C220-E011

SHIMADZU
Excellence in Science

Contributing to the Development and Reliability of the Aerospace Industry

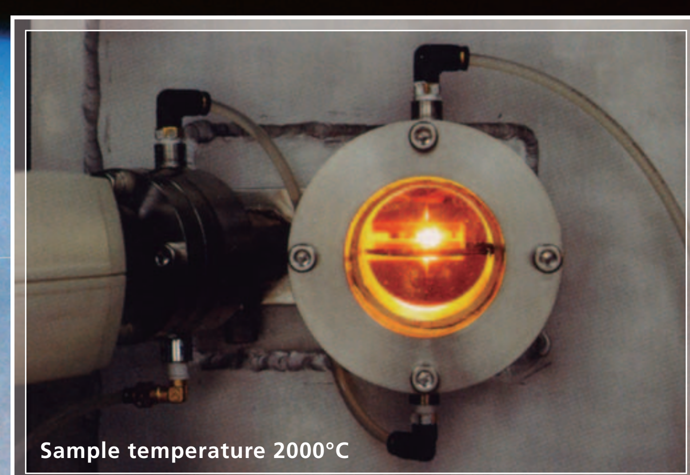
Testing and Evaluation Equipment for the Aerospace Industry

Shimadzu's Material Strength Testing and Evaluation Equipment Contributes to the Ongoing Development of Aerospace Materials

Diverse metal materials, organic materials, inorganic materials, and composite materials (FRP, MMC, CMC) are used in aircraft, satellites, spacecraft, rockets, and space robots. Such materials have been developed to provide the required properties of lightness, strength, durability, heat resistance, and machinability.

To ensure the safety of designed and manufactured aircraft, mechanical properties are measured and evaluated in terms of their structure, strength, and material performance. Evaluations are performed according to the various environments to which aircraft and space transfer vehicles are directly subjected. Examples of such evaluations include static testing to evaluate the strength and rigidity of aircraft materials and structures, dynamic testing to determine the strength with respect to fatigue and vibrations, and impact testing to evaluate the impact strength and fracture properties.

Shimadzu is applying it's technical expertise cultivated through both physical testing in materials development and full-scale testing in quality control in order to develop materials for aerospace applications. Utilize Shimadzu's extensive knowledge of materials testing and evaluation for your application.



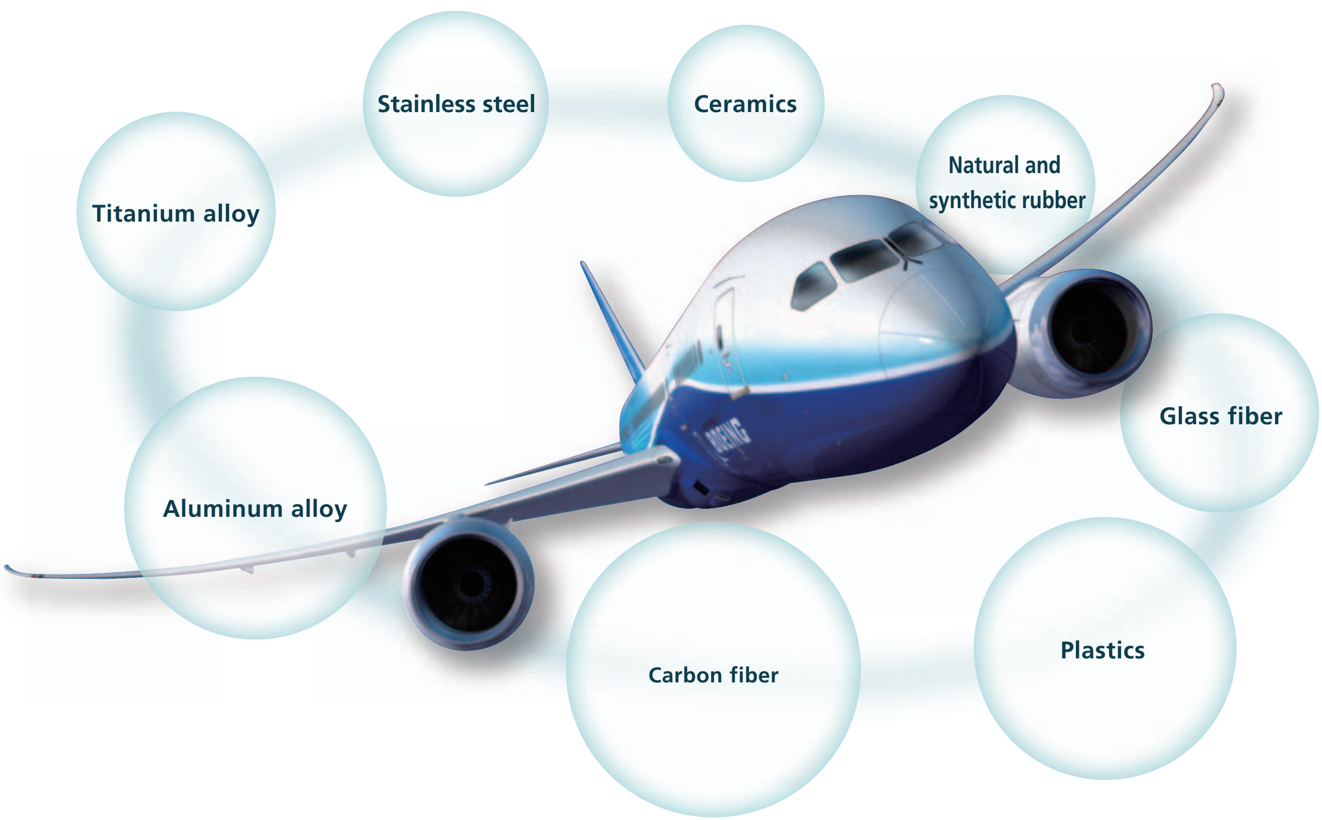
Sample temperature 2000°C

Ultra-High-Temperature Testing in an Oxidizing Atmosphere with a High-Frequency Induction Heating Furnace

When a space transfer vehicle re-enters the atmosphere, the temperature exceeds one thousand several handred degrees. The development of materials that can withstand higher temperatures would permit the design of more efficient space transfer vehicles.

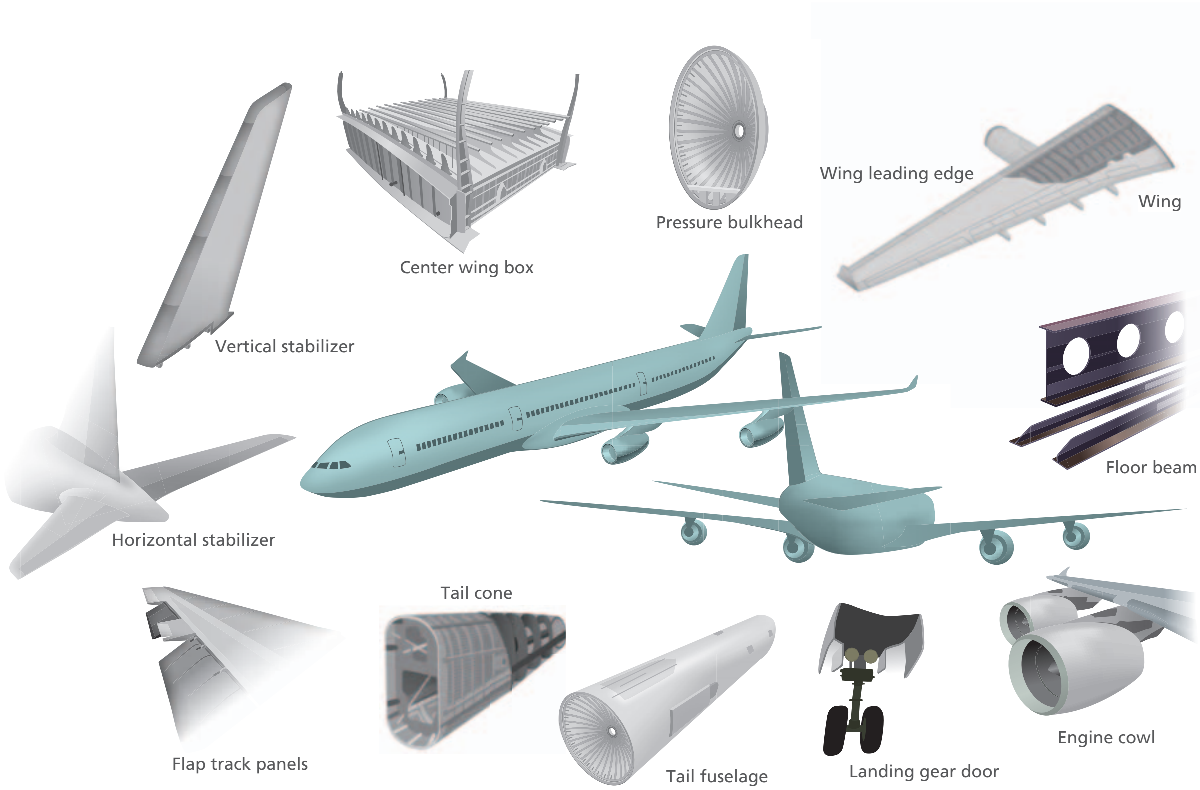
Even Lighter Innovative Materials

Materials used in aircraft can be broadly categorized into metal, non-metal, and composite materials. All of them are light but strong, and offer excellent machinability and heat resistance, and have been developed to provide the properties required for aircraft.
Metals are the major materials used in aircraft structures, of which the majority are aluminum alloys. Titanium alloys and stainless steel are also used for parts around the afterburner and for parts of the aircraft structure subjected to the jet exhaust.
Since plastics are light, easy to color-mold, and transparent to electromagnetic waves, and also good electrical and thermal insulators, they are widely used in modern aircraft for the window glass, interior material, and radome.
Apart from applications as reinforcement in glass-fiber-reinforced resins, glass materials are inserted between the aircraft outer surface and interior lining as sound and thermal insulators.
As synthetic rubber materials offer better weather resistance, heat resistance, oil resistance, and chemical resistance than natural rubber, they are widely used in gaskets, packing, hoses, duct couplings, and waterproof sheets. Natural rubber is commonly used in aircraft tires due to superior rubber elasticity, tear strength, and abrasion resistance mechanical properties.



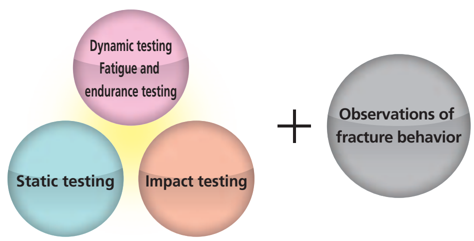
Growing Use of Composite Materials

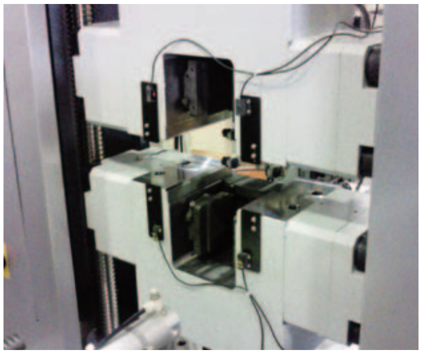
Composite materials combine different materials to achieve greater specific strength than is available from a single material. Fiber-reinforced plastics (FRP) are typical composite materials. Among these are glass-fiber-reinforced plastics (GFRP), which are widely used for aircraft wing fillets, fairings, control surfaces, radomes, wing tips, and cabin floors. Widely used in important components such as aircraft wings, center wing boxes, and horizontal and vertical stabilizers, carbon-fiber-reinforced plastics (CFRP) combine plastics with carbon fibers having high specific modulus of elasticity and specific strength.
The evaluation of fundamental mechanical properties is essential for new materials, such as composites. Ongoing standardization of sample shapes and test methods is intended to improve the stability of material quality and enhance reliability.



Some Parts in Which CFRP Is Used

Aircraft are designed to meet the requirements indicated in the design standards. Inspection and testing of the aircraft structure and strength are performed at the manufacturing stage and flight testing is conducted to confirm the performance and flying quality of the completed aircraft. Testing includes static and fatigue testing at the materials development stage, endurance testing of all parts and components, and impact testing to evaluate the fast fracture characteristics of the materials. In recent years, it has become more important to observe fracture behavior. High-speed video cameras are now commonly used to perform more sophisticated evaluations through synchronized observations of the tested material behavior and the S-S curve.





For the tensile testing of composite materials such as CFRP, it is important to firmly grasp the sample, without twisting it. Hydraulic parallel tightening grips are ideal for tensile testing, as they firmly grasp the samples completely straight and without slippage.

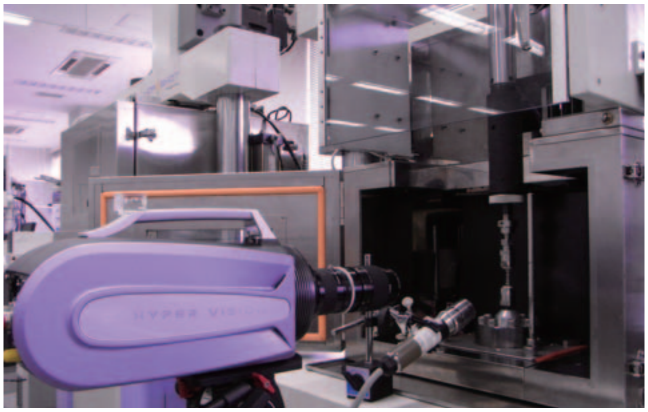
Strength Testing and Fracture Observations for CFRP

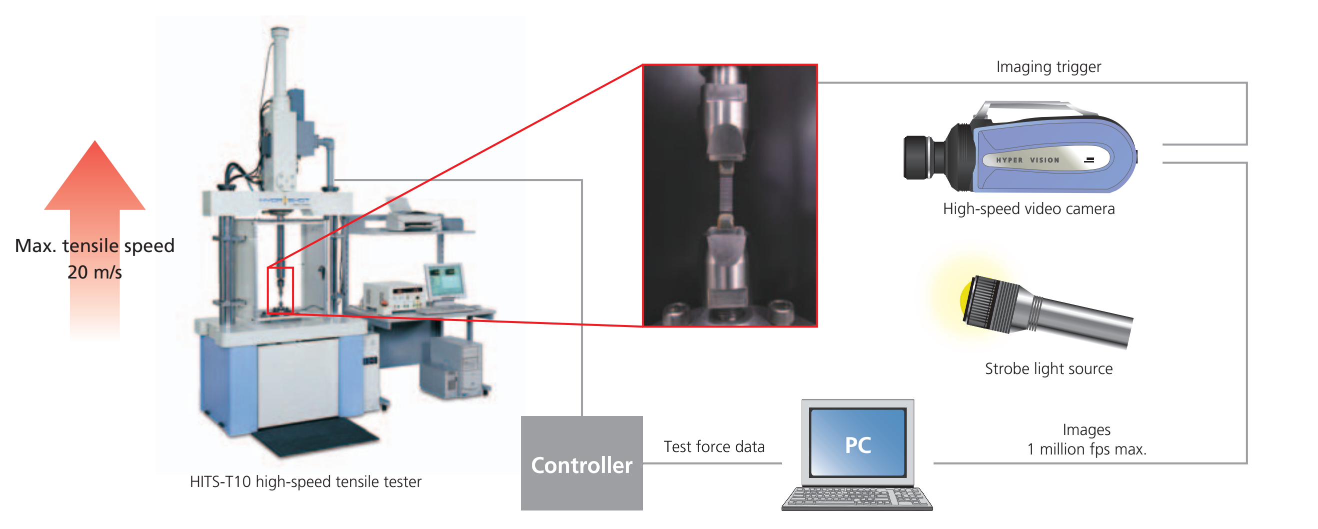
— Imaging at Up to One Million Frames Per Second —

Tensile-Impact Strength Testing and Fracture Observations for CFRP

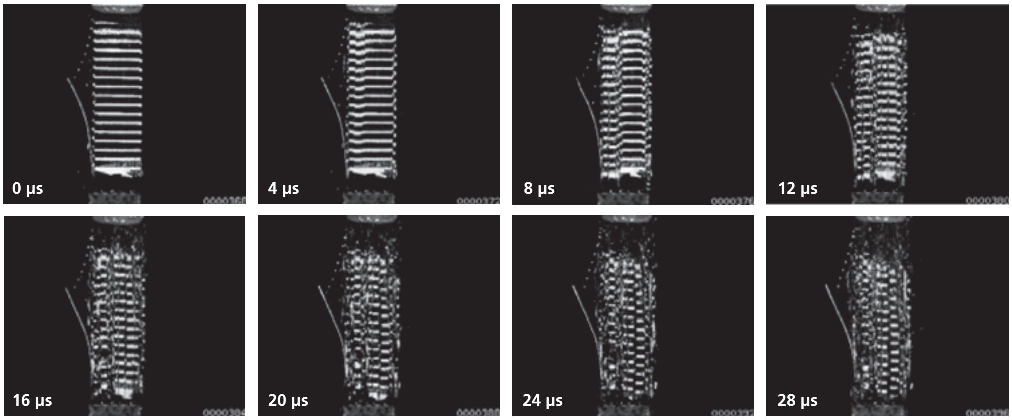
The development of composite materials requires not only static testing to verify functionality but also testing to determine impact strength and crack propagation.
As an example, we used a high-speed tensile impact tester together with a high-speed video camera to observe the tensile impact fracture of CFRP samples. Images were acquired by using the tester to output an imaging start signal synchronized with the tensile load to externally trigger the camera. We also used strobe lighting equipment to synchronize the illumination to the imaging timing.

The combination of an impact tester and high-speed video camera permits the evaluation of material impact properties and the observation of fracture properties simultaneously. This supports the development of a wide range of materials from individual functional resins to composite materials.





System Configuration



CFRP unidirectional (UD) material
High-speed observations of fracture behavior
250,000 fps

Sample: L20 × W6.25 × T0.3 mm
Loading rate: 6 m/s (22 km/h)

JAXA (Japan Aerospace Exploration Agency)
Products were developed based on joint research with the Advanced Composites Group, Aerospace Research and Development Directorate at JAXA, according to Promotion Program for Output Utilization

— 300 kHz Data Acquisition —

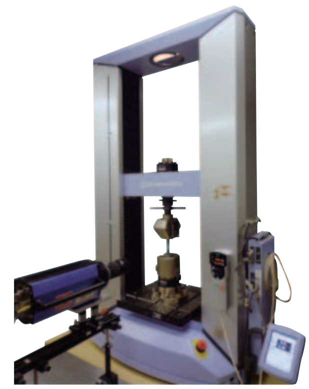
Static Tensile Strength Testing and Fracture Behavior Observations for CFRP

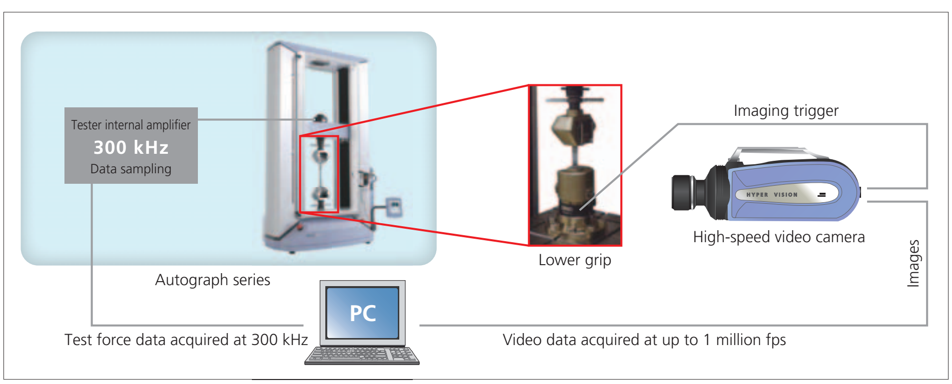
Tensile testing and evaluation of CFRP demands not only the acquisition of conventional S-S curves but also observations of fracture behavior in order to achieve more detailed analysis of strength properties.
Shimadzu achieves observations of the CFRP fracture process at high temporal resolution through 300 kHz test-force data storage, fracture detection by a load amplifier, and trigger signal output to a high-speed video camera (100 continuous frames at one million fps). A rigid and specially-shaped lower grip was developed to accurately transmit sudden reductions in test force to the load cell, so that reliable observations of fracture behavior are ensured.

Special Autograph AG-Xplus with the latest measurement control functions + HyperVision high-speed video camera with the highest specs in its class

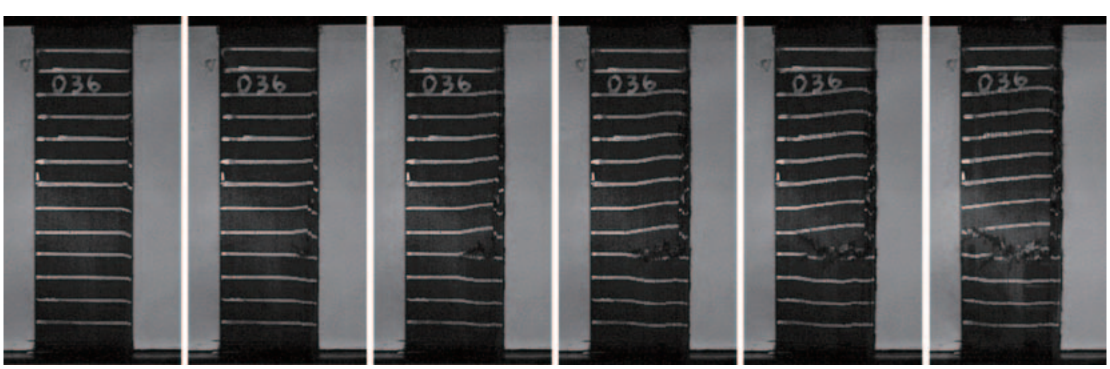

HPV-2A high-speed video camera


Lower grip


AG-X + HyperVision + novel lower grip



System Configuration


0 µs 4 µs 8 µs 16 µs 20 µs 24 µs

CFRP 0° unidirectional (UD) material
High-speed observations of fracture behavior
250,000 fps

Sample: L160 × W20 × T0.57 mm
Loading rate: 2 mm/min

Designing for Safety

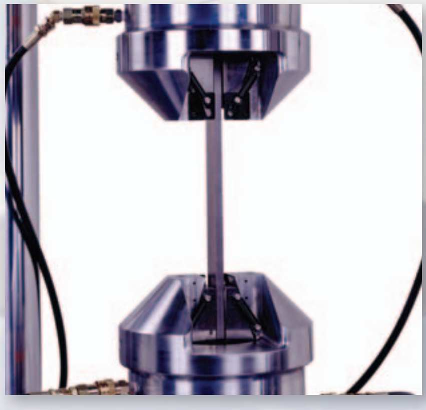
An understanding of the material fatigue properties under a variety of environments and situations provides important indicators at the design stage. Predicting the fatigue life of materials allows the establishment of maintenance plans for periodic replacement of parts subjected to stress and for regular inspections to detect fine cracks in materials in order to replace them before fracture occurs. Therefore, understanding the fatigue properties of materials is important to ensure a long aircraft life, maintain passenger safety, and guarantee reliable flying.

Fatigue Strength Testing of Composite Materials

ASTM D 3479/D 3479M-96

Constant-Load Amplitude Tension-Tension Fatigue Testing of CFRP

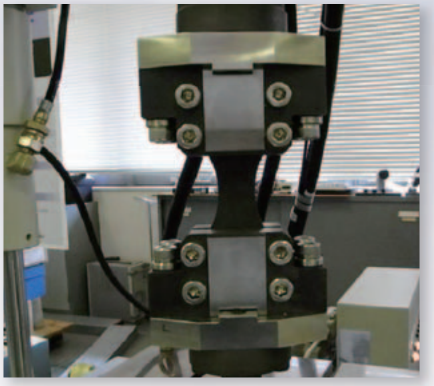
This jig can be used for the constant-load amplitude tension-tension fatigue testing in the direction of the fibers in CFRP unidirectional reinforced materials or textile-reinforced materials stacked in layers. Front-opening hydraulic grips offer superior ease-of-operation and high accuracy for tensile and compression testing across a wide test-force range.



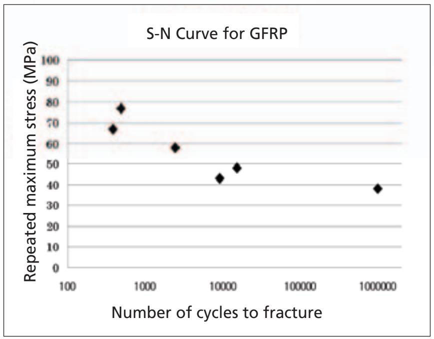
Front-opening hydraulic grips

Fatigue Strength Evaluation of GFRP

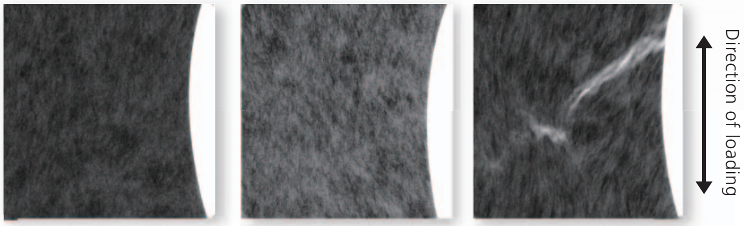
For aircraft materials such as composites that have been in use for many years, great weight is placed on impact resistance and fatigue strength according to the environment in which they were used.
As an example, we performed fatigue testing on GFRP and then plotted the resulting S-N curve to show the relationship between the maximum load stress among the six stress standards (one sample per standard) and the number of cycles to sample fracture. Internal observations reveal that glass fibers inside the sample that had no particular orientation before fatigue testing began to align somewhat in the direction of loading after one million load cycles, and were uniformly aligned vertically just before fracture.



Sample Held in Manual Grips for Flat Samples



Fatigue Test Results



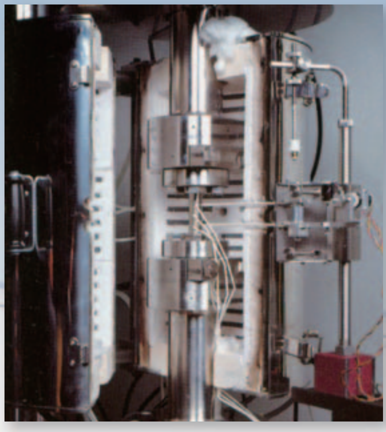
Start of fatigue testing After one million load cycles Before fracture

Internal X-Ray Images of GFRP

Axial Force and Torsion Testing and Evaluation

A multiaxial stress situation is created by applying compound axial forces (tensile or compression) and torsion to allow fatigue testing of structural materials under conditions close to actual-use conditions.

Axial-force/torsion compound detector
Detector for torsional displacement angle between gauge marks



Axial-force/torsion compound testing in resistance heating furnace

Testing and Evaluation in Controlled-Temperature Environments

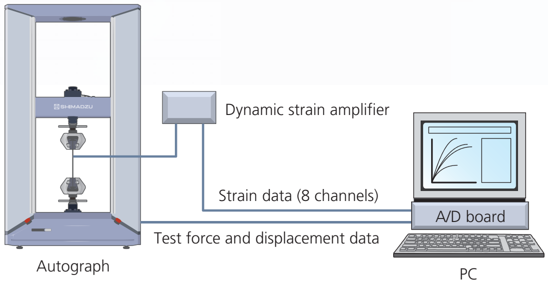
The ambient temperature for materials used in aircraft and space transfer vehicles can extend across an extremely broad range from several tens to several hundreds of degrees below zero at the low-temperature end to plus several hundred to a thousand degrees at the high-temperature end. Strength testing under the same conditions as actual operation is required to evaluate the appropriate operational temperature range for each material.

Testing and evaluation in thermostatic chamber

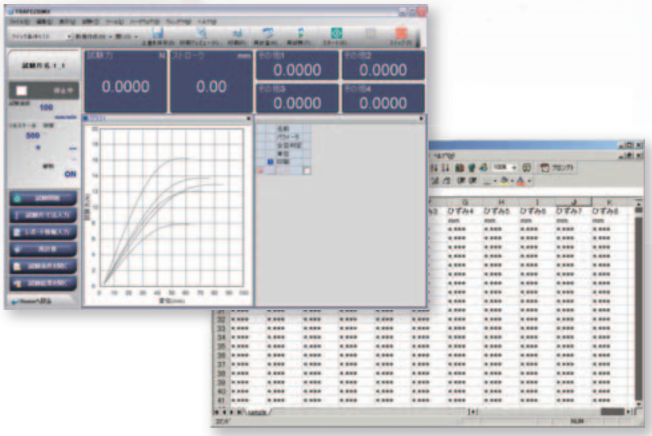
Ultra-low-temperature tester

Full-Scale Testing (Multi-Point Strain Measurements)

The computer can read up to eight channels of strain gauge data synchronized with data from the tester, such as test force, stroke, and extensometer data. Multi-channel software permits data sampling synchronized with the load forces by using multiple strain gauges affixed to the sample.



Multi-Channel Strain Measurement and Evaluation System



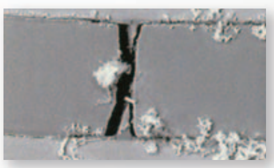
Multi-Channel Software

Clarifying the Fatigue Fracture Mechanism

The aging of today's commercial transport aircraft has caused the relationship between design life and safety to be reviewed, resulting in the introduction of the concept of damage-tolerant design. Damage-tolerant design involves the investigation of fatigue crack propagation speed, initiation sites, and method of inspection. In practice, it is a method to design adequate residual strength, with respect to both single load transmission and multiple load transmission, to stop crack propagation or reduce propagation speed until the crack is discovered during maintenance.
Fatigue, endurance, and reliability testing must be performed on materials subjected to pressure fluctuations due to repeated take-offs and landings and high-altitude flight.

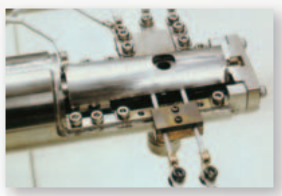
Observations of Fatigue Fracture Behavior Using an SEM Servo

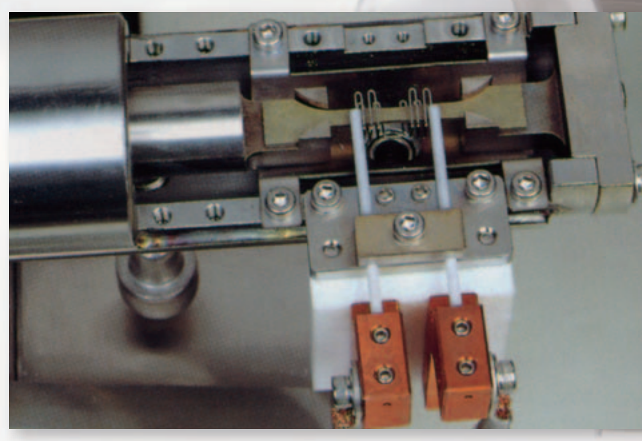
Repeated loads applied during fatigue testing result in deformation of the test sample. Even small movements that can be ignored on a macro scale appear extremely large when magnified by a scanning electron microscope (SEM). SEM images synchronized with the sample deformation can be obtained by electrically moving the SEM field-of-view in synchronization with these movements. The jigs holding the sample are compact enough to be installed inside the SEM sample chamber. The compact heating unit permits programmed heating of samples up to 800°C to support a variety of tests.



N=4.5 × 10^5 Cycles 20 μm

Fatigue Testing of SiC-Fiber-Ti-15-3 Composite Material at 823 K (550°C)



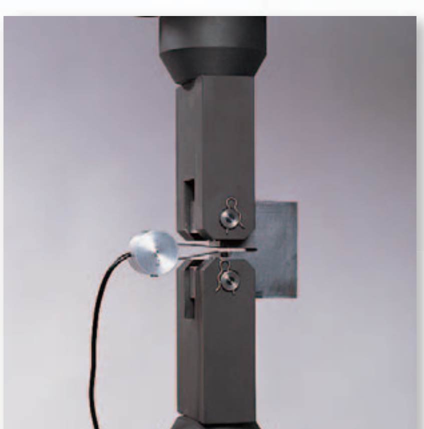


Compact Test Jigs are Easily Installed in the SEM Sample Chamber

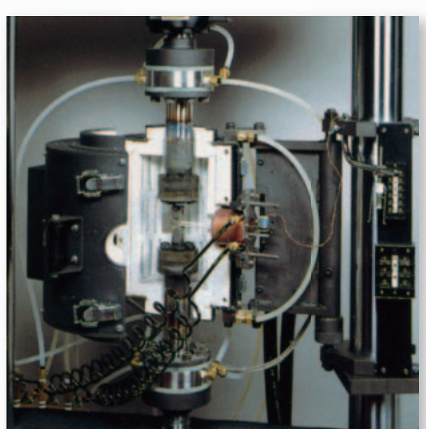
ASTM E339 / E1820

Fracture Toughness Testing

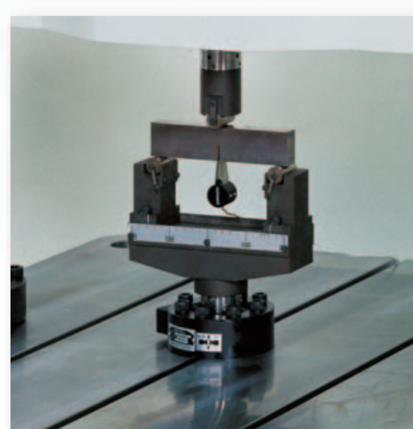
It is extremely important to design aircraft against fatigue. The pressure in the passenger cabin applies loads to the airframe during high-altitude flight. These become fatigue loads that are applied cyclically during each take-off and landing cycle.
Fracture toughness testing involves applying static or dynamic loads to a notched sample to investigate the brittle crack initiation and propagation and the fracture conditions and status.
Special grips for compact test samples complying with ASTM standards, a COD bending test jig, and a crack opening displacement gauge support the evaluation of a material's fracture toughness and crack propagation.



CT Sample Grips and Clip Gauge



Fatigue Toughness Testing with a Resistance Heating Tester

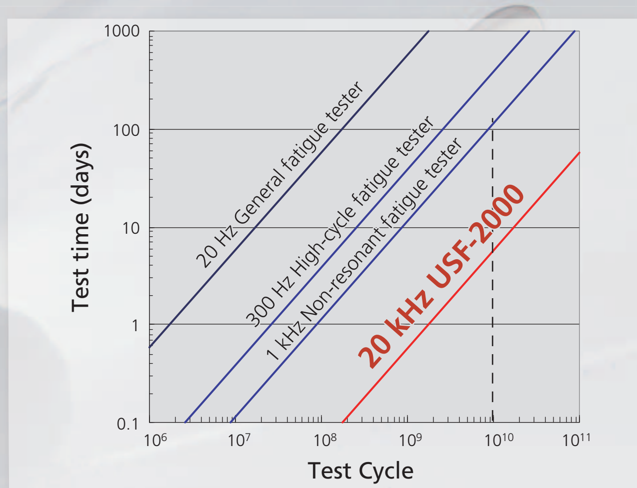


COD Test Jig

Gigacycle Fatigue Testing

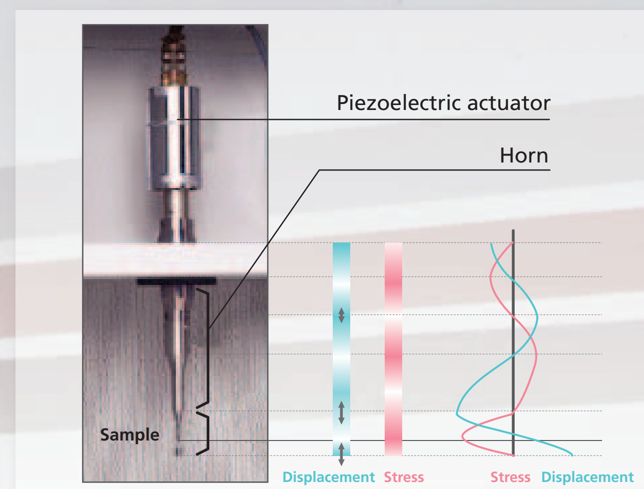
It is necessary to guarantee the long-term effective, reliable use of many products and equipment, including aircraft, automobiles, railways, marine structures, and electrical plants.
To ensure the safety of engine turbine blades and wheel axles, the conventional 10^7 cycle fatigue limit is no longer adequate; clarification of fatigue in the ultra-long-life range from 10^8 to 10^{10} cycles is now needed for all materials.

The piezo-electric element in the ultrasonic fatigue tester generates a vibration of 20 kHZ, which is amplified by the horn and transmitted to the sample, to achieve oscillation rates of 20 kHz. This permits significantly shorter test cycle times.

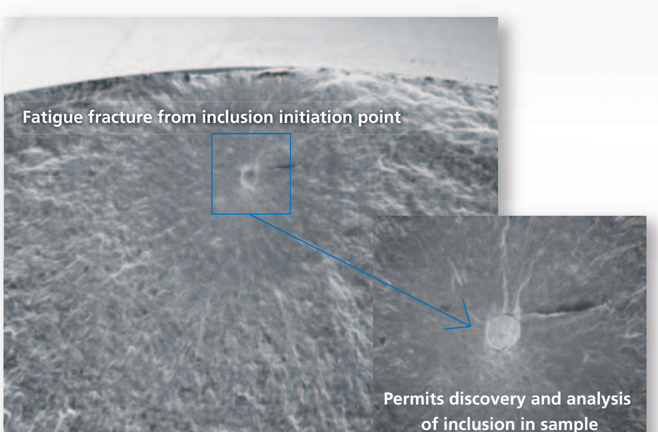


Cycle Time Comparison Between Ultrasonic and Conventional Fatigue Testers

USF Series Ultrasonic Fatigue Tester



Schematic Representation of Test Force Loads on a Sample



Images of Inclusion

More Efficient Discovery of Inclusions

Confirming whether samples contain inclusions and the subsequent analysis of any inclusion found is an effective way to ensure the supply of materials with high fatigue strength. When an ultrasonic fatigue tester is used to cause an internal fracture in the sample, the largest inclusion in the volume of the portion that has a potential risk to fracture becomes the initiation point of the fracture. Inclusions can be easily detected by observing the fracture surfaces. This is a much more efficient method of inclusion detection than conventional methods.

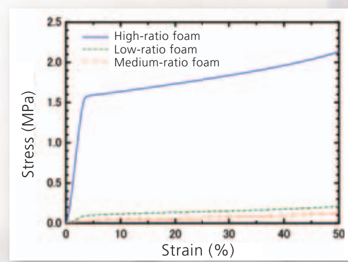
Both Safety and Comfort

Some flights last many hours. Good aircraft design is essential to provide a safe environment for both passengers and crew.
Thermal insulation material such as glass wool is used in the so-called insulation blanket between the outer surface and interior lining of the aircraft fuselage. It insulates the interior against the outer temperature and absorbs noise. It can protect the occupants from temperatures of several tens of degrees below zero at an altitude of 10,000 meters.

Since openings such as doors and windows in the outer cladding reduce the structural strength of the aircraft, they should be kept to a minimum and made as small as possible. However, they are indispensable to prevent passengers from feeling claustrophobic or oppressed. Thorough strength testing and fatigue and endurance testing of materials are performed to maintain passenger comfort in the aircraft and ensure safety.

Compression Testing of Foam Plastics

Due to their lightness, foam plastics are used in a variety of applications, including as thermal insulation, sound insulation, and cushioning material. The graph on the right shows the results of compression testing on three types of foam plastic, each with a different foaming agent content. The low-foam plastic exhibits significantly higher compressive stress than the other two types. It is apparent that the stress did not increase significantly above about 3 % strain for any of the samples.



Stress – Strain Graph from Compression Testing

— TRViewX Video Type Non-Contact Extensometer —

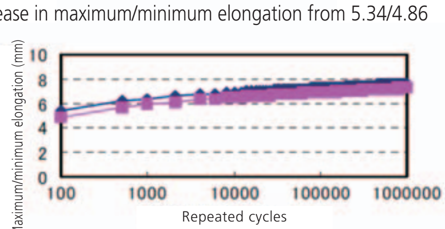
Applications of Measured Values for Actual Samples to CAE Analysis

The Shimadzu TRViewX Video Type Non-Contact Extensometer offers world-leading performance. It offers ASTM E83 Class B2 (Class C in thermostatic bath) elongation measurement accuracy and ASTM E83 Class C amplitude measurement accuracy performance. It supports measurement of composite materials, resin films, metal foils, and other materials which are difficult to measure with a conventional contact displacement gauge. In addition, it can record the sample status during testing or play back the video in synchronization with the S-S curve.

TRViewX Video Type Non-Contact Extensometer

Endurance Testing of Synthetic Yarn

The performance of synthetic fibers has improved dramatically. Lighter, tougher, and stronger, they have a significant effect on the development of new materials in the aerospace field. The tensile testing and repeated load testing of synthetic yarns are indispensable for the development of synthetic fibers.
Polyester yarn was subjected to one million load cycles of a 2.14 N ±0.54 N, 10 Hz sinusoidal load. The results indicate a progressive degradation with a gradual increase in maximum/minimum elongation from 5.34/4.86 mm at the start to 7.58/7.26 mm at the end.



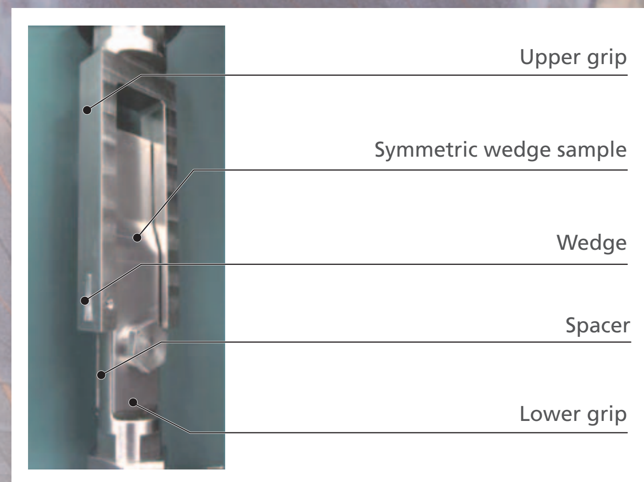
Repeated Cycles – Elongation Curve

Polyethylene Yarn Held in Grips for Yarn

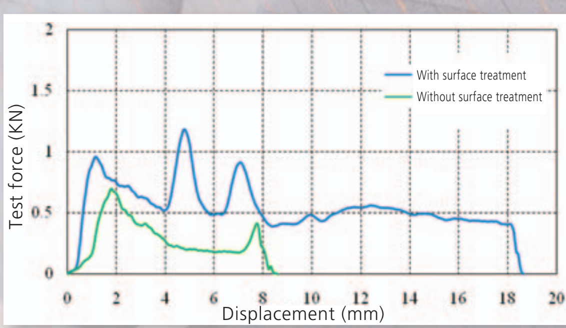
Dynamic (Impact) Cleavage Resistance Test of High-Strength Adhesive Bonds

Joining parts together with adhesives offers advantages, including improved fatigue resistance and stress distribution in the joint due to the surface contact, over conventional bolted or welded joints. Research is still being conducted into adhesives and adhesion methods.

Two materials with different surface-treatment conditions (SS400 stainless steel, with and without surface treatment) were stuck together with a thermosetting-resin adhesive to form a symmetric wedge sample. Loads were applied to cleave the adhesive joint with a hardened steel wedge. The maximum test force and deformation up to fracture differed according to whether or not surface treatment had been performed. The adhesion surfaces also appeared different after debonding.



Sample Mounted in Tester



Test Force – Displacement Curve from Impact Cleavage Testing

Observations of Sample Surfaces after Debonding

Testing of Aircraft Window Materials

Windows in the aircraft passenger cabin comprise a total of three layers of stretched or non-stretched acrylic sheet and polycarbonate sheet. These are fastened with a sealant into the window openings in the external skin. Even if one of the two outer sheets is lost, the remaining sheet must be able to withstand the maximum pressure loads from the passenger cabin, air forces, and external temperature.
Three- and four-point bending testing, ring bending testing, and compression testing are generally used to evaluate the strength of window materials. Surface coatings are evaluated using hardness testing and friction and wear testing.

Strength and Endurance Testing of Electronic Components

An aircraft is packed with various kinds of sensors and electronic equipment, including weather radar and wireless communication devices. As such important equipment is directly related to the flight of the aircraft, it must be durable enough to prevent defects over a long period of use. Surface-mounted electronic components on circuit boards must be subjected to stringent testing under many hypothetical situations of bonding forces, shear peeling forces, and stresses due to repeated thermal expansion and contraction cycles.

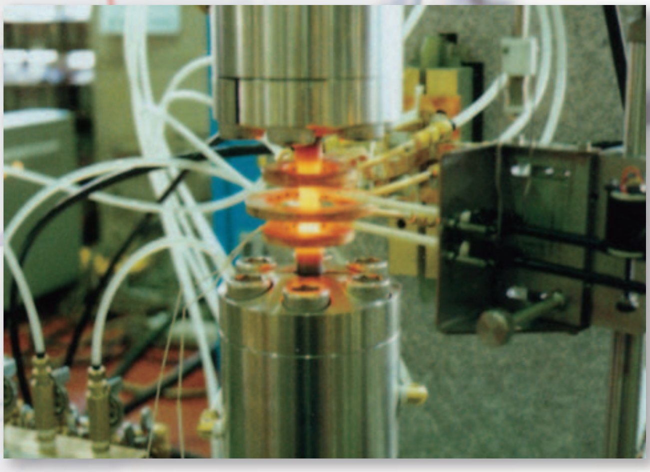
Endurance Testing of a Printed Circuit Board

Faster, Further, and More Efficient

The combustion chambers and the turbine rotor blades and stator vanes in the aircraft turbofan and other jet engines operate in the severest of environments. Maximum temperatures significantly exceed 1000°C. The turbine inlet temperature may be higher than 1500°C in modern, large, high-performance jet engines.
Therefore, super-heat-resisting alloys are the major materials used for such core components of jet engines. It is no exaggeration to say that dramatic advances in these super alloys and in the manufacturing processes for high-temperature parts have directly led to larger and faster aircraft with higher output and better fuel efficiency.
The development of such materials demands the evaluation of their mechanical properties in the actual operating environment. Shimadzu supports such testing by combining a materials tester with environment control equipment.

High-Temperature Testing System Using High-Frequency Induction Heating

The high-temperature testing system exploits the characteristics of high-frequency induction heating for a range of high-temperature tests. The types of testing performed include general high-temperature/low-cycle fatigue testing; thermal fatigue testing with a chiller; high-temperature/low-cycle testing, thermal fatigue testing, or simulated thermal cycle testing in a vacuum or inert-gas atmosphere within an atmosphere conditioning chamber; crack propagation testing or fracture toughness testing on CT or CCT samples; superplastic deformation testing; and creep testing.



High-Temperature Testing System Using High-Frequency Induction Heating

Evaluating Creep Properties at 1600°C

Creep testing and stress rupture testing of materials at high temperatures are extremely important methods for acquiring detailed data for component design in the aerospace industry. Creep testing involves applying a constant load to a material maintained at constant temperature to deform the sample. The relationship between the deformation and time is measured. Stress rupture testing measures the time to fracture of a sample under constant load and temperature.

Data for measurement of the turbine blade service life can be acquired from the creep and stress rupture data for the high-performance materials. As a result, the turbine blade deformation rate can be predicted, allowing the blades to be replaced before they contact the engine casing. This data can be used to create a maintenance plan that requires turbine blade replacement after a certain period of operation.

Creep Characteristics Evaluation Tester

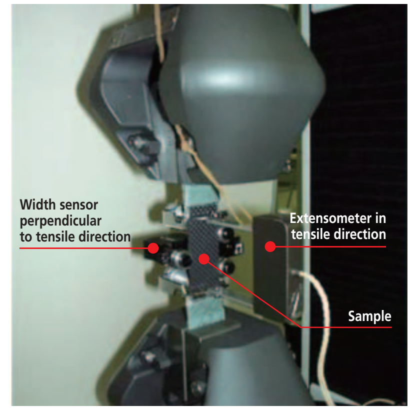
Examples of Applicable Standards

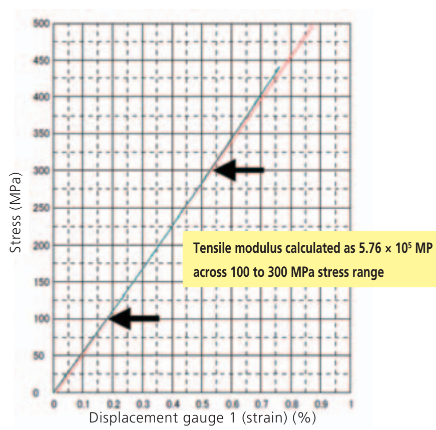
ASTM D 3039 /D 3039M-07
ASTM D 3518 /D 3518M-94
ASTM D 5766 /D 5766M-11

Static Tensile Testing of CFRP

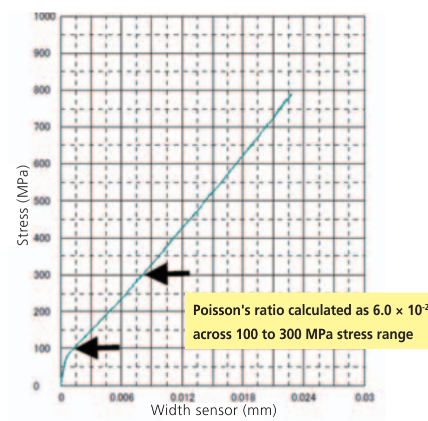
Tensile testing was performed on JIS K7073-1988 Type IV samples (strip sample with no tabs, fiber direction perpendicular to direction of tensile load), with an extensometer attached for strain measurement in tensile direction and a width sensor to measure strain perpendicular to the tensile direction.

Poisson's ratio is approximately 0.3 for mild steel and 0.46 to 0.49 for elastic rubber. However, the value of 0.06 is an order of magnitude smaller for CFRP, showing that its deformations are extremely low.





Stress – Strain Diagram



Stress – Width-Direction Displacement Diagram

ASTM E1012

Axial Adjustment for Testing

Axial adjustment of the tester is extremely important to reduce the risk of breaking samples at the chuck during tensile testing of CFRP or GFRP. Axial adjustment is often a prerequisite for the stable acquisition of data for aircraft-grade CFRP.

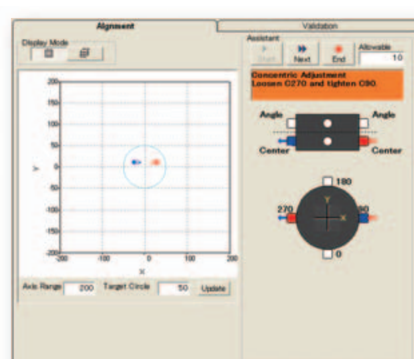
This axial adjustment system provides a test environment conforming to ASTM E1012, enhancing the reliability of the data.

Axial Adjustment System

The axial adjustment system uses an axial-center sensor, strain amplifier unit, and special axial adjustment software to adjust the inclination between grip centers and to adjust the axis in the horizontal direction. Eliminating bending stresses and lateral shear stresses on the sample ensures highly reliable data.

Axial Adjustment Software

When loads are applied to the special sample, this dedicated software reads the signals from the strain gauge attached to the sample. The axis can be adjusted by manual movements of the adjustment jig based on this information.

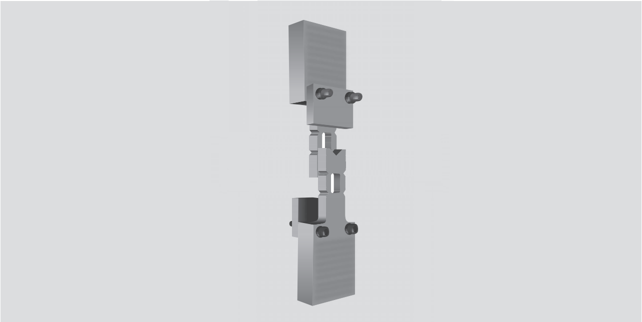


Testing Compliant with Various CFRP Testing Standards

ASTM D6484 / D6484M

Open-Hole Compression Strength Testing on Polymer Matrix Composite Laminate

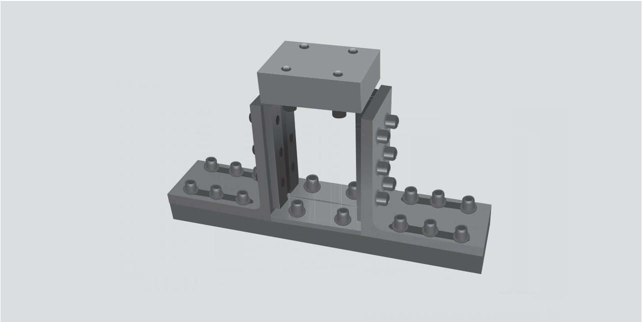
ASTM D6484 is a typical method used to determine the compressive strength of CFRP open-hole samples. This is a shear-force method that applies a force in the longitudinal direction to both sides of the sample to determine the compressive strength of the holes.
On the other hand, the method prescribed in JIS K7093 is an end-load method that directly applies compression forces to the ends of the sample to determine its compressive strength. It is known to provide results equivalent to those obtained by the ASTM D6484 method, while using smaller samples and jigs.



ASTM D7137 / D7137M

Testing the Compressive Residual Strength Characteristics of a Damaged Polymer Matrix Composite Plate

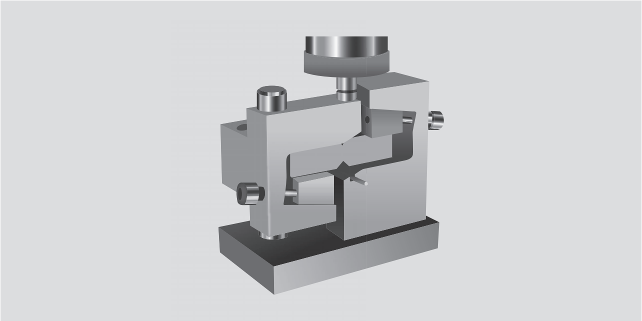
Compression testing according to ASTM D7137 / D7137M is intended for samples damaged by impact testing. The impact testing is prescribed in ASTM D7136. This jig was developed by the Boeing Company. The testing is performed on rectangular samples made of composite material that have already been subjected to impact testing. The sample is mounted on the jig and subjected to compression loads. The load at fracture is then compared to the compression strength it exhibits when no impact force has been applied, so that the residual strength of the sample can be determined. Determining the damage resistance of layered composite plates is useful for product development and material selection.



ASTM D5379 / D5379M
JIS K7079-2

In-Plane Shear Testing—Double-V-Notched Sample Shearing

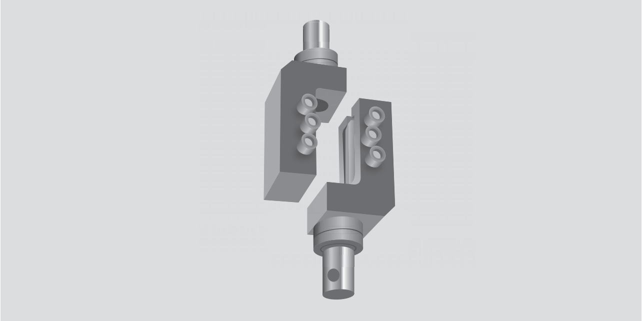
The in-plane shear strength, in-plane shear fracture strain, and in-plane shear elastic modulus of carbon-fiber-reinforced plastics can be determined by the Iosipescu test, which is an in-plane shear test on double-V-notched samples. This testing method is applicable to unidirectional (UD) materials and laminates comprising unidirectional reinforcing layers or textile reinforcing layers (cross laminates, quasi-isotropic laminates, etc.).



ASTM D7078 / D7078M

V-Notched Rail Shear Testing and Evaluation of Composites

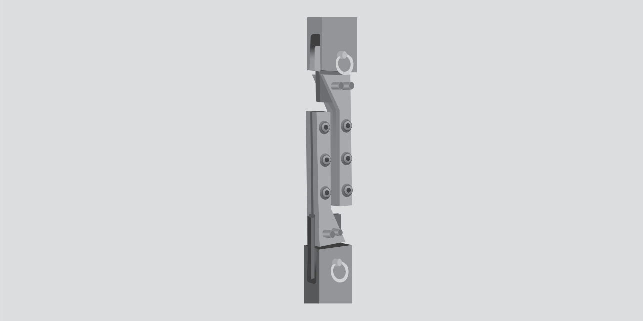
This testing applies shear forces to mounted samples with 90-degree V-notches at the top and bottom. In ASTM D5379, loads are applied to the top and bottom ends of the sample, while in ASTM D7078, the surfaces are grasped to apply higher shear loads. It permits testing of larger samples than those specified by ASTM D5379.



ASTM D4255 / D4255
JIS K7079

In-Plane Shear Testing

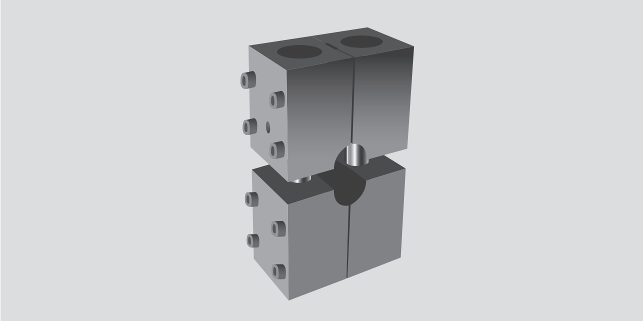
The in-plane shear test jig is designed to test fiber-reinforced plastics. This test method is generally called the two-rail method. The jig mechanism easily generates in-plane shear on the sample to achieve stable test results.



ASTM D6641 / D6641M

Compression Testing and Evaluation of Polymer Matrix Composite Laminate Using a Combined Loading Compression (CLC) Test Jig

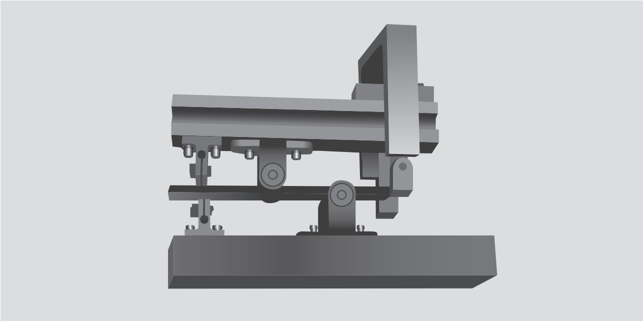
Combined loading compression (CLC) testing uses a combination of shear loads and end face loads. This method uses strip test samples with no tabs. It offers the advantage of simultaneous strength and elastic-modulus measurements.
In this method, a strip sample is held vertically by pairs of upper and lower blocks with their top and bottom faces aligned with the top and bottom ends of the sample in order to directly compress the sample from its top end.



ASTM D6671/ D6671M

Evaluation of Interlaminar Fracture Toughness of CFRP Cross Laminate by MMB Testing

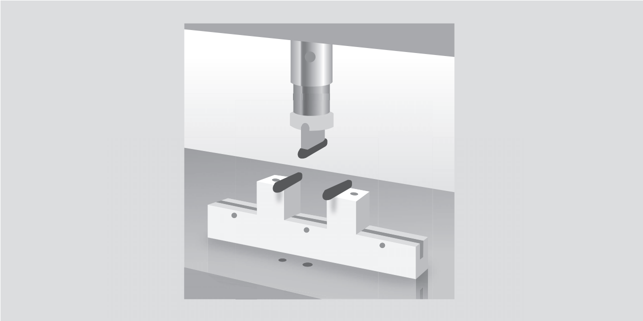
As CFRP composites are laminated for practical use, they have low interlaminar fracture strength and interlaminar fracture toughness. Therefore, when the materials are subjected to shock loads, delamination cracks readily form between the layers, which can become initiation points for fracture. Generally, the crack-tip deformation modes are Mode I (open type), Mode II (in-plane shear type), Mode III (out-of-plane shear type), or a combination of the three. As delamination occurs due to a mixed deformation mode where Mode I and Mode II occur simultaneously, it is important to evaluate the mixed-mode fracture toughness.
This jig is used for mixed-mode bending (MMB) testing by applying a combination of Mode I and Mode II deformations to flat fiber-reinforced plastic materials to measure the fracture toughness values.



ASTM D2344 / D2344M
ASTM D790
ASTM D6272
ASTM D7264 / D7264M
ISO178 JIS K7171

Three- and Four-Point Bending Testing

The bending properties of plastics are important for numerous applications. Various standards describe appropriate testing procedures. Three- or four-point bending testing is used to measure the strength properties of comparatively rigid materials. For this type of testing, it is recommended to directly measure the sample strain using deflection gauges or other strain gauges. As the fulcrum span is determined according to the sample thickness, it is important to know the range of sample dimensions before selecting the jig.

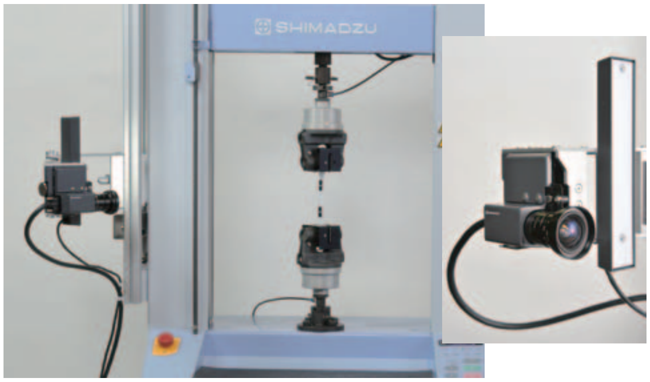


Shimadzu Materials Testers

Precision Universal Testers

Autograph AG-Xplus Series

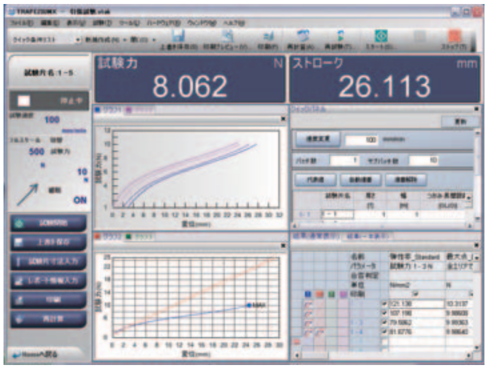
To alleviate the burden on the environment, this series features a power-saving function as standard to reduce the power consumption in a standby state by 10% to 25% in comparison to previous models. The short-column model (SC model) and high-speed model (HS model) have been newly added to the product range. The control resolution has been increased by a factor of eight to improve the reliability of testing, and auto-tuning makes stress control and strain control simple.
High-speed sampling in just 0.2 milliseconds (5 kHz) captures even sharp fluctuations in test force when a brittle material fails.



Video Type Non-Contact Extensometer

TRViewX

The TRViewX permits accurate measurements across a wide range of elongations, without affecting the sample. It even permits measurement of films that are difficult to measure with a conventional contact extensometer. It offers extension measurements with accuracy equivalent to JIS B7741 Class 0.5.



Material Testing Operation Software

TRAPEZIUM X

Now compatible with Windows 7, TRAPEZIUM X offers data search and preview functions and allows the user to create reports with a flexible layout. In addition, its visual wizard settings, Quick Panel, and Quick Parameter List make it possible to perform a wide range of operations, from simple test control to testing based on complex user-defined test patterns.

High-Speed Video Camera

HyperVision HPV-2A

This high-speed video camera offers a high 312 × 260 pixel (approx. 81 kpixel) resolution at all imaging speeds up to ultra-fast imaging at one million frames per second. Four cameras can be operated from a single computer to achieve fully synchronized imaging.

Electromagnetic Force Fatigue/Endurance Testing Systems

Servopulser EMT Series

This series of fatigue and endurance testing systems uses a quiet, clean, and oil-free electromagnetic actuator. It permits rapid cycle testing with a maximum test stroke of ±50 mm at speeds up to 2 m/s. The test space is large enough to mount an optional thermostatic chamber for testing in controlled environments.

Electromagnetic Force Micro Material Testers

Micro-Servo MMT Series

This series of fatigue testers uses a quiet, clean, and oil-free electromagnetic actuator. The four models in the product range offer maximum test forces from 10 N to 500 N. They offer rapid cycle testing with gram-order test forces and micron-level accuracy. These testers are ideal for dynamic strength evaluations of minute materials and parts.

Ultrasonic Fatigue Tester

USF-2000

This fatigue tester uses ultrasonic vibrations to perform rapid, gigacycle-order fatigue testing of materials.
It offers an ultra-fast 20 kHz test frequency. The test stress range is from 180 to 900 MPa. Use the computer supplied for monitoring and test condition setup.

High-Speed Impact Testers

Hydroshot HITS Series

Demands for increased safety and reliability make the evaluation of the dynamic strength (impact characteristics) of materials and parts even more important. These instruments can capture maximum test force, energy, and displacement data at test rates up to 72 km/hour (20 m/s).
The available models are the HITS-T10 tensile load type and HITS-P10 punch type. They support testing in temperature-controlled environments.

This brochure may contain references to products that are not available in your country.
Please contact us to check the availability of these products in your country.

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