test equipment includes:

- **Microscale Combustion Calorimeter (Pyrolysis Combustion Flow Calorimeter)** – Is one of only a few in the world. It was developed under a cooperative effort with the University of Massachusetts (UMASS), Amherst and the Federal Aviation Administration (FAA) for use by synthetic chemists who develop materials on a very small scale. It indicates the heat release capacity, total heat release, and char yield on milligram quantities of materials to predict the flammability characteristics of fibers, polymers, coatings, etc. while under development.
- **$C0_2$ Laser** – Simulates the thermal threat from an improvised explosive device (IED).

### Combustion Monitoring and Analysis Laboratory

Evaluates and analyzes the thermal processes and combustion by-products of fuel-burning equipment, such as field feeding food service burners, tent heaters, water heaters, and other support type equipment, is performed in this laboratory. It contains the following equipment:

- **Combustion analysis equipment**
- **Inline water flow metering equipment**
- **Dedicated exhaust systems to contain or remove combustion or steam by-products**
  - Provides the capability to evaluate the optical and electro-optical properties of developmental protective eyewear materials over wavelengths ranging from the ultraviolet (UV) to the near infrared (NIR).
  *(For more detail see Applied Science section.)*

## SO 9001:2000 AND ISO 17025:1999 CERTIFIED TEXTILES AND FABRIC TESTING AND EVALUATION FACILITY, ISO 9001:2008 TEXTILE PERFORMANCE TESTING FACILITY

This facility is an accredited laboratory that complies with the standard requirements of Quality Management Systems ISO 9001:2000 and ISO 17025:1999. It contains specialized and standardized equipment to fully characterize the performance and durability of textile based materials.

### Abrasion Resistance Testers

Determine the abrasion resistance of woven and knitted fabrics:

- **Flexing, Folding Bar (Stoll) Method** – Subjects the specimen to unidirectional reciprocal folding and rubbing under controlled conditions of pressure and tension.
- **Inflated Diaphragm (Stoll) Tester** – Inflates the specimen over a rubber diaphragm under controlled air pressure, and subjects it to either unidirectional or multidirectional rubbing action.
- **Martindale Tester** – Subjects the specimen to a geometric/straight line rubbing motion.
- **Taber Abrasion Tester** – Subjects the specimen to rotary rubbing action under controlled conditions or pressure and abrasive action.
- **Wyzenbeek Abrasion Tester** – Subjects the specimen to unidirectional rubbing action under controlled conditions of pressure, tension, and abrasive action.
- **Accelerated Solvent Extractor** – Offers a rapid, safe, and very efficient means of extracting wax, oil, fats, soap, and other finishes/treatments from fabrics using high pressure and elevated temperature.

### Air Permeability Tester

Measures the air permeability of all kinds of woven and nonwoven fabrics, ranging from dense airbag fabrics to blankets.

### Color Spectrophotometers

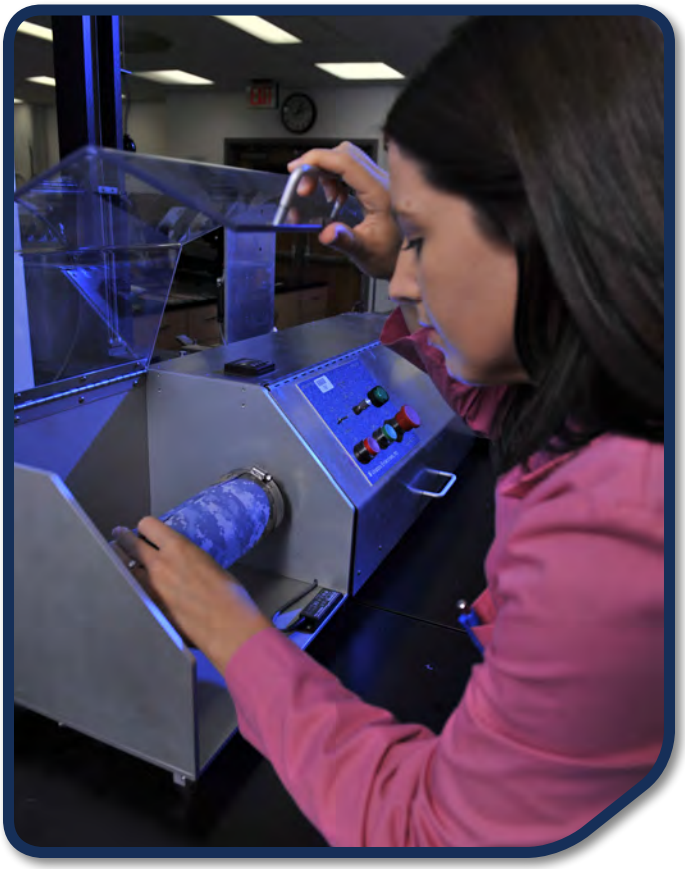
Define color acceptability requirements ,and monitors shade quality control. Color may be measured in terms of reflectance or transmittance. These instruments provide the "fingerprint" of a color which can be communicated to others for development purposes. It is used to measure color in the visible, UV, and NIR range. It meets the American Association of Textile Chemists and Colorists (AATCC) test procedures.

### Dynamic Absorption Tester

Measures the resistance of fabrics to wetting by water. It is particularly suitable for measuring the water-repellent efficacy of finishes applied to fabrics because it subjects the treated fabrics to dynamic conditions similar to those often encountered during actual use. This test method is applicable to any textile fabric that may or may not have been given a water-resistant or water-repellent finish.

### Electrostatic Decay Meter

Measures the electrostatic dissipative properties of a fabric substrate in a temperature and humidity controlled chamber to determine its ability to quickly dissipate an electric charge.



### Fade-Ometers (Carbon Arc and Xenon Lamp)

Determine the colorfastness of textile materials when exposed to either a carbon arc or xenon arc light source. These instruments meet test conditions specified by the AATCC.

### Flexural Rigidity Tester

Determines the stiffness (bending length) and flex (flexural rigidity) of cloth by employing the principle of cantilever bending of the cloth under its own weight. It is applicable where cloth is to be tested at extreme temperatures, as well as under standard conditions.

### Fourier Transform Infrared Spectroscope

Identifies chemical finishes, fibers, and other chemical elements present in a material.

### Gas Chromatography/Mass Spectrophotometer/ Pyrolyzer (GC/MS/PY)

Provides a means to quantitatively measure chemical compounds and identify unknown chemicals in a textile substrate.

### Hydrostatic Pressure Test (High And Low)

Measures the resistance of a fabric to the penetration of water under hydrostatic pressure. It is applicable to all types of fabrics, including those treated with a water resistant or repellent finish.

### Textile Tearing Resistance Testers:

- **Elmendorf Tear Tester** – Determines the force required to propagate a single-rip tear, starting from a cut in a woven fabric using a falling pendulum type apparatus.
- **Puncture-Propagation Tear Tester** – Measures the dynamic tear resistance of laminated, coated fabrics and films.

### Laundering Facility

Is used to evaluate the staining and colorfastness and other fabric surface appearance attributes to frequent washings. These properties are evaluated against a multitude of typical washing elements such as vigorous agitation, detergents, and chlorine bleach.

The fabric color loss and surface changes resulting from detergent solution and abrasive action of five typical hand, home, or commercial launderings, with or without chlorine, are roughly approximated by one 45-min test. However, the staining effect produced by such launderings cannot always be predicted by the 45-min test. Staining is a function of the ratio of colored to undyed fabrics, fiber content of fabrics in the wash load, and other end-use conditions which are not always predictable.

This facility can determine the dimensional changes in woven and knit fabrics when subjected to repeated automatic laundering procedures commonly used in the home.

This facility can also be used to determine the dimensional changes in woven and knitted fabrics made of fibers other than wool when subjected to laundering procedures commonly used in a commercial laundry. Ranges of laundering test procedures from severe to mild are used to simulate various types of commercial launderings available. Various drying procedures are established for typical drying techniques. These tests are not accelerated and must be repeated to determine dimensional changes after multiple launderings.

Laundering equipment includes:

- **Field Laundry Machine with Programmable Formulas** — Has a 60-lb capacity and determines the dimensional changes of garments to simulated field laundering processes.
- **New Yorker Hot Head Press** – Simulates typical pressing techniques at commercial laundering installations and their potential effects on the dimensional properties of textile materials and garments. This equipment offers consistent controllable conditions with very tight tolerances.

### Scorch Tester

Assesses the resistance of color of textiles of all kinds and in all forms to the action of dry heat, excluding pressing.

### Spray Tester

Measures the resistance of fabrics to wetting by water. It is especially suitable for measuring the water-repellent efficacy of finishes applied to fabrics. It is not intended, however, for use in predicting the probable rain penetration resistance of fabrics, since it does not measure penetration of water through the fabric. It is applicable to any textile fabric, regardless of whether it has been given a water-repellent finish.

### Vertical Flame Test Chamber

Characterizes the flammability properties of textile materials. It meets National Fire Protection Association (NFPA) and ASTM International standards for testing.

**Weather-Ometer - Xenon-Lamp**

Provides a means to expose textile materials of all kinds, including coated fabrics and products in an artificial weathering apparatus using controlled conditions. Various properties are measured after exposure such as strength, finish and color degradation. It meets test conditions specified by American Association of Textile Chemists and Colorists (ATCC).

## OPACITY TESTING EQUIPMENT

This equipment tests fabric materials for their opacity to lights of visible (400 to 750 nanometers) and combined visible and non-visible (200 to 930 nanometers) wavelengths. The test is a laboratory simulation of observations made through night-vision devices.

## RAINCOURT FACILITY

This facility measures 40 ft by 40 ft, making it one of the largest raincourts in the United States. Large scale products can be evaluated and human test subjects have room to perform exercises (such as riding a bicycle) that help identify design problems in their wet-weather clothes.

## CAMOUFLAGE EVALUATION FACILITY

The equipment in this facility provides the ability to evaluate camouflage patterns year round against simulated woodland, desert, urban, and arctic backgrounds. Live plants in the desert and woodland scenes add realism for in-house measurements. The facility is equipped with specialized lighting to allow for simulation of daylight, as well as varying degrees of moonlit night skies for evaluation against night vision devices. Sensing devices used in the evaluation of camouflage items within the facility include: passive night vision devices, third-generation AN/PVS-7D binocular, AN/PVS-14, monocular, Sony low light level video camera with NIR illuminator, alpha short-wave infrared (SWIR) camera.

## HELIUM-POWERED BALLISTIC TEST APPARATUS

This research device is used for the initial assessment of new materials and is primarily used for fragmentation testing of yarns, fabric, or laminate samples. The device shoots a .22 caliber fragment simulating projectile at low to moderate velocity. It provides researchers and manufacturers information to gauge the potential ballistic performance of these items early in the production or pre-production phase.

## HYDRAULIC HELMET PRESS

Has a maximum pressure up to 350 tons and a maximum temperature of 650° F. The size of the platens is 24×24 inches.

## LOADBEARING LABORATORY

This laboratory designs and fabricates textiles based military individual equipment. the facility has designers, industrial sewing machines, and fabrication equipment. Individual equipment items worn by the Warfighter are conceived and prototyped in this facility before they are transitioned to production. The laboratory requires climate control, compressed air, special lighting, and special electrical supply. This facility offers the capability

to produce working load-bearing prototypes based on user requirements along with patterns and guide samples for production. multiple site visits are conducted to solicit customer feedback and to work with manufacturers in a production setting.

## MAN-IN-SIMULANT TEST (MIST) CHAMBER

The MIST chamber uses methyl salicylate (oil of wintergreen) vapor as a simulant for HD agent to conduct system level evaluations of chemical protective ensembles. The ensemble being tested is placed on an articulated manikin for 2 hours in a 100 mg/m$^3$ circulating vapor. Test pads containing a sorbent powder are adhered to the manikin's skin where they adsorb vapor leaking in through the donned protective ensemble. The on-site facility offers a means to rapidly evaluate new protective ensemble designs.

## MICROCLIMATE CONDITIONING LABORATORY

This laboratory tests and evaluates the thermal performance and fluid flow characteristics of microclimate conditioning systems, including pressure drop, cooling rate, and power consumption. A programmable environmental chamber (Thermotron sm-8-3800), capable of temperature and relative humidity ranges of -68° c to 180° C and 10% to 98%, respectively, is used to evaluate systems in a variety of conditions. It can also be used to evaluate systems in accordance with some mil-std-810 environmental test requirements. An air flow test rig has also been developed to assess the pressure drop of air distribution garments and to characterize the performance of air based microclimate conditioning systems.

## PERMEATION TEST LABORATORY

This laboratory includes specialized instrumentation and equipment for characterizing the performance of chemical-biological (CB) protective materials to include chemical resistance, aerosol penetration, and moisture vapor transmission at varying humidity. Swatch testing capabilities include using the Aerosol, Vapor and Liquid Assessment Group (AVLAG) cell for permeation testing of air-permeable, semi-permeable, and impermeable materials with various chemical warfare agent simulants and other chemicals.

## SPECIAL PURPOSE SHOCK TUBE FOR BLAST ASSESSMENT

This device is a specially designed shock tube for testing fabric samples in a controlled environment. The device determines the appropriate types of sensors to be used for measuring the effects of shock waves on fabrics. This information will be used to help build an anthropometric device to be used for designing and testing blast protective equipment.

## BALLISTIC EYEWEAR TEST APPARATUS

This air and helium powered device allows for the assessment of the ballistic protective properties of developmental and commercial eyewear. It is capable of shooting either 5.8 grain or 17 grain fragment simulating projectiles at up to 950 ft/s, or the .25 inch round ball used for the ANSI Z87.1 safety eyewear test. It can also assess flat or curved samples, or the complete eyewear "as worn" on a headform, and at ambient or at extreme temperatures (-60° F to +160° F).

## FOOTWEAR PERFORMANCE LABORATORY

This laboratory provides biomechanical and physical analyses for both military and commercial footwear. The laboratory contains equipment that is integral to the us army, us special operations command, USMC, U.S. Navy, and U.S. Air Force footwear programs to perform R&D work, as well as quality assurance verification testing. It houses the following equipment:

### Dynamic Stiffness Tester

Measures both the longitudinal and torsional stiffness of footwear.

### Dynamic Shoe Flexibility Tester

A motor-driven whole shoe forefoot flexibility tester.

### Heated Sand Bath

Measures the conductive heat transfer through a soling system.

### Computerized Impact Testing System

Measures the impact characteristics of boots, sport shoes, and materials or components such as footbeds.

### Pedar Dynamic Pressure System

Measures pressure distribution beneath the sole of the foot inside a boot.

### Whole Shoe Flexer (Dry)

A qualitative test to measure the durability of footwear during repeated flexing.

### Whole Shoe Flexer (Wet)

A qualitative test to measure the waterproof characteristics of footwear during repeated flexing while submerged in water.

### Slip Resistance Tester and Ice Tray Apparatus

Measures both coefficient of static and dynamic friction of a soling system on various walkway surfaces and conditions where slip is most likely to occur.

### Biomechanical Abrasion Tester

Provides an accelerated wear simulation for footwear under realistic terrain conditions.

## DESIGN, ENGINEERING, AND FABRICATION CENTER

### Prototype Fabrication Shop

Provides a broad range of capabilities that incorporate the use of metal, wood, plastic, and composite materials. A high degree of precision is guaranteed with the use of the latest Computerized Numerically Controlled (CNC) machining and cutting equipment. A Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) System will assist you with exact drawings and tight tolerances to ensure that the item will meet your needs. Capabilities include:

- CNC and Proto Trak lathes
- CNC milling with tolerances to .001 inches
- Precision honing and grinding to .0001 inches
- Turning of parts up to 20 inches in diameter and up to 60 inches in length
- Single prototype parts to small production runs

### Sheet Metal Shop

Provides anything from a simple panel to a complex stainless steel mobile kitchen with a variety of sheet metal material types and thicknesses to choose from. Sheet metal materials range from lightweight aluminum to highly corrosion resistant stainless steel, mild steel, alloy steel, and other sophisticated sheet metals to fulfill special requirements. All sheet metal manufacturing can be made in accordance with commercial and/or precision tolerances. Metal working capabilities consist of:

- Rolling steel up to a ¼ inch thick
- Simple hand forming to heavy 225-ton computerized press brake
- Cutting up to ⅜ inch steel with 4ft manual or 10ft computerized power shears
- Notching and punching up to ¼ inch steel
- Epoxy and high shear insert installation riveting
- Soldering, all types
- Riveting

### Waterjet Cutting Center

Has a large platform (4ft×8ft) which cuts material up to 5 inches thick. This technology cuts with extremely high pressure (55,000 psi) water through a .030 inch nozzle and garnet mixture and cuts metals, stone, ceramic, and composites. The computer controlled system cuts almost any material in any two-dimensional configuration with great accuracy and is controlled by a computer program.

### Welding Shop

Performs structural welding fabrication and non-destructive testing of welds and base materials. The shop offers assistance in the practical approach to design of weldments, applicable regulations, and specifications. Both manual and semi-automatic welding can be performed. Materials can be welded in any thickness of at least 0.030 inch. Carbon steel can be cut up to a maximum thickness of 6 inches. Material types welded and/or cut are carbon and

alloy steel, stainless steel, aluminum, copper and copper alloys, and titanium. Welding and cutting processes or combinations include:

- Manual shielded metal arc
- Manual and automatic gas tungsten arc spot welding
- Manual tungsten inert gas welding
- Metallic inert gas welding
- Resistance spot welding
- Manual oxy-acetylene flame cutting, brazing and welding
- Plasma cutting up to 5/8 inch
- Manual carbon arc gouging
- Plastic Welding

### Wood and Plastic Shop

Provides a wide variety of prototype and modeling capabilities:

- Wood patterns and models
- Thermoforming plastic fabrication up to 30×36 inches
- Plastic fabrication of all types and sizes
- Specialty items molded for unconventional use
- Prototype injection molded parts for engineering evaluation
- Thermoforming mold making in aluminum, epoxy, silicone rubber, or urethane elastomers in any duro-meter

## COMPUTER AIDED DESIGN (CAD) AND RAPID PROTOTYPING LABORATORY

### Sinter Station 2500 Plus Rapid Prototyping System

Fabricates functional prototypes directly from CAD data. It uses nylon with a 6000-psi yield strength, producing prototypes that resemble an injection-molded part in form and function. The system builds with an accuracy of .005 inch, which can be further refined with multiple builds and scaling adjustments. It has a maximum build envelope of 14.5×12.5×17.5 inches.

### Testing Services:

- **Load Testing** - Can test an Instron load cell up to 130,000 lbs in tension or compression.
- **Ballistic Eyewear Test System**
- **Reverse Engineering/Inspection** - Includes scanning an object into a CAD file or inspecting an item to .005 inches.

### Engineering Services:

- Computer aided design
- Finite element analysis (structural and/or thermal)
- Engineering analysis with computational tools (matlab®, labview®, lanwindows®)

## SPECIALIZED EQUIPMENT (ENGINEER, PROTOTYPE AND DEVELOPMENT)

### Rapid K Heat Flow Meter Thermal Conductivity Instrument

Provides ASTM C-1518 thermal conductivity by means of a heat flow meter, and has a 12×12 inch sample required K range from 0.1 to 3.0 BTU-inch/hr ft$^2$ F (0.015 to 0.43 W/m° C). Sample thickness should be greater than 0.5 inch and less than 2 inches. The temperature capability ranges from 10° F to 400° F (-12° C to 200° C). Either compressed or uncompressed samples can be tested.

### Sweating Guarded Hot Plate

Is housed inside an environmental chamber with ability to maintain temperatures of -67° C to +177° C, +/- 0.5° and relative humidity at 10% to 98%, +/- 3%. Test method ISO 11092 "Measurement of Thermal and Water Vapor Resistance under Steady-State Conditions (Sweating Guarded Hot Plate Test)" is routinely used. A 21×21 inch sample is required.

## DESIGN, PATTERN, AND PROTOTYPE FACILITY

In this facility, NSRDEC designs and develops dress and combat clothing and equipment items and fabricates end item clothing prototypes such as ballistic and chemical protection. These prototypes allow for initial fit/wear tests and assist in the preparation of technical data packages for large-scale procurement. The CAD apparel design system allows for pattern input, lifetime storage, graded sizing, updates, and modifications. These patterns can be sent electronically directly to the contractor or printed on plotter paper, oak tag, or on CD.

### Adobe Illustrator CS3 (Apparel Design)

Creates professional product, apparel, and accessory drawings using comprehensive drawing tools. This state-of-the-art computer design program allows for creation of original color swatches, editing text, importing hand drawn art work, and creating filters, effects, and endless options for customized drawings. The art created with this Adobe program is a valuable tool for the designer in creating specification drawings, presentation boards, catalogs, and many other products.

### Automated Cutter

Utilizes a cutting edge flat bed cutter that can cut out the patterns in fabric and/or oak tag in a timely and accurate fashion. The sample cutter is a compact, plug and play, turnkey system. This system produces samples, prototypes, or short production runs with minimum disruption to the business flow.

### Flat Head Fusing Press

Performs a lamination process for all fusible clothing applications, producing cooling panels with triple layer lamination, tubing in the middle of cotton T-shirt materials, and ballistic panel fabrication. The press size is 24×32 inches and has a temperature range up to 350° F.

### Pattern Design and Grading (CAD)

Aids in design of patterns. Using this CAD system provides us state-of-the-art technology to expedite the fabrication of clothing related prototypes. This approach is unique and is much more productive than traditional processes. The increased speed dramatically shortens the product development cycle, which in turn increases profitability. Pattern input into the system allows the option of lifetime electronic storage of patterns.

### Pattern Design Software

Improves quality and helps create and grade more patterns in less time. Pattern design includes functions that enable basic to complex pattern making tasks. The powerful grading tools speed up time-consuming tasks associated with creating graded sizes. The wide range of pattern making and grading tools means flexibility for the user. Both the digitizer and the pattern scanner allow for quick and efficient input of the pattern pieces into the pattern design system. The digitizer workstation consists of a digitizing table with menu and a cursor. The pattern scanner consists of a large scanning sleeve and supporting software. Both methods allow you to enter internal locations on a pattern piece.

### Prototype Design Laboratory

Produces items ranging from dress and combat clothing to heavy duty equipment and ballistic items. In the design shop there are a number of state-of-the-art machines that are used to create high quality, factory producible items, e.g., ultrasonic cutter, computerized single needle, industrial bartack, keyhole and straight buttonhole, fusing machine, seam sealing machine and pressing equipment.

### Welding and Seam Tape Machine

Welds urethane and other thermoplastic type materials in any shape for either inflatable or waterproof seam applications. The welding and seam tape machine can seal in circular shapes or with other designs and has option to apply seam tape over seams.

## TENTAGE AND ADVANCED FLEXIBLE BARRIER PROTOTYPE FACILITY

This facility couples the knowledge of fabrics, non-wovens, high performance insulations, flexible photovoltaics, closures, and stealth and barrier materials with cutting-edge design and modeling capabilities.

The team maintains a large stock of in-house fabrics, closures, and hardware to reduce lead times. It also maintains extensive contact with the Defense Supply Center Philadelphia and the DoD shelter industrial base to obtain MILSPEC components.

The facility boasts access to in-house fabric and Instron testing, a full-scale Rain Room and Environmental Chambers for evaluation of materials and components, and a knowledgeable field support team to train users or set up shelter systems in remote locations.

There are three main foci:

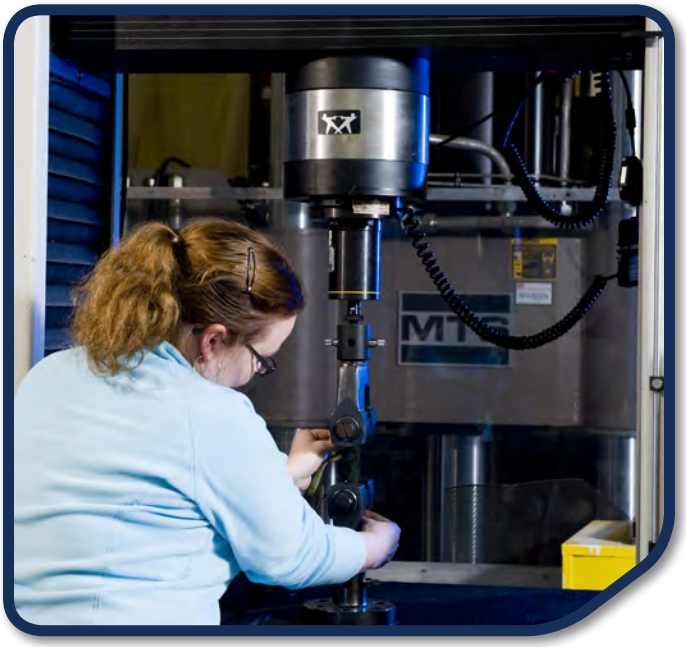
- Design and fabrication of tentage prototypes and supporting fabric accessories, such as command posts, advanced solar covers, and low profile/ reduced signature individual surveillance shelters.
- Small production run capabilities, including refurbishment of field tentage and accessories such as passageways, insulated water pillow tanks, shower and laundry transition endwalls, and a variety of bootwalls.
- Global war on Terrorism programs to include CB protected shelter systems, liners, transition assemblies, airlocks, and specialized fastening/sealing accessories.

The facility is staffed by well-trained professionals with extensive experience, complemented by a large range of medium and heavy duty sewing machines, ultra sonic heat sealing and cutting, thermal hot air and hot wedge heat sealing, and tape sealing and mobile track sealers. Fabrication efforts are augmented with AutoCad capabilities to provide Level I documentation of designs and in-house task order contracting services to document designs at Level III.

## HIGH PERFORMANCE FIBER FACILITY (HPFF)

The HPFF will combine NSRDEC, academia and industry expertise in novel fiber/textile technology to invent and rapidly transition new optical, electronic, high strength, flame retardant and reactive materials to Warfighters and First Responders. The HPFF utilizes a compounding extruder to uniformly mix additives into polymers, and houses extensive, multi-scale fiber extrusion equipment and accessories, a yarn twister, a semi-automated loom, and state-of-the-art analytical capabilities. The Thermo Prism TSE-16 16mm twin-bore programmable co-rotating twin-screw (24:1 L/D ratio, 5 heated zones, 32°C limit) extruder has an output range of 2-5lbs/hr, two Brabender feeders (pellets or powders) and a Scheer-Bay pelletizing system. Fiber extrusion equipment includes a mono/bi/tri-component system which can place additives in precise areas of fibers. Cross-section types include side-by-side, sheath/core, islands-in-the-sea, and segmented pie morphologies which can be used to develop lighter, reactive/responsive fabrics that will make the wearer safer, more comfortable and higher performing. Mono/bi/tri-component fibers can also be used in soft shelter, parachute, vehicle and numerous household fabric applications. In addition, a DACA Spinline comprised of high-pressure piston extruder, godet, heaters module, and winder can be used to process gram quantities of materials to make monofilament fibers. A microcompounder is available to prepare small quantities of material for the DACA Spinline. Fiber can then be converted to yarns and woven textiles using a Yarn Doubling and Twisting Machine model UNI 1X1 750 and an AVL Industrial Dobby Loom Model IDL-24, 24 inch Cloth Width, respectively. Fiber/yarn/textile analysis is accomplished using microscopy (Scanning Electron Microscopy, Transmission Electron Microscopy, Environmental Electron Microscopy and Atomic Force Microscopy), Instron mechanical analysis, thermal analysis, x-ray diffractometry, nuclear magnetic resonance spectroscopy, liquid chromatography/mass spectrometry and laser evaluation.

HART
SHORT

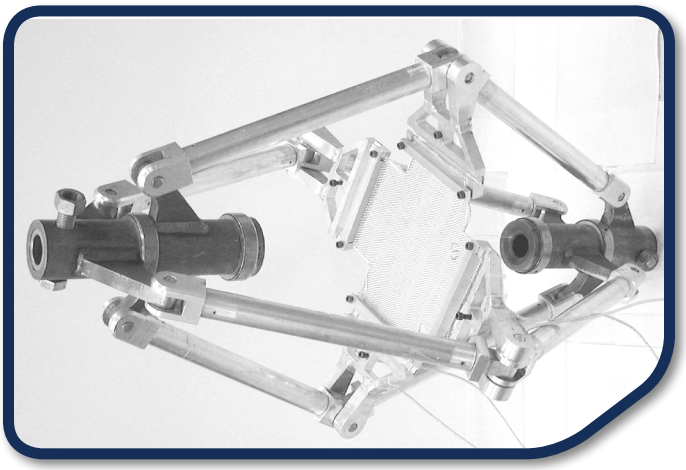


## INSTRON 4201 TENSILE TESTING MACHINE WITH ENVIRONMENTAL CHAMBER

This machine has a complete load cell range from 1 to 2,500 g and tensile testing of 225 lbs, 450 lbs, and 1,000 lbs for testing of closures, seam structures, fabric, and any tensile, compression, cyclic or 3-point flexure test. The software automatically allows for machines to cycle compress or pull any structure at a preset load or elongation cycling determinations with or without environmental chamber capabilities. The chamber is capable of temperature ranges from -200° F to +480° F with a relative humidity range of 20% to 95% within a temperature range of 65° F to 94° F. The chamber can also be set up to run independently of the Instron. Jaws and grips are available for any given material, including webbing, cording, and special applications.

## INSTRON 5889 LOAD FRAME

This apparatus tests loads up to 130,000 lbs in either tension or compression and has a crosshead travel of 72 inches. The system is controlled with an automated interface that allows load driven control, displacement driven control, and custom load profiling. Automated data acquisition at rates as high as 5 kHz are provided for electronic documentation. Applications include, but are not limited to, high strength webbings, ropes, and hardware.



## INSTRON TENSILE OR BREAKING STRENGTH TESTERS

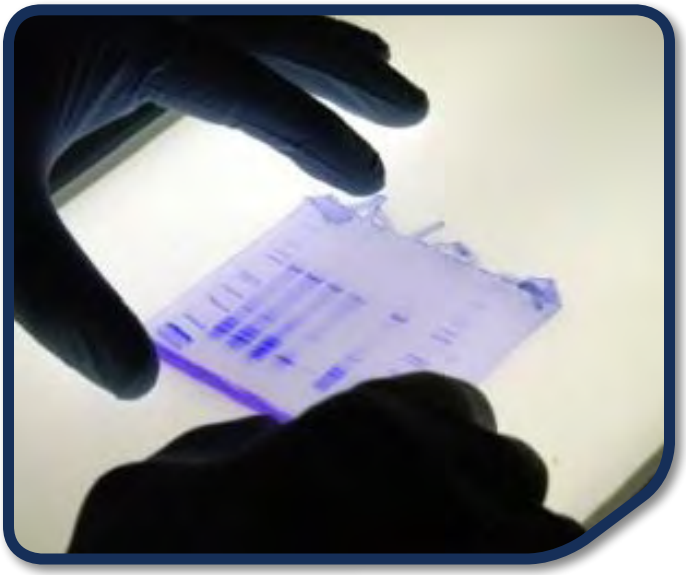
There are several Instron testers to measure the strength properties of wide range of materials from delicate fibers to very high strength webbings, ropes, and cordage.

## COMBINED BIAXIAL TENSION & SHEAR TEST FIXTURE

There are test fixtures for characterizing mechanical properties of a wide variety of materials, including fabrics, composites, elastomers, metals, biological tissues, and others. The fixtures enable more accurate determination of strength and stiffness properties for materials subjected to combined stress states such as biaxial tension and shear, which is important factor for materials used in inflatable structures. The fixtures accommodate a choice of independent or simultaneous application of in-plane shear and multi-axial loadings on a swatch of material. The resulting material properties enhance the fidelity of structural models used as efficient alternatives to expensive full-scale structural tests.

## ELECTROFORCE 3330 TEST SYSTEM

The Bose Electroforce 3330 is a test system with an axial electromagnetic linear motor, a torsional motor, and an environmental chamber for high and low temperature testing. The characteristics of the linear motor lends itself to dynamic studies of material properties as well as fatigue testing at cyclic frequencies up to 100 Hz. A frictionless flexural suspension system has proven to provide billions of cycles, resulting in high durability. The system has a load capacity of 3000 Newtons and a torsional capacity of 70 Newton-meters, with the ability to apply the loads simultaneously, while controlling the environmental temperature. The test system also has software for accurate waveform control and Dynamic Mechanical Analysis capabilities.



## BIOTECHNOLOGY LABORATORY

This facility performs cutting edge research in the following areas: genetic engineering, peptide/protein characterization, anaerobic/aerobic bacteria, novel materials, non-leaching antimicrobials, biomimetic templating, fiber spinning and bioenergy. Capabilities include: Fermentation facility; Polymerase Chain Reaction (PCR); DNA sequencing gel system; peptide synthesizer; fluorimeter; High Performance Liquid Chromatography (HPLC); BIAcore Processing Unit; anaerobic chamber, antimicrobial testing and a Tecan high throughput robotic system.

## CHEMICAL AND MATERIAL ANALYSIS LABORATORY

Capabilities include a Fourier Transform Infrared (FTIR) spectrometer with microscope and gas chromatograph (GC), a GC/mass spectrometer (GC-MS), GC systems with selective detectors, multi-pump liquid chromatograph (LC), a residual gas analyzer (RGA)/MS with flows down to 1 ml per minute, a thermo-mechanical analyzer; differential scanning calorimeter, a high-resolution thermo-gravimetric analyzer, and a dynamic mechanical analyzer.

## MICROSCOPY LABORATORY

The laboratory includes several microscopes used to analyze the surface and the internal structure of materials. Capabilities include:

### Electron Microscopy

- **Jeol Fastem 2010 High-Performance Transmission Electron Microscope (TEM)** – Operates at 200 kV, is capable of 2 angstrom resolution, and is equipped with a Gatan Image Filter (GIF) digital camera setup and an EDAX Corp. energy dispersive X-ray spectrometer (EDS) for quantitative analysis and X-ray mapping of samples. The TEM can operate in Scanning Transmission Electron Microscope (STEM) mode and is equipped with a cyrostage for imaging samples cooled down to -180°C.
- **Zeiss EVO-60 Scanning Electron Microscope (SEM)** – Is a high-vacuum SEM with a resolution of 3 nm, equipped with an EDAX Corp. EDS detector that is able to perform traditional X-ray mapping, as well as the newer technique of spectral mapping. It is equipped with a J.C. Nabity electron beam lithography system and is capable of writing patterns with 50-nm line widths.
- **FEI/Philips XL-30 Environmental Scanning Electron Microscope (ESEM)** – Is used for imaging biological and other electron-beam sensitive materials in a "wet" low-vacuum mode. This ESEM is equipped with an Oxford Corp. EDS system for elemental analysis of samples, and has a high-temperature stage (~900° C), a Peltier-cooled cold-staged (~0° C), and a fiber/film tensile stage for various dynamic sample analysis experiments.

### Atomic Force

- **Veeco Dimension III –** Allows general imaging in contact mode, electrochemical contact mode atomic force microscope AFM, and scanning tunneling microsocopy (STM).

- **Veeco Dimension IIIA –** Allows general imaging in contact and non-contact (intermittent) mode, as well as imaging in liquid magnetic force microscopy and in lateral (friction) force microscopy.
- **Nanonics Imaging Ltd. MultiView 1000 –** Allows general imaging in contact and non-contact (intermittent) mode, as well as imaging in liquid near-field scanning optical microscopy (NSOM), nano-thermal analysis, confocal microscopy, detection of change in refractive index of materials, fluorescence microscopy, 3-D lithography, and an environmental chamber with vacuum pump and cooling unit.

In support of the various microscopes, we also have the following sample preparation equipment:

### LEICA Cryo-Ultramicrotome

Used for cutting nanometer-thin sections of materials at either room temperature or frozen down to cryogenic temperatures (-180°C) with diamond knives.

### Smartcut Diamond Wafering Saw

Used for rough cutting of high-strength, high-toughness, high-hardness materials.

### Balzars Union MED 010 Sputter Coater

Used to deposit conductive metal films or a carbon coating onto SEM samples to improve image contrast and prevent electrical charge buildup on non-conductive SEM samples.

### High Purity Coating Metals

Include gold, gold/palladium (70/30), chromium, nickel, platinum, platinum/palladium (90/10), copper, silver.

## NUCLEAR MAGNETIC RESONANCE (NMR) SPECTROMETER

This apparatus is used in work conducted in the aforementioned laboratories. It consists of a console that houses all the electronic components, a superconducting magnet that the sample is placed on during analysis, probes that are used to analyze the sample (inside the magnet), a computer to control the instrument, and various heaters. An NMR is used to analyze samples to determine such things as purity of a compound, to confirm the structure of a compound (e.g., that a chemical reaction produced the desired end product), and to examine interactions between materials (e.g., how two materials might bind to each other and how that interaction influences molecular motions or how small molecules diffuse through larger molecules or membranes). It operates at 400 mHz frequency and is capable of analyzing both solid and liquid samples. It has multinuclear, multidimensional, and variable temperature capabilities.

## FOURIER TRANSFORM INFRARED (FTIR) SPECTROMETER

NSRDEC has a Nicolet 6700 FTIR with microscope that is used in work conducted in the aforementioned laboratories. This system includes diffuse reflectance, thermogravimetric analysis (TGA), and internal total reflectance (ITR) attachments for the evaluation of liquids, solids, fibers, and fabrics. The microscope has a programmable stage for characterization across surfaces. The spectral range is 1 to 20 μm (100000 $cm^{-1}$ to 500 $cm^{-1}$).

## LASER AND ELECTRO-OPTICAL TEST FACILITY

Numerous wave lengths, output posers, and pulse width lasers are available to test the performance of linear and nonlinear optical components and to evaluate the physical and optical properties of development materials. The facility contains the following lasers:

### Continuum ND/YAG Leopard Picosecond Laser

Has 50-ps pulse width and 1064-, 532-, and 355-nm wavelengths.

### Continuum Optical Parametric Generator (Pumped by Leopard)

Is tunable from UV to red.

### Continuum ND:YAG/Ruby Custom Nanosecond Laser Nd:YAG

Has 10-ns pulse width, 1064, 532-nm output, and Ruby 30-ns pulse width and 694-nm output.

### Coherent Innova AR/KR Laser

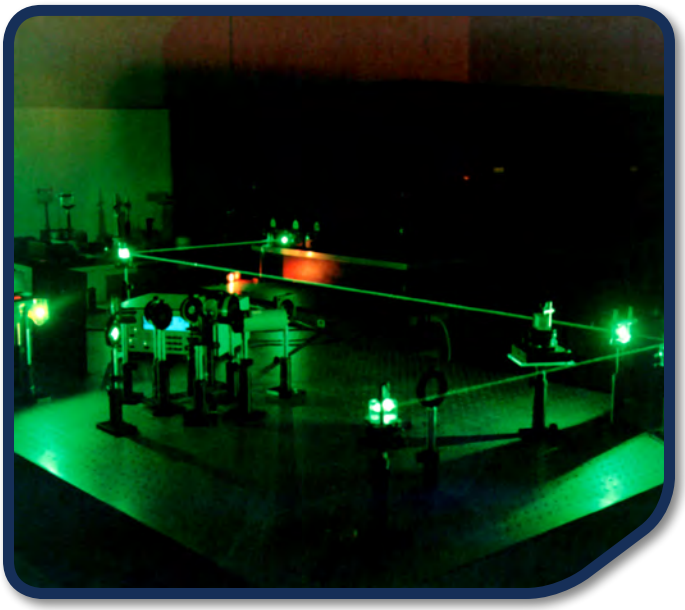
Has continuous wave and tunable output from UV to red wavelengths.

### Light Age Model 101 PAL Alexandrite Laser

Has 50-ns pulse width, tunable output of 650 nm to 750 nm, and stokes and anti-stokes raman cells.

### LeCroy LC574A 4 gHz Oscilloscope.

Eyewear can be assessed to verify end-item compliance with American National Standards Institute (ANSI) standards. An optical spectroscopy laboratory is available for evaluating optical materials at wavelengths ranging from the UV to the visible to the infrared (IR), using a double beam spectrophotometer with integrating spheres and several fiber optic spectrometers. Optoelectronic characterization is obtained via a microprobe station and electrical source/measurement meters. The complex optical response of nanostructured optical components can be documented using custom holders and positioners and multiple calibrated detector systems.



## AERIAL DELIVERY DESIGN AND FABRICATION FACILITY

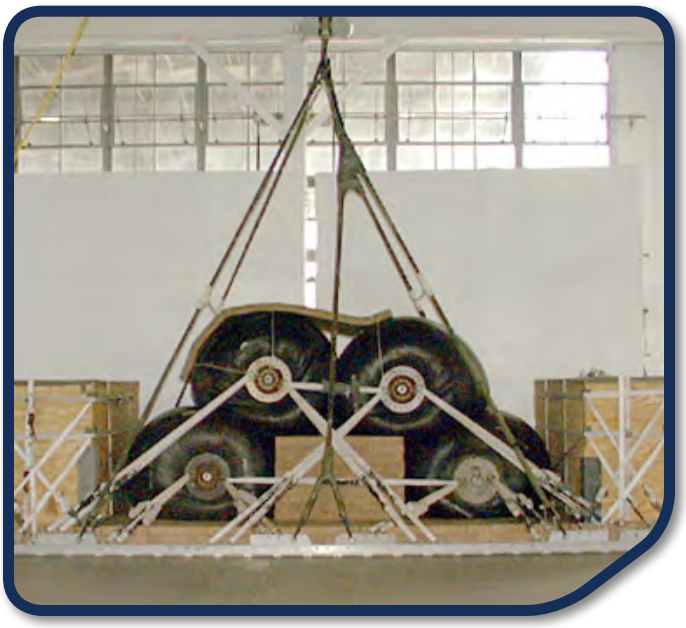
Skilled personnel are equipped to design and develop various prototype airdrop items. This facility has all classes of sewing machines, ranging from lightweight to heavyweight machines as well as ultrasonic machines. Together with engineers and specialists working with airdrop technology, the prototype staff can develop designs with state-of-the-art tools and technologies for the individual Warfighter.

## CERTIFICATION AGENCY FOR AIRDROP AND HELICOPTER SLING LOAD (HSL)

NSRDEC is the DoD certification agency for HSL and airdrop systems, equipment, and materials. In the certification program we test and certify how equipment is loaded, transported, and delivered by airdrop.

We can test:

- Strength of any fittings (which are used to attach items like tiedowns and recovery parachutes)
- Cushioning materials that absorb the impact of landing on the ground
- Rigging
- Load distribution in the aircraft, using NSRDEC's Roller Test Facility
- Impact of a simulated airdrop, using NSRDEC's Drop Tower



## 45-FOOT HIGH DROP TOWER

The Drop Tower is used to simulate and measure the impact shocks that are exerted on parachute loads when they hit the ground. It is also used for HSL static lift to establish rigging procedures and evaluate the effectiveness of lifting/sling load provisions.

- Crane height: 39 ft
- Crane capacity: 40 tons
- Cement surface: 40 $ft^2$

## AIRCRAFT ROLLER TEST FACILITY

This facility simulates C-17, C-130J, and C-130H aircraft roller beds. It has 160 instrumented rollers that are able to measure point loading of cargo inside an airdrop aircraft. It has an overhead lift capability which consists of two gantry cranes. Each gantry has two instrumented lifting hooks with a 7.5 ton capacity. The Roller Test Facility is also equipped to simulate up to 80,000 lbs of parachute extraction force.

KEY

## ADVANCED FOOD PROCESSING LABORATORY

Includes equipment for the production and testing of food and food components to facilitate state-of-the-art ration development. The production equipment, which is all pilot plant scale, includes:

### Small Scale Production Equipment

- **All-Fill Piston Filler and Food Yield Quantifier** – Measures semi-solid food matrices to specific volumetric/gravimetric quantities for pilot scale food productions.
- **Dough Sheeter** – Automatically or manually rolls out various types of bread, pizza dough, and pastries to a predetermined thickness, utilizing a stepped rolling mechanism to gently reduce the thickness of the dough with or without imparting excessive shearing forces.
- **High-Temperature/Short Time Extruder** – Uses screw conveyors in which a dough/grain mass is conveyed along a barrel toward a perforated die plate. As it is conveyed, the dough is "cooked" and textured by a combination of shear, friction, and pressure. Food extruders are used to produce breakfast cereals, pasta, pet food, and a variety of puffed snacks.
- **Impingement Oven (Pizza Oven)** – Cooks two to four times faster than conventional ovens by surrounding the food with small jets of hot air while moving the product through the oven chamber via a chain conveyor.
- **Meat Processing Chamber** – Is a temperature regulated chamber that provides an environment for various types of meat production to include cutting, grinding, pureeing, flaking, and vacuum infusion.
- **Rheon Encruster** – Co-extrudes dough and filling into various shapes (e.g., spherical, bar, and cylindrical) to create fully enrobed sweet or savory items (sandwiches, pies, and cookies). Product weight, filling, dough ratio, and length are flexible. Optional devices such as a solid feeder and double filling feeder are also available.
- **Starch Research and Baking Area** – Offers numerous ovens, proofers/retarders, and dough forming equipment to provide virtually everything required for standard R&D and small scale productions for a variety of baked items.
- **Retorts** – Provide dependable thermal processing and validation of all in-house productions utilized for product development efforts and field testing. Both steam and steam/water retorts are coupled with validator systems.
- **Nordenmatic Tube Filler and Sealer Machines** – Are used in the annual production of highly specialized tube foods for the U.S. Air Force. These unique, special purpose rations provide shelf stable, nutritious components (entrées, fruits, puddings, and desserts) to meet the strict dietary requirements of pilots conducting demanding, high-altitude reconnaissance missions while

fully encapsulated in pressurized flight suits. The Nordenmatic model NM400 is an automated aluminum tube filler/sealer used to fill and seal food product in aluminum tubes similar to those used for tooth paste applications. This apparatus is capable of filling and sealing up to 1,440 4.5-to-5.0-oz tubes per production run. Likewise, the Nordenmatic model NM250 is an automated plastic-laminate tube filler used to fill and seal food product in specialized plastic or laminate fabricated tubes. It can produce up to 800 4.5-to-5.0-oz tubes per production run.

### Bench Top Electroporator

Is used for electrochemical studies related to pulsed electric field processing and to genetic transfer experiments.

### Freeze Dryer

Removes moisture through sublimation, which directly converts water from a frozen state to a vapor. Removal of this unbound moisture is one of the most effective methods for producing a shelf stable product while retaining the product's inherent natural flavor and color.

### High-Pressure Processing

- **High-Pressure Processing Unit** – Studies the effects of pressures up to 80,000 psi and temperatures up to 70° C on food quality and microbial and enzymatic activity. The unit is lab scale with a 2-L capacity.
- **Avure PT-1 High-Pressure Kinetics Unit** – Studies microbial spore inactivation kinetics at pressures up to 100,000 psi and temperatures over 100° C.

### Microwave Digestive System

Is a pressurized microwave system with electronic control of temperature and time for treatment of food materials and biological tissues.

### OHMIC Heating Unit

Treats model food samples with electric current that induces heating patterns that mimic electrical circuits.

### Fermenter

Isolates and produces target strains of "good" microorganisms and subsequently harvests various bacteriocins for use in food preservation research. Includes a vertical autoclave unit to ensure sterility of the fermentation vesicle.

## ANALYTICAL MICROBIOLOGY LABORATORY

This laboratory contains equipment that performs a broad array of microbiological analyses for pathogenic and spoilage microorganisms. It performs challenge studies and validates processing methods. The microbiological equipment includes:

### Anaerobic Glove Boxes

Are used in a variety of applications where durable and economical enclosures are required: microbiology, incubation chamber, inert gas atmosphere, oxygen ($O_2$) controlled environment, tissue and culture work. Inside the chamber, a strict 0-5 parts per million (ppm) $O_2$ atmosphere is maintained through a hydrogen gas (5% mix) reacting with palladium catalyst to remove $O_2$.

### Biolog Microstation System

Is capable of identifying more than 2000 species of bacteria, yeast, and filamentous fungi. Its proprietary carbon-source utilization technology and 95 tests per microplate provide more information than any other phenotypic microplate or strip test on the market.

### Biolog OMNILOG® ID System

Is a fully-automated system capable of identifying Gram positive and Gram negative bacteria. In concert with the semi-automated MicroStation™ Reader, identification capabilities are extended to anaerobes, yeasts, and filamentous fungi. Both systems are based on the same patented carbon source utilization technology. A "metabolic fingerprint" is generated from test reactions performed within pre-filled 96-well microplates and compared to hundreds of identification profiles in a corresponding Biolog database. We have all six Biolog databases in-house for identification capabilities in excess of 2000 species of bacteria, yeast, and filamentous fungi. Results can also be used to create a customized database or to track specific organism characteristics and frequency of isolation.

### Class II Biological Safety Cabinet

Protects and reduces exposure to the laboratory workers and the environment by containment when handling Level 1 and Level 2 biological agents. It also maintains a sterile work area to prevent contamination of samples.

### Pathogen Detection Systems:

- **Bioveris M1M Biosensor Analyzer** – Is used for rapid detection of pathogenic bacteria and toxins. This rapid detection technology is useful for identifying bacteria that can cause illness or fatalities in food that is consumed by the Warfighter. Samples are measured and analyzed automatically. The analyzer processes a single sample in about 1 min and an entire 96-well plate in approximately 90 min, and it targets food pathogens.
- **Protocol Colony Counter** – Is equipped with a unique colony detection system which combines special LED illumination and digital color camera control with powerful software. It has a built in computer to minimize the footprint on the lab bench. The system compensates for writing on plates, variations in agar thickness, touching colonies, meniscus effects, spreaders, bubbles, debris, different sized colonies, and different colored media. Measuring applications include enumeration of pour, spread, and spiral plates, multi-well plate analysis, and inhibition zone measurement.
- **Water Activity Meters** – ConsiFwater activity of a food product in less than 5 min, determining the quality, safety, and shelf life of that food product.
- **Meso Scale Diagnostics (MSD) Sector PR2 Detection System** – Is an imaging-based electrochemiluminescence (ECL) detection system. It uses the MSD MULTI-ARRAY® plates which are disposable multi-well plates with screen printed carbon ink electrodes on the bottoms of the wells. Patterned microarrays of antibodies on these electrodes can be used to detect selected biological agents in a sandwich immunoassay format. The use of the multiple spot carbon ink electrodes allows the simultaneous detection of several biological agents including viruses, toxins, and bacteria in each well. The system can also be used for high-throughput screening of biological agents.
- **Idaho Technologies Ruggedized Advanced Pathogen Identification Device (R.A.P.I.D.) PCR** – Is a specialty instrument for military field hospitals, first responders, and other rough environments. This instrument integrates Idaho Technology's LightCycler® Instrument technology into a portable, impact resistant package. Distinctive software allows simple "push button" use of the R.A.P.I.D. System by field personnel with minimal training. This allows for field identification of possibly dangerous pathogens quickly, safely, and accurately. The R.A.P.I.D can be used for identification of food pathogen or for biological threat agents such as Brucella species, Bacillus anthracis, F. tularensis, Y. pestis, C. botulinum Type A, Smallpox, Listeria monocytogenes, E. coli O157, Salmonella, Campylobacter, and Cryptosporidium.
- **iQ5 Multicolor Real-Time PCR Detection System** – Is capable of multiplexing up to five fluorophores in each reaction vessel. It has intuitive software for protocol setup that enables utilization of embedded tools for end-point fluorescence analysis that simplifies qualitative assessment of sample abundance in single- or multi-color assays. In addition the software has multiple options for data analysis and presentation that provide a comprehensive view of assay results and advanced gene expression analysis methods that include publication-quality statistics and graphs for relative quantification. The system also has a flexible allelic discrimination analysis tool that allows automatic sample identification in genotyping experiments.

### Fluorescent And Chemiluminescent Detection Systems

- **Fluorescent Microscope** – Is a multifunction fluorescence detection system that allows for the visualization of fluorescently labeled antibodies bound to cellular components. The technology is extremely useful for the evaluation of antibody binding assays, including biofilm detection and planktonic cell capture on immunomagnetic beads.
- **Imaging System** – Consists of a sensitive charge-coupled device (CCD) camera with a darkroom that allows for the detection of fluorescent and chemiluminescent labeled protein, DNA, and RNA in electrophoresis gels or on nitrocellulose membranes. It can also be used to detect bacterial cells that are labeled with HRP antibodies reacting with chemiluminescent substrates.
- **Lumitec Luminometer** – Is a sensitive photomultiplier based detection system that is used to test antibodies with chemiluminescent labels for biosensor development.
- **Analyte 2000 Immunoassay System** – Is a laser based fiber optic fluorometer that is used for assays to test antibodies in biosensor development studies.
- **Zeiss LSM 710 Confocal Laser Scanning Microscope System** – is capable of continuous spectral detection over the whole wavelength range with up to10 dyes used simultaneously, performing virtually any fluorescence application. Additional laser lines can be added if experiments require new excitation sources. Multicolor imaging can be performed without spectral crosstalk, enabling the use of the latest fluorescent proteins. Molecules, such as proteins, and their interactions can be analyzed using all current methods of imaging. The FlexGate main beam splitter provides up to 50 combinations of excitation laser lines and may be exchanged by the user. On the detection side, emission bands can be flexibly selected without emission filters or secondary dichroics owing to new bandpass sliders in front of 2, 3, or 34 spectral detectors. Additional external detectors can be attached to the coupling port. The optics are designed for a range of 350 to 1100 nm and, as a result, lasers – including pulsed lasers and powerful bleach lasers – can be freely combined from near UV (405 nm), VIS, and IR (Ti:Sa) ranges.

- **Hyperspectral Scanning Prototype System** – is capable of a full spectral analysis (400 nm to 720 nm) of both reflected light and emitted fluorescence light from a sample placed on the line scanning table. The system includes both a white light and UV light source for capturing reflected and fluorescence based spectral analysis. After data capture, each waveband can be seen as photograph with the full accompanying spectral analysis.
- **The Fluoroskan Ascent FL** – is equipped with both fluorometric and luminometric measurement technologies, providing a full coverage for fluorometric and luminometric applications in the same run. The system is compatible with 1- to 384-plate formats, as well as PCR plates. The system also can hold up to three on-board dispensers for automatic addition of reagents.

### Veterinary Services Activity (VSA) Food Diagnostic Field Test Kit

Was assembled by the U.S. Army Medical Material Agency (USAMMA) as a portable laboratory, providing veterinary food inspectors with the tools and capabilities to make decisions regarding the safety and quality of food being purchased and consumed by US forces overseas. Equipment includes the Charm II analyzer and the Charm novaLUM, which are instruments that can detect aflatoxins, antibiotics, and insecticides in a variety of food matrices and measure sanitation of surfaces; two centrifuges, one high speed and another to spin down blood; a bacterial plate counter; a microscope; an incubator; a refrigerator; a balance; a pH meter; and a chlorine analyzer/colorimeter.

### Food Sample Processing and Analysis:

- **Pulsifier®** – Is a revolutionary new technology for processing food samples for microbiological examination. Unlike paddle-type instruments the Pulsifier® beats the outside of the plastic bag containing the food sample at a high frequency, producing shock waves and intense stirring which drives the microbes out of the food matrix and into suspension. The Pulsifier® offers processed samples that are more compatible with the demands of rapid microbiology methods. It features less food matrix destruction and a cleaner aqueous phase, making filtration and pipetting easier and minimizing interference with EIA and PCR methods. Microbial recovery is at least equivalent to paddle type instruments, and minimal temperature increases of the sample during processing protects damaged organisms.
- **Refrigerated and Non-Refrigerated Centrifuges** –
  - **Avanti J 20 XP Ultracentrifuge** – Is a high-performance centrifuge designed for high throughput and versatility. Teamed with the J-Lite® JLA-8.1000 6-L rotor, polycarbonate and polypropylene bottles, the Avanti J 20 XP centrifuge can process 6 L in 10 min. It is routinely used to concentrate and wash cell suspensions.
  - **Forma 5590 Hp Centrifuge** – Is one of the most powerful microcentrifuges on the market. This unit offers G-forces as high as 21,000 xg and features selectable acceleration and deceleration rates for precise control over every run. Designed with space conservation (12×13 inches) and performance in mind these powerful microcentrifuges are ideal for use in research, clinical, and production laboratories.
- **Wasp2 Spiral Plater Counter and Plater** – Eliminates the need for serial dilutions, offers a reduction in cost per test, and standardizes counting methods. It is fully microprocessor controlled and allows depositions onto 10 cm and 15 cm plates in log volumes of 50 µl, 100 µl, and 200 µl and allows a linear deposition of up to 400 µl. The plater is usually used when large microbiology studies are done, e.g., micro challenge and stability studies.
- **Stackable Incubator Shaker** – Is a large capacity, heavy duty biological incubator shaker with adjustable and programmable temperature (4° to 80° C) and speed (25 to 400 rpm) ranges.
- **Ultrasonic Processor** – Consists of a high wattage power supply and a sound proof enclosure to house and protect the user from the sonicator horns and high-power sonification water bath. The intended use for this specialized equipment is the disruption of bacteria, yeast, and fungi cell walls for the extraction of protein, RNA, and DNA without the use of traditional chemicals that could interfere with sensitive analytical instrumentation (i.e., HPLC, gene arrays, PCR, rtPCR, ELISA based detection).

## FOOD MICROBIOLOGY CLEANROOM

This facility is a customized 12'×12' class 10,000 cleanroom used for preparation, production, and purification of food bacterial cultures. The cleanroom creates positive pressure via HEPA – purified air with room volume exchanges 60 times per hr. The room can be utilized for aerobic and anaerobic fermentation studies, enzyme analysis, pilot-plant scale production of probiotics, prebiotics, and antimicrobials/bacteriocins. Biological end-products can be approved for inclusion into ration items for storage studies and/or consumption. The equipment consists of:

### Two BioFlo 110 Advanced Batch Fermenters

Provide the capability to isolate/produce target strains of "good" microorganisms and subsequently harvest various bacteriocins for use in food preservation research. A total of 12 L of working capacity allows for bench top R&D, as well as pilot scale production quantities.

### Thermo Scientific Sorvall Centrifuge

Allows for rapid separation of large volumes of biological suspensions from fermenters/bioreactors. The high-speed, continuous centrifuge processes at a rate up to 54 L per min. The system is ideal for harvesting of plant/animal cultures, protein precipitates, and bacteria; for yeast separation; and for cell enrichment.

**Barnstead Imperial III Incubator/Freezer**

Has a large internal capacity. This enables insertion of equipment and/or gas pack jars, allowing for both aerobic and anaerobic incubation. Freezer has vacuum insulation panels, allowing temperatures to be lowered to -112° F for long-term specimen storage/preservation.

**Tomy ES-315 Portable Vertical Autoclave**

Is dedicated to sterilizing food fermentation equipment that is used in production of biological end-products that are approved for food consumption.

## FOOD SAFETY TESTING LABORATORY

This laboratory develops screening assays, tests and modifies biosensor equipment, and optimizes food safety testing protocols for the military and civilian sector applications.

## FLEXIBLE FOOD PACKAGING LABORATORY

This laboratory contains equipment to fabricate and test prototype packages of many types and sizes (e.g., bags, pouches, trays, cartons, etc.). This equipment can be used to simulate the shock and vibration a package endures during shipping and handling, with the capability to fabricate packages that can withstand production runs and to test how well packaging materials or packages perform in environmental extremes (such as desert, arctic, or tropical conditions) in the packaging environmental chambers. The equipment consists of:

### Compression Tester

Is a fully automated test system used to determine the compression strength, load carrying capacity, or long-term stacking strength of large packages. The tester uses a precision load frame, system controller, and personal computer. A command signal from the control system to the load frame advances the upper platen toward the product and applies a compressive force until the test concludes. The system controller measures and records force, deflection, and time data in accordance with ASTM Standards D-642 and D-4577.

### Drop Tester

Simulates the fall of a packaged shipping container. The container is lifted to a standard height and dropped ten times on the bottom corner of the manufacturer's joint, i.e., the three edges leading away from that corner and all faces, in accordance with ASTM Standard D-5276.

### Incline Impact Tester

Tests impact resistance of shipping containers in accordance with ASTM Standard D-880.

### Environmental Chambers

Tests the durability of packaging materials and ensures the quality of food in extreme environmental conditions. Since military rations are shipped and stored around the globe, environmental testing ensures that Warfighters receive high-quality rations no matter where they are located.

### Pouch/Tray Burst Testers

Measures the ability of pouches and trays to withstand changes to internal pressure.

### Vibration Table

Simulates the forces and motions of motor trucks, railroad cars, and aircraft. This is standard practice for performance testing of shipping containers and palletized unit loads. It is used to verify protective capabilities of packaging in accordance with ASTM Standard D-999.

### Spray Chamber

Tests the water resistance of shipping containers in accordance with ASTM Standard D-951.

### Hermetic Sealers

- **Metal Traycan Sealer/Polymeric Tray Sealer** – Hermetically seals both metal and polymeric trays prior to thermal processing.
- **Thermal Impulse Heat Sealers** – Are adjustable, and apply uniform, consistent air-tight/water-tight seals in most thermoplastic films and laminates.
- **Vacuum/Gas Flush Heat Sealer** – Evacuates headspace and applies a fusion (hermetic) seal to the pouches. The pouch is isolated from the atmosphere in an enclosed chamber. The chamber is then evacuated, and two bars are used to heat-seal the pouch.

### Packaging Fabrication Equipment

- **Ultrasonic Welder** – Enables the precision, high-strength joining of thermoplastics using ultrasonics.
- **Horizontal Form-Fill Seal Machine** – Fabricates the right-sized packaging on-line with rollstock materials. A base cavity is drawn, the product filled, and the lidding applied on-line. This simulates the commercial production of some military food products.
- **Kongsberg XL22 Computer Aided Manufacturing Table with Artios Design Software** – Provides the capability to design and manufacture container packaging samples made of a wide range of corrugated fiberboard, solid fiberboard, and foam materials.

### Packaging Quality Analysis

- **Mead Jar Tester** – Enables the non-destructive examination of leakage paths through finished cans and flexible/rigid packages.
- **Headspace Gas Analyzer** – Draws a headspace sample and analyzes it for oxygen and carbon dioxide content. The system is used for package integrity testing, quality control in food applications, and bioprocess and fermentation testing. The unit is rugged, and portable when needed via battery operation. The analyzer measures oxygen from 0.1%-100%.
- **Taptone Seal Integrity Tester** – Is a non-destructive device that measures the seal integrity of small trays and containers.

## FOOD ANALYSIS LABORATORY

This laboratory conducts chemical, physical, structural, and textural characterization of food and food components and chemical heating technologies to facilitate state-of-the-art ration development. The analytical equipment includes:

### High Performance, Liquid, and Gas Chromatography:

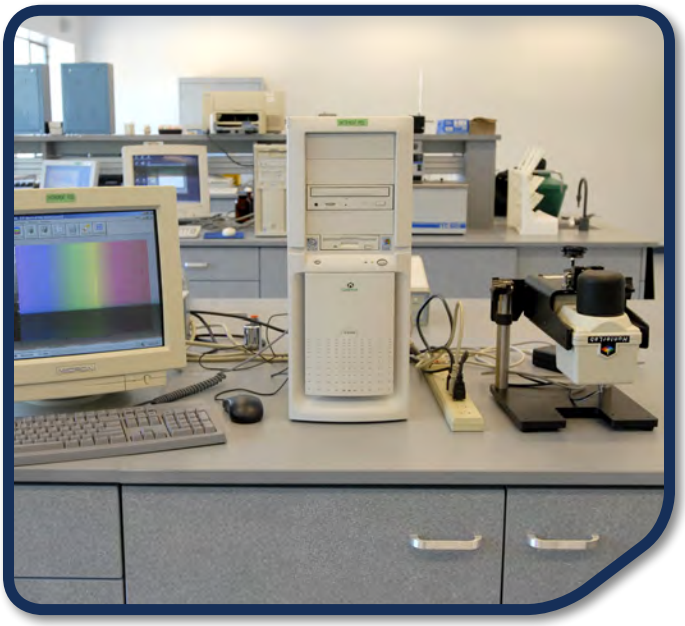
- **Agilent 1200 HPLC** – Is an analytical instrument that also performs ion chromatography. It separates and determines organic and inorganic solutes in a sample. The compound to be analyzed is dissolved in a solvent, injected and permeated through a porous solid stationary phase, and elutes the solutes into a flow-through detector. The compounds elute as individual peaks in a chromatogram which can be analyzed and quantified. The HPLC has a diode array, fluorescence, and a refractive index detector. An additional interface allows ion chromatography to be performed using the same instrument. Ion chromatography separates almost any type of charged molecule, often used for proteins and peptides.
- **Liquid Chromatograph** – Measures antioxidants, sugars, organic acids, vitamins, and other food components.
- **Siemens Ultramat 23 Gas Analyzer for IR Absorbent Gases** – Uses the non-dispersive infrared (NDIR) absorbance method to continuously and highly selectively measure one or more IR active gases, with absorption bands in the IR region from 2 to 9 µm, e.g., CO, $CO_2$, NO, $SO_2$, $NH_3$, $H_2O$, $CH_4$, and other hydrocarbons. This can be used to measure headspace in ration components.
- **Gas Chromatograph-Agilent 6890** – Separates compounds that have volatility and thermal stability. By separating the sample into individual components, it is easier to qualitate and quantitate various sample components. It is estimated that 10 to 20% of known compounds can be analyzed. The detector used with this system is a flame ionization detector.
- **Agilent 5975 GC/MS** – Is designed to separate gas phase ions according to their mass to charge ratio (m/z) value. It yields qualitative information about a pure component.

### Spectrophotometers

- **SPEX Fluorolog-2 Fluoroscence Spectrofluorometer** – Measures the intensity of fluorescence radiation over a region of wavelengths that has a stationary excitation wavelength, resulting in an emission scan, or scans an excitation spectrum that has a fixed emission wavelength. Two different detection modes (i.e., front-face for solid samples or right-angle for fluid samples), variable entrance and exit slit widths, computer controlled settings, and data acquisition can be used to tailor measurements for a wide variety of samples.
- **UV/VIS, Fluorescence, and Refractive Index Detection Personal Digital Assistant Spectrophotometers** – Used in conjunction with HPLC for analysis of a variety of biomolecules present in foods.
- **LabScan XE Spectrophotometer, Hunter Lab** – Is the most precise and accurate instrument for measuring color in food products. It has scanning capability across the entire visible spectrum (400 to 700 nm), which allows for precise specification of any color.

### Colorimeter

Quantifies color by measuring the three primary color components (red, green, and blue) of light seen by the human eye. The tristimulus measurement provides color information on the light reflected (solids) or transmitted (liquids) from foods. The system is capable of multiple illuminants, observers, indices, and color scales. The software allows for plotting color scans, changes in color trends, and color mapping.



### Laser Diffraction Particle Size Analyzer

Uses reverse Fourier lens optics incorporated in a binocular lens system, enabling the optimization of light scattering across a wide range in a single scan. It has 126 optical detectors, 15 to 90 s analysis time, 0.375 µm to 948.2 µm particle size range, and 1% reproducibility, allowing for the most accurate measurement of particle size.

### Laser Scanning Confocal Microscope

Performs single image and series scans, using dual Argon/Krypton lasers, fast shutters, automated slit/point aperture, a filter wheel, a Z-drive, and a cooled-CCD camera. It optically sections samples. It can also generate 3-D images that can discern spatial distributions of various components, using fluorescent dyes and analysis software.

### Osmometer

Is a high-precision, low-volume (10 µl) vapor pressure osmolality instrument capable of measuring a wide range

of biological materials. Measurement time is 1 to 2 min. The unit is capable of simple statistical functions and a 0 to 3300 mmol/kg measurement range. Osmolality measures a solution freezing point and ultimately solution concentration.

### Rheoviscometer

Provides shear stress versus shear strain relationships (thickness) for liquid foods through rotational shear. It provides measurements accurate to within +/- 1.0% and a repeatability of +/- 0.2%. A temperature controlled small sample adapter with a rheologically correct cylindrical geometry provides a defined system for extremely accurate viscosity measurements.

### Solution Calorimeter and High Sensitivity Scanning

Monitors exothermic chemical reactions using a sensitive thermocouple interfaced for digital data acquisition. The system includes a high sensitivity scanning calorimeter that is used for monitoring chemical reactions by measuring heat and the effects of heat on macromolecules. It is useful in structure-function studies of proteins, nucleic acids, and lipid membrane assemblies.

### Soxtec System HT 1043 Soxhlet Fat Extractor

Extracts lipids from foods using a semi-continuous method. Oil and fat from solid material are extracted by repeated washing (percolation) with an organic solvent, usually hexane or petroleum ether. The solvent is able to be re-used for different extractions.

### Super Critical Fluid Converter

Allows for the supercritical use of fluids, especially carbon dioxide, and introduces the supercritical fluid into a model system. It changes the physical properties of a gas via pressure and temperature, which gives it the diffusivity of a gas and the solvating power of a liquid. The altered liquid works extremely well as a processing media and is used for research of antimicrobial and anti-enzymatic properties.

### Super Critical Fluid Fat Extractor

Determines fat content by employing non-hazardous carbon dioxide gas in a supercritical state.

### Protein Analyzer

Calculates the nitrogen content of materials determined by combustion and protein content. As an environmentally superior alternative to the wet-chemistry Kjeldahl method, nitrogen by combustion provides no chemical waste. The system is equipped with an auto-loader capable of analyzing up to 40 samples without operator supervision. The per sample analysis time is 1 to 3 min.

### Texture Analyzer

Measures the force and distance in tension or compression. A wide range of programs include stress relaxation, adhesion, fatigue cycling, and compression cycling. Full statistical analysis capabilities are included. The system has a high range of speeds with high force and speed accuracy. It also provides stress versus strain relationships and fracturability on a wide range of solid foods.

### Thermal Analysis Equipment

Has a set of techniques in which the physical properties (glass transitions, melting point, and heat capacity) of a material, or its reaction products, are measured as a function of temperature. The methods have widespread use in quality control and research on polymers, pharmaceuticals, clays, metals, alloys, and foods.

- **Differential Scanning Calorimeter (DSC)** - Is a technique in which the differences in heat flow are measured. DSC is a calorimetric method which measures differences in energy and has now become the most widely used of all thermal methods.
- **Dynamic Mechanical Analysis (DMA)** - Is a technique in which an oscillating (or vibratory) force is applied to a material and the resulting displacement is measured. DMA is used to characterize the viscoelastic properties of materials. Temperature scanning during mechanical analysis is used to analyze state changes.
- **Mass Balance** - Uses a gravimetric method which also relies on measuring the weight of a sample

prior to and after dehydration. Mass balance utilizes an all-in-one approach whereby a sample sits on a balance and a heating element continuously dries the sample. Mass balance is a fast, efficient, and simple quality analysis method.

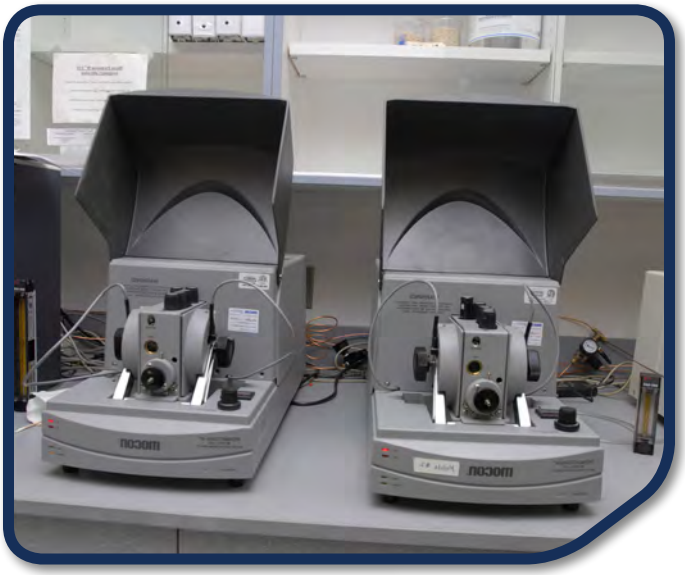
- **Moisture Analysis** – Is a computer-assisted system for an accurate and rapid measurement of moisture in most food material. Unlike traditional vacuum oven methods that take 12 to 24 hours, this system can provide accurate readings in 5 to 10 minutes; hence it is a versatile unit for a rapid moisture analysis for prototype ration development.
- **TGA** – Is a technique in which the mass of a sample in a controlled atmosphere is recorded continuously as a function temperature or time as the temperature is increased. The resulting thermal decomposition curve provides information on the thermal stability, shelf life, and bulk composition of the material analyzed.
- **Vacuum Oven** – Uses a gravimetric method which relies on measuring the weight of a sample prior to and after dehydration and assigning the difference in weight to moisture content. The vacuum oven method uses scrubbed dry air to create a vacuum and reduces the need for higher oven temperatures, thereby improving accuracy. Moisture analysis using a vacuum oven is a widely accepted AOAC method for many food products.
- **Time Domain Nuclear Magnetic Resonance (NMR)** – Uses low-field NMR to detect water mobility parameters of food samples (T1 and T2 relaxation times).

## FOOD PACKAGING, POLYMER PROCESSING, AND CHARACTERIZATION LABORATORY

### Polymer Processing and Compounding

- **Combination Twin and Single Screw Extruder** – Has interchangeable barrels and a modular design which give this extruder the capability to easily be switched from a twin to a single screw extruder. The extruder can produce blown and cast film. It can also quickly and easily produce plastic strand and pellets with a three strand die and pelletizing line.
- **Dr Collin GmbH Multilayer Blown and Cast Film Extrusion System** – Has five-layer blown film capability and nine-layer cast film capability with a feed block layering system and an adjustable slit die for film thickness control. This system uses five extruders and can combine five different polymers in many different configurations in order to maximize barrier and mechanical properties while minimizing material costs.
- **ThermoPrism Twin Screw Extruder** – Has programmable twin screw extruder elements for low-to-high shear processing, which is ideal for the incorporation of nanoparticles and other additives into commercial polymers. The extruder has blown and cast film production capabilities, and a strand die with pelletizing line for compounding and fabrication of custom made plastic pellets.

- **DSM Microcompounder** – Is a twin screw compounder with force controlled screw speed and individual barrel temperature controls. The unit has a 15-g maximum capacity that can be extruded into strand or film using several different dies. In addition the system has an injection molding unit that can produce tensile testing and thermal analysis specimens.
- **Laboratory Bench-Top Hot Melt Coater/ Laminator** – Is capable of producing coated samples of hot melt adhesives and then laminating them to a variety of films and papers.




### Polymer Film Characterization

- **MOCON Oxygen Transmission Testing Machine** – Determines the oxygen barrier properties of polymeric films by measuring the transmission rate of oxygen gas through the material. Monolayer and multilayer film, sheet, and packages can be tested using a variety of different supplies and equipment. In-house capabilities for oxygen permeation testing include three modulus which are able to test six different samples simultaneously. It conforms to ASTM Standard D-3985.
- **MOCON Water Vapor Transmission Testing Machine** – Determines the water vapor barrier properties of polymeric films by measuring the transmission rate of humidified nitrogen gas through the material. Monolayer and multilayer film, sheet, and packages can be tested. In-house capabilities for water vapor permeating testing include three modules which are able to test six different samples simultaneously. It conforms to ASTM Standard F1249.

- **Illinois Instruments Oxygen Analyzer** – Determines the oxygen barrier properties of polymeric films by measuring the transmission rate of oxygen gas through the material. Monolayer and multilayer film and sheet can be tested at varying temperatures and relative humidities. In-house capabilities for oxygen permeation testing include two moduli which are able to test four different samples simultaneously. Can be used to compare oxygen transmission results to the MOCON permeation equipment for greater data validity. It conforms to ASTM Standard D-3985.
- **Dart Drop Impact Resistance Tester** – Measures the impact resistance of plastic films, sheet, and laminate. The system also includes a cold chamber which can be used with liquid nitrogen to test at cold temperatures and a total energy system which includes an IR speed trap to measure the speed of the dart before and after impact. It conforms to ASTM Standard D-1709.
- **Gelbo Flex Tester** – Determines whether plastic films and laminates can withstand repetitive stress and strain. This machine demonstrates the visual results of pin-holing, stress cracking, and delamination. It conforms to ASTM Standard F-392.

- **Elmendorf Tear Tester** – Measures the force required to propagate a tear through a constant radius specimen. Tear resistance can help to determine an optimum thickness and also shows the ability of a packaging material to withstand rough handling. It conforms to ASTM Standard D-1922.
- **Instron Tensile Tester** – Is used to test the tensile and seal strength properties of plastic films, sheet, and laminate. It conforms to several ASTM Standards, including D-638.

### Pre-Processing Conditioning and Analysis

- **Melt Flow Indexer** – Measures the melt flow resistance of thermoplastic resins. The melt flow rate is an indirect measure of a polymer viscosity and molecular weight. It conforms to ASTM Standard D-1238.

## SENSORY CONSUMER AND TECHNICAL TESTING LABORATORIES

These laboratories conduct a wide range of studies to characterize the sensory properties of and consumer responses to foods, beverages, and other consumer products. Additional in-house facilities include sensory panel and focus group rooms. Trained panels for flavor, texture, and hand feel are available for descriptive sensory testing and consumer studies for individual foods and entire meals. This also includes interaction of food and eating with factors such as attitudes and cognitive performance. Existing human use protocols enable testing for a wide range of FDA-approved and experimental products with a large volunteer consumer panel.

## BURNER TEST FACILITY

The equipment in this facility tests and evaluates 200 to 200,000 BTU/hr JP-8 and diesel fired combustion systems, including burners, military kitchen appliances, camping stoves, pocket stoves, water heaters, shelter heaters, and heat-driven generators and cogenerators. Combustion efficiency, heat transfer, and energy balance are also determined to reconcile total energy in with total energy out. Assessments of safety, health, ergonomics, maintenance, and reliability are also evaluated. Specialized test equipment includes:

**Bachrach Portable Gas Combustion Analyzer –**

Is an emissions analyzer for combustion systems of various fuel types. The analyzer measures $O_2$, $CO_2$, CO, combustion efficiency, stack temperature, and ambient temperature.

**Dranetz PP1 Power Platform Energy Analyzer –**

Is an electric power consumption analyzer. It measures the AC power waveform, power quality, and in-rush current.

**Quintox Gas Combustion Analyzer –**

Is an emissions analyzer for combustion systems of various fuel types. This analyzer measures $O_2$, $CO_2$, CO, $NO_X$, combustion efficiency, $SO_X$, stack temperature, and ambient temperature with printout capabilities.

**FLIR Systems SC2000 ThermaCam Handheld IR Thermal Imager –**

Is a high performance uncooled, long wave focal plane array (FPA) IR system. It features both thermal and visual imaging, real-time 14-bit digital output, advanced microbolometer detector technology, precision temperature measurement capabilities up to +2000° C, and outstanding thermal sensitivity.

**Panametrics PT868 Ultrasonic Flow Meter –**

Is a portable flow meter for noninvasive measurement of flows within pipes and processes.

## REFRIGERATION CALORIMETER TEST CHAMBER

This 225 $ft^2$ chamber tests and evaluates refrigeration equipment. It has 4.5 inch super insulated walls, fans for air circulation, an array of thermostatically controlled heaters to provide a controlled interior ambient temperature of up to 135° F, and a fire suppression system. The room is designed to accommodate refrigeration units up to 300 $ft^3$, although units from 3 to 50 $ft^3$ are typically tested. State-of-the-art data acquisition capability includes 72 channels of temperature data and an energy analyzer. Work has included performance testing of various refrigeration systems and long -term testing of shipboard ice making equipment for the Navy.

## NAVY TEST LABORATORY

This facility is used for the testing and evaluation of equipment items for use by Navy Afloat and other potential military applications. The facility includes: a 440-V power supply required for Navy shipboard operation; a tilt table machine for simulating 15° pitch and rolls experienced on board ships; and grease and condensation ventilation hoods which are necessary for the evaluation of kitchen, sanitation, and refrigeration equipment and systems. In addition the facility includes a supervisory control data acquisition (SCADA) network capable of process control monitoring and meal production planning of food service equipment.

MOUNTAIN

DoD photo by Staff Sgt. Marcus J. Quarterman, U.S. Army

***THE SCIENCE BEHIND THE WARRIOR: YESTERDAY, TODAY AND TOMORROW.***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