OUELLETTE THERMAL TEST FACILITY (TTF)

WHAT IS IT:

The Thermal Test Facility is an 8,100 square foot state-of-the-art facility that houses a large propane test cell, a laser and photonics lab and three other laboratories. The facility was designed to support the Department of Defense (DoD) in evaluating and characterizing the effect of flame/thermal threats and hazards on materials and assist in the development of new and improved materials for use in clothing and individual equipment items for protection of the individual Soldier. The facility is a joint Army/Navy facility and houses a number of instrumented manikins including a traversing manikin developed for the US Navy Clothing and Textile Research Facility (NCTRF).

CAPABILITIES:

The Natick Soldier Research, Development and Engineering Center (NSRDEC) is the primary facility within DoD for the development of clothing and equipment for the protection of the individual Soldier. To date there are only four ASTM F1930 test systems operational in North America.

The Thermal Test Facility is the only known facility in the nation that has the capability to test and evaluate the thermal performance of milligram quantities of materials through full scale systems such as clothing and tents. This facility provides NSRDEC scientists and engineers with unprecedented research evaluation capabilities for the evaluation of flame and thermal protective materials, clothing, and equipment.

- **Propane Test Cell:** The Propane Test Cell supports the evaluation of the combustion and thermal characteristics/burn injury predictions of full scale systems in a propane fire. The propane test cell in the TTF houses an instrumented manikin, a propane delivery system, as well as alarms and an exhaust system. All building systems are controlled from within the control room and include a wet scrubber system, fire alarm/wet deluge system, propane delivery system, underground storage tank, data acquisition system, and system software to safely run the test. A vaporizer outside the building is used to supply the proper gas flow rate to the burners for testing. All valves in the propane system and all building systems are monitored through the HMI (human machine interface), ensuring all safety conditions are satisfied before and while testing is performed.
    - **Instrumented Stationary Manikin - ASTM F1930 Test:** Eight burners are positioned around an instrumented manikin equipped with 123 skin sensors that are uniformly distributed over the entire body, (with the exception of the hands and feet which contain no sensors). The sensors are connected to a data acquisition system and run through heat guarded cables for protection. The instrumented manikin is held from a stanchion in the middle of the burner setup, during testing the manikin is fully engulfed in flame to

simulate a flash fire scenario. Data obtained from the sensors, is run through a burn injury prediction model. This test provides information on predicted burn injury as well as interactions between clothing system materials, garment design, garment layering, and component interfaces.

- **Propane Fire Pit:** The Burn Pit is 8 feet x 12 feet and contains 9 - 7 foot ribbon burners approximately 6 inches below floor level covered by grates. The burners are programmable through the computer system in the control room to allow for the operation of one or more burners, individual adjustable timed sequencing of burner ignitions, individual adjustable burner heights and individual adjustable durations.
- **Traversing Manikin:** The test system consists of a modified ISO 9705 room with eight sand burners on the floor all of which are repositionable to simulate various fire scenarios. The burners, fed by vaporized propane gas, are lit and the room is set on fire. An instrumented manikin suspended on a motorized traversing mechanism travels through the burning room. The sensors on the manikin record the temperatures reaching the manikin in the sensored areas and the heat flux data is run through burn injury models to predict burn injury.

- **Laser and Photonics Lab:** The Laser Lab provides the capability to evaluate the optical and electro-optical properties of developmental materials over wavelengths ranging from the ultraviolet to the near infrared.
- **Flammability Testing Laboratory:** The Flammability Testing Laboratory contains equipment designed to conduct fabric swatch level tests, and contains an environmentally controlled conditioning chamber. Fabric swatch tests provide information on a fabric's propensity to ignite and continue to burn after exposure to an ignition source; the ability of a fabric or layered fabric configuration to prevent thermal and/or radiant heat transfer; fabric break open by flame, and other tests. Equipment includes:
  - **Vertical Flame Chamber Horizontal Vertical Flame Chamber.**
  - **Limiting Oxygen Index Chamber Thermal Protective Performance Tester.**
  - **Thermal Barrier Test Apparatus (TBTA):** A bench-scale test apparatus using single or multiple layers of fabric samples (5″ × 7″) that can be exposed to heat fluxes up to 3 cal/sq cm/sec for a specific exposure time. TBTA has both a skin simulant sensor and a heat flux gage located beneath the sample, a radiant heat source above the sample and the capability of running data through a variety of burn injury models including the model used in full scale testing (ASTM F1930). This apparatus allows testing of samples at variable orientations (0, 30 45, 60, 90° rotations) and is capable of evaluating non-FR materials as well. One of the most important capabilities of this equipment is the collection of data after the actual test exposure. Like the full scale test, this test apparatus can provide information on how well the sample dissipates heat (or if it retains heat) an extremely valuable tool when looking at burn injury predictions.
  - **The Dr. Knox Tester:** Similar to the TPP tester, it has a radiant and convective heat source but also includes a hot air impingement tester.
- **Materials Analysis Laboratory:** Characterization of small quantities of materials (milligram quantities) is conducted in the Materials Analysis Laboratory in the TTF. The testing done

in this lab aids in the development of materials when limited quantities are available. In addition, the laboratory has the ability to characterize a material's flame and thermal properties prior to scaling up production trials of a polymer, coating, fiber, and/or material blend. Available equipment:

- **Pyrolysis Combustion Flow Calorimeter (PCFC)** or Microscale Combustion Calorimeter (MCC).
- **Pyrolysis unit with Gas Chromatograph/Mass Spectrophotometer (GC/MS).**
- **Co2 Laser** - A 2500 Watt CO2 laser is used to simulate the thermal portion of an Improvised Explosive Device (IED) type event - short, intense, high heat flux, instantaneous exposure. The test procedure for this analysis is currently under development and is more appropriately categorized as a swatch level test. However, it is possible to collect the gases being emitted during this test and analyze them using the GC/MS unit which is collocated in this laboratory.

- **Burner Combustion Analysis Laboratory:** The Burner Combustion Analysis Laboratory provides the capability to test, evaluate, and analyze the thermal processes and combustion by-products of equipment such as field feeding food service burners, tent heaters, water heaters, and other support type equipment for safe and efficient performance that meet joint services requirements wherever the mission around the world. Available equipment:
  - **Combustion Analysis Equipment.**
  - **Inline water flow metering Equipment.**
  - **Dedicated Exhaust Systems** to contain or remove combustion or steam by-products
  - **Collin Blown Film Extruder with Counter Rotating Die** - A single screw extruder has the capability of processing at high temperatures (maximum temperature 450^{0}C). A counter-rotating mandrel die to study superimposed shear flows in polymer processing was designed by Virginia Technical University (VTU) and fabricated by Dr. Collin Gmbh (Germany) for upward blown film production. This die has demonstrated in-plane alignment of exfoliated and dispersed nanoclay tactoids resulting in superimposed transverse shear fields. The die is on loan through a joint educational agreement between NSRDEC and VTU for several ongoing NRSDEC projects. This equipment is available to academia, industry and other government agencies for Testing Service Agreements.
  - **Thermoprism Tse-16 Twin-screw Extruder:** Used for compounding small amounts of nanocomposite materials, as well as polymers with other additives such as oxygen scavengers or anti-oxidants. The equipment has critical compounding capabilities such as programmable screw elements, which enable the operator to design the screw configuration for the specific polymer, additive and application. This equipment is available to academia, industry and other government agencies for Testing Service Agreements (TSA).

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