STRUCTURAL TESTING

At the National Wind Technology Center (NWTC), researchers measure their success by the number of blades they fail. Ultimate static-strength testing, in which blades are tested to failure, is just one type of blade structural evaluation available to the wind industry. NWTC researchers conduct a full range of structural evaluations including ultimate static-strength, fatigue, vibration, and nondestructive tests.

Structural testing offers many benefits to wind turbine companies. Wind turbine companies use Center facilities to verify and improve new blade designs, analyze blade structural properties, and help improve manufacturing processes. Blade testing can provide important information that helps accelerate the design process. Nondestructive testing techniques provide cost-effective methods for determining how blades age and predicting service life and maintenance requirements.

Comprehensive structural testing can assure turbine customers that a blade is adequately designed. Prototype field testing seldom offers this assurance, because prototype machines seldom encounter the most extreme conditions during testing. In contrast, structural testing puts a blade through its entire design life cycle.

When purchasing wind turbines, customers seek more than assurances, however. Many require that the wind turbines they purchase be certified. Blade testing is an important part of the international certification process. Although no U.S. organization currently certifies wind turbine systems, U.S. turbine manufacturers use test results from the Center in seeking certification for their turbines in Europe. They also use the test results to affirm the quality of U.S. turbine technology in foreign markets.

Structural-Testing Facilities

The National Renewable Energy Laboratory (NREL) has three wind turbine blade test facilities, including a new high bay in the Industrial User Facility. The high bay is large enough to test any blade expected during the next five years. Two testing areas are equipped with stands rated at 1 million foot-pounds capacity; the other has a 4 million foot-pound stand. Each area has an overhead crane for applying loads to the blade during static-strength testing.

Warren Gretz, NREL PIX 00213

During ultimate static-strength testing at the National Wind Technology Center, loads are distributed across multiple points on the blade (shown above) or concentrated in a single location. The maximum static load is 35 tons.

The test areas have closed-loop servo-hydraulic systems for fatigue testing. With the system, operators can apply loads, vary the amplitude of loads on the blade, deflect blades, and change the frequency and location of loading. The system capabilities are adequate to perform certification testing for blade design standards.

In 1995, NREL's National Wind Technology Center developed a sophisticated data acquisition system, known as the Blade Structural Testing Real-time Acquisition Interface Network, or BSTRAIN, to monitor structural testing. The system is based on LabView software developed by National Instruments. The same company manufactured signal-conditioning hardware that routes data from blade tests into BSTRAIN for monitoring and analysis.

The new system provides great flexibility in test monitoring and data analysis. It can automatically collect blade test data as well as permit selective manual operation. BSTRAIN allows 24-hour continuous video surveillance of tests to ensure that critical events are monitored during unattended operation. It is capable of detailed analysis of structural tests, early detection of blade problems, automatic control of signal drift, and recording blade stiffness changes throughout the test.

Recommended Tests

The National Wind Technology Center recommends both ultimate static-strength and fatigue testing for wind turbine blades. Both tests are necessary to verify a new blade design. In some cases, researchers may recommend nondestructive evaluations to obtain more detailed information about failure modes and assess quality assurance procedures.

Ultimate Static-Strength Testing

Ultimate static-strength testing helps turbine designers predict a blade's ability to withstand extreme loads such as those caused by hurricane-force winds or unusual transient conditions. Designers use static-strength tests to compare a blade's actual strength with design specifications and determine whether their buckling analysis was correct.

Fatigue Testing

By simulating continuous operating loads, fatigue testing helps designers understand blade materials and the structural details of the design. Structural details such as joints, ply drops, and geometric transitions are more difficult to model during early design work and are often the weak link in a blade's structure.

Vibration Testing

Vibration testing identifies a structure's natural vibration frequencies. The information sheet entitled Vibration Testing describes the Center's vibration-testing capabilities.

Nondestructive Testing

Unlike the tests described above, acoustic emissions, ultrasonic, and photoelastic strain tests do not damage blades. Acoustics testing identifies possible failure locations during static-strength or fatigue testing. Researchers attach microphones to a turbine blade under test. As loading increases on the blade, glass fibers break in areas experiencing high strain, creating pinging sounds.

Researchers use ultrasonic testing to examine high-strain areas identified during acoustics testing or from previous static and fatigue tests. A signal sent into the blade goes through (undamaged) smooth laminate, but bounces off any air gaps, pinpointing flaws beneath the blade's surface.

During photoelastic strain testing, researchers identify strain patterns on turbine blades by coating them with a strain-sensitive material. When viewed under polarized light, colorful strain patterns are clearly visible. The strain patterns can be used to infer stress patterns and blade loads.

Nondestructive tests are conducted in collaboration with researchers from Sandia National Laboratories.

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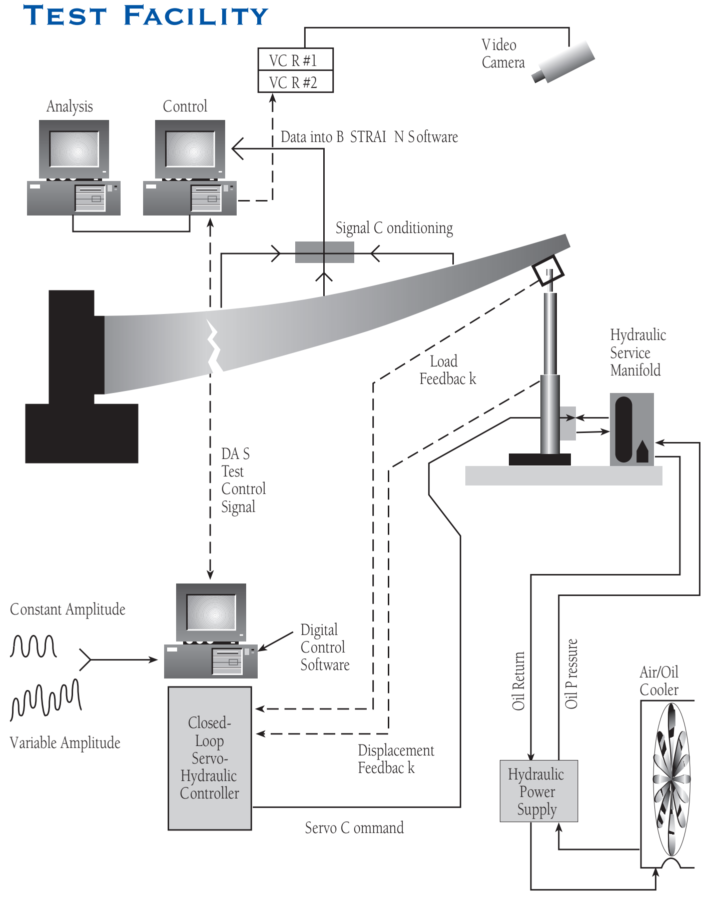
Structural Test Facility



Structural-Testing Equipment

Number of Test Bays	4
Maximum Blade Length	100 ft
Maximum Test Stand Capacity	one @ 4 million ft-lb two @ 1 million ft-lb
Fatigue Test System	Closed-loop servo-hydraulic
Maximum Oil Flow	75 gpm
Maximum Fatigue Load	28,000 lbs
Maximum Fatigue Stroke	50 in.
Maximum Static Test Load	70,000 lbs
Maximum Static Displacement	20 ft
Data Acquisition System	National Instruments
Software	LabView; BSTRAIN, NREL custom
Maximum Data Channels	48

NREL

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