Low-Cylce Test for Fatigue (LCF) and Thermo-Mechanical Fatigue (TMF) Testing

Low-Cycle Fatigue (LCF) Testing

Low Cycle Fatigue (LCF) testing provides important information for the design of industrial products in particular for the aerospace, automotive and power generation industries.
It is specific important for situations in which components or portions of components undergo either mechanically or thermally induced cyclic plastic strains that cause failure within relatively few (that is, approximately <105) cycles. Information obtained from strain-controlled fatigue testing may be an important element in the establishment of design criteria to protect against component failure by fatigue. Low Cycle Fatigue data are also useful in the areas of materials research and development, process and quality control, product performance, and failure analysis.

Low Cycle Fatigue Tests are normally run in strain control mode with the load as a dependent variable. ASTM E606 and ISO 12016 specify the standard practice for strain controlled LCF Testing simulating the mechanical loading into the plastic region. In many areas including engine components Low Cycle Fatigue tests are performed at high to ultra-high temperatures under air or in vacuum.

Results of a strain-controlled fatigue test program may be used in the formulation of empirical relationships between the cyclic variables of stress, total strain, plastic strain, and fatigue life. They are commonly used in data correlations such as curves of cyclic stress or strain versus life and cyclic stress versus cyclic plastic strain obtained from hysteresis loops at some fraction (often half) of material life. Examination of the cyclic stress–strain curve and its comparison with monotonic stress–strain curves gives useful information regarding the cyclic stability of a material, for example, whether the values of hardness, yield strength, ultimate strength, strain-hardening exponent, and strength coefficient will increase, decrease, or remain unchanged (that is, whether a material will harden, soften, or be stable) because of cyclic plastic straining.

As the cyclic frequency need not be high, even at 0.5 to 1 Hz, 10E5 cycles can be reached in just over one to two days. In fact, higher frequencies would not be desirable at lower life levels where cyclic plasticity could be significant. Energy dissipation due to rapid cyclic plasticity wold cause considerable and highly undesired, specimen heating, assuming the specimen is not already being heated to an elevated test temperature. Due to this fact LCF Tests can be performed either on electromechanical LFMZ Test Systems or on servohydraulic LFV series. Both solutions provide excellent sample alignment as either the electromechanical spindle drive of the LFMZ series as well as the servohydraulic actuator of the LFV series is in line with the sample, load cell and alignment fixture.

Thermomechanical Fatigue (TMF) Testing

Thermomechanical Fatigue is a major cause of component failure in industrial machinery and structures exposed to temperature conditions and mechanical loads that change of over time. TMF affects a range of components, including aircraft and ship engines, components used in gas turbines for power generation and compressors for gas and oil pipelines or train wheels and brakes.
Thermomechanical Fatigue Test Systems are able to replicate the real-world service conditions of these components and simulate the complex effects of simultaneous thermal and mechanical strain. The TMF Test are more sophisticated than the isothermal fatigue LCF Tests due to fluctuation temperatures, commonly higher heating rates and the extraction of the thermal and mechanical strain components from the total measured strain. Mostly TMF tests are conducted under high temperature or vacuum conditions using in-phase, out-of-phase, or a combined mechanical and thermal cycling.

ASTM E2368-04 and ISO 12111 standards as well as EUR22281 Code-of Practice specify the standard practice for strain controlled thermomechanical fatigue testing.

Typical System Configuration of a LCF and TMF Testing System

w+b offers suitable test systems for LCF & TMF testing under air, vacuum or any other environmental conditions with the possibility to realize additional customer-specific requirements as simulating of multiaxial states of stress through axial/torsional drive etc.
Depending on requirements and existing infrastructure we are able to offer servohydraulic or electromechanical Test Systems

walter+bai ag · Industriestrasse 4 · 8224 Löhningen · Switzerland
Tel. +41 (0)52 687 25 25 · Fax +41 (0)52 687 25 20 · info@walterbai.com · www.walterbai.com

Servohydraulic LFV Testing Systems

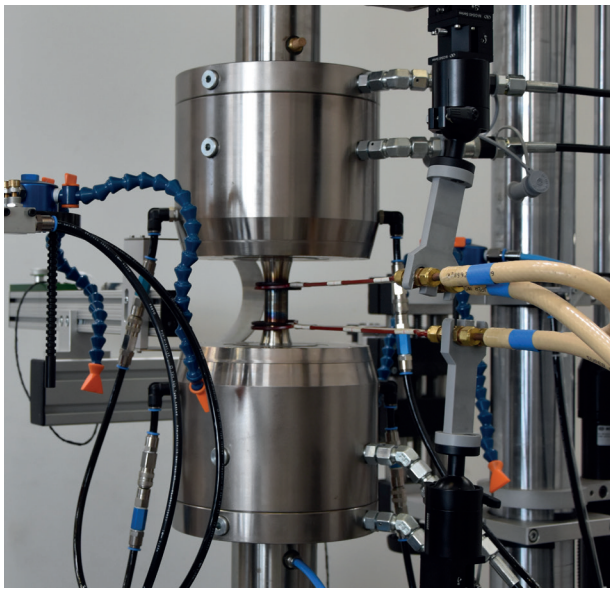
The LFV Series of Test Systems are well suited to perform LCF or TMF Test from ambient to high temperature. It comprises ultra-high-stiffness frame with the advantage of quick control reaction and universality of a servohydraulic test system and seamlessly integrated accessories including everything required to perform LCF or TMF tests in an easy-to-use and repeatable way.

System Highlights of the LFV Platform for LCF & TMF Testing:

- Flexible system for static to dynamic applications
- Rigid machine frame providing high axial and lateral stiffness, precision aligned for repeatable testing
- Increased stiffness means higher efficiency as the amount of energy needed to overcome the frame deformation in each loading cycle is less.
- Hydraulically movable upper crosshead with passive clamping system
- Actuator integrated in the machine's base to shorten the force train.
- Double ended, equal area linear actuator providing equal tension and compression force for the best control accuracy.
- Actuator with hydrostatic bearings for the best friction free static and dynamic performance, allows high side-loads and emergency running. The hydrostatic bearing actuators represent the high-end solution with virtually service-free operation.
- Hydrostatic bearings are supplied with system pressure independent of the relative movement between the piston rod and the bearing.
- Four (4) pockets are situated in the bearing bush. Each pocket is bordered by a bearing land. When under pressure, fluid is continuously fed to the pockets
- The actuator has integrated cushioning. Cushioning reduces the piston velocity as it approaches the end cap and lowers the stresses on cylinder components and reduces vibration transmitted to the machine structure.
- Latest ultra-high-speed and high resolution digital control system with 14.4 kHz closed loop control and data-acquisition rate and 24 Bit analogue-digital conversion
- With coaxial integrated digital piston stroke transducer
- Actuator anti-rotation device avoiding the natural tendency of the actuator to rotate
- Servo-valve with manifold mounted direct on the actuator for the highest possible response and most accurate test control
- Close coupled accumulators to minimize hydraulic pressure fluctuations and filter is mounted direct at the actuator
- High accurate fatigue rated load cell mounted between upper crosshead and alignment fixture or upper grip or fixture. Thus any mass acceleration introduced into the load cell is avoided.
- Installed alignment fixture between upper crosshead and grips for easy and accurate alignment verification and adjustment.
- Machine supplied with 4 anti-vibration feet for effectively reduce and isolate vibrations, to reduce noise as well as elastic storage decoupling.
- Durable structured coating (paint)
- Use of high quality components and assemblies of reputable companies
- Bolts for lifting the machine
- Adjustable machine feet to level the testing machine
- The machine is free-standing on shock absorbers, requiring no special foundations
- Ergonomically working height
- Compact and space saving design
- Optimized Heating Systems
- Suitable high resolution strain measurement and control units.
- Specialized application software for productive LCF and/or TMF testing according to international standards

Electromechanical LFMZ Testing Systems

This electromechanical test systems are optimized to perform LCF or TMF Test from ambient to high temperature. It comprises the specialized load frame design with seamlessly integrated accessories including everything required to perform LCF or TMF tests in an easy-to-use and repeatable way.



System Highlights of the LFMZ Platform for LCF & TMF Testing:

- Fluid-Free non-hydraulic Test System provides reduced installation and operating cost
- Clean and Quite Operation. As there is no hydraulic involved in the electromechanical drive the system operates clean and very quiet
- Low Maintenance costs as there is no hydraulic power pack or water-cooling system involved. It makes it easy to maintain and does not need the complex maintenance routines as servohydraulic systems
- Latest ultra-high-speed and high resolution digital control system with 14.4 kHz closed loop control and data-acquisition rate and 24 Bit analogue-digital conversion
- Rigid machine frame providing high axial and lateral stiffness for repeatable testing
- Central electromechanical drive provides in-line load train from the drive through grip system, the sample, the load cell and alignment fixture providing best possible sample alignment.
- System with high-resolution ball screw driven actuator with pre-stressed ball nut and backlash free torsion security device.
- Spindle system complete bedded in oil to reduce friction for the best control accuracy even at lowest stain levels and extend lifetime of the spindle.
- Pre-loaded and backlash-free cycloid gear-box for complete backlash-free drive LCF and other through-zero testing.
- Optimized gear-reduction provides best control accuracy and maximum mechanical resolution of the test system.
- Installed brushless AC Servomotor provides high responsive control.
- High responsive, maintenance-free AC servomotor to drive the central actuator providing faster starts and stops, best control, and highest accuracy at an extremely low noise level.
- AC servomotor provides continuous high test speed up to nominal force for continuously operation
- High accurate fatigue rated load cell mounted between upper crosshead and alignment fixture or upper grip or fixture. Thus any mass acceleration introduced into the load cell is avoided.
- Installed alignment fixture between upper crosshead and grips for easy and accurate alignment verification and adjustment.
- Ball Scree Protection over fully travel through oil- and moisture-resistant, sealed bellows made from polyester fabric, coated with polyurethane inside and outside.
- Adjustable maximum and minimum safety switches to protect operator, sample and machine.
- Machine supplied with 4 anti-vibration feet for effectively reduce and isolate vibrations, to reduce noise as well as elastic storage decoupling.
- Durable structured coating (paint)
- Use of high quality components and assemblies of reputable companies
- Bolts for lifting the machine
- Adjustable machine feet to level the testing machine
- The machine is free-standing on shock absorbers, requiring no special foundations
- Ergonomically working height
- Compact and space saving design
- Optimized heating systems attachable
- Suitable high resolution strain measurement and control units.

walter+bai ag · Industriestrasse 4 · 8224 Löhningen · Switzerland
Tel. +41 (0)52 687 25 25 · Fax +41 (0)52 687 25 20 · info@walterbai.com · www.walterbai.com