MTS TestSuite™

Fracture Templates User Guide

100-256-573 H

be certain.

MTS Trademarks

Proprietary Software

Software Verification and Validation

MTS software is developed using established quality practices in accordance with the requirements detailed in the ISO 9001 standards. Because MTS-authored software is delivered in binary format, it is not user accessible. This software will not change over time. Many releases are written to be backwards compatible, creating another form of verification. The status and validity of MTS' operating software is also checked during system verification and routine calibration of MTS hardware. These controlled calibration processes compare the final test results after statistical analysis against the predicted response of the calibration standards. With these established methods, MTS assures its customers that MTS products meet MTS' exacting quality standards when initially installed and will continue to perform as intended over time.

Manual Part Number	Publication Date	Release
100-256-573 H (English)	August 2015	MTS TestSuite MP 4.1 or later
100-256-573 G (English)	October 2014	MTS TestSuite MP 3.0
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100-256-573 D (English)	September 2012	MTS TestSuite MP 2.3

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How to Get Technical Support

Start with your manuals

The manuals supplied by MTS provide most of the information you need to use and maintain your equipment. If your equipment includes software, look for online help and README files that contain additional product information.

Technical support methods

MTS provides a full range of support services after your system is installed. If you have any questions about a system or product, contact Technical Support in one of the following ways.

Type of Support	Details
Web site	www.mts.com > Contact Us > In the **Subject** field, choose **To escalate a problem**; **Problem Submittal Form**
E-mail	Worldwide: tech.support@mts.com Europe: techsupport.europe@mts.com
Telephone	Worldwide: 1 800 328 2255 - toll free in U.S.; +1 952 937 4000 - outside U.S. Europe: +800 81002 222, International toll free in Europe

Outside the U.S.

For technical support outside the United States, contact your local sales and service office. For a list of worldwide sales and service locations and contact information, use the Global MTS link at the MTS web site:

www.mts.com > **About MTS Systems** > **Global Presence** > **Choose a Region**

Before You Contact MTS

MTS can help you more efficiently if you have the following information available when you contact us for support.

Know your site number and system number

The site number contains your company number and identifies your equipment type (such as material testing or simulation). The number is typically written on a label on your equipment before the system leaves MTS. If you do not know your MTS site number, contact your sales engineer.

Example site number: 571167

When you have more than one MTS system, the system job number identifies your system. You can find your job number in your order paperwork.

Example system number: US1.42460

Know information from prior technical assistance

If you have contacted MTS about this problem before, we can recall your file based on the:

- MTS case number
- Name of the person who helped you

Identify the problem

Describe the problem and know the answers to the following questions:

- How long and how often has the problem occurred?
- Can you reproduce the problem?
- Were any hardware or software changes made to the system before the problem started?
- What are the equipment model numbers?
- What is the controller model (if applicable)?
- What is the system configuration?

Know relevant computer information

For a computer problem, have the following information available:

- Manufacturer's name and model number
- Operating software type and service patch information
- Amount of system memory
- Amount of free space on the hard drive where the application resides
- Current status of hard-drive fragmentation
- Connection status to a corporate network

Know relevant software information

For software application problems, have the following information available:

- The software application's name, version number, build number, and (if available) software patch number. This information can typically be found in the About selection in the Help menu.
- The names of other applications on your computer, such as:
    - Anti-virus software
    - Screen savers
    - Keyboard enhancers
    - Print spoolers
    - Messaging applications

If You Contact MTS by Phone

A Call Center agent registers your call before connecting you with a technical support specialist. The agent asks you for your:

- Site number
- Email address
- Name
- Company name
- Company address
- Phone number where you can be reached

If your issue has a case number, please provide that number. A new issue will be assigned a unique case number.

Identify system type

To enable the Call Center agent to connect you with the most qualified technical support specialist available, identify your system as one of the following types:

- Electrodynamic material test system
- Electromechanical material test system
- Hydromechanical material test system
- Vehicle test system
- Vehicle component test system
- Aero test system

Be prepared to troubleshoot

Prepare to perform troubleshooting while on the phone:

- Call from a telephone close to the system so that you can implement suggestions made over the phone.
- Have the original operating and application software media available.
- If you are not familiar with all aspects of the equipment operation, have an experienced user nearby to assist you.

Write down relevant information

In case Technical Support must call you:

- Verify the case number.
- Record the name of the person who helped you.
- Write down any specific instructions.

After you call

MTS logs and tracks all calls to ensure that you receive assistance for your problem or request. If you have questions about the status of your problem or have additional information to report, please contact Technical Support again and provide your original case number.

Problem Submittal Form

Use the Problem Submittal Form to communicate problems with your software, hardware, manuals, or service that are not resolved to your satisfaction through the technical support process. The form includes check boxes that allow you to indicate the urgency of your problem and your expectation of an acceptable response time. We guarantee a timely response—your feedback is important to us.

You can access the Problem Submittal Form at www.mts.com > Contact Us (upper-right corner) > In the **Subject** field, choose **To escalate a problem; Problem Submittal Form**

Preface

Before You Begin

Safety first!

Before you use your MTS product or system, read and understand the safety information provided with your system. Improper installation, operation, or maintenance can result in hazardous conditions that can cause severe personal injury or death, or damage to your equipment and specimen. Again, read and understand the safety information provided with your system before you continue. It is very important that you remain aware of hazards that apply to your system.

Other MTS manuals

In addition to this manual, you may receive additional manuals in paper or electronic form.

You may also receive an MTS System Documentation CD. It contains an electronic copy of the manuals that pertain to your test system.

Controller and application software manuals are typically included on the software CD distribution disc (s).

Documentation Conventions

The following paragraphs describe some of the conventions that are used in your MTS manuals.

Hazard conventions

Hazard notices may be embedded in this manual. These notices contain safety information that is specific to the activity to be performed. Hazard notices immediately precede the step or procedure that may lead to an associated hazard. Read all hazard notices carefully and follow all directions and recommendations. Three different levels of hazard notices may appear in your manuals. Following are examples of all three levels. (for general safety information, see the safety information provided with your system.)

Danger: Danger notices indicate the presence of a hazard with a high level of risk which, if ignored, will result in death, severe personal injury, or substantial property damage.

Warning: Warning notices indicate the presence of a hazard with a medium level of risk which, if ignored, can result in death, severe personal injury, or substantial property damage.

Caution: Caution notices indicate the presence of a hazard with a low level of risk which, if ignored, could cause moderate or minor personal injury or equipment damage, or could endanger test integrity.

Other special text conventions

Important:

Important notices provide information about your system that is essential to its proper function. While not safety-related, if the important information is ignored, test results may not be reliable, or your system may not operate properly.

Note:

Notes provide additional information about operating your system or highlight easily overlooked information.

Recommended:

Recommended notes provide a suggested way to accomplish a task based on what MTS has found to be most effective.

Tip:

Tips provide helpful information or a hint about how to most efficiently accomplish a task.

Access:

Access provides the route you should follow to a referenced item in the software.

Example: Examples show specific scenarios relating to your product and appear with a shaded background.

Special terms

The first occurrence of special terms is shown in italics.

Illustrations

Illustrations appear in this manual to clarify text. They are examples only and do not necessarily represent your actual system configuration, test application, or software.

Electronic manual conventions

This manual is available as an electronic document in the Portable Document File (PDF) format. It can be viewed on any computer that has Adobe Acrobat Reader installed.

Hypertext links

The electronic document has many hypertext links displayed in a blue font. All blue words in the body text, along with all contents entries and index page numbers, are hypertext links. When you click a hypertext link, the application jumps to the corresponding topic.

Overview

Template Overview

Templates

Templates eliminate the need to re-create existing information and provide an easy way to run standard tests. Test templates can come from one of several sources:

- An existing test - you open a copy of an existing test and assign it a default name (the original test is not changed). The new test does not contain test runs or analysis runs from the source test.
- A test that is converted to a template - you can convert a test to a test template (File > Save As > Template). With the exception of test and analysis runs, specimen definitions, and completed reports, the template contains all other test information.
- A template supplied by MTS - MTS offers a variety of templates designed to comply with test method standards (such as ASTM). MTS templates provide all the components you need to run a test, analyze the test data, and create reports of the results.

Test template content

A template can include all or part of the basic test definition information for one test:

- Procedure
- Monitor displays
- Variables
- Analysis definitions
- Resources

Note:
Although a template can include test resources, if the template is designed for a particular controller configuration, the resources may not map to (match) the test station resources in your system.

Test definitions

You can add a test definition to a test from a template. The source of the template can be any existing test or template that has tests. With the exception of test and analysis runs, specimen definitions, and completed reports, the new test contains all other test information.

Template locations

Projects and project templates exist on disk as folders with the .Project folder name extension. They are typically located at C:\MTS TestSuite\Projects and C:\MTS TestSuite\Templates, respectively. Report templates are located in the C:\MTS TestSuite\Report Templates folder.

Note: Do not rename, move, or change the contents of the Projects or Templates folders outside of the MTS TestSuite applications. To rename an open project, use the Project Summary window in any application.

Fracture Templates

Fatigue Crack Growth (FCG)

The following templates are available for Fatigue Crack Growth (FCG) tests and analysis:

Fatigue Crack Growth Templates

Template	Description
ASTM E 647 FCG Compliance	This template complies with ASTM standard E647-08 and is designed to run FCG compliance or bend tests, analyze the resulting data, and provide reports of the results.
ASTM E 647 FCG DCPD	This template complies with ASTM standard E647-08 and is designed to run FCG DC Potential Drop (DCPD) tension tests, analyze the resulting data, and provide reports of the results.
Legacy FCG	This template is designed to analyze data acquired from tests run with the MTS Model 793.40 Fatigue Crack Growth Test Application and provide reports of the results.

JIC Fracture Toughness

The following templates are available for JIC Fracture Toughness tests and analysis:

JIC Fracture Toughness Templates

Template	Description
ASTM E 1820 JIC	This template complies with ASTM Standard E-1820-08 and is designed to determine the fracture toughness (JIC) value of materials.
Legacy JIC	This template is designed to analyze data acquired from tests run with the MTS Model 793.50 JIC Fracture Toughness Test Application.

KIC Fracture Toughness

The following templates are available for KIC Fracture Toughness tests and analysis:

KIC Fracture Toughness Templates

Template	Description
ASTM E 399 KIC	This template complies with ASTM Standard E 399 and is designed to determine the plane-strain fracture toughness (KIC) value of materials.
Legacy KIC	This template is designed to analyze data acquired from tests run with the MTS Model 793.50 KIC Fracture Toughness Test Application.

CTOD Fracture Toughness

The following template is available for KIC Fracture Toughness tests and analysis:

CTOD Fracture Toughness Templates

Template	Description
ASTM E1290 CTOD	This template is in compliance with ASTM E 1290 - 07 and is designed to determine the fracture toughness value of materials.

Legacy Template Overview

Importing Legacy Data

Import Legacy Data provides support in MTS TestSuite for data archived from previous software products. The currently supported versions include:

- Model 790.20—Low-Cycle Fatigue (LCF), High-Cycle Fatigue (HCF), and Advance Low-Cycle Fatigue (ALC) version 4.2 or later
- Model 790.40—Fatigue Crack Growth (FCG) version 4.2 or later
- Model 790.50—Fracture Toughness with J-Integral Characterization of Fracture Toughness (JIC), Linear Elastic Plane-Strain Fracture Toughness of Metallic Materials (KIC), and E1820 Crack-Tip Opening Displacement (CTOD) version 4.2 or later

Specialized templates map the archived data to the current format and variables for analysis:

- Advance Low-Cycle Fatigue (ALC)
- E1820 Crack-Tip Opening Displacement (CTOD)
- Fatigue Crack Growth (FCG)
- High-Cycle Fatigue (HCF)
- J-Integral Characterization of Fracture Toughness (JIC)
- Linear Elastic Plane-Strain Fracture Toughness of Metallic Materials (KIC)
- Low-Cycle Fatigue (LCF)

Legacy files

Legacy files have a similar naming convention. File names are not case-sensitive: <name><data type>.<extension>

Legacy File Names

Item	Description
Name	The user-supplied name.
Data Type	**Important:** You must select the RD file. Only the RD file is processed. The data type is one of four following types created for an archive: • BS—Batch-specimen data • PR—Procedure data • RD—Raw data • TR—Test results
Extension	The extension indicates the type of test, such as E1820, FCG, or KIC.

Import process

You can import legacy data in the Multipurpose Elite, Fatigue Analyzer, and Fracture Analyzer applications.

If you import legacy data in Multipurpose Elite, you can review the imported data in View Results. You cannot create tests or test runs that you can run in the application.

The data is mapped from the legacy format and variables to the current format and variables by the application. No user intervention is required.

When the import is complete, your test is saved and the test run is initialized. In Explorer, the test run name appears blue. The next step is to create an analysis run in an analysis application.

Properties

Import Legacy Data Properties

Item	Description
Template	Show the name of the Legacy template for the test type, such as Legacy FCG.
Files	Show the name of the file you select to import, such as **FCG_archiverd.FCG**.

Import Legacy Data Procedure

To import legacy data:

1. Click **File > Import > Legacy Data**.
2. In the Import Legacy Data window, click **Select**, click the Legacy template for the legacy test type, and click **OK**.

3. Click **Add**, navigate to the location of the legacy data files, select the raw data file (**nameRD.EXT**), and click the **Open** button.
4. Click **OK**.

   An informational message provides the name of the specimen selected for the test.
5. Click **OK** to clear the success or error message.

   If there was an error during the import process, the message log contains more detailed information about the error.

Test Setup

Open the Controller Station

To open the controller station:

1. Start the Station Manager application.
2. In the Open Station window, select a a configuration file.
3. Click **Open** to open the configuration file.

Prepare Controller Station for Operation

The following procedure provides a basic outline of the steps required to prepare the controller station for specimen installation and test operation.

1. Make sure all sensors are properly calibrated.
2. Make sure the test channels are properly tuned.
3. Make sure the polarity of the sensor signals are properly set for the test.
4. Set up error detectors.
5. Set up limit detectors.
6. After the Series 793 Station Manager application is properly set up for operation, make sure the user access level is not set to **Configuration**.

   The test control application will not allow you to connect to a station when the Station Manager application user access level is set to **Configuration**.

Crack Opening Displacement (COD) Sensor Signal Polarity

The following templates require you to invert the polarity of the Crack Opening Displacement (COD) clip gage sensor signal in the Series 793 Station Manager application when used:

- ASTM E 1820 JIC template with an SE(B) specimen
- ASTM E1290 CTOD template with an SE(B) specimen

Note:
When running other template and specimen combinations, make sure that the COD sensor signal is set to Normal in the Station Manager application.

You can manually set the signal polarity in each instance, or you can create separate station configuration and parameter sets for the different signal polarities for use with the corresponding template and specimens.

Enable Manual Control

To enable manual control of the Station Manager controller:

1. On the Station Manager Station Controls toolbar, click **Manual Command**.
2. Select the **Enable Manual Command** check box.

3. Select a control mode.

   You control the actuator for specimen installation with a control knob on a control panel mounted near the load unit. Select your preference for a control mode, a channel limited channel (CLC) control mode, a load control mode, or a stroke control mode can be used.

4. Make sure error and limit detectors are set up.

   Because of the potential danger of working near high-pressure hydraulic systems, you must set proper limit and error detectors before installing specimens.

5. Apply hydraulics, and if necessary, reset interlocks.

   Warning:
   Applying hydraulics can result in sudden actuator motion.

   A moving actuator can injure anyone in its path.

   Always clear the actuator area before applying hydraulics.

   Use the Station Manager's Station Controls panel for the following steps.

   A. Click **Reset** to clear interlocks.

      If the interlock remains on, use the Message Logs window to identify and correct the cause of the interlock.

   B. Click **HPU Power Low**, and then click **HPU Power High**.

      The buttons stop flashing when pressure is reached.

   C. Click **HSM Power Low**, and then click **HSM Power High**.

      When possible, use low pressure to install specimens.

Install Specimen

The following procedure provides a basic outline of the steps required to install a specimen. Refer to the load unit and grip manuals for detailed instructions on installing and operating these components in your system.

1. Using manual control, move the actuator close to the specimen grips.

   Warning:
   Actuator movement can occur when you install a specimen.

   Unexpected actuator movement can result in personal injury, as your hands will be in a crush zone during this step.

   Ensure that hydraulic power is turned off before placing your hands near the actuator. Read and understand the safety information in the Safety manual, Series 793 Software manuals, and Load Frame product manuals.

2. Install the specimen in the grips.

3. Zero the control channel sensor output signal.
4. Install the specimen gage.
5. Zero the gage sensor output signal.

Disable Manual Control

To disable manual control of the Station Manager controller:

1. In the Station Manager application, click Manual Command button in the Station Controls panel. The Manual Command window opens.
2. Deselect the Enable Manual Command check box and close the window.
3. Turn off hydraulics in the Station Manager application.
    A. Click **HSM Power Off**.
    B. Click **HPU Power Off**.

Fatigue Crack Growth (FCG) Template

Set Up the Test

Fatigue Crack Growth (FCG) Templates Overview

There are two versions of Fatigue Crack Growth templates. Both templates comply with ASTM standard E647-08.

- ASTM E 647 Fatigue Crack Growth Compliance
- ASTM E 647 Fatigue Crack Growth DCPD

The primary difference between the two templates is how the crack size is measured. The compliance template uses a Crack Opening Displacement (COD) clip gage to measure the crack opening. The DC Potential Drop (DCPD) template uses electrical leads that carry voltage, and the change in voltage relates to a change in crack size.

Control modes

The template guides you through the steps of running a test and provides all the software components you need to run a fatigue crack growth test in one of two control modes:

- Constant Load—The test cycles between a specified minimum and maximum load.
- Delta K—The test cycles between the minimum and maximum loads that correspond to the desired minimum and maximum stress intensities (K).

Features

The main features of the FCG template are listed below:

- The main template window guides you through setting up all test parameters, performing crack size checks, precracking the specimen, and running the test.
- As the test runs, you can stop the test to change test parameters.
- Comprehensive monitor views help you monitor test progress.
- Tabular and graphical displays make it easy to review test results.
- Analysis definitions provide all necessary analysis calculations and views to analyze test runs.
- Report templates help you generate reports for analysis runs.

Set Up a Test

To create and run a new test:

1. Create a new test from a template.
   A. Click **File > New > Test from Template**.
   B. In the Create from Existing Test window, select a test.
   C. Click **OK**.

      The new test is automatically created and assigned a default name. You can change the name and enter comments about the new test by clicking the **Edit** button and making the changes.

2. Create a new test run.
    A. Click **New Test Run** button.
    B. Select a specimen from the Select a Specimen window and then click **OK**.

       To create a new specimen click **Add a new item**.
    C. Review the variables in the Setup Variables window, modify values as necessary, and then click **OK**.
3. Apply hydraulic power to the system.
    A. Reset the interlocks if needed.
    B. Click the **Low**, then **High**, power buttons.
4. In the MTS TestSuite Custom Message window for the template, click the buttons to define test parameters, perform setup tasks, and run tests.
5. When prompted, click **Run** to run the test.

Define Test Parameters

Test Parameters

After a new test run is added to the test, the Main Menu window appears. This window provides access to all necessary test parameters. Click the parameter buttons in the Main Menu window to specify parameter values for the test.

Precrack Parameters

Precrack Parameters

Parameter	Description
Precrack Final Crack Limit	Specify the desired crack size to achieve in the precrack activity. When the specified crack size is achieved, the activity stops.
Precrack Frequency	Specify the cycle frequency of the command signal for the precrack activity.
Precrack Load Ratio	Specify the ratio of the minimum to maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
Precrack Lower Least Squares Fit Percentage	Specify the percentage of the measured load range used as the lower limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.
Precrack Upper Least Squares Fit	Specify the percentage of the measured load range used as the upper limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.

Parameter	Description
Percentage	
Precrack Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. The load is applied at this level to ensure the crack is open. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.
Precrack Cycle Limit	Specify the number of cycles at which precrack activity stops.
Precrack Final Maximum K	Specify the maximum stress intensity desired at the end of precrack activity. The initial precrack Maximum K is 1.4 times the Final Maximum K value.
Shutdown Station at End of Precrack	Select **Yes** to cause an interlock at the end of precrack. This can shut down hydraulics, if desired.

Crack Growth Parameters

In the Crack Growth Parameters section of the main menu, you select the c**ontrol mode** for the test and then specify the parameters for the selected mode:

- **Delta-K**
- **Constant Load**

Delta K Control Mode Parameters

Delta K Control Mode Parameters

Parameter	Description
FCG Load Ratio	Specify the ratio of the minimum to maximum K applied to the specimen. The minimum K is determined by this value and the maximum K is specified by you.
FCG Initial - K Max	Specify the initial maximum stress intensity (K) value used in Delta-K control.
Normalized K Gradient (C)	Specify the rate of change to stress intensity as the crack site changes. Negative values cause the alternating stress intensity to decrease.

Parameter	Description
FCG Frequency	Specify the cycle frequency of the command signal.
FCG Wave Shape	Specify the wave shape of the command signal. The choices are **True Sine** or **True Ramp**. Typically, you use a True Ramp wave shape where uniform strain-rate sensitivity is important, and a True Sine wave shape where a continually varying strain rate is acceptable because of the higher frequencies of some tests. This MTS template does not support hold times or creep-fatigue crack growth testing.
FCG Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.

Constant Load Control Mode Parameters

Constant Load Control Mode Paramters

Parameter	Description
FCG Load Ratio	Specify the ratio of the minimum to maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
FCG End Level 1	Specify the desired maximum load of the command signal.
FCG Frequency	Specify the cycle frequency of the command signal.
FCG Wave Shape	Specify the wave shape of the command signal. The choices are **True Sine** or **True Ramp**. Typically, you use a True Ramp wave shape where uniform strain-rate sensitivity is important, and a True Sine wave shape where a continually varying strain rate is acceptable because of the higher frequencies of some tests. This MTS template does not support hold times or creep-fatigue crack growth testing.
FCG Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.

Data Storage Parameters Properties

Data Storage Parameters

Parameter	Description
Precrack Save Percent Limit	Specify the percentage of precrack activity that must complete before data is saved to disk.
Store Every Nth Precrack Cycle	Specify the cycle intervals written to disk during the precrack activity.
Crack Size Change Store	Specify the amount of crack length change that will cause data to be stored to disk. Typically, operators will *not* store every cycle, but will only store data when the crack grows by a significant amount, such as 0.05 mm.
FCG Lower Least Squares Fit Percentage	Specify the lower load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG Upper Least Squares Fit Percentage	Specify the upper load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG N Cycle Save	Specify the cycle intervals written to disk during the test. Typically, this is more than 10,000.

Test Termination Parameters

Test Termination Parameters

Parameter	Description
FCG Final Crack Limit	Specify the crack size limit that, if exceeded, ends the test.
FCG Crack Growth Rate Limit	Specify the crack growth rate limit that, if exceeded, ends the test.
Outside Crack Growth Limits Allowed	Specify the number of times the **FCG Crack Growth Rate Limit** can trip before the MPE application ends the test.
FCG Cycle Limit	Specify the maximum number of cycles to run before the test ends. This parameter is not used for FCG DCPD tests.
Shut Down Station at End of Test	Select **Yes** to cause an interlock at the end of the test. This can shut down hydraulics, if desired.

Assign Precrack Values

Specify these parameters if the specimen was precracked on another load frame. When the precrack parameters are specified here, you can then skip **Precrack Specimen** in the Main Menu window.

Precrack Parameters

Parameter	Description
Precrack Cycles Completed	Specify the number of precrack cycles completed.
Precrack Final Crack Size	Specify the final crack size calculated from compliance.
Precrack Final P	Specify the final load during precrack.
Precrack P Maximum	Specify the maximum load measured during precrack.
Precrack Final K	Specify the final K during precrack.
Precrack K Maximum	Specify the maximum K value during precrack.
Precrack Comments	Specify any additional comments.

Calculator

Use the Calculator to calculate the load to use for new specimens. You can also use the Calculator to calculate stress intensity (K). Load is calculated from the crack size value and stress intensity (K) value. Stress intensity (K) is calculated from the crack size value and load value.

Typically, you use the Calculator after the crack size is checked. If the crack size check is performed, the Multipurpose Elite application supplies the crack size value for the Calculator. You can also enter a crack size value manually. You must enter the load or stress intensity value manually.

Calculate Load P

Load P Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the load calculation.
Stress Intensity K	Specify the stress intensity (K) value to use in the load calculation.

Calculate Stress Intensity K

Stress Intensity K Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the stress intensity (K) calculation.
Load	Specify the load value to use in the stress intensity (K) calculation.

Run the Test

Setpoint/Span Times for Delta-K Control

MTS-supplied fracture test templates calculate setpoint and span values for those portions of a fracture test that use Delta-K control. For example, the fracture test templates use Delta-K control to pre-crack the specimen, and the Fatigue Crack Growth template can optionally run in Delta-K control mode.

When a fracture test template uses Delta-K control, it calculates and sends out setpoint and span values for Delta-K control at a rate of every 1.0 second to the Series 793 Station Manager application. However, the Station Manager application has default settings for Setpoint/Span Times of 2.0 seconds, which is the time used to ramp the span and setpoint values. When the Setpoint/Span Times in the Station Manager application are slower than the setpoint and span update rate in the fracture test template, the controller may not complete the ramp to a command before the template sends out new span and setpoint corrections for Delta-K control.

Before running a test with an MTS fracture test template, make sure in the Station Manager application that the **Tools > Channel Options > Command Options > Setpoint/Span Times** are set to approximately 0.5 seconds for both **Setpoint** and **Span**.

Caution:

Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Turn On Hydraulic Power

Use the control panel to apply hydraulic power.

1. If the **Interlock** indicator is on, click **Reset** to release system interlocks.

   If the interlock remains on, use the message logs to identify and correct the cause of the interlock.

   Warning:
   Applying hydraulic power can result in sudden actuator motion.

   A moving actuator can injure anyone in its path.

   Always clear the actuator area before applying hydraulic power.

2. Click **Low Power**.

   This action sets the hydraulic power unit to high pressure and the hydraulic service manifold to low pressure.

3. Click **High Power**.

   This action sets the hydraulic service manifold to high pressure.

Perform Crack Size Check

This activity applies a load to the specimen and verifies the crack size and the modulus for tests that use a Crack Opening Displacement (COD) clip gage to measure the crack opening.

1. Click **CSC** on the main menu.
2. Optionally, click **Change Parameters**. These parameters determine how to measure crack size, and how to calculate crack size and modulus.

Crack Size Check Parameters

Parameter	Description
Entered Crack Size	Specify the crack size used to calculate the elastic modulus. The default value is equal to the specimen notch size.
Elastic Modulus	Specify the modulus used for crack size calculations.
Ramp to Percent	Specify the percent of load applied on the specimen in order to check the crack size. The load is ramped from zero to the specified percentage of load. The percentage is based on the last load command.
Ramp Time	Specify the time to ramp to the target load.

1. Click **Measure Crack Size**.
2. Click **Run** on the control panel to start the crack size check. Optionally, if you want to review or

change parameters, click **Return to Main Menu**.

3. When finished with this activity, click **Close**.

Entering DCPD Initial Crack Values

This activity applies a load to the specimen and measures the initial voltage across the specimen crack for DC Potential Drop (DCPD) tests.

1. On the main menu, click **Enter Initial Crack**.
2. Specify the following parameters, and then click **OK**. The parameters determine the load level that is applied and how the voltage is measured.

DCPD Initial Crack Value Parameters

Parameter	Description
DCPD Voltage Option	**On/Off**—Turn the current that is applied to the specimen on and off. **Reverse**—Reverse the current that is applied to the specimen. **Always On**—Do not turn the current Off. This is rarely used with moderns hardware, but is available for older, legacy hardware.
Initial Crack Size	Specify the crack size that was used to perform the voltage-to-crack-size calibration.
Initial Crack Load	Specify the load level at which the voltage is measured.
Use Reference Specimen	This option allows testing without a reference specimen. MTS recommends using a reference specimen. However, this is not always possible.

3. Review the parameters.
   A. Click **Yes** to start with the parameters that are shown.
   B. Click **No** to return to the main menu and to change parameters.
4. Click **Run** on the control panel to start the activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.
5. When the activity is finished, the MPE application returns to the main menu.

Precrack Specimen

1. Click **Precrack** in the Main Menu window.
2. Click **Run** on the control panel to start the precrack activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity has started to run, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.

3. To review the process of the precrack activity, monitor the runtime displays.
4. Typically, the activity stops when a desired precrack parameter is achieved. In this case, review the activity end result, and then click **Close**.
5. Check the precrack results, and if necessary, correct the values.

Run the Fatigue Crack Growth (FCG) Test

1. Click **FCG Test**.
2. Review the parameters.
   A. Click **Yes** to start with the parameters that are shown.
   B. Click **No** to return to the main menu, change parameters, and click FCG Test.
3. Click **Run** on the control panel to start the activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity starts, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
4. To review the process of the test activity, monitor the runtime displays.
5. Typically, the activity stops when a desired test termination parameter is achieved. In this case, review the activity end result, and then click **Close**.

Enter Measured Crack Sizes

The software automatically enters the crack sizes from the end of the precrack activity and the crack sizes from the end of the test. By default, the **Precrack** values are the last series of crack sizes measured during the precrack activity and the **Crack** values are the last series of crack sizes measured during the test. These crack sizes are used during data analysis. Optionally, you can change these values for the test run.

Measured Crack Size Parameters

Parameter	Description
Precrack	Specify the series of crack measurements made at the end of the precrack activity.
Crack	Specify the series of crack measurements made at the end of the test activity.

End Fracture Test

1. When finished with the test run, click **Done** in the Main Menu window.
2. Click **HPU Power Off**.

3. In the Series 793 Station Manager application, set the **Tools > Channel Options > Command Options > Setpoint/Span Times** back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

View Test Results

After the test run completes, you can view the test results.

1. In the Explorer panel, click the name of the test run.
2. Click **Results**.
3. Click on the different tabs to view different types of results.

Fracture Test Results

The Test Results show the following information about the test run:

- **Variable Summary**shows all the parameters and their last values for the test run.
- **Crack Size Check Cycle - Data Acquisition** shows data that was acquired during the crack size check activity.
- **Precrack Command - Data Acquisition**shows data that was acquired during the precrack activity.
- **Data Acquisition**shows data that was acquired during the test activity.

The test does not generate any reports. You can generate reports with the results generated during post-test analysis.

Analyze Data

Fatigue Crack Growth Analysis Definition

The template is preconfigured with an analysis definition that conforms to the analysis portion of the ASTM standard. The analysis definition can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application and contains the following tables and charts.

Analysis Inputs Table

The Analysis Inputs table contains the parameters used for the analysis. In the Display Name column, the FCG da/dN Curve Fit row indicates the Secant or Polynomial fit calculation method. You can make the corrections indicated in the message log by adding or changing the input values. If the variable is an array, the entry is added to the expansion table. Click the + at the left of the row to see a table of entries. Click another row to activate the Refresh All Analysis Views button in the toolbar at the top of the window. When you click that button, the application recalculates the analysis. You can change the calculation method by changing the Value column entry of the FCG da/dN Curve Fit row. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

You can add and change values by typing in the table cell. Click another row to activate the Refresh All Analysis Views button, and click the button. The Modified column becomes filled with a check mark in rows where you specify the value.

Variable Summary Table

The Variable Summary table provides the data output of the test. The table contains the following columns by default:

- Category
- Display Name
- Value
- Unit
- Modified
- Original Value
- Array
- Number of Stored Points
- Calculate
- Calculation

Crack Length, Min/Max K, Load by Cycles Table

The Crack Length, Min/Max K, Load by Cycles table provides values for the cycles in the FCG Cycle Array column. Additional default columns are:

- FCG Crack Size Array (not used for FCG DCPD analysis)
- FCG K Maximum (not used for FCG DCPD analysis)
- FCG K Minimum (not used for FCG DCPD analysis)
- FCG P Max Array (not used for FCG DCPD analysis)
- FCG P Min Array (not used for FCG DCPD analysis)
- FCG COD Voltage Active Array
- FCG Crack Voltage Reference Array

Validity Results Table

The Validity Results table includes the Display Name, Value, Modified Indicator, Original Value, and Calculation. The Display Name includes the validity criteria. The Value and Original Value columns contain indicators that are Yes or No values. The validity of the test results can change because of changes in test values.

da/dN, Delta K by Cycles Table

The da/dN, Delta K by Cycles table lists all data points collected in the Fatigue Crack Growth da/dN array. If no valid points are collected, an error may occur. If data is reduced using the Secant fit method, two valid points are required or an error may occur. If data is reduced using the Polynomial fit method, an error may occur if the number of valid points is less than the two times the polynomial fit number plus 1. The number of valid points is used to calculate the Apparent Delta-K Threshold. Invalid data points are not used in calculations.

The Apparent Threshold calculation can fail:

- The da/DN-Delta K data is not available.
- The Least Square Fit limits are outside the range of the da/dN-Delta K data points.
- The Least Square Fit limits range is a number of valid da/dN-Delta K data points less than two times the polynomial fit number plus 1.

Crack Length, Min/Max K, Load by Cycles Table

The Crack Length, Min/Max K, Load by Cycles table provides values for the cycles in the FCG Cycle Array column. Additional default columns are:

- FCG Crack Size Array
- FCG K Maximum
- FCG K Minimum
- FCG P Max Array
- FCG P Min Array
- FCG COD Voltage Active Array
- FCG Crack Voltage Reference Array

Charts

The charts provide visual indicators of the crack growth rate and the forces that affect the rate.

- The da/dN vs. Delta K chart characterizes the specimen material's resistance to stable crack extension under cyclic loading.
- The Load vs. Cycle chart indicates the load range between the minimum and maximum values during the last or other specified cycle.
- The Crack Opening Displacement vs. Cycle chart indicates the minimum and maximum crack opening displacement during the last or other specified cycle.
- The Crack Size vs. Cycles chart indicates the crack growth during a number of cycles.
- The K vs. Cycles chart indicates the stress intensity factor, K, between its minimum and

maximum amount during a number of cycles.

- The Delta K vs. Array chart indicates the FCG Delta K Applied Array versus the FCG Crack Size Array.

Analyze the Test Runs

Each test that you create from an MTS template contains a default analysis definition that can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application.

To analyze the test runs, use one of the following methods to open the test in one of the Analyzer applications:

- From either the Fatigue Analyzer or Fracture Analyzer application, click **File > Open Test** and select the test that you want to analyze.
- Open the test in the Multipurpose Elite application and on the **Tools** menu, click **Fatigue Analyzer** or **Fracture Analyzer**.

  The selected Analyzer application opens the test.

For more information

See the *Fatigue Analyzer User Guide* for information on how to create an analysis run.

JIC Fracture Toughness Template

Set Up the Test

JIC Fracture Toughness Template

The MTS ASTM E 1820 JIC template complies with ASTM E-1820-08 for determining the fracture toughness (JIC) value of materials.

The JIC template provides all the components you need to run a test, analyze the test data, and create reports of the results.

Control modes

The template guides you through the steps of running a test and provides all the software components you need to run a test in one of two control modes:

- Crack opening displacement (COD)—The test uses a COD gage signal to provide control feedback.
- Displacement—The test uses a displacement transducer signal to provide control feedback.

Features

The main features of the JIC template are listed below:

- The main template window guides you through setting up all test parameters, performing crack size checks, precracking the specimen, and running the test.
- As the test runs, you can stop the test to change test parameters.
- Comprehensive runtime views help you monitor test progress.
- Tabular and graphical displays make it easy to review test results.
- Analysis definitions provide all necessary analysis calculations and views to analyze test runs.
- You can modify the analysis method and reapply the calculations to the data.
- Report templates help you generate reports for analysis runs.

Set Up a Test

To create and run a new test:

1. Create a new test from a template.
    A. Click **File > New > Test from Template**.
    B. In the Create from Existing Test window, select a test.
    C. Click **OK**.

    The new test is automatically created and assigned a default name. You can change the name and enter comments about the new test by clicking the **Edit** button and making the changes.

2. Create a new test run.
    A. Click **New Test Run** button.
    B. Select a specimen from the Select a Specimen window and then click **OK**.

       To create a new specimen click **Add a new item**.
    C. Review the variables in the Setup Variables window, modify values as necessary, and then click **OK**.
3. Apply hydraulic power to the system.
    A. Reset the interlocks if needed.
    B. Click the **Low**, then **High**, power buttons.
4. In the MTS TestSuite Custom Message window for the template, click the buttons to define test parameters, perform setup tasks, and run tests.
5. When prompted, click **Run** to run the test.

Define Test Parameters

Test Parameters

After a new test run is added to the test, the Main Menu window appears. This window provides access to all necessary test parameters. Click the parameter buttons in the Main Menu window to specify parameter values for the test.

Precrack Parameters

Precrack Parameters

Parameter	Description
Precrack Final Crack Limit	Specify the desired crack size to achieve in the precrack activity. When the specified crack size is achieved, the activity stops.
Precrack Frequency	Specify the cycle frequency of the command signal for the precrack activity.
Precrack Load Ratio	Specify the ratio of the minimum to maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
Precrack Lower Least Squares Fit Percentage	Specify the percentage of the measured load range used as the lower limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.
Precrack Upper Least Squares Fit	Specify the percentage of the measured load range used as the upper limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.

Parameter	Description
Percentage	
Precrack Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. The load is applied at this level to ensure the crack is open. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.
Precrack Cycle Limit	Specify the number of cycles at which precrack activity stops.
Precrack Final Maximum K	Specify the maximum stress intensity desired at the end of precrack activity. The initial precrack Maximum K is 1.4 times the Final Maximum K value.
Shutdown Station at End of Precrack	Select **Yes** to cause an interlock at the end of precrack. This can shut down hydraulics, if desired.

JIC Parameters

In the JIC Parameters section of the main menu, you select COD or Displacement as the control mode for the test, and then specify the parameters for the selected mode.

COD Mode Parameters

Parameter	Description
JIC Absolute Unload	Specify the amount of force, in force units, to unload in both the unload and reload segments.
JIC COD Increment	Specify the COD increment that will be added to the current COD level at the beginning of each ramp segment to determine a maximum COD for this step. If the maximum COD is reached before the maximum displacement or load level is reached, it triggers the next segment of the step.
JIC Crack Propagation Hold Time	Specify the length of time to hold at constant COD or Displacement in the hold crack propagation activity. If this time is zero, the hold crack propagation activity is bypassed.
JIC Frame Stiffness	Specify the inverse of the compliance of the test system. This term is used to determine the displacement due to load frame deflection and the deformation of fixtures. The resulting displacement is subtracted from the measured displacement when calculating the energy absorbed by the specimen. This is particularly important when using SE(B) specimens.
JIC Load Ramp Rate	Specify the ramp rate for the initial ramp segment when it is done in load control.
JIC Number	Specify the number of unload and reload segment pairs to perform in each step

Parameter	Description
of Unloads	increment of the JIC test.
JIC Percent of Final Precrack Load	Specify the percentage of the load of the final precrack cycle to use as the load for the end of the first ramp segment.
JIC Percent Unload	Specify the amount of force to unload as a percentage of the increment peak load.
JIC Ramp Displacement Limit Increment	Specify a value other than zero to apply a displacement limit during the ramp segment of a JIC step. The limit trips if the measured displacement exceeds the specified limit value during the ramp segment of a step. When the limit trips, the JIC step immediately switches to the hold segment of the JIC step.
JIC Ramp Load Limit Increment	Specify a value other than zero to apply a load limit during the ramp segment of a JIC step. The limit trips if the measured load exceeds the specified limit value during the ramp segment of a step. When the limit trips, the JIC step immediately switches to the hold segment of the JIC step.
JIC Ramp Rate	Specify the rate for the ramp segment of the JIC step.
JIC Reload Rate	Specify the rate at which the system reloads the specimen to the load value at the beginning of the first unload segment in each step increment. If the ramp rate is invalid for the specimen being tested, the application corrects the value of the ramp rate when you click **Run** to start the test.
JIC Unload Method	Specify the method for determining the amount of force to apply in both the unload and reload segments: • **Absolute**—Specify that the amount force to apply is in absolute terms. • **Percentage**—Specify that the amount of force to apply is a percentage of the increment peak load. • **Minimum of absolute and percentage**—Specify that the amount force to apply is the smaller resulting value of the two methods above.
JIC Unload Rate	Specify the rate at which the system unloads the specimen in the unload segments in each step increment. If the ramp rate is invalid for the specimen being tested, the application corrects the value of the ramp rate when you click **Run** to start the test.

Displacement Mode Parameters

Parameter	Description
JIC Absolute Unload	Specify the amount of force, in force units, to unload in both the unload and reload segments.
JIC Displacement Increment	Specify the displacement increment added to the current displacement level at the beginning of each ramp segment to determine a maximum displacement for this step. If the maximum displacement is reached before the maximum COD or load level is reached, it triggers the next segment of the step.
JIC Crack Propagation Hold Time	Specify the length of time to hold at constant COD or Displacement in the hold crack propagation activity. If this time is zero, the hold crack propagation activity is bypassed.
JIC Frame Stiffness	Specify the inverse of the compliance of the test system. This term is used to determine the displacement due to load frame deflection and the deformation of fixtures. The resulting displacement is subtracted from the measured displacement when calculating the energy absorbed by the specimen. This is particularly important when using SE(B) specimens.
JIC Load Ramp Rate	Specify the ramp rate for the initial ramp segment when it is done in load control.
JIC Number Of Unloads	Specify the number of unload and reload segment pairs to perform in each step increment of the JIC test.
JIC Percent Of Final Precrack Load	Specify the percentage of the load of the final precrack cycle to use as the load for the end of the first ramp segment.
JIC Percent Unload	Specify the amount of force to unload as a percentage of the increment peak load.
JIC Ramp COD Limit Increment	Specify a value other than zero to apply a COD limit during the ramp segment of a JIC step. The limit trips if the measured COD exceeds the specified limit value during the ramp segment of a step. When the limit trips, the JIC step immediately switches to the hold segment of the JIC step.
JIC Ramp Load Limit Increment	Specify a value other than zero to apply a load limit during the ramp segment of a JIC step. The limit trips if the measured load exceeds the specified limit value during the ramp segment of a step. When the limit trips, the JIC step immediately switches to the hold segment of the JIC step.
JIC Ramp Rate	Specify the rate for the ramp segment of the JIC step.
JIC Reload Rate	Specify the rate at which the system reloads the specimen to the load value at the beginning of the first unload segment in each step increment. If the ramp rate is

Parameter	Description
	invalid for the specimen being tested, the application corrects the value of the ramp rate when you click **Run** to start the test.
JIC Unload Method	Specify the method for determining the amount of force to apply in both the unload and reload segments: • **Absolute**—Specify that the amount force to apply is in absolute terms. • **Percentage**—Specify that the amount of force to apply is a percentage of the increment peak load. • **Minimum of absolute and percentage**—Specify that the amount force to apply is the smaller resulting value of the two methods above.
JIC Unload Rate	Specify the rate at which the system unloads the specimen in the unload segments in each step increment. If the ramp rate is invalid for the specimen being tested, the application corrects the value of the ramp rate when you click **Run** to start the test.

Data Storage Parameters Properties

Data Storage Parameters

Parameter	Description
Precrack Save Percent Limit	Specify the percentage of precrack activity that must complete before data is saved to disk.
Store Every Nth Precrack Cycle	Specify the cycle intervals written to disk during the precrack activity.
Crack Size Change Store	Specify the amount of crack length change that will cause data to be stored to disk. Typically, operators will *not* store every cycle, but will only store data when the crack grows by a significant amount, such as 0.05 mm.
FCG Lower Least Squares Fit Percentage	Specify the lower load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG Upper Least Squares Fit Percentage	Specify the upper load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG N Cycle Save	Specify the cycle intervals written to disk during the test. Typically, this is more than 10,000.

Test Termination Parameters

Test Termination Parameters

Parameter	Description
JIC Maximum Load	Specify the load that, if reached, stops the test.
JIC Maximum COD	Specify the Crack Opening Displacement that, if reached, stops the test.
JIC Maximum Displacement	Specify the displacement that, if reached, stops the test.
JIC Maximum Crack Size	Specify the crack size that, if reached, stops the test.
JIC Maximum Crack Extension	Specify the crack extension that, if reached, stops the test.

Assign Precrack Values

Specify these parameters if the specimen was precracked on another load frame. When the precrack parameters are specified here, you can then skip **Precrack Specimen** in the Main Menu window.

Precrack Parameters

Parameter	Description
Precrack Cycles Completed	Specify the number of precrack cycles completed.
Precrack Final Crack Size	Specify the final crack size calculated from compliance.
Precrack Final P	Specify the final load during precrack.
Precrack P Maximum	Specify the maximum load measured during precrack.
Precrack Final K	Specify the final K during precrack.
Precrack K Maximum	Specify the maximum K value during precrack.
Precrack Comments	Specify any additional comments.

Calculator

Use the Calculator to calculate the load to use for new specimens. You can also use the Calculator to calculate stress intensity (K). Load is calculated from the crack size value and stress intensity (K) value. Stress intensity (K) is calculated from the crack size value and load value.

Typically, you use the Calculator after the crack size is checked. If the crack size check is performed, the Multipurpose Elite application supplies the crack size value for the Calculator. You can also enter a crack size value manually. You must enter the load or stress intensity value manually.

Calculate Load P

Load P Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the load calculation.
Stress Intensity K	Specify the stress intensity (K) value to use in the load calculation.

Calculate Stress Intensity K

Stress Intensity K Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the stress intensity (K) calculation.
Load	Specify the load value to use in the stress intensity (K) calculation.

Run the Test

Setpoint/Span Times for Delta-K Control

MTS-supplied fracture test templates calculate setpoint and span values for those portions of a fracture test that use Delta-K control. For example, the fracture test templates use Delta-K control to pre-crack the specimen, and the Fatigue Crack Growth template can optionally run in Delta-K control mode.

When a fracture test template uses Delta-K control, it calculates and sends out setpoint and span values for Delta-K control at a rate of every 1.0 second to the Series 793 Station Manager application. However, the Station Manager application has default settings for Setpoint/Span Times of 2.0 seconds, which is the time used to ramp the span and setpoint values. When the Setpoint/Span Times in the Station Manager application are slower than the setpoint and span update rate in the fracture test template, the controller may not complete the ramp to a command before the template sends out new span and setpoint corrections for Delta-K control.

Before running a test with an MTS fracture test template, make sure in the Station Manager application that the **Tools > Channel Options > Command Options > Setpoint/Span Times** are set to approximately 0.5 seconds for both **Setpoint** and **Span**.

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Turn On Hydraulic Power

Use the control panel to apply hydraulic power.

1. If the **Interlock** indicator is on, click **Reset** to release system interlocks.

   If the interlock remains on, use the message logs to identify and correct the cause of the interlock.

   Warning:
   Applying hydraulic power can result in sudden actuator motion.

   A moving actuator can injure anyone in its path.

   Always clear the actuator area before applying hydraulic power.

2. Click **Low Power**.

   This action sets the hydraulic power unit to high pressure and the hydraulic service manifold to low pressure.

3. Click **High Power**.

   This action sets the hydraulic service manifold to high pressure.

Perform Crack Size Check

This activity applies a load to the specimen and verifies the crack size and the modulus for tests that use a Crack Opening Displacement (COD) clip gage to measure the crack opening.

1. Click **CSC** on the main menu.
2. Optionally, click **Change Parameters**. These parameters determine how to measure crack size, and how to calculate crack size and modulus.

Crack Size Check Parameters

Parameter	Description
Entered Crack Size	Specify the crack size used to calculate the elastic modulus. The default value is equal to the specimen notch size.
Elastic Modulus	Specify the modulus used for crack size calculations.
Ramp to Percent	Specify the percent of load applied on the specimen in order to check the crack size. The load is ramped from zero to the specified percentage of load. The percentage is based on the last load command.

Parameter	Description
Ramp Time	Specify the time to ramp to the target load.

1. Click **Measure Crack Size**.
2. Click **Run** on the control panel to start the crack size check. Optionally, if you want to review or change parameters, click **Return to Main Menu**.
3. When finished with this activity, click **Close**.

Precrack Specimen

1. Click **Precrack** in the Main Menu window.
2. Click **Run** on the control panel to start the precrack activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity has started to run, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
3. To review the process of the precrack activity, monitor the runtime displays.
4. Typically, the activity stops when a desired precrack parameter is achieved. In this case, review the activity end result, and then click **Close**.
5. Check the precrack results, and if necessary, correct the values.

Run JIC Fracture Toughness Test

1. Perform the crack size check at least three times after precracking the specimen.

   This must be done to run the JIC test.
2. Click **JIC Test**.
3. Click **Run** on the control panel to start the test activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity starts, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero command and saves the test data.
4. Review the process of the test activity by monitoring the runtime displays.
   - Monitor Axial Force, Axial COD, Axial Displacement values.
   - Monitor Axial Force versus Time plot.
   - Review Summary table.
   - Review Statistics table.

5. Typically, the activity stops when a desired test termination parameter is achieved. In this case, review the activity end result, and then click **Close**.

Enter Measured Crack Sizes

The software automatically enters the crack sizes from the end of the precrack activity and the crack sizes from the end of the test. By default, the **Precrack** values are the last series of crack sizes measured during the precrack activity and the **Crack** values are the last series of crack sizes measured during the test. These crack sizes are used during data analysis. Optionally, you can change these values for the test run.

Measured Crack Size Parameters

Parameter	Description
Precrack	Specify the series of crack measurements made at the end of the precrack activity.
Crack	Specify the series of crack measurements made at the end of the test activity.

Fatigue to Fracture

When the test completes, you need to "mark" the final crack length. One method to do this is to fatigue the specimen.

1. Click **Fatigue to Fracture** on the main prompt menu.
2. Review the fatigue to fracture parameters and click **OK**.
3. Click **Run** on the control panel.
4. After about 10 minutes, click **Stop** on the control panel.
5. Click **Fatigue to Fracture** on the main prompt menu.
6. Enter a Max Load value of about 20% greater than the previous value, and then click **OK**.
7. Click **Run** on the control panel.
8. Repeat steps 4 through 7 until the specimen breaks.

End Fracture Test

1. When finished with the test run, click **Done** in the Main Menu window.
2. Click **HPU Power Off**.
3. In the Series 793 Station Manager application, set the **Tools > Channel Options > Command Options > Setpoint/Span Times** back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

View Test Results

After the test run completes, you can view the test results.

1. In the Explorer panel, click the name of the test run.
2. Click **Results**.
3. Click on the different tabs to view different types of results.

Fracture Test Results

The Test Results show the following information about the test run:

- **Variable Summary**shows all the parameters and their last values for the test run.
- **Crack Size Check Cycle - Data Acquisition** shows data that was acquired during the crack size check activity.
- **Precrack Command - Data Acquisition**shows data that was acquired during the precrack activity.
- **Data Acquisition**shows data that was acquired during the test activity.

The test does not generate any reports. You can generate reports with the results generated during post-test analysis.

Analyze Data

JIC Fracture Toughness Analysis Definition

The template is preconfigured with an analysis definition that conforms to the analysis portion of the ASTM standard. The analysis definition can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application and contains the following tables and charts.

Analysis Inputs Table

The Analysis Inputs table contains the parameters used for the analysis. You can make the corrections indicated in the message log by adding or changing the input values. If the variable is an array, the entry is added to the expansion table. Click the + at the left of the row to see a table of entries. Click another row to activate the Refresh All Analysis Views button in the toolbar at the top of the window. When you click that button, the application recalculates the analysis. You can change the calculation method. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

You can add and change values by typing in the table cell. Click another row to activate the Refresh All Analysis Views button and click the button. The Modified column becomes filled with a check mark in rows where you specify the value.

Variable Table

The Variable table provides the final values of the variables defined in the Variable Editor. You can change one or more values in this table and rerun the calculations in the same way described for the Analysis Inputs table. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

Validity Results Table

The Validity Results table includes the Display Name, Value, Modified Indicator, Original Value, and Calculation. The Display Name includes the validity criteria. The Value and Original Value columns contain indicators that are Yes or No values. The validity of the test results can change because of changes in test values.

Step Validity Table

The Step Validity table provides for each test the step data values and validity results. The table includes the J Delta a(p), J Exclusion, J MinMax, CTOD Delta a(p), CTOD Exclusion, CTOD MinMax, and CTOD Step arrays.

Channels by Step Table

The Channels by Step table lists all data points collected in arrays:

- Segment Type Array
- Complete Load Data
- Complete COD Data
- Complete Displacement Data
- Complete JIC Step Array

Charts

The charts provide visual indicators of the data reported in the tables.

- The Crack Sizes vs. Steps chart indicates as a curve how the crack grows during the load steps.
- The Load vs. Time chart indicates changes in the load during the test.
- The Displacement vs. Time chart indicates changes in the displacement during the test.
- The Load vs. Load Line Displacement chart indicates changes in the load as the load line displacement changes.
- The Load vs. COD chart indicates how the load changes as the load crack opening displacement gage reading changes during the test.
- The Ramp Hold Load vs. Ramp Hold COD chart indicates how the load changes as the crack opening displacement gage reading changes during the ramp-and-hold steps.
- The J vs. Delta a(p) chart indicates the J-integral value at each point of physical crack

extension.

- The CTOD vs. Delta a(p) chart indicates the crack tip opening displacement value at each point of physical crack extension.

Analyze the Test Runs

Each test that you create from an MTS template contains a default analysis definition that can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application.

To analyze the test runs, use one of the following methods to open the test in one of the Analyzer applications:

- From either the Fatigue Analyzer or Fracture Analyzer application, click **File > Open Test** and select the test that you want to analyze.
- Open the test in the Multipurpose Elite application and on the **Tools** menu, click **Fatigue Analyzer** or **Fracture Analyzer**.

  The selected Analyzer application opens the test.

For more information

See the *Fatigue Analyzer User Guide* for information on how to create an analysis run.

KIC Fracture Toughness Template

Set Up the Test

KIC Template

The MTS ASTM E 399 KIC template complies with ASTM E 399 for determining the fracture toughness (KIC) value of materials.

The KIC template provides all the components you need to run a test, analyze the test data, and create reports of the results.

Control modes

The template guides you through the steps of running a test and provides all the software components you need to run a test in one of two control modes:

- Crack opening displacement (COD)—The test uses a COD gage signal to provide control feedback.
- Displacement—The test uses a displacement transducer signal to provide control feedback.

Features

The main features of the KIC template are listed below:

- The main template window guides you through setting up all test parameters, performing crack size checks, precracking the specimen, and running the KIC test.
- As the test runs, you can stop the test to change test parameters.
- Comprehensive runtime views help you monitor test progress.
- Tabular and graphical displays make it easy to review test results.
- Analysis definitions provide all necessary analysis calculations and views to analyze test runs.
- You can modify the analysis method and reapply the calculations to the data.
- Report templates help you generate reports for analysis runs.

Set Up a Test

To create and run a new test:

1. Create a new test from a template.
    A. Click **File > New > Test from Template**.
    B. In the Create from Existing Test window, select a test.
    C. Click **OK**.

    The new test is automatically created and assigned a default name. You can change the name and enter comments about the new test by clicking the **Edit** button and making the changes.

2. Create a new test run.
    A. Click **New Test Run** button.
    B. Select a specimen from the Select a Specimen window and then click **OK**.

       To create a new specimen click **Add a new item**.
    C. Review the variables in the Setup Variables window, modify values as necessary, and then click **OK**.
3. Apply hydraulic power to the system.
    A. Reset the interlocks if needed.
    B. Click the **Low**, then **High**, power buttons.
4. In the MTS TestSuite Custom Message window for the template, click the buttons to define test parameters, perform setup tasks, and run tests.
5. When prompted, click **Run** to run the test.

Define Test Parameters

Test Parameters

After a new test run is added to the test, the Main Menu window appears. This window provides access to all necessary test parameters. Click the parameter buttons in the Main Menu window to specify parameter values for the test.

Precrack Parameters

Precrack Parameters

Parameter	Description
Precrack Final Crack Limit	Specify the desired crack size to achieve in the precrack activity. When the specified crack size is achieved, the activity stops.
Precrack Frequency	Specify the cycle frequency of the command signal for the precrack activity.
Precrack Load Ratio	Specify the ratio of the minimum to maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
Precrack Lower Least Squares Fit Percentage	Specify the percentage of the measured load range used as the lower limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.
Precrack Upper Least Squares Fit	Specify the percentage of the measured load range used as the upper limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.

Parameter	Description
Percentage	
Precrack Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. The load is applied at this level to ensure the crack is open. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.
Precrack Cycle Limit	Specify the number of cycles at which precrack activity stops.
Precrack Final Maximum K	Specify the maximum stress intensity desired at the end of precrack activity. The initial precrack Maximum K is 1.4 times the Final Maximum K value.
Shutdown Station at End of Precrack	Select **Yes** to cause an interlock at the end of precrack. This can shut down hydraulics, if desired.

KIC Parameters

In the KIC Parameters section of the main menu, you specify the **KIC Force Ramp Rate**, which is the rate for the ramp segment of the KIC step.

Data Storage Parameters Properties

Data Storage Parameters

Parameter	Description
Precrack Save Percent Limit	Specify the percentage of precrack activity that must complete before data is saved to disk.
Store Every Nth Precrack Cycle	Specify the cycle intervals written to disk during the precrack activity.
Crack Size Change Store	Specify the amount of crack length change that will cause data to be stored to disk. Typically, operators will *not* store every cycle, but will only store data when the crack grows by a significant amount, such as 0.05 mm.

Parameter	Description
FCG Lower Least Squares Fit Percentage	Specify the lower load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG Upper Least Squares Fit Percentage	Specify the upper load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG N Cycle Save	Specify the cycle intervals written to disk during the test. Typically, this is more than 10,000.

Test Termination Parameters

Test Termination Parameters

Parameter	Description
COD Limit	Specify **Yes** to end the test when the COD limit is reached.
Load Limit	Specify **Yes** to end the test when the load limit is reached.
Displacement Limit	Specify **Yes** to end the test when the displacement limit is reached.

Assign Precrack Values

Specify these parameters if the specimen was precracked on another load frame. When the precrack parameters are specified here, you can then skip **Precrack Specimen** in the Main Menu window.

Precrack Parameters

Parameter	Description
Precrack Cycles Completed	Specify the number of precrack cycles completed.
Precrack Final Crack Size	Specify the final crack size calculated from compliance.
Precrack Final P	Specify the final load during precrack.
Precrack P Maximum	Specify the maximum load measured during precrack.
Precrack Final K	Specify the final K during precrack.
Precrack K Maximum	Specify the maximum K value during precrack.
Precrack Comments	Specify any additional comments.

Calculator

Use the Calculator to calculate the load to use for new specimens. You can also use the Calculator to calculate stress intensity (K). Load is calculated from the crack size value and stress intensity (K) value. Stress intensity (K) is calculated from the crack size value and load value.

Typically, you use the Calculator after the crack size is checked. If the crack size check is performed, the Multipurpose Elite application supplies the crack size value for the Calculator. You can also enter a crack size value manually. You must enter the load or stress intensity value manually.

Calculate Load P

Load P Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the load calculation.
Stress Intensity K	Specify the stress intensity (K) value to use in the load calculation.

Calculate Stress Intensity K

Stress Intensity K Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the stress intensity (K) calculation.
Load	Specify the load value to use in the stress intensity (K) calculation.

Run the Test

Setpoint/Span Times for Delta-K Control

MTS-supplied fracture test templates calculate setpoint and span values for those portions of a fracture test that use Delta-K control. For example, the fracture test templates use Delta-K control to pre-crack the specimen, and the Fatigue Crack Growth template can optionally run in Delta-K control mode.

When a fracture test template uses Delta-K control, it calculates and sends out setpoint and span values for Delta-K control at a rate of every 1.0 second to the Series 793 Station Manager application. However, the Station Manager application has default settings for Setpoint/Span Times of 2.0 seconds, which is the time used to ramp the span and setpoint values. When the Setpoint/Span Times in the Station Manager application are slower than the setpoint and span update rate in the fracture test template, the controller may not complete the ramp to a command before the template sends out new span and setpoint corrections for Delta-K control.

Before running a test with an MTS fracture test template, make sure in the Station Manager application that the **Tools > Channel Options > Command Options > Setpoint/Span Times** are set to approximately 0.5 seconds for both **Setpoint** and **Span**.

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Turn On Hydraulic Power

Use the control panel to apply hydraulic power.

1. If the **Interlock** indicator is on, click **Reset** to release system interlocks.

   If the interlock remains on, use the message logs to identify and correct the cause of the interlock.

   Warning:
   Applying hydraulic power can result in sudden actuator motion.

   A moving actuator can injure anyone in its path.

   Always clear the actuator area before applying hydraulic power.

2. Click **Low Power**.

   This action sets the hydraulic power unit to high pressure and the hydraulic service manifold to low pressure.

3. Click **High Power**.

   This action sets the hydraulic service manifold to high pressure.

Perform Crack Size Check

This activity applies a load to the specimen and verifies the crack size and the modulus for tests that use a Crack Opening Displacement (COD) clip gage to measure the crack opening.

1. Click **CSC** on the main menu.
2. Optionally, click **Change Parameters**. These parameters determine how to measure crack size, and how to calculate crack size and modulus.

Crack Size Check Parameters

Parameter	Description
Entered Crack Size	Specify the crack size used to calculate the elastic modulus. The default value is equal to the specimen notch size.
Elastic Modulus	Specify the modulus used for crack size calculations.
Ramp to Percent	Specify the percent of load applied on the specimen in order to check the crack size. The load is ramped from zero to the specified percentage of load. The percentage is based on the last load command.
Ramp Time	Specify the time to ramp to the target load.

1. Click **Measure Crack Size**.
2. Click **Run** on the control panel to start the crack size check. Optionally, if you want to review or change parameters, click **Return to Main Menu**.
3. When finished with this activity, click **Close**.

Precrack Specimen

1. Click **Precrack** in the Main Menu window.
2. Click **Run** on the control panel to start the precrack activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity has started to run, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
3. To review the process of the precrack activity, monitor the runtime displays.
4. Typically, the activity stops when a desired precrack parameter is achieved. In this case, review the activity end result, and then click **Close**.
5. Check the precrack results, and if necessary, correct the values.

Run the KIC Fracture Toughness Test

1. Click **KIC Test**.
2. Review the parameters.
   A. Click **Yes** to start with the parameters that are shown.
   B. Click **No** to return to the main menu, change parameters, and click **KIC Test**.

3. Click **Run** on the control panel to start the activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity starts, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.

4. Review the process of the test activity by monitoring the runtime displays.
   - On the KIC Test tab, monitor Force versus COD plot.
   - On the KIC Data tab, monitor Time, Force, COD, and Displacement values in the array table.

5. Typically, the activity stops when a desired test termination parameter is achieved. In this case, review the activity end result, and then click **Close**.

Enter Measured Crack Sizes

The software automatically enters the crack sizes from the end of the precrack activity and the crack sizes from the end of the test. By default, the **Precrack** values are the last series of crack sizes measured during the precrack activity and the **Crack** values are the last series of crack sizes measured during the test. These crack sizes are used during data analysis. Optionally, you can change these values for the test run.

Measured Crack Size Parameters

Parameter	Description
Precrack	Specify the series of crack measurements made at the end of the precrack activity.
Crack	Specify the series of crack measurements made at the end of the test activity.

End Fracture Test

1. When finished with the test run, click **Done** in the Main Menu window.
2. Click **HPU Power Off**.
3. In the Series 793 Station Manager application, set the **Tools > Channel Options > Command Options > Setpoint/Span Times** back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

View Test Results

After the test run completes, you can view the test results.

1. In the Explorer panel, click the name of the test run.
2. Click **Results**.
3. Click on the different tabs to view different types of results.

Fracture Test Results

The Test Results show the following information about the test run:

- **Variable Summary**shows all the parameters and their last values for the test run.
- **Crack Size Check Cycle - Data Acquisition** shows data that was acquired during the crack size check activity.
- **Precrack Command - Data Acquisition**shows data that was acquired during the precrack activity.
- **Data Acquisition**shows data that was acquired during the test activity.

The test does not generate any reports. You can generate reports with the results generated during post-test analysis.

Analyze Data

KIC Fracture Toughness Analysis Definitions

The template is preconfigured with an analysis definition that conforms to the analysis portion of the ASTM standard. The analysis definition can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application and contains the following tables and charts.

Analysis Inputs Table

The Analysis Inputs table contains the parameters used for the analysis. You can make the corrections indicated in the message log by adding or changing the input values. If the variable is an array, the entry is added to the expansion table. Click the + at the left of the row to see a table of entries. Click another row to activate the Refresh All Analysis Views button in the toolbar at the top of the window. When you click that button, the application recalculates the analysis. You can change the calculation method. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

You can add and change values by typing in the table cell. Click another row to activate the Refresh All Analysis Views button and click the button. The Modified column becomes filled with a check mark in rows where you specify the value.

Test Summary Table

The Test Summary table provides the final values of the variables defined in the Variable Editor. You can change one or more values in this table and rerun the calculations in the same way described for the Analysis Inputs table. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

Validity Results Table

The Validity Results table includes the Display Name, Value, Modified Indicator, Original Value, and Calculation. The Display Name includes the validity criteria. The Value and Original Value columns contain indicators that are Yes or No values. The validity of the test results can change because of changes in test values.

K-R Curve

The K-R Curve table provides per-cycle data. If the specimen is a Single Edge (Bend) type, the table does not receive data. The table includes:

- Load Intercept
- COD Intercept
- Effective Stress Intensity
- Physical Stress Intensity
- Net Section Stress
- Validity

Channels by Time

The Channels by Time table lists all data points collected in arrays:

- KIC Time Array
- KIC Load Array
- KIC Crack Opening Displacement Inverted Array
- Displacement Inverted Array

Charts

The charts provide visual indicators of the data reported in the tables.

- The Load vs. Time chart indicates changes in the load during the test.
- The COD vs. Time chart indicates changes in the crack opening displacement during the test.
- The Displacement vs. Time chart indicates changes in the displacement during the test.
- The Load vs. COD chart indicates how the load changes as the load crack opening displacement gage reading changes during the test. This chart shows pop-ins, if any occur in

the test.

- The K-R Curve chart indicates the valid and invalid stress intensity data points.

Analyze the Test Runs

Each test that you create from an MTS template contains a default analysis definition that can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application.

To analyze the test runs, use one of the following methods to open the test in one of the Analyzer applications:

- From either the Fatigue Analyzer or Fracture Analyzer application, click **File > Open Test** and select the test that you want to analyze.
- Open the test in the Multipurpose Elite application and on the **Tools** menu, click **Fatigue Analyzer** or **Fracture Analyzer**.

  The selected Analyzer application opens the test.

For more information

See the *Fatigue Analyzer User Guide* for information on how to create an analysis run.

Run the CTOD Fracture Toughness Test

Set Up the Test

CTOD Fracture Toughness Template

The MTS ASTM E1290 CTOD template complies with ASTM E 1290 - 07 for determining the fracture toughness value of materials.

The CTOD template provides all the components you need to run a test, analyze the test data, and create reports of the results.

Control modes

The template guides you through the steps of running a test and provides all the software components you need to run a test in one of two control modes:

- Crack opening displacement (COD)—The test uses a COD gage signal to provide control feedback.
- Displacement—The test uses a displacement transducer signal to provide control feedback.

Features

The main features of the CTOD template are listed below:

- The main template window guides you through setting up all test parameters, performing crack size checks, precracking the specimen, and running the test.
- As the test runs, you can stop the test to change test parameters.
- Comprehensive runtime views help you monitor test progress.
- Tabular and graphical displays make it easy to review test results.
- Analysis definitions provide all necessary analysis calculations and views to analyze test runs.
- You can modify the analysis method and reapply the calculations to the data.
- Report templates help you generate reports for analysis runs.

Set Up a Test

To create and run a new test:

1. Create a new test from a template.
    A. Click **File > New > Test from Template**.
    B. In the Create from Existing Test window, select a test.
    C. Click **OK**.

    The new test is automatically created and assigned a default name. You can change the name and enter comments about the new test by clicking the **Edit** button and making the changes.

2. Create a new test run.
    A. Click **New Test Run** button.
    B. Select a specimen from the Select a Specimen window and then click **OK**.

       To create a new specimen click **Add a new item**.
    C. Review the variables in the Setup Variables window, modify values as necessary, and then click **OK**.
3. Apply hydraulic power to the system.
    A. Reset the interlocks if needed.
    B. Click the **Low**, then **High**, power buttons.
4. In the MTS TestSuite Custom Message window for the template, click the buttons to define test parameters, perform setup tasks, and run tests.
5. When prompted, click **Run** to run the test.

Define Test Parameters

Test Parameters

After a new test run is added to the test, the Main Menu window appears. This window provides access to all necessary test parameters. Click the parameter buttons in the Main Menu window to specify parameter values for the test.

Precrack Parameters

Precrack Parameters

Parameter	Description
Precrack Final Crack Limit	Specify the desired crack size to achieve in the precrack activity. When the specified crack size is achieved, the activity stops.
Precrack Frequency	Specify the cycle frequency of the command signal for the precrack activity.
Precrack Load Ratio	Specify the ratio of the minimum to maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
Precrack Lower Least Squares Fit Percentage	Specify the percentage of the measured load range used as the lower limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.
Precrack Upper Least Squares Fit	Specify the percentage of the measured load range used as the upper limit for linear least squares fit compliance determination. This parameter is not used for FCG DCPD tests.

Parameter	Description
Percentage	
Precrack Measure Load Level Percent	Specify the percent of maximum load level at which the voltage is measured. The load is applied at this level to ensure the crack is open. All voltage data below this load will not be used to calculate crack length. This parameter is used only for FCG DCPD tests.
Precrack Cycle Limit	Specify the number of cycles at which precrack activity stops.
Precrack Final Maximum K	Specify the maximum stress intensity desired at the end of precrack activity. The initial precrack Maximum K is 1.4 times the Final Maximum K value.
Shutdown Station at End of Precrack	Select **Yes** to cause an interlock at the end of precrack. This can shut down hydraulics, if desired.

CTOD Parameters

In the CTOD Parameters section of the Main menu, you select **COD** or **Displacement** as the **control mode** for the test, and then specify the **Ramp Rate**, which is the rate for the ramp segment of the CTOD step.

Data Storage Parameters Properties

Data Storage Parameters

Parameter	Description
Precrack Save Percent Limit	Specify the percentage of precrack activity that must complete before data is saved to disk.
Store Every Nth Precrack Cycle	Specify the cycle intervals written to disk during the precrack activity.
Crack Size Change Store	Specify the amount of crack length change that will cause data to be stored to disk. Typically, operators will *not* store every cycle, but will only store data when the crack grows by a significant amount, such as 0.05 mm.

Parameter	Description
FCG Lower Least Squares Fit Percentage	Specify the lower load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG Upper Least Squares Fit Percentage	Specify the upper load limit for linear least squares fit compliance used to determine when to start saving data to disk. This parameter is not used for FCG DCPD tests.
FCG N Cycle Save	Specify the cycle intervals written to disk during the test. Typically, this is more than 10,000.

Test Termination Parameters

Test Termination Parameters

Parameter	Description
JIC Maximum Load	Specify the load that, if reached, stops the test.
JIC Maximum COD	Specify the Crack Opening Displacement that, if reached, stops the test.
JIC Maximum Displacement	Specify the displacement that, if reached, stops the test.
JIC Maximum Crack Size	Specify the crack size that, if reached, stops the test.
JIC Maximum Crack Extension	Specify the crack extension that, if reached, stops the test.

Assign Precrack Values

Specify these parameters if the specimen was precracked on another load frame. When the precrack parameters are specified here, you can then skip **Precrack Specimen** in the Main Menu window.

Precrack Parameters

Parameter	Description
Precrack Cycles Completed	Specify the number of precrack cycles completed.
Precrack Final Crack Size	Specify the final crack size calculated from compliance.
Precrack Final P	Specify the final load during precrack.
Precrack P Maximum	Specify the maximum load measured during precrack.

Parameter	Description
Precrack Final K	Specify the final K during precrack.
Precrack K Maximum	Specify the maximum K value during precrack.
Precrack Comments	Specify any additional comments.

Calculator

Use the Calculator to calculate the load to use for new specimens. You can also use the Calculator to calculate stress intensity (K). Load is calculated from the crack size value and stress intensity (K) value. Stress intensity (K) is calculated from the crack size value and load value.

Typically, you use the Calculator after the crack size is checked. If the crack size check is performed, the Multipurpose Elite application supplies the crack size value for the Calculator. You can also enter a crack size value manually. You must enter the load or stress intensity value manually.

Calculate Load P

Load P Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the load calculation.
Stress Intensity K	Specify the stress intensity (K) value to use in the load calculation.

Calculate Stress Intensity K

Stress Intensity K Parameters

Parameter	Description
Crack Size	Specify the crack size value to use in the stress intensity (K) calculation.
Load	Specify the load value to use in the stress intensity (K) calculation.

Run the Test

Setpoint/Span Times for Delta-K Control

MTS-supplied fracture test templates calculate setpoint and span values for those portions of a fracture test that use Delta-K control. For example, the fracture test templates use Delta-K control to pre-crack the specimen, and the Fatigue Crack Growth template can optionally run in Delta-K control mode.

When a fracture test template uses Delta-K control, it calculates and sends out setpoint and span values for Delta-K control at a rate of every 1.0 second to the Series 793 Station Manager application. However, the Station Manager application has default settings for Setpoint/Span Times of 2.0 seconds, which is the time used to ramp the span and setpoint values. When the Setpoint/Span Times in the Station Manager application are slower than the setpoint and span update rate in the fracture test template, the controller may not complete the ramp to a command before the template sends out new span and setpoint corrections for Delta-K control.

Before running a test with an MTS fracture test template, make sure in the Station Manager application that the **Tools > Channel Options > Command Options > Setpoint/Span Times** are set to approximately 0.5 seconds for both **Setpoint** and **Span**.

Caution:
Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

Turn On Hydraulic Power

Use the control panel to apply hydraulic power.

1. If the **Interlock** indicator is on, click **Reset** to release system interlocks.

   If the interlock remains on, use the message logs to identify and correct the cause of the interlock.

   Warning:
   Applying hydraulic power can result in sudden actuator motion.

   A moving actuator can injure anyone in its path.

   Always clear the actuator area before applying hydraulic power.

2. Click **Low Power**.

   This action sets the hydraulic power unit to high pressure and the hydraulic service manifold to low pressure.

3. Click **High Power**.

   This action sets the hydraulic service manifold to high pressure.

Perform Crack Size Check

This activity applies a load to the specimen and verifies the crack size and the modulus for tests that use a Crack Opening Displacement (COD) clip gage to measure the crack opening.

1. Click **CSC** on the main menu.
2. Optionally, click **Change Parameters**. These parameters determine how to measure crack size, and how to calculate crack size and modulus.

Crack Size Check Parameters

Parameter	Description
Entered Crack Size	Specify the crack size used to calculate the elastic modulus. The default value is equal to the specimen notch size.
Elastic Modulus	Specify the modulus used for crack size calculations.
Ramp to Percent	Specify the percent of load applied on the specimen in order to check the crack size. The load is ramped from zero to the specified percentage of load. The percentage is based on the last load command.
Ramp Time	Specify the time to ramp to the target load.

1. Click **Measure Crack Size**.
2. Click **Run** on the control panel to start the crack size check. Optionally, if you want to review or change parameters, click **Return to Main Menu**.
3. When finished with this activity, click **Close**.

Precrack Specimen

1. Click **Precrack** in the Main Menu window.
2. Click **Run** on the control panel to start the precrack activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

   To suspend the activity after the activity has started to run, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

   To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
3. To review the process of the precrack activity, monitor the runtime displays.
4. Typically, the activity stops when a desired precrack parameter is achieved. In this case, review the activity end result, and then click **Close**.
5. Check the precrack results, and if necessary, correct the values.

Run the CTOD Fracture Toughness Test

1. Click **CTOD Test**.
2. Review the parameters.
    A. Click **Yes** to start with the parameters that are shown.
    B. Click **No** to return to the main menu, change parameters, and click **CTOD Test**.
3. Click **Run** on the control panel to start the test activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

    To suspend the activity after the activity starts, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

    To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
4. Review the process of the test activity by monitoring the runtime displays.
    - On the CTOD Test tab, monitor Force versus COD plot.
    - On the CTOD Statistics tab, monitor Time, Force, COD, and Displacement values in the array table.
5. Typically, the activity stops when a desired test termination parameter is achieved. In this case, review the activity end result, and then click **Close**.

Perform Fatigue Crack Mark

1. Click **Crack Size Check** in the Main Menu window.
2. In the Main Menu window, click **Fatigue Crack Mark**.
3. Specify the **Crack Growth Parameters**.

    This test activity uses fatigue crack growth with a constant load control mode.
4. Review the parameters.
    A. Click **Yes** to start with the parameters that are shown.
    B. Click **No** to return to the Main menu, change parameters, and click **Fatigue Crack Mark**.
5. Click **Run** on the control panel to start the test activity. Optionally, if you want to review or change parameters, click **Return to Main Menu**.

    To suspend the activity after it starts, click **Hold**. When you suspend the activity, data collection stops and the application attempts to hold at the mean level.

    To stop the activity, click **Stop**. When you stop the activity, the application immediately ramps to zero load and saves the test data.
6. Review the process of the test activity by monitoring the runtime displays.
7. Typically, the activity will stop when a desired test parameter is achieved. In this case, review the activity end result, and then click **Close**.

Constant Load Control Mode Parameters

Constant Load Control Mode Parameters

Parameter	Description
FCG Load Ratio	Specify the ratio of the minimum-to-maximum load applied to the specimen. The minimum load is determined by this value and the maximum load is specified by you.
FCG End Level 1	Specify the desired end level of the command signal.
FCG Frequency	Specify the cycle frequency of the command signal.
FCG Wave Shape	Specify the wave shape of the command signal. The choices are **True Sine** or **True Ramp**. Typically, you use a True Ramp wave shape where uniform strain-rate sensitivity is important, and a True Sine wave shape where a continually varying strain rate is acceptable because of the higher frequencies of some tests.
FCG Measure Load Level	Specify the voltage that is measured at this load level. This parameter is used only for FCG DCPD tests.

Enter Measured Crack Sizes

The software automatically enters the crack sizes from the end of the precrack activity and the crack sizes from the end of the test. By default, the **Precrack** values are the last series of crack sizes measured during the precrack activity and the **Crack** values are the last series of crack sizes measured during the test. These crack sizes are used during data analysis. Optionally, you can change these values for the test run.

Measured Crack Size Parameters

Parameter	Description
Precrack	Specify the series of crack measurements made at the end of the precrack activity.
Crack	Specify the series of crack measurements made at the end of the test activity.

End Fracture Test

1. When finished with the test run, click **Done** in the Main Menu window.
2. Click **HPU Power Off**.

3. In the Series 793 Station Manager application, set the **Tools > Channel Options > Command Options > Setpoint/Span Times** back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

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Lower **Setpoint/Span Times** in the Series 793 Station Manager application can cause specimen or equipment damage.

Decreasing the **Setpoint/Span Times** default of 2.0 seconds after the test run completes can be too fast for other actuator commands, and can cause specimen or equipment damage.

After the fracture test run has completed, set the **Setpoint/Span Times** in the Station Manager application back to their previous values before you use it to command the actuator for other purposes (for example, for specimen removal or installation).

View Test Results

After the test run completes, you can view the test results.

1. In the Explorer panel, click the name of the test run.
2. Click **Results**.
3. Click on the different tabs to view different types of results.

Fracture Test Results

The Test Results show the following information about the test run:

- **Variable Summary**shows all the parameters and their last values for the test run.
- **Crack Size Check Cycle - Data Acquisition** shows data that was acquired during the crack size check activity.
- **Precrack Command - Data Acquisition**shows data that was acquired during the precrack activity.
- **Data Acquisition**shows data that was acquired during the test activity.

The test does not generate any reports. You can generate reports with the results generated during post-test analysis.

Analyze Data

CTOD Analysis Definition

The template is preconfigured with an analysis definition that conforms to the analysis portion of the ASTM standard. The analysis definition can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application and contains the following tables and charts.

Analysis Inputs Table

The Analysis Inputs table contains the parameters used for the analysis. You can make the corrections indicated in the message log by adding or changing the input values. If the variable is an array, the entry is added to the expansion table. Click the + at the left of the row to see a table of entries. Click another row to activate the Refresh All Analysis Views button in the toolbar at the top of the window. When you click that button, the application recalculates the analysis. You can change the calculation method. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

You can add and change values by typing in the table cell. Click another row to activate the Refresh All Analysis Views button and click the button. The Modified column becomes filled with a check mark in rows where you specify the value.

Test Summary Table

The Test Summary table provides the final values of the variables defined in the Variable Editor. You can change one or more values in this table and rerun the calculations in the same way described for the Analysis Inputs table. After you refresh the values, the ones you modified have check marks in the Modified column. The original test data is not lost and does not change.

Validation Results Table

The Validity Results table includes the Display Name, Value, Modified Indicator, Original Value, and Calculation. The Display Name includes the validity criteria. The Value and Original Value columns contain indicators that are Yes or No values. The validity of the test results can change because of changes in test values.

Pop-Ins CTOD Table

The Pop-Ins CTOD table provides data that corresponds to the pop-ins that are marked in the Pop-Ins Plot. The table includes:

- F(n)
- Pop-In(n)
- Vg(n)
- CTODc(n)
- CTODu(n)
- ap(n)

Channels by Time Table

The Channels by Time table lists all data points collected in arrays:

- Time Array
- Load Array
- CTOD Array
- Displacement Array

Charts

Charts provide visual indicators of the data reported in the tables.

- The Load vs. Time chart indicates changes in the load during the test.
- The COD vs. Time chart indicates changes in the crack opening displacement during the test.
- The Displacement vs. Time chart indicates changes in the displacement during the test.
- The Load vs. COD chart indicates how the load changes as the load crack opening displacement gage reading changes during the test. This chart shows pop-ins, if any occur in the test.
- The Pop-Ins Plot indicates where pop-ins have occurred in a Load vs. COD chart. The Pop-Ins CTOD table provides the actual values of the pop-ins.

Analyze the Test Runs

Each test that you create from an MTS template contains a default analysis definition that can be used to analyze the test run in either the Fatigue Analyzer or Fracture Analyzer application.

To analyze the test runs, use one of the following methods to open the test in one of the Analyzer applications:

- From either the Fatigue Analyzer or Fracture Analyzer application, click **File > Open Test** and select the test that you want to analyze.
- Open the test in the Multipurpose Elite application and on the **Tools** menu, click **Fatigue Analyzer** or **Fracture Analyzer**.

  The selected Analyzer application opens the test.

For more information

See the *Fatigue Analyzer User Guide* for information on how to create an analysis run.

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