Unique ORNL HTS Program Capabilities

ORNL cable test facility

In order to achieve market acceptance of superconducting technologies for grid applications, prototype and pre-commercial power equipment must be thoroughly tested. The ORNL cable test facility is particularly suited for superconducting cable testing due to its unique integration of specialized capabilities. These include a unique sub-cooled high-pressure circulating liquid nitrogen system (soon to be installed), capable of flowing liquid nitrogen at rates required for very long cables, high-current power supplies and high-voltage capabilities. This one-of-a-kind comprehensive facility is the only one in the U.S., is actively used in collaboration with U.S. cable manufacturer, and is available to the DOE program and its stakeholders.

(Specifications: Sub-cooled down to 67K; High pressures up to 20 bar; Flow rates for hundreds of meters of cable testing; High currents up to 25,000 A DC, 4,000 A_{rms} AC single phase, 3,000 A_{rms} AC three phase; High voltages up to 220 kV withstand)

ORNL fault current test facility

Fault current limiter is a highly sought after technology that can prevent equipment damage, promote grid reliability and resiliency, and defer expensive equipment upgrade. After ongoing upgrade that is slated for completion at the end of 2008, the ORNL fault current test facility will uniquely combine high voltage, high fault current, high pressure and cryogenic environment under a well integrated setting. Upgrade of this one-of-a-kind facility is leveraged with DOE and DHS funds, and is intended to operate as a national resource for power equipment testing. The facility is already scheduled for usage in collaboration with U.S. superconducting power equipment manufacturers, and will be available to the DOE program and its stakeholders.

(Specifications: Sub-cooled down to 67K; High pressures up to 20 bar; High fault currents up to 60,000 A_{rms} AC at high test voltages up to 600 V AC)

ORNL high-voltage dielectrics research and testing facility

A thorough understanding and the ability to meet challenges posed by high-voltage conditions are vital to the practical application of power equipment for the grid. In a real-world setting, severe stresses are imposed upon the dielectric insulation and the system as a whole. In addition, the new extreme operation conditions faced by superconducting power equipment are yet to be well understood. The ORNL high-voltage dielectrics research and testing facility integrates expertise in modeling, novel materials fabrication and high-voltage testing with a combination of unique testing systems that operate under realistic extreme conditions. This one-of-a-kind comprehensive facility is the only one in the U.S., is actively used in collaboration with U.S. superconducting wire and equipment manufacturers, and is available to the DOE program and its stakeholders.

(Selected capabilities and specifications: Novel dielectric nano-composites development, fabrication and testing; Large-volume cryostats for testing model cables, terminations, subassemblies, components and materials ; Cryogenic temperatures; Accessible pressures range from vacuum to 15 atmospheres; BIL impulses up to 800 kV; AC withstands up to 200 kV; Partial discharge; Lifetime aging tests up to months at a time) .

ORNL conductor design and engineering test facility

The ability to carry a large amount of current is but the most basic requirement of a commercial superconducting wire. Thorough understanding of other characteristics such as ac losses, wire stability, mechanical integrity and joint behavior is also vital to the practical application of superconducting power equipment. The ORNL conductor design and engineering test facility is consisted of a collection of well integrated expertise and equipment that addresses these challenges in a coordinated manner. This facility serves to bridge the knowledge gap between small lab-scale samples and large-scale systems. Capability of the unique facility spans the entire wire engineering space from design conception to model sample fabrication to characterization and validation in a rapid feedback manner. This one-of-a-kind facility is actively used in collaboration with U.S. superconducting wire and equipment manufacturers, and is available to the DOE program and its stakeholders.

(Specifications: Losses in AC magnetic fields up to 150 mT, DC magnetic fields up to 6 T; Temperatures between 20 K and 77 K; Variety of cooling geometries; High AC and DC currents up to 1,000 A)

ORNL clean-room rolling facility

Fabrication of high-quality single crystal-like flexible metal templates used in the ORNL-invented RABiTS process requires specialized rolling equipment in a clean environment. The ORNL clean-room rolling facility harbors a unique custom-designed rolling mill that allows for the continuing improvement in the metal template. This unique facility is actively used in collaboration with multiple U.S. superconducting wire manufacturers, and is available to the DOE program and its stakeholders.

(Specifications: Class 1,000 clean room; Four-high rolling mill with polished rollers; Front- and back-tension controls)

ORNL lab-scale wire fabrication facilities

In order to achieve broad market adoption, superconducting power equipment must provide an attractive mix of value propositions, chief among them are low wire cost and high wire performance. ORNL lab-scale wire fabrication facilities house a variety of unique and custom-designed machines that are used to fabricate various wire components by different manufacturing techniques. These machines are used in various combinations to develop complete prototype superconducting wires with specific attributes, including ultra-high performance, high throughput and low cost. Many of the machines are one-of-a-kind in the U.S., are actively used in collaboration with multiple U.S. superconducting wire manufacturers, and are available to the DOE program and its stakeholders.

(Selected equipment: Pulsed laser deposition system with three chambers; Reel-to-reel vacuum induction heater; Reel-to-reel single-gun electron beam evaporation equipment; Reel-to-reel three-gun electron beam evaporation equipment; Reel-to-reel large-area radio-frequency sputtering system; Reel-to-reel low-pressure reaction furnace)

ORNL reel-to-reel slot die coater system

The non-vacuum solution-based approach to superconducting wire manufacturing is universally agreed as the lowest cost route toward commercial wire production. However, the requirement of large-area single crystal-like coatings that are also continuous and uniform is new to the technology, and is under intense worldwide competition. The custom-designed ORNL reel-to-reel slot die coater system with integrated furnace is uniquely suited to address this challenge. This versatile coater system is actively used in collaboration with U.S. superconducting wire manufacturer, and is the only system available to the DOE program and its stakeholders. (Specifications: Coating speeds up to 600 m/hr; Temperatures up to 1,200 degrees C; Controlled environment for type of gas and amount of humidity)

ORNL four-gun electron beam evaporation system

Solution approach to high-performance superconductor is a low cost route to produce commercial superconducting wires. Unfortunately, efforts to improve wire performance through elemental modification are complicated by solution chemistry and stability issues. Electron beam evaporation is a companion method that mimics the solution approach without the aforementioned complications. Although more expensive as a production technique, it is nevertheless a more efficient and cost effective way to develop the appropriate chemistry for follow-on solution adaptation. The ORNL four-gun electron beam evaporation system is uniquely suited for this task. This system is actively used in collaboration with U.S. superconducting wire manufacturer, and is the only such system available to the DOE program and its stakeholders.

ORNL reel-to-reel x-ray diffractometer

The performance of superconducting wires depends on the perfection, uniformity and continuity of the superconductor crystallographic orientation. Novel reel-to-reel x-ray diffractometer is an effective and efficient way to locate and characterize the flaws in long-length wires. The unique ORNL reel-to-reel x-ray diffractometer, which is the only unit capable of handling 4 cm-wide wires, has inspired a similar unit built by a U.S. superconducting wire manufacturer and remains the only one available to the DOE program and its stakeholders.

ORNL contactless superconducting wire characterization equipment

Superconducting wires are highly anisotropic (that is, wire performance changes with the direction of magnetic field). Consequently, the wire performance must be thoroughly characterized under all applicable temperature and magnetic field conditions. However, as the wire performance is improved, it becomes difficult or impossible to pass progressively large test electric currents through the wire. ORNL has developed a novel experimental contactless wire characterization equipment that will allow wire performance testing at all applicable temperature and magnetic field conditions. This is the only such equipment in the world, and is available to the DOE program and its stakeholders.

ORNL thermal reactor / desorption equipment with built-in diagnostic systems

During the development and manufacturing of superconducting wires, issues that affect wire performance and reliability including superconductor formation and delamination can arise. It is necessary to detect and understand these phenomena in real time. The ORNL resistively-heated superconductor thermal reactor /desorption equipment with built-in X-ray detector and mass spectrometer is uniquely suitable for this task. It is the only such equipment in the world, is actively used in collaboration with U.S. superconducting wire manufacturers, and is available to the DOE program and its stakeholders.