Fatigue & Fracture Testing Solutions

Productivity-enhancing modules for use with MTS TestSuite™ Multipurpose Software

Fatigue Modules

- » Low-Cycle Fatigue
- » High-Cycle Fatigue
- » Advanced Low-Cycle Fatigue
- » Advanced High-Cycle Fatigue
- » Thermomechanical Fatigue
- » Multipurpose Analyzer

Fracture Modules

- » Fatigue Crack Growth
  - Clip Gage
  - DCPD
- » Fracture Toughness
  - KIc
  - CTOD
  - JIc-CTOD
- » Multipurpose Analyzer

Build on the power of MTS TestSuite Multipurpose Software with modules designed for fatigue and fracture testing. These modules include the test templates, report templates and analysis definitions required to efficiently run tests and comply with standards for specific fatigue and fracture applications.

As part of the MTS TestSuite Multipurpose family, the modules benefit from the same advantages found in all MTS TestSuite solutions. You'll be able to design and run tests with an intuitive, graphical workflow interface, react to events as they occur with user-configurable Runtime Views and create standard reports with plots, tables and summaries in Microsoft Excel format. You'll also have the utmost control to customize the modules to meet your needs.

Additionally, the modules help you minimize test setup time by saving and storing procedures for future use with similar tests. You can easily change parameters during test execution, facilitating quick response to the test in progress. For yet more flexibility, you can verify test design with the Virtual Specimen feature that allows you to predict how a test article will perform in a test without using an actual specimen. This feature saves time in setup and protects valuable test articles from damage.

Along with the modules, there are options for sophisticated analysis and reporting. For more in-depth analysis, you can use the standalone Multipurpose Analyzer to gain insight into your post-test data, and the Reporter Add-In to create and modify reports in Excel.

Customizable to your needs

The Fatigue and Fracture modules offer customization capabilities to meet your requirements. Test templates are designed for modification to meet specific lab needs. Tests can be customized in the graphical Test Editor and with the built-in Iron Python open-source programming language interface for calculations modification. The Runtime View is also freely configurable. With the Multipurpose Analyzer you can add variables, calculations and charts for effective "what if" studies.

**VIRTUAL SPECIMEN: TEST TO FAILURE WITHOUT DAMAGE**

Included as a standard feature with all Fatigue and Fracture modules, the Virtual Specimen allows you to gain insight into how a test article will perform in a test without having to physically damage the specimen. First, you define the parameters that determine the behavior of the virtual specimen. Next, simply conduct your virtual test to receive physically meaningful feedback of specimen behavior without damaging a real specimen. You'll find Virtual Specimen to be useful for demonstrations, training and design verification for standard tests on specimens with standard geometries.

Avoid test specimen damage with the Virtual Specimen feature, which uses a mathematical model of the test specimen to represent modulus, diameter, width and thickness, gage length, yield strength, ultimate stress and degradation.

POWERFUL, FLEXIBLE REPORTING FUNCTIONALITY

The Fatigue and Fracture modules include a standard report generation capability that allows you to create reports during runtime. When you create a report, the placeholder values in the report template are replaced with the data and images for a particular test or analysis run. This modular approach allows you to use the same template for any number of similar tests. You can also easily create and manage multiple report templates to produce a library of reusable report designs. For more detailed reporting after runtime, use the optional MTS TestSuite Reporter Add-In for Microsoft Excel.
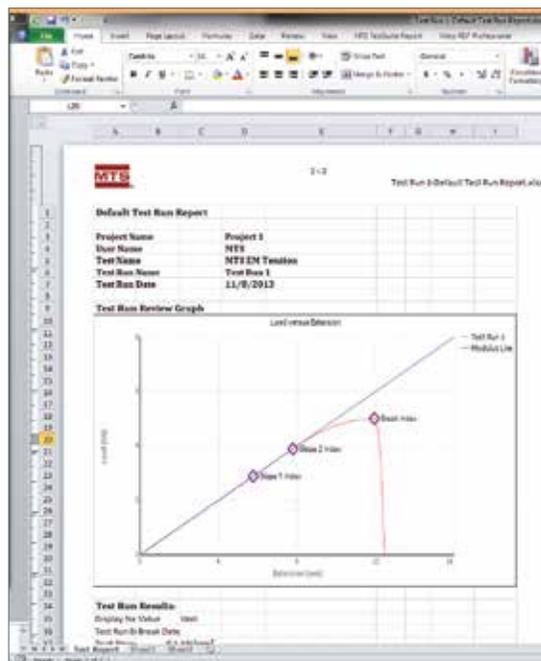
Standard reports can be created during runtime.

Low-Cycle Fatigue (LCF) Module

The MTS TestSuite LCF module contains the test and report templates and calculations you need for low-cycle fatigue (LCF) testing up to 12 Hz in strain control, using an extensometer as a feedback transducer. Predefined test templates let you efficiently test to ASTM E606 and D3479 strain-controlled low-cycle fatigue test standards. Plus, you can smoothly transition to high-frequency, load-controlled fatigue testing by accelerating tests that are primarily elastic.

Additional features include:

» Online hysteresis loop plotting

» User-scheduled loop storage

» Test shutdown and restart

» Test parameter changes during test execution

» Sine and triangle wave shape

» Virtual Specimen

Test setup

LCF test preparation begins with test parameter assignment, including setting end levels and frequency. The next step involves termination parameter entry, including minimum cycles to stable cycle, stable cycle percentage drop, load change for detecting crack initiation and failure

detection, and peak strain level monitor. Data storage parameter entry is the final test setup step. With load change as the storage criterion and cycle detection outside the strain noise band, stored parameters include starting cycles, ending cycles, any nth cycle and number of cycles per log decade.

Running a test

The LCF module features simple and comprehensive support for all stages of test operation. Steps include confirming the zero and full-scale extensometer readings for verification purposes, confirming the material constant for loading and unloading modulus, and running strain tests to failure, with the option to hold and restart at any point

while the test is in process. The Runtime View intuitively displays modulus check, hysteresis loops, load peak and valley per cycle, and time trace per cycle. A scope can be configured during runtime. At any time in the Runtime View, a tabular view of actual peaks and valleys can be copied and pasted into Excel for generating a report.

Reporting and analysis

When your test is complete, you can issue a report against a pre-defined template. Reports can include all input information and measurements, and you can amend them with user-entered calculations based on reported values. With the Multipurpose Analyzer, you also have the option to gain additional insight into your post-test data.
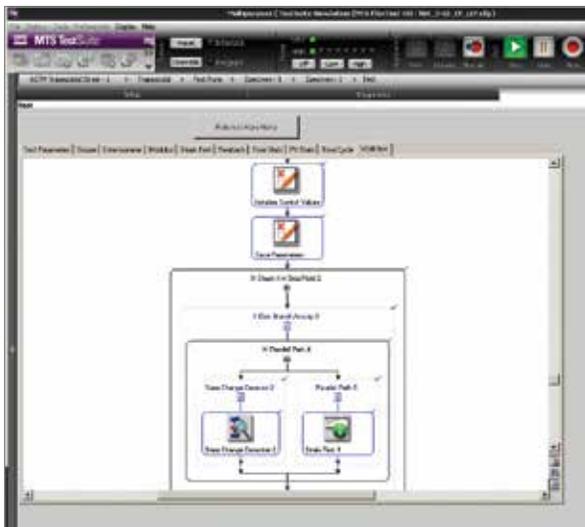
The Workflow View provides an easy-to-understand visual depiction of all steps required to run your LCF test, including steps with parallel paths.
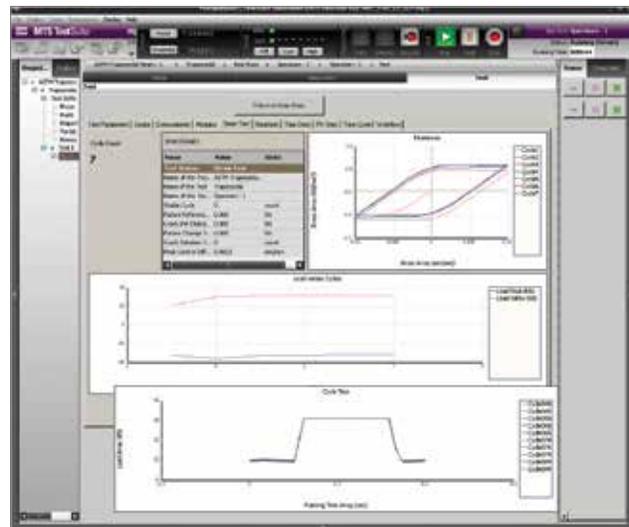
Simultaneously monitor hysteresis loops, load peak and valley per cycle and time trace per cycle in the Runtime View.

High-Cycle Fatigue (HCF) Module

The MTS TestSuite HCF module includes the test templates, report templates and calculations required to design and run high-cycle fatigue tests up to 70 Hz in load control. Predefined test templates let you efficiently test to ASTM E466 and D3479 test standards.

Additional features of this module include:

» Online hysteresis loop plotting

» User-scheduled loop storage

» Test shutdown and restart

» Test parameter changes during test execution

» Sine wave shape

» Virtual Specimen

Test setup

Test setup in the HCF module starts with the assignment of end-level and frequency testing parameters. Termination parameters are entered next, including displacement change for failure and peak load monitor. With the storage criterion as the displacement change, data storage parameter entry is the final step of test setup. Stored parameters include starting cycles, ending cycles, any nth cycle and number of cycles per log decade.

Running a test

The HCF Main Menu allows you to load your test and run it through failure, with flexibility to hold and restart the test at any time. The Runtime View enables the simultaneous monitoring of hysteresis loops, displacement peak and valley per cycle and load-time trace per cycle, including tabular views of actual peaks and valleys.

Reporting and analysis

When your HCF test is complete, you can issue a report against a pre-defined template. Reports can include all input information and measurements, and you can amend them with user-entered calculations based on reported values. With the Multipurpose Analyzer, you also have the option to gain additional insight into your post-test data.
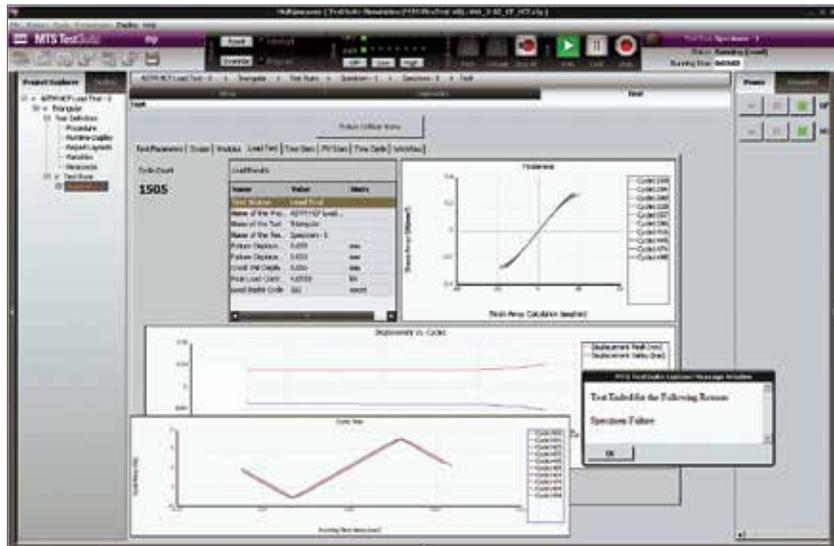
The Runtime View provides a comprehensive view of HCF tests in progress, including hysteresis loops, displacement peak and valley per cycle, and load-time trace per cycle.

Advanced Low-Cycle Fatigue (ADVLCF) Module

The MTS TestSuite ADVLCF module includes the activities, calculations, and test and report templates you need to run constant-amplitude strain-controlled fatigue testing up to 12 Hz, with predefined templates to test to ASTM E606 and D3479 standards. This module calculates and corrects for thermal expansion during non-ambient testing, and a custom waveform activity enables efficient definition of arbitrary waveforms, including user-defined hold times. You can also smoothly transition to high-frequency, load-controlled fatigue testing by accelerating tests that are primarily elastic.

Other ADVLCF module features include:

- » Elevated temperature support, including set-point control for the temperature controller and thermal strain compensation
- » Online hysteresis loop plotting
- » User-scheduled loop storage
- » Test shutdown and restart
- » Test parameter changes during test execution
- » Virtual Specimen

Test setup

The first step to setting up a test in the ADVLCF module involves entering temperature and ramp-time for up to three temperature zones, followed by entering two end levels, frequency, two hold times and two ramp rates. Next, you enter termination parameters that include minimum cycles to stable cycle, stable cycle percentage drop, load change for detecting crack initiation, load change for failure detection, and peak strain level monitor. ADVLCF test setup concludes with data storage parameter entry. With the storage criterion as the load change, stored parameters include starting cycles, ending cycles, any nth cycle and number of cycles per log decade.

Running a test

When you're ready to run your test, the ADVLCF module first requires the confirmation of zero and full-scale strain extensometer verification readings. Next, measure strain at room and test temperature for thermal compensation, and confirm the material constant for loading and unloading modulus at room and test temperature. To assign the ramp to the test temperature, select a point for the temperature controller to reach. You now can run your ADVLCF test to failure, with the option to hold and restart at any time.

Reporting and analysis

After your ADVLCF test is complete, you have the option to issue a report against a pre-defined template. Build your reports using all input information and measurements, and make amendments with user-entered calculations based on reported values. The Multipurpose Analyzer also gives you the option to gain additional insight into your post-test data.
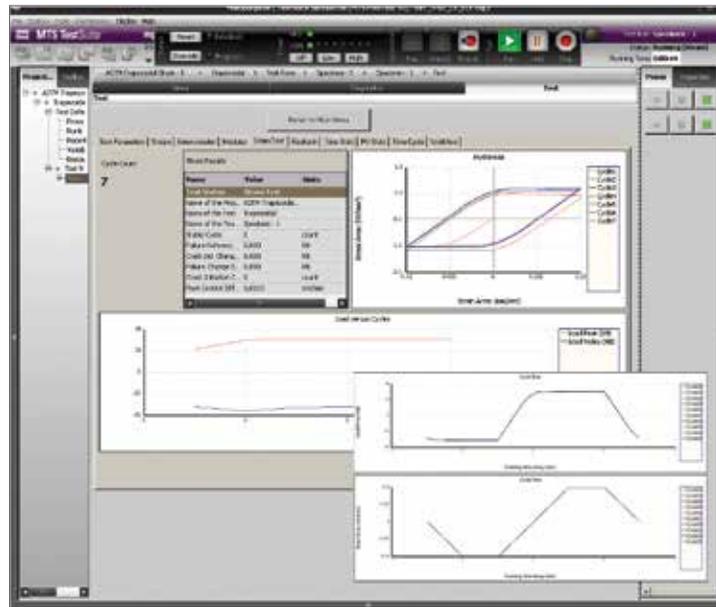
The Runtime View provides detailed and simultaneous monitoring of hysteresis loops, peak valley load per cycle, load-time trace per cycle, strain-time trace per cycle, and other ADVLCF testing activity

Advanced High-Cycle Fatigue (ADVHCF) Module

The MTS TestSuite ADVHCF module provides a complete menu of the activities, calculations and test and report templates you need to conduct accurate, efficient high-cycle fatigue testing up to 70 Hz in load control, with feedback via a load cell. Predefined templates simplify testing to ASTM E466 and D3479 standards. The ADVHCF module also provides advanced support of elevated temperatures, including set-point control for the temperature controller and thermal strain compensation.

Other features include:

» Online hysteresis loop plotting

» User-scheduled loop storage

» Test shutdown and restart

» Test parameter changes during test execution

» Sine wave shape

» Virtual Specimen

Test setup

ADVHCF module test setup first involves test parameter entry, including assignment of temperature and ramp-time for three temperature zones. Next, enter the end levels and frequency, followed by termination parameters that include displacement change, peak load level change and total cycles. Stored parameter entry includes starting cycles, ending cycles, any nth cycle, number of cycles per log decade, and temperature sampling rate. The final step involves assigning ramp-to-start and ramp-to-test temperature. The ramp-to-start setting cools to room temperature. The ramp-to-test setting assigns the testing temperature for the temperature controller to reach.

Running a test

By clicking "Load Test" on the ADVHCF Main Menu, your test will begin and run through failure, with the option to hold and restart at any time. The Runtime View provides visually intuitive monitoring of ramp to test temperature progress, along with the simultaneous display of test setup parameters, load versus displacement, displacement versus cycles, and peak valley load versus cycles. The Runtime View also allows up to three thermocouples to be monitored. At any point during the test, a tabular view of actual peaks and valleys can be copied and pasted into Excel for report generation.

Reporting and analysis

After your ADVHCF test is finished, you can issue a report against a pre-defined template. Reports can include all input information and measurements, and you can amend them with user-entered calculations based on reported values. The optional Multipurpose Analyzer provides additional insight into your post-test data, including detailed temperature-versus-cycles analysis.

The Runtime View provides a comprehensive view of ADVHCF tests in progress, test setup parameters, load versus displacement, displacement versus cycles, peak valley load versus cycles and much more.

Thermomechanical Fatigue (TMF) Module

TMF tests characterize the response of materials to both cyclic mechanical loading and fluctuating temperature, producing a synergistic response that can not be predicted with isothermal fatigue testing. This testing is essential to characterizing components designed to withstand fluctuating temperatures for longer periods of time. The MTS TestSuite TMF module contains all of the test, analysis and report templates and calculations you need to conduct thorough and precise tests with mechanical and thermal cycling.

The MTS TestSuite TMF module includes predefined templates for testing to ASTM E2368 and European Validated Code of Practice for Strain-Controlled Thermo Mechanical Fatigue Testing, EUR 22281 EN. Templates can be modified to conform to most TMF tests described in ASTM or ISO standards, by adjusting test logic and employing the Iron Python open-source programming language interface to adjust and create any kind of calculation.
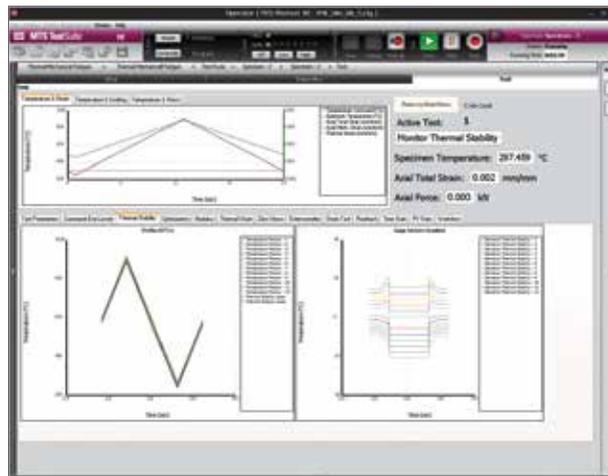
Test setup

The first step to setting up a test in the TMF module involves entering temperature and strain end levels and hold times. Next, you enter termination parameters that include minimum cycles to stable cycle, stable cycle percentage drop, strain change for detecting crack initiation, and strain change for failure detection. The TMF test setup concludes with data storage parameter entry. With the storage criterion as the load change, stored parameters include starting cycles, ending cycles, any nth cycle and number of cycles per log decade.

The Runtime View of thermal stability at batch level offers simple validation that the temperature gradient has been achieved.
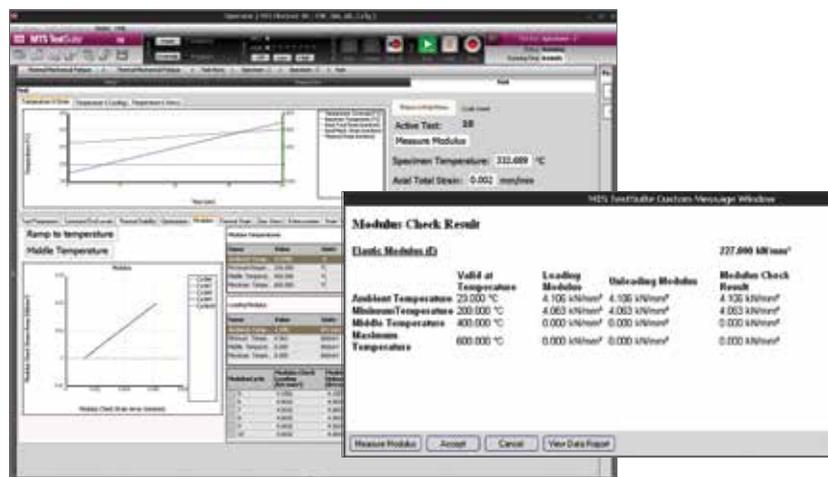
Running a test

When your TMF test begins, the first step involves extensometer verification, followed by a modulus measurement and monitoring thermal stability for each specimen. Second, apply a ramp in strain control to identify thermal and mechanical strain components, followed by validating that near-zero stress can be achieved. The final step involves cycling strain and temperature with arbitrary phase.

Reporting and analysis

After completing a TMF test, you can issue a report against a pre-defined template. Reports can include all input information and measurements, and you can amend them with user-entered calculations based on reported values. The optional Multipurpose Analyzer provides additional insight into your post-test data, including detailed temperature-versus-cycles analysis.


The modulus check confirms the material constant for loading and unloading modulus. Shown here are thermal ramps, modulus measurement, and comparison to known values. A results screen confirms the material constant for loading and unloading modulus.

View intuitive graphical depictions of zero load and temperature cycling only to measure the correlation coefficients between expansion and temperature.
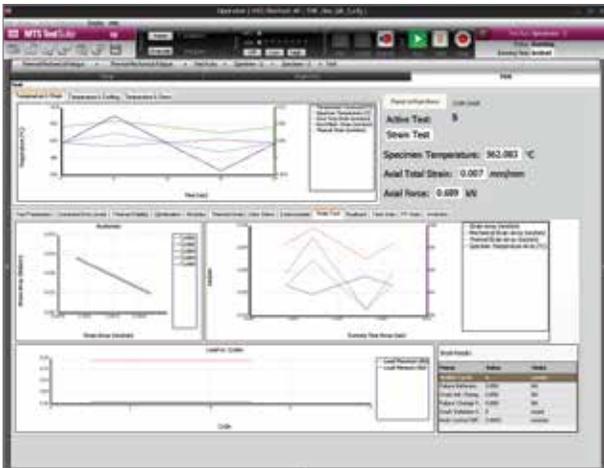

During the main part of the strain test, the Runtime View lets you cycle temperature and mechanical strain to failure while monitoring temperature and mechanical strain feedback and the peak and valley for mechanical strain.

To run a "zero stress" test, simply set the control so that "0" mechanical strain is applied while cycling temperature and monitoring stress.

MULTIPURPOSE ANALYZER

This powerful, standalone application lets you achieve new levels of insight by conducting custom, in-depth analyses of fatigue test data files to create informative results. Over time, you'll build an extensive analysis library that allows you to meet your specific testing requirements with speed and accuracy. An advanced data tool also allows users to post-process test data for performing in-depth analysis in a graphical and tabular manner.
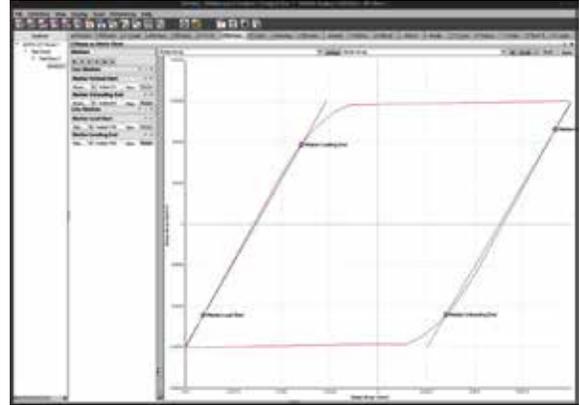
Make critical decisions through interactive numerical and graphical analysis.

The Multipurpose Analyzer is the ideal solution for:

» Analysis of completed tests (can be separate from the test system computer)

» Re-analysis of a data set requiring updated parameters

» Analysis of multiple specimen data sets

» Cross-specimen analysis to compare two different sets of test data

» "What if?" analysis to evaluate hypothetical scenarios

By purchasing a license for the optional MTS TestSuite Reporter Add-In package, you can also generate custom analysis reports.

Fracture Testing

Fatigue Crack Growth Modules

MTS TestSuite Fatigue Crack Growth (FCG) Modules conveniently package the test and report templates and calculations you need for fatigue crack growth assessment. Predefined templates let you efficiently test to the ASTM E647 standard. Features include online load-displacement, crack length vs. cycles, and da/dN plotting, as well as test shutdown and test parameter changes during test execution.
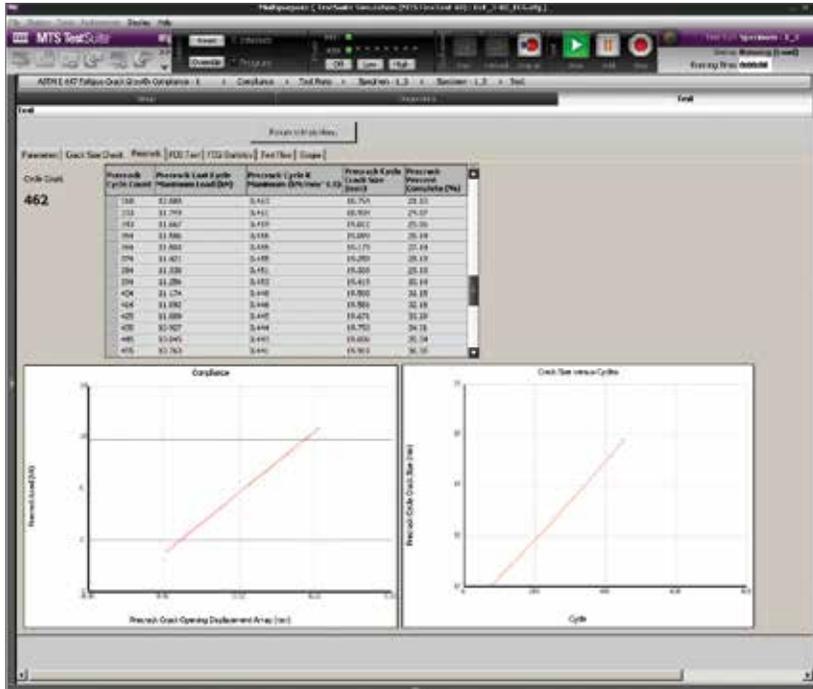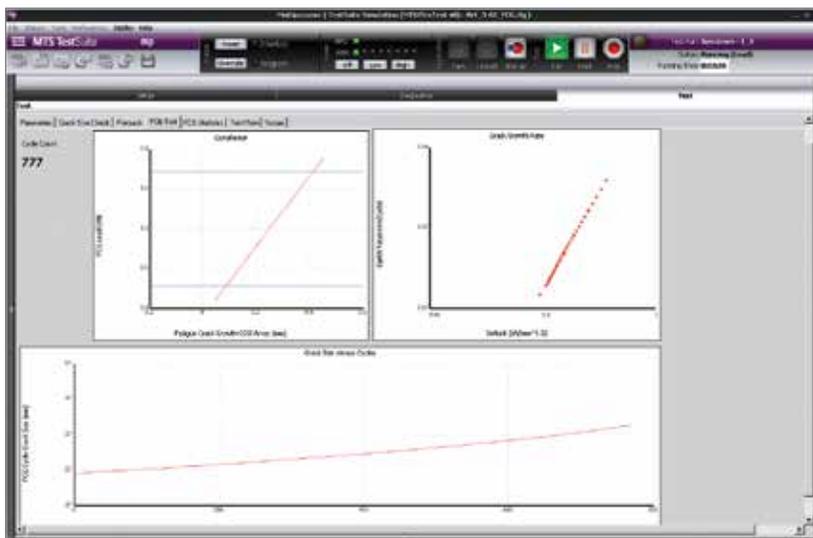

The Runtime View provides a comprehensive view of the pre-crack portion of a test, test setup parameters, displaying tabular results per cycle, load versus COD and crack size versus cycles.

You can also monitor the fatigue crack growth portion of the test in the Runtime View, with displays that include load versus COD, da/dN versus Delta K and crack size versus cycle.

CLIP GAGE FATIGUE MODULE

The Clip Gage Module runs FCG tests using a clip gage and the compliance method for the crack length measurement, using a predefined test template to test to the ASTM E647 test standard. The typical test includes crack size check, pre-crack assessment, and growing the crack for characterization purposes, on FFC(T), M(T) and SE(B) specimen types.

Module features include online load displacement, crack length versus cycles, and da/dN plotting. You have flexibility to shut down a test or change the parameters at any time during test execution.

DIRECT CURRENT POTENTIAL DROP (DCPD) MODULE

The MTS TestSuite DCPD Module measures crack length via a voltage that is correlated to the crack length. It also measures a reference specimen to correct for fluctuations in current or specimen conductivity during tests. The DCPD module is capable of reversing the power supply current to correct for thermoelectric voltages. Users can enter specific DPCP calibrations for non-standard lead placement or non-standard geometries.
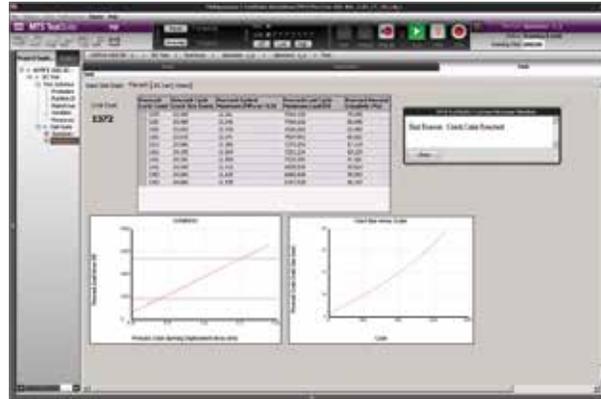
Get the test and report templates, and calculations required to design and run fracture toughness tests. Predefined templates let you efficiently test to ASTM E399, E1290 and E1820 standards.

» KIc module

» CTOD module

» JIc-CTOD module

KIC MODULE

The KIc module performs fatigue pre-cracking and uses the compliance method as the primary crack length measurement. KIc fatigue crack growth tests consist of crack size check, pre-crack and the UIc test. The main test is executed in load, crack opening displacement, or actuator displacement control. A predefined test template lets you efficiently test to the ASTM E399 test standard. Supported specimens include FFC(T) and SE(B).

CRACK TIP OPENING DISPLACEMENT (CTOD) MODULE

The CTOD Module provides test methods for the determination of critical crack-tip opening displacement (CTOD) values, at one or more of several crack extension events. These CTOD values can be used as a measure of fracture toughness. The module includes a predefined test template for ASTM E1290. Supported specimens include FFC(T), LLC(T), and SE(B).

The Runtime View of the pre-crack portion of the JIc test can simultaneously display tabular results per cycle, load versus COD, and crack size versus cycles.
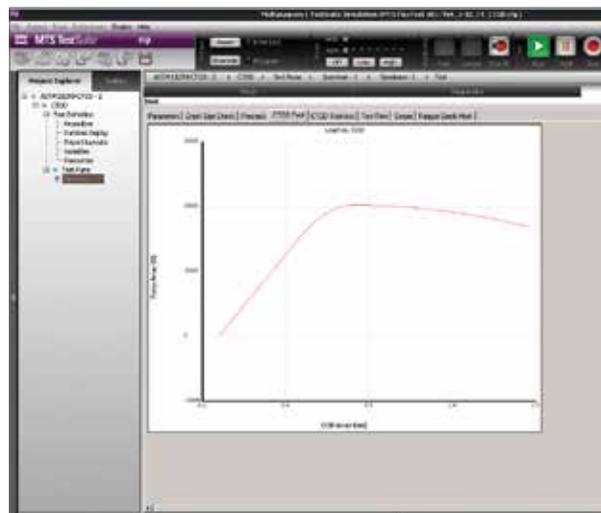
The Runtime View of the pre-crack portion of the CTOD intuitively displays load versus COD.
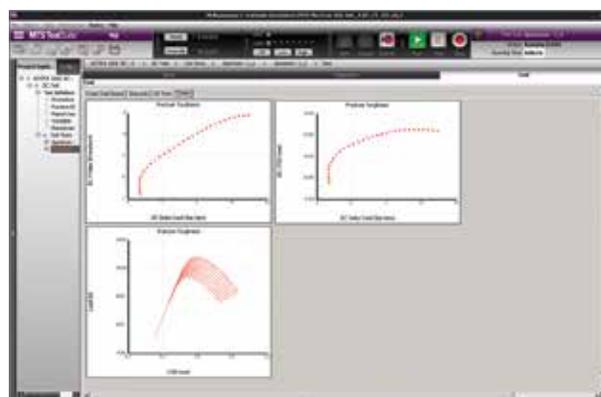
As your CTOD test runs, runtime view allows you to monitor crack extension versus J, crack extension versus CTOD, and load versus COD.

JIC-CTOD MODULE

The JIc-CTOD Module calculates J-R curves, CTOD R curves, critical J and critical CTOD values, with a predefined test template for ASTM E1820. The module supports fatigue pre-cracking and uses the compliance method as the primary crack length measurement, and features online load-displacement plotting, test shutdown and restart, and the capability to change test parameters during execution. Supported specimens include FFC(T), LLC(T) and E(B).

MULTIPURPOSE ANALYZER

The Multipurpose Analyzer is needed to process test data and calculate actual fracture results such as fatigue crack growth validity criteria and toughness values. The Multipurpose Analyzer provides a standalone package for digging deeper into a test run's data.

Easily conduct custom, in-depth analyses of test data to create informative results. An advanced data tool allows users to post-process test data. You'll be building a useful library with each completed analysis, which can be leveraged to efficiently meet your analysis requirements.
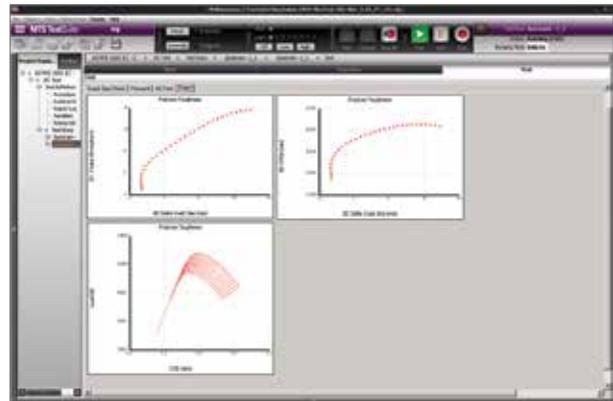
You can also generate analysis reports with the optional MTS TestSuite Reporter Add-In (additional license required).
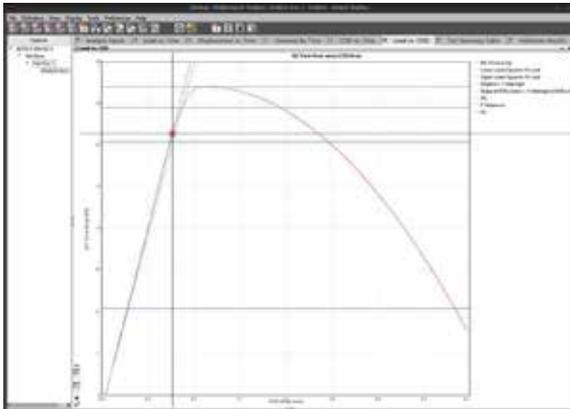
The Multipurpose Analyzer provides numerical analysis, filtering and graphical display of results.

The Runtime View of the pre-crack portion of the JIc test displays tabular results per cycle, load versus COD, and crack size versus cycles.

The Runtime View of the JIc test displays crack extension versus J and CTOD, as well as load versus COD.

MTS TestSuite Fatigue Modules and Supported Standards

Fatigue Modules	Scope	ASTM Standards	Contents
Low-Cycle Fatigue	LCF testing up to 12 Hz Includes templates for LCF and transition to HCF tests	E606 D3479	Test Template Report Template Analysis Definition
High-Cycle Fatigue	High-cycle fatigue testing up to 70 Hz	E466 D3479	Test Template Report Template Analysis Definition
Advanced Low-Cycle Fatigue	Constant-amplitude, strain-controlled fatigue testing up to 12 Hz Calculates and corrects for thermal expansion during non-ambient temperature testing	E606 D3479	Test Template Report Template Analysis Definition Custom Wave Form Activity
Advanced High-Cycle Fatigue	High-cycle fatigue testing up to 70 Hz Calculates and corrects for thermal expansion during non-ambient temperature testing	E466 D3479	Test Template Report Template Analysis Definition
Thermomechanical Fatigue (TMF)	Thermomechanical fatigue testing	E2368 European Validated Code of Practice for Strain-Controlled TMF Testing EUR 22281 EN	Test Template Report Template

MTS TestSuite Fracture Modules and Supported Standards

Fracture Modules	Scope	ASTM Standards	Contents
Clip Gage Fatigue Crack Growth	Fatigue crack growth testing using a clip gage and compliance method as measurement	E647	Test Template Report Template Analysis Definition
Direct Current Potential Drop (DCPD) Fatigue Crack Growth	Fatigue crack growth tension testing using DCPD systems to measure crack length	E647	Test Template Report Template Analysis Definition
KIc Fracture Toughness	Fatigue pre-cracking, using the compliance method as primary crack length measurement	E399	Test Template Report Template Analysis Definition
Crack-Tip Opening Displacement (CTOD) Fracture Toughness	Determines critical CTOD values at one or more of several crack extension events CTOD values can be used as measures of fracture toughness	E1290	Test Template Report Template Analysis Definition
JIc-CTOD Fracture Toughness	Fatigue pre-cracking, using the compliance method as primary crack length measurement	E1820	Test Template Report Template Analysis Definition