Bluehill 2 Calculations Reference

Reference Manual - Software

Help V 2.12 Revision A

The difference is measurable®

Electromagnetic Compatibility

Where applicable, this equipment is designed to comply with International Electromagnetic Compatibility (EMC) standards.

To ensure reproduction of this EMC performance, connect this equipment to a low impedance ground connection. Typical suitable connections are a ground spike or the steel frame of a building.

Proprietary Rights Notice

Trademarks

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General Safety Precautions

Materials testing systems are potentially hazardous.

Materials testing involves inherent hazards from high forces, rapid motions, and stored energy. You must be aware of all moving and operating components in the testing system that are potentially hazardous, particularly force actuators or a moving crosshead.

Carefully read all relevant manuals and observe all Warnings and Cautions. The term Warning is used where a hazard may lead to injury or death. The term Caution is used where a hazard may lead to damage to equipment or to loss of data.

Instron products, to the best of its knowledge, comply with various national and international safety standards, in as much as they apply to materials and structural testing. Our products are designed to the Instron Safety Standard (ICP-CS503), which is available on request. This standard is derived from various national and international standards including IEC61010-1. We certify that our products comply with all relevant EU directives (CE mark).

Because of the wide range of applications with which our instruments are used, and over which we have no control, additional protection devices and operating procedures may be necessary due to specific accident prevention regulations, safety regulations, further EEA directives or locally valid regulations. The extent of our delivery regarding protective devices is defined in your initial sales quotation. We are thus free of liability in this respect.

At your request, we will gladly provide advice and quotations for additional safety devices such as protective shielding, warning signs or methods of restricting access to the equipment.

The following pages detail various general warnings that you must heed at all times while using materials testing equipment. You will find more specific Warnings and Cautions in the text whenever a potential hazard exists.

Your best safety precautions are to gain a thorough understanding of the equipment by reading your instruction manuals and to always use good judgement.

It is our strong recommendation that you should carry out your own safety risk assessment on the use of the test system, test methods employed, specimen loading and specimen behavior at failure.

Warnings

Crush Hazard - Allow only one person to handle or operate the system at all times.

Operator injury may result if more than one person operates the system. Before working inside the hazard area between the grips or fixtures, ensure that no other personnel can operate the computer or any of the system controls.

Crush Hazard - Take care when installing or removing a specimen, assembly, structure, or load string component.

Installation or removal of a specimen, assembly, structure, or load string component involves working inside the hazard area between the grips or fixtures. Keep clear of the jaws of a grip or fixture at all times. Keep clear of the hazard area between the grips or fixtures during actuator or crosshead movement. Ensure that all actuator or crosshead movements necessary for installation or removal are slow and, where possible, at a low force setting.

Hazard - Press the Emergency Stop button whenever you consider that an unsafe condition exists.

The Emergency Stop button removes hydraulic power or electrical drive from the testing system and brings the hazardous elements of the system to a stop as quickly as possible. It does not isolate the system from electrical power, other means are provided to disconnect the electrical supply. Whenever you consider that safety may be compromised, stop the test using the Emergency Stop button. Investigate and resolve the situation that caused the use of the Emergency Stop button before you reset it.

Flying Debris Hazard - Make sure that test specimens are installed correctly in grips or fixtures in order to eliminate stresses that can cause breakage of grip jaws or fixture components.

Incorrect installation of test specimens creates stresses in grip jaws or fixture components that can result in breakage of these components. The high energies involved can cause the broken parts to be projected forcefully some distance from the test area. Install specimens in the center of the grip jaws in line with the load path. Insert specimens into the jaws by at least the amount recommended in your grip documentation. This amount can vary between 66% to 100% insertion depth; refer to supplied instructions for your specific grips. Use any centering and alignment devices provided.

Hazard - Protect electrical cables from damage and inadvertent disconnection.

The loss of controlling and feedback signals that can result from a disconnected or damaged cable causes an open loop condition that may drive the actuator or crosshead rapidly to its extremes of motion. Protect all electrical cables, particularly transducer cables, from damage. Never route cables across the floor without protection, nor suspend cables overhead under excessive strain. Use padding to avoid chafing where cables are routed around corners or through wall openings.

Warnings

High/Low Temperature Hazard - Wear protective clothing when handling equipment at extremes of temperature.

Materials testing is often carried out at non-ambient temperatures using ovens, furnaces or cryogenic chambers. Extreme temperature means an operating temperature exceeding 60 °C (140 °F) or below 0 °C (32 °F). You must use protective clothing, such as gloves, when handling equipment at these temperatures. Display a warning notice concerning low or high temperature operation whenever temperature control equipment is in use. You should note that the hazard from extreme temperature can extend beyond the immediate area of the test.

Hazard - Do not place a testing system off-line from computer control without first ensuring that no actuator or crosshead movement will occur upon transfer to manual control.

The actuator or crosshead will immediately respond to manual control settings when the system is placed off-line from computer control. Before transferring to manual control, make sure that the control settings are such that unexpected actuator or crosshead movement cannot occur.

Robotic Motion Hazard - Keep clear of the operating envelope of a robotic device unless the device is de-activated.

The robot in an automated testing system presents a hazard because its movements are hard to predict. The robot can go instantly from a waiting state to high speed operation in several axes of motion. During system operation, keep away from the operating envelope of the robot. De-activate the robot before entering the envelope for any purpose, such as reloading the specimen magazine.

Hazard - Set the appropriate limits before performing loop tuning or running waveforms or tests.

Operational limits are included within your testing system to suspend motion or shut off the system when upper and/or lower bounds of actuator or crosshead travel, or force or strain, are reached during testing. Correct setting of operational limits by the operator, prior to testing, will reduce the risk of damage to test article and system and associated hazard to the operator.

Electrical Hazard - Disconnect the electrical power supply before removing the covers to electrical equipment.

Disconnect equipment from the electrical power supply before removing any electrical safety covers or replacing fuses. Do not reconnect the power source while the covers are removed. Refit covers as soon as possible.

Warnings

Rotating Machinery Hazard - Disconnect power supplies before removing the covers to rotating machinery.

Disconnect equipment from all power supplies before removing any cover which gives access to rotating machinery. Do not reconnect any power supply while the covers are removed unless you are specifically instructed to do so in the manual. If the equipment needs to be operated to perform maintenance tasks with the covers removed, ensure that all loose clothing, long hair, etc. is tied back. Refit covers as soon as possible.

Hazard - Shut down the hydraulic power supply and discharge hydraulic pressure before disconnection of any hydraulic fluid coupling.

Do not disconnect any hydraulic coupling without first shutting down the hydraulic power supply and discharging stored pressure to zero. Tie down or otherwise secure all pressurized hoses to prevent movement during system operation and to prevent the hose from whipping about in the event of a rupture.

Hazard - Shut off the supply of compressed gas and discharge residual gas pressure before you disconnect any compressed gas coupling.

Do not release gas connections without first disconnecting the gas supply and discharging any residual pressure to zero.

Explosion Hazard - Wear eye protection and use protective shields or screens whenever any possibility exists of a hazard from the failure of a specimen, assembly or structure under test.

Wear eye protection and use protective shields or screens whenever a risk of injury to operators and observers exists from the failure of a test specimen, assembly or structure, particularly where explosive disintegration may occur. Due to the wide range of specimen materials, assemblies or structures that may be tested, any hazard resulting from the failure of a test specimen, assembly or structure is entirely the responsibility of the owner and the user of the equipment.

Hazard - Ensure components of the load string are correctly pre-loaded to minimize the risk of fatigue failure.

Dynamic systems, especially where load reversals through zero are occurring, are at risk of fatigue cracks developing if components of the load string are not correctly pre-loaded to one another. Apply the specified torque to all load string fasteners and the correct setting to wedge washers or spiral washers. Visually inspect highly stressed components such as grips and threaded adapters prior to every fatigue test for signs of wear or fatigue damage.

Table of Contents

Chapter 1
Calculations Library

The calculation library provides information on the calculations that are available with your software. The software organizes all calculations into six libraries and different combinations of these libraries are loaded by default when you open a particular test type.

What calculations are available?

There are six calculation libraries and different combinations are loaded by default when you open a particular test type.

The software shows only those calculations that are applicable to the current test type. However, you can include all the calculations from all the test types.

To include all calculations:

1. Go to the **Admin** tab and select **Configuration > Options** in the navigation bar.
2. Select **Show all available calculations in all test types**.

This section contains two tables. Table 1-1 on page 1-2 shows the contents of each calculation library.

Table 1-1. Calculation Library Types

Calculation Libraries and their Contents					
Base *	**General ***	**User Calculations ***	**Creep/ Relaxation**	**Metals**	**Peel, Tear, Friction**
Break	Slack correction	User calculation	Creep/ Relaxation	Yield point extension	First peak
Break location	Modulus		Hold preset point	Tensile strength	Average value
Absolute peak	Yield			Non-proportional elongation	Coefficient of friction
Local peak	Area Reduction			n-value	Seam slippage
Percent of break	Poisson's ratio			r-value	
Preset point	Compliance correction				
	Slope				
* These calculations are common to all test types					

Compliance correction is not a true calculation, and is not available in the Peel, Tear, and Friction test type.

Slack correction also includes gauge length correction, but not in Peel, Tear, and Friction or Flexure test types.

The Tension and Compression profiler test types include all calculations except coefficient of friction and the Metals calculations.

When using a 4-point bend fixture for flexural testing, use a deflectometer to measure the specimen deflection directly at the mid-span point on the specimen. You must set up the method to use output from the deflectometer as the axial strain source. If you don't use a deflectometer, the software uses the crosshead extension at the point of contact of the fixture, which may be significantly different from the specimen deflection at mid-span.

% of Break

This calculation is a specific preset point calculation, where the preset point is a percentage of the value of a channel at break.

Parameters

You must specify:

- a channel.
- a value for the percentage of break between 0 and 100.
- a break calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the break point on the graph.

The system includes the percentage of break value with the calculation description. For example, if you select Tensile Extension at 50% of break, the description appears as:

50% of Break (Tensile extension)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- uses a break point determined by a previous calculation as a starting point.
- determines the value at the break point of the specified channel.
- determines the value of the same channel that corresponds to the specified percentage of break.

Results

All channels in the system are available.

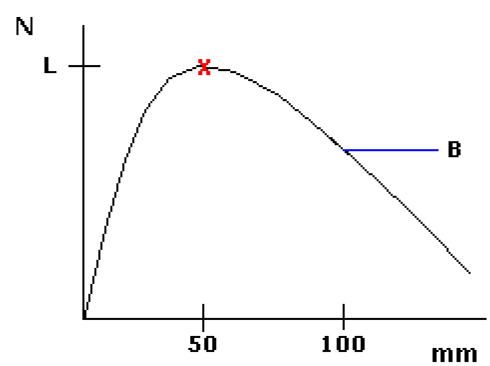
Example

The percent of break is set for 50% extension. The result required is **Load**. After performing the break calculation, the system determines the value of extension at break. If this value is 100mm, then the value of extension at 50% of break is 50mm. The result is therefore the value of load when extension is 50mm.

B = break point

x = 50% of break marker

L = load at 50% of break



Fails to calculate

The algorithm will not calculate a result if the break calculation that it depends on is not calculated.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Absolute Peak calculation

This calculation detects the maximum peak value on the specified channel.

Parameters

You must specify:

- a channel
- a peak type, either maximum or minimum

  Selecting a minimum peak detects the lowest value. Conversely, a maximum peak detects the highest value.

You have the option to select **Indicate on graph** to indicate the absolute peak point on the graph.

When you select an absolute peak calculation, the peak type and channel labels appear in the **Description** field. For example, if you select the compressive strain channel with a maximum peak type, the calculation description appears as:

Maximum Compressive Strain

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the data on the specified channel.
- (for maximum) sequentially compares each point with the highest point found so far to determine the absolute maximum.
- (for minimum) sequentially compares each point with the lowest point found so far to determine the absolute minimum.
- assigns that point as the peak.

Results

All channels in the system are available.

For metals testing only, absolute peak should not be used to detect the upper yield point or tensile strength point since it cannot distinguish between them.

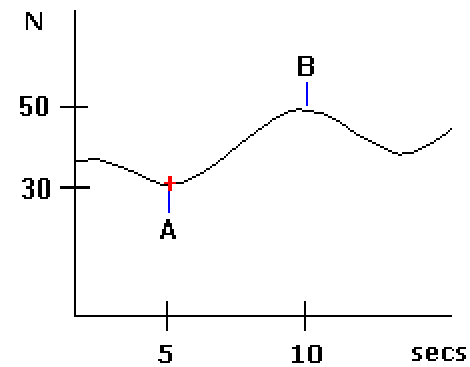
Example

The parameters are set to a minimum peak type on the **Load** channel. The system detects a peak at 30N because this point is the lowest data point in all the data. The **Time** channel result at the minimum peak is 5.0 seconds. For a maximum peak, the system detects a 50N peak at 10.0 seconds.

+ = Peak Marker

A = Minimum Peak

B = Maximum Peak



Area Reduction calculation

This calculation meets the requirements for the EN10002 and ASTM E8 standards. It determines the difference between the initial specimen area and the final specimen area, expressed as a percentage of the initial specimen area. Enter the initial dimensions before a test and the final dimensions after a test, either manually or with a measuring device.

Fails to calculate

The algorithm will not calculate a result if you do not enter the parameters required to determine the final area.

Results

Reduction of Area
Initial Area
Final Area

Average Value calculations

These calculations are used to test properties such as adhesion, fabric and paper tear resistance.

Average Value (All Peaks)

This calculation accumulates all peaks in the user-specified range of data to determine an average value.

Parameters

You must specify:

- **All Peaks** type of average value calculation.
- start value or channel. This can be a channel or a particular data point such as the first peak.
- start value in the units of the start value channel unless the start value is first peak.
- end value channel.
- end value in the units of the end value channel.
- sensitivity as a percentage of the maximum load.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
  - If the start channel is set to either First Peak or % Peel Length.
  - If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value on the graph.

The system includes the type of average value calculation in the calculation description. For example, if you select an **All Peaks** type of calculation, the description appears as:

Average Value (All Peaks)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

If the Average Value region start channel is First Peak or % Peel Length, the system retrieves the index of the First Peak from the parent First Peak calculation.

Algorithm

The system:

- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the peaks.
- accumulates all the peaks in the Average Value region.
- calculates the average value result by dividing the value of the accumulated peaks by the number of peaks accumulated.

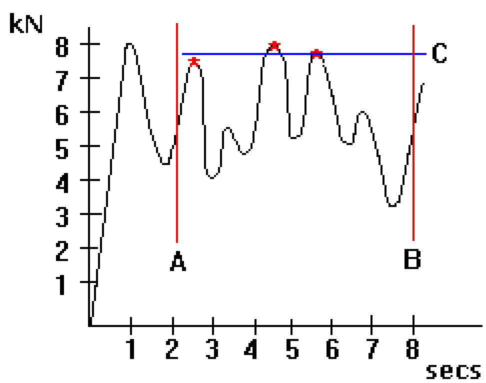
Example

Start is set for the **Time** channel with a **Start value** of 2.0 seconds and an **End value** of 8.0 seconds. **Sensitivity** is set to 25% which detects a 2 kN rise and fall in load. The system detects three peaks which have an average value of 7.7 kN.

A = Start Value

B = End Value

C = Average Value



Fails to calculate

The algorithm will not calculate a result if:

- no peaks were found in the data.
- the parent First Peak calculation failed.
- the start and/or end point was not found.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Average Value (Automatic Peaks)

This calculation examines the number of peaks found in the data to determine which evaluation method to use.

Parameters

You must specify:

- **Automatic Peaks** type of average value calculation.
- start value or channel. This can be a channel or a particular data point such as the first peak.
- start value in the units of the start value channel unless the start value is first peak.
- end value channel.
- end value in the units of the end value channel.
- sensitivity as a percentage of the maximum load.
- Method A limit as a number of peaks.
- Method B limit as a number of peaks.
- Method C as a number of regions.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
    - if the start channel is set to either First Peak or % Peel Length.

- if the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value on the graph.

The system includes the type of average value calculation in the calculation description. For example, if you select a **Automatic Peaks** type of calculation, the description appears as:

Average Value (Automatic Peaks)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

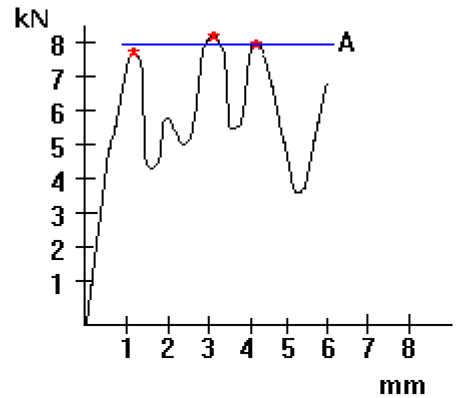
- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the peaks.
- if the number of peaks found is less than or equal to the specified value for Method A limit, accumulates all the peaks in the data.
- if the number of peaks found is greater than the specified value for Method A limit or less than or equal to the specified value for Method B limit, finds the first peak in the data, based on increasing elongation. The system discards the data before the first peak. Of the remaining data, uses the middle 80% (based on elongation) to accumulate peaks.
- if the number of peaks found is greater than the specified value for Method B limit, finds the indices of the first peak of the Average Value region of the data based on the specified value for the start and end values. The system divides the data in the Average Value region by the specified value for Method C number of equal regions based on elongation. It accumulates the peak closest (in terms of elongation) to the end of each region except the last.
- calculates the average value result by dividing the value of the accumulated peaks by the number of peaks accumulated.

If the Average Value region start channel is First Peak or % Peel Length, the system retrieves the index of the First Peak from the parent First Peak calculation.

Example

Sensitivity is set to 25% which detects a 2 kN rise and fall in load. The **Method A limit** is set to 5. The system detects three peaks which have an average value of 7.7 kN.

A = Average Value



Fails to calculate

The algorithm will not calculate a result if:

- no peaks were found in the data.
- the parent First Peak calculation failed.
- the start and/or end point was not found.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Average Value (High and Low Peaks)

This calculation averages the value of the specified number of highest and lowest peaks detected between specified values. When first peak is the start value, average peaks becomes a dependent calculation that requires the result from the first peak calculation.

Parameters

You must specify:

- **High and Low Peaks** type of average calculation.
- start value or channel. This can be a channel or a particular data point such as the first peak.
- start value in the units of the start value channel unless the start value is first peak.
- end value channel.
- end value in the units of the end value channel.
- sensitivity as a percentage of the maximum load.
- number of high and low peaks to average. If the data does not contain more than twice the specified number of peaks, all peaks are used.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
    - If the start channel is set to either First Peak or % Peel Length.
    - If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value on the graph.

The system includes the type of average value calculation and the number of high and low peaks to average in the calculation description. For example, if you select a **High and Low Peaks** type of calculation with the number of high and low peaks to average to 3, the description appears as:

Average Value (3 High and Low Peaks)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

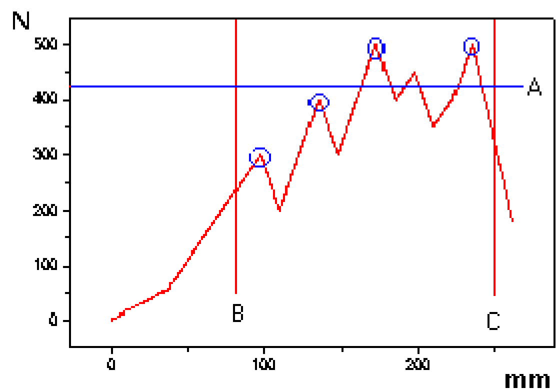
- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the peaks.
- sums the values of the specified number of highest and lowest peaks.
- divides the sum of the peaks by the number of peaks.

Example

Start is set for the **Extension** channel with a **Start value** of 85 mm and an **End value** of 250mm. The number of peaks to average is 2.

The system detects the two highest and the two lowest peaks and calculates the average value.

A = Average Value Marker
B = Start Value
C = End Value



If there are more high and low peaks specified than the system detects in the specified range, all the peaks that it detects are included in the calculation. In this example, if the specified number of peaks to average is 3, the system would not be able to find 3 high and 3 low peaks. In this case, it would average all five peaks in the range.

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain the specified start or end value.
- the data does not contain any peaks that meet the specified criteria.

Results

Average Load
Average Load/Width
Start Energy

Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Average Value (Integral)

This calculation uses energy divided by the change in extension to determine the average value of the load data between specified points.

Parameters

You must specify:

- a start value or channel. This can be a channel or a particular data point such as the percent of peak load drop.
- a starting value in the units of the start value channel.
- an end value or channel. This can be a channel or a particular data point such as the first peak.
- an end value in the units of the end value channel.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
  - If the start channel is set to either First Peak or % Peel Length.
  - If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value with a horizontal line on the graph.

The system includes the type of average value calculation in the calculation description. For example, if you select an **Integral** type of calculation, the description appears as:

Average Value (Integral)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

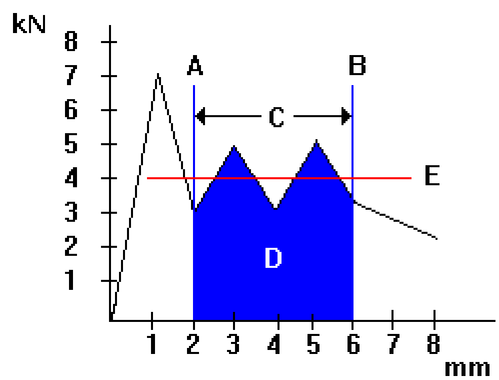
Algorithm

The system:

- searches all the data for the specified start and end values.
- determines the change in extension between the points.
- determines the energy by calculating the area between the points.
- uses the following equation to determine the average value:
  Average load = {energy/change in extension}

Example

The start value is set for 3 kN on the **Load** channel. The end value is set for 6 mm on the **Extension** channel. Between the points, the energy is 16 joule and the extension changes by 4 mm. By dividing the energy by the change in extension, the system calculates an average load value of 4 kN.



A = Start Value

B = End Value

C = Change in Extension

D = Energy

E = Average Value Marker

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain the specified start or end value.
- the same value is specified for the start and end values.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Average Value (Peaks and Troughs)

This calculation averages the value of a specified number of highest peaks and lowest troughs detected between specified points. When first peak is the start value, average peaks and troughs becomes a dependent calculation that requires the result from the first peak calculation.

Parameters

You must specify:

- the **Peaks and Troughs** type of average calculation.
- a start value or channel. This can be a channel or a particular data point such as the first peak.
- a starting value in the units of the start value channel.
- an end value or channel. This can be a channel or a particular data point such as the first peak.
- an end value in the units of the end value channel.
- a sensitivity as a percentage of the full-scale channel value.
- number of peaks and troughs to average. If the data does not contain at least the number of specified peaks and troughs, the system will not calculate the average.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:

- If the start channel is set to either First Peak or % Peel Length.
- If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value with a horizontal line on the graph.

The system includes the type of average value calculation and the number of peaks and troughs to average in the calculation description. For example, if you select a **Peaks and Troughs** type of calculation with the number of troughs to average to 8, the description appears as:

Average Value (8 Peaks and Troughs)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

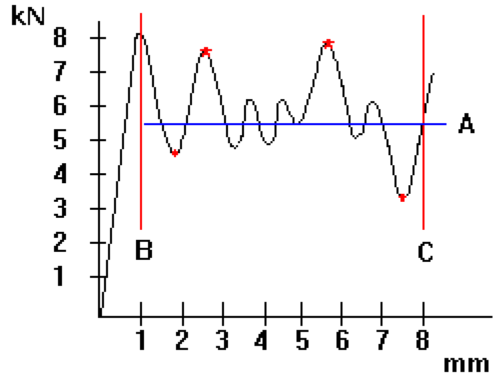
Algorithm

The system:

- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the peaks and troughs.
- sums the values of the specified number of highest peaks and lowest troughs.
- divides the sum of the peaks and troughs by the specified number of peaks and troughs. The result is an average value.

Example

The **Start value** is 8 kN on the **Load** channel, the **End value** is 8 seconds on the **Time** channel. Sensitivity is set to 30%, the number of peaks is set to 2. The system detects 2 peaks with an average value of 7.7 kN and 2 troughs with an average value of 4 kN. The average value of the peaks and troughs is 5.85 kN.



+ = Peak/trough

A = Average Value Marker

B = Start Value

C = End Value

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain the specified start or end value.
- the data does not contain any peaks or troughs that meet the specified criteria.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Average Value (Peaks)

This calculation averages the value of the specified number of highest peaks detected between specified values. When first peak is the start value, average peaks becomes a dependent calculation that requires the result from the first peak calculation.

Parameters

You must specify:

- the **Peaks** type of average calculation.
- a start value or channel. This can be a channel or a particular data point such as the first peak.
- a starting value in the units of the start value channel unless the start value is first peak.
- an end value channel.
- an end value in the units of the end value channel.
- a sensitivity as a percentage of the maximum channel value.
- the number of peaks to average. If the data does not contain at least the specified number of peaks, the system will not calculate the average.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
    - If the start channel is set to either First Peak or % Peel Length.
    - If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value on the graph.

The system includes the type of average value calculation and the number of peaks to average in the calculation description. For example, if you select a **Peaks** type of calculation with the number of peaks to average to 8, the description appears as:

Average Value (8 Peaks)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

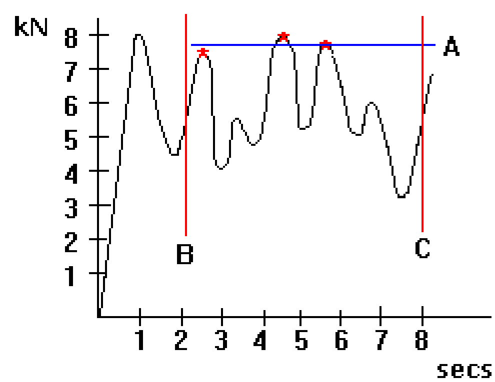
The system:

- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the peaks.
- sums the values of the specified number of highest peaks.
- divides the sum of the peaks by the number of peaks.

Example

Start is set for the **Time** channel with a **Start value** of 2.0 seconds and an **End value** of 8.0 seconds. The number of peaks to average is 3. Sensitivity is set to 25% which detects a 2 kN rise and fall in load.

The system detects the three highest peaks which have an average value of 7.7 kN.



+ = Peak

A = Average Value Marker

B = Start Value

C = End Value

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain the specified start or end value.
- the data does not contain any peaks that meet the specified criteria.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks

Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Average Value (Regions)

This calculation averages the value of the highest peak detected within each specified region. When first peak is the start value, average value becomes a dependent calculation that requires the result from the first peak calculation.

Parameters

You must specify:

- the **Region** type of average value calculation.
- a start value or channel. This can be a channel or a particular data point such as the percent of peak load drop.
- a start value in the units of the start value channel.
- an end value or channel. This can be a channel or a particular data point such as the first peak.
- an end value in the units of the end value channel.
- a sensitivity as a percentage of the highest channel value.
- number of regions.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:
    - If the start channel is set to either First Peak or % Peel Length.
    - If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value with a horizontal line on the graph.

The system includes the type of average value calculation and the number of regions to average in the calculation description. For example, if you select a **Regions** type of calculation with 8 regions to average, the description appears as:

Average Value (8 Region)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

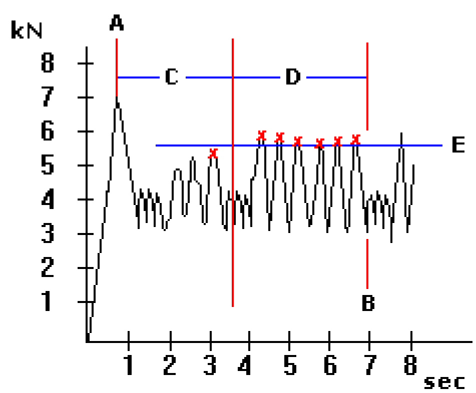
Algorithm

The system:

- divides the data into the specified number of regions.
- using the specified sensitivity, determines the value of all the peaks in each region.
- sorts the peak value list to the get the highest peak in each region.
- averages the highest peak in all of the regions.

Example

The **start value** is set for the first peak on the **Load** channel and the sensitivity is set to 30% which detects a 2 kN rise and fall in load. The **end value** is set for 7 seconds on the **Time** channel. The number of regions is set for 2. The system calculates an average value of 5.3 kN for the first region and 5.7 kN for the second region. The average value for all the regions is 5.5 kN.



A = Start Value

B = End Value

C = First Region

D = Second Region

E = Average Value Marker

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain the specified start or end value.

- the data does not contain any peaks that meet the specified criteria.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Average Value (Troughs)

This calculation averages the value of the troughs detected between specified points. When first peak is the start value, average peaks and troughs becomes a dependent calculation that requires the result from the first peak calculation.

Parameters

You must specify:

- the **Troughs** type of average value calculation.
- a start value or channel. This can be a channel or a particular data point such as the first peak.
- a starting value in the units of the start value channel unless the start value is first peak.
- an end value or channel. This can be a channel or a particular data point such as the first trough.
- an end value in the units of the end value channel.
- a sensitivity as a percentage of the maximum channel value.
- the number of troughs to average. If the data does not contain at least the specified number of troughs, the system will not calculate the average.
- the first peak calculation in the **Parent calculation** field if any of the following conditions exist:

- If the start channel is set to either First Peak or % Peel Length.
- If the end channel is set to % Peel Length.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the average value on the graph.

The system includes the type of average value calculation and the number of troughs to average in the calculation description. For example, if you select a **Troughs** type of calculation with the number of troughs to average to 8, the description appears as:

Average Value (8 Troughs)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

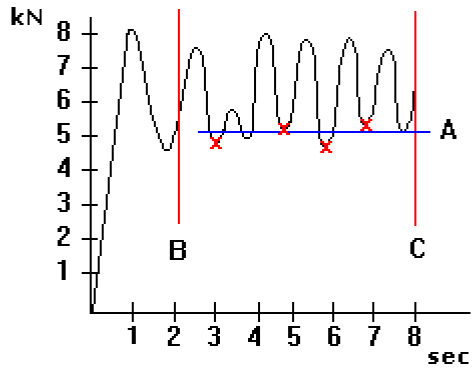
- searches all the data between the specified start and end values.
- using the specified sensitivity, determines the value of all the troughs.
- sums the values of the specified number of lowest troughs.
- divides the sum of the troughs by the number of troughs.

Example

Start is set for the **Time** channel with a **Start value** of 2 seconds and an **End value** of 8 seconds. The number of troughs to average is 4. Sensitivity is set to 25% which detects a 2 kN fall and rise in load.

The average value of the troughs between the start and end values is 5 kN.

x = Trough
A = Average Value
B = Start Value
C = End Value



Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain any troughs that meet the specified criteria.
- the data does not contain the specified number of troughs.

Results

Average Load
Average Load/Width
Start Energy
Delta Energy
Delta Peel Extension
Number of Peaks
Number of Troughs
Median Peak
Peak Range

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Break calculations

Break calculations do not necessarily require a specimen to be physically separated. The following subsections describe the types of calculations that detect a break according to the criteria you set.

Break (Automatic Load Drop)

This calculation detects the specimen break as the point where the load begins to decrease rapidly.

Parameters

You must specify the **Automatic Load Drop** type of Break.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system starts at the end of the load versus time curve and searches backward until the slope stops getting less negative, e.g. when it encounters a local peak in the first derivative, where the load is greater than one-third maximum load of the entire curve. This is point N1.

The system then retraces its steps in the forward direction until it encounters a local peak in the second derivative. This is point N2. The specimen is deemed to have broken at that point. However, if the difference in load between the point before N2 and N2 itself is greater than half the difference in load between N1 and N2, then the point before N2 is chosen as the break point instead of N2. No interpolation between points is performed in this case.

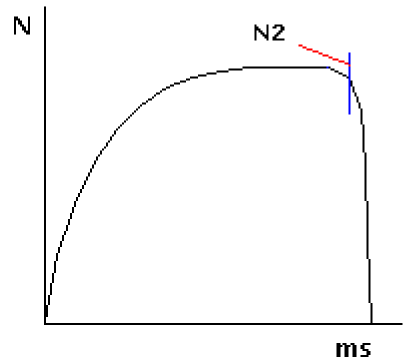
Results

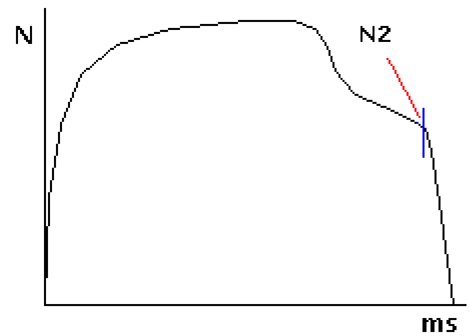
All channels in the system are available.

Example

The automatic "break" point is found on the shoulder of the curve, where the load starts dropping rapidly toward zero. This applies to both sharp and gradual drops.

N2 = Automatic break point





Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Break (Cursor)

This calculation assigns the specimen break to a point that you select on the curve after the specimen is tested.

Parameters

You must specify the **Cursor** type of Break.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system assigns the specified cursor point as the break.

Results

All channels in the system are available.

Break (Load)

This calculation detects the specimen break as a specified load value.

Parameters

You must specify a break point value less than the data's maximum load point.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

The system includes the break value with the calculation description. For example, if you select a value of 20 N, the calculation description appears as:

Break (Load 20 N)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the test data on the load channel for the maximum load point.
- searches the data beyond the maximum load point for the first point where the load is less than or equal to the specified load value.
- assigns that point as the break.

Results

All channels in the system are available.

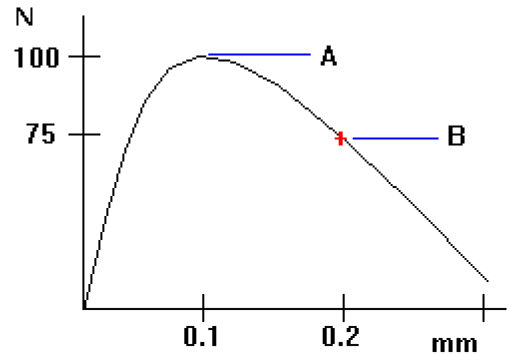
Example

The load at break value is set for 75 N. The system detects the maximum load, which is 100 N, and then searches the remaining data for the first data point equal to or less than 75 N.

+ = Break Marker

A = Maximum Load

B= Specified Break



Fails to calculate

The algorithm will not calculate a result if:

- the load does not drop to the specified value.
- the maximum load is the last data point.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Break (Load/Extension Rate)

This calculation detects the specimen break as a drop in load at a specified rate. The rate of the drop is derived from the change in load divided by a change in extension.

Parameters

You must specify a rate value.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

The system includes the rate value in the calculation description. For example, if you select a rate of 20 N/mm, the calculation description appears as:

Break (Load/Extension Rate 20 N/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the data on the **Load** channel for the maximum load point.
- searches the load and extension data beyond the maximum load point for the first point where the slope of the curve is equal to or less than the negative of the specified rate.
- assigns that point as break.

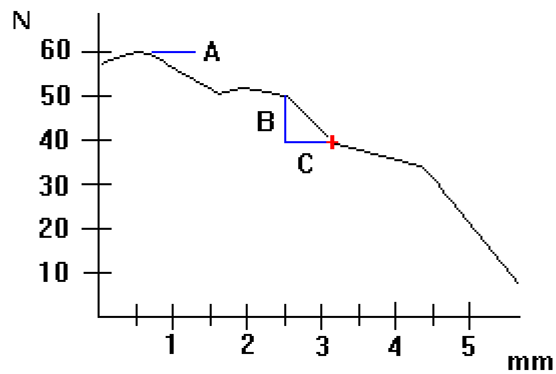
Results

All channels in the system are available.

Example

The rate is set to 20 N/mm. The system first finds the maximum load point, which is 60 N, and searches from that point to the end of the data for the first occurrence of the load dropping at the rate of 20 N/mm.

When the load drops from 50 N to 40 N, between extension points 2.5 mm and 3 mm, the system assigns the break. The system determined that the change in load divided by the change in extension (10N/0.5 mm) is equivalent to the specified rate of 20 N/1 mm.



+ = Break Marker

A = Maximum Load

B = Load Change

C = Extension Change

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain a slope that is equal to or less than the specified rate.

- the maximum load is the last data point.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Break (Load/Strain Rate)

This calculation detects the specimen break as a drop in load at a specified rate. The rate of the drop is derived from the change in load divided by a change in strain.

Parameters

You must specify a rate of change in load/strain.

You have the option to select **Indicate on graph** to indicate the preset point on the graph.

The system includes the rate value in the calculation description. For example, if you select a rate of 20 N/mm/mm, the calculation description appears as:

Break (Load/Strain Rate 20 N/mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the data on the Load channel for the maximum load point.
- searches the data beyond the maximum load point for the occurrence when the slope of the curve is equal to or less than the specified rate.
- assigns that point as break.

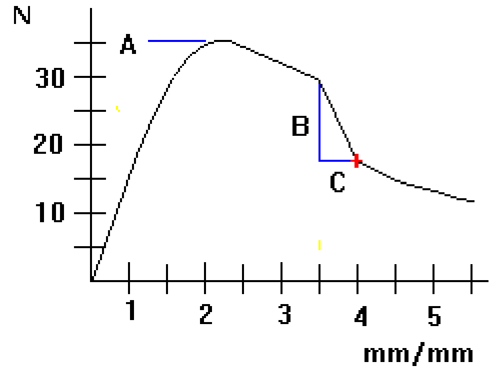
Results

All channels in the system are available.

Example

The rate is set to 20 N/mm/mm. The system first finds the maximum load point, which is 35 N, and searches from that point to the end of the data for the first occurrence of the load dropping at the rate of 20 N/mm/mm.

When the load drops from 30 N to 20 N, between strain points 3.5 mm/mm and 4 mm/mm, the system assigns the break. The system determines the break point by calculating that the rate of 10N/0.5 mm/mm is equivalent to the specified rate of 20 N/1 mm/mm.



+ = Break Marker

A = Maximum Load

B = Load Change

C = Strain Change

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain a slope that is equal to or less than the specified rate.
- the maximum load is the last data point.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Break (Percent of Maximum Load)

This calculation detects the specimen break as a drop to a load value by a specified percentage of the maximum load attained.

Parameters

You must specify a percentage of maximum load between 0 and 100. For example, if the maximum load is 100 N and the specified value is 60%, the system detects a break at 60 N.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

The system includes the break value with the calculation description. For example, if you select a value of 80%, the calculation description appears as:

Break (% Maximum Load 80)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the data on the load channel for the maximum load point.
- searches the data beyond the maximum load point for the first point where the load is less than or equal to the specified percentage of the load. If the value falls between two points, the system interpolates the value.
- assigns that point as the break.

Results

All channels in the system are available.

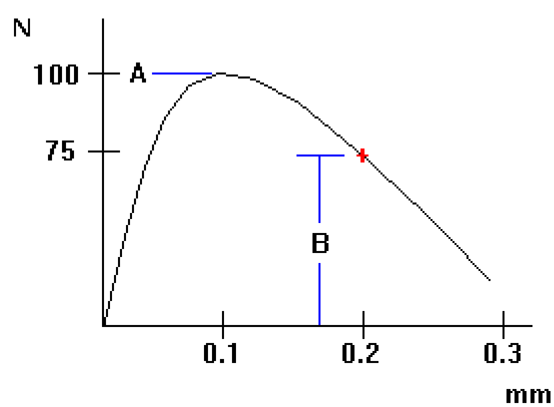
Example

The percent value is set for 75% of maximum load. The system detects a maximum load of 100 N and then searches the remaining data for the load data point of 75 N. Therefore the break at percent of maximum load is 75 N.

+ = Break Marker

A = Maximum Load

B = % of Maximum Load



Fails to calculate

The algorithm will not calculate a result if:

- the load does not drop below the specified percent of maximum load after the maximum load point.
- if the maximum load is the last data point.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Break (Standard)

This calculation detects the specimen break as the highest load in the last 100 ms of data.

Parameters

You must specify the **Standard** type of Break.

You have the option to select **Indicate on graph** to indicate the break point on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the last 100 ms of the load channel data.
- sequentially compares each point with the next to determine the maximum value.
- assigns the maximum point as the break.

Results

All channels in the system are available.

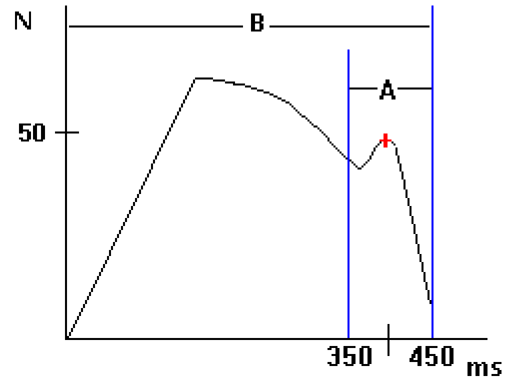
Example

The total time of the data is 450 ms. The system searches the data from 450 to 350 ms for the maximum load. The system determines the break as a 50 N load at 400 ms.

+ = Break Marker

A = 100 ms

B = Total Time



Fails to calculate

The Break (Standard) algorithm will not calculate a result if there is less than 100 ms of data.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Break Location

This calculation determines if the specimen breaks inside the gauge length, outside the gauge length or reports an indecisive result (could be outside the gauge length or inside the gauge length). It is a dependent calculation that requires a result from a break calculation.

Parameters

You must specify a break calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to:

- edit the **Inside GL** (gauge length) description by clicking in the **Inside Break** field and typing new or additional details. Any changes to the description appear in the Result table.

- edit the **Unsure** description by clicking in the **Unsure Break** field and typing new or additional details. Any changes to the description appear in the Result table.
- edit the **Outside GL** description by clicking in the **Outside Break** field and typing new or additional details. Any changes to the description appear in the Result Table.
- edit the location factor value by clicking in the **Location Factor** field and typing a new value. The default value is 0.0.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

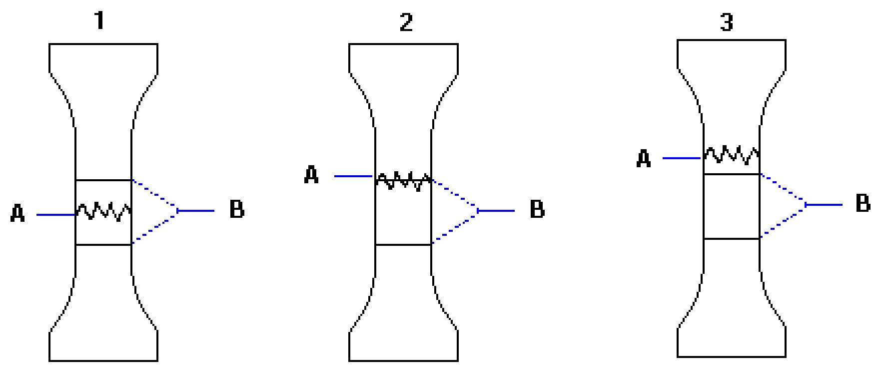
Algorithm

The system:

- finds the total elongation at maximum force.
- finds the break according to the calculation you chose.
- determines the extensometer and crosshead extensions at the maximum force and break points.
- calculates the effective parallel length of the specimen by comparing the extensometer and crosshead extensions over the region between any yield phenomena and the maximum force point.
- determines the point where the specimen starts to neck based on the start of non-uniform elongation and hence the portion of local deformation that occurs after the maximum force point.
- compares the extension difference between the extensometer reading and the crosshead/actuator for the region between the maximum force and specimen break point to determine the location of the break. The break location can occur inside the gauge length, outside the gauge length or can be indecisive.

Any total elongation result is not valid if the specimen breaks outside of the gauge length or the break location is indecisive. The break location factor ranges from 0.0 to 1.0. It represents the fraction of the specimen elongation that occurs after the uniform elongation, which is attributable to local deformation in the specimen neck region. A value of 1.0 means that all the deformation that occurs after the uniform elongation occurs in the specimen neck whereas a value close to 0.0 means that the specimen elongates uniformly to break. A location factor of 0.0 indicates that the system will automatically determine a value from the measured data. If the automatic value is unsuitable for a particular material type, a manual location factor may be entered.

Example



A = Break

B = Gauge length

Specimen 1 illustrates a break inside the gauge length. The determined strain at break is correct.

Specimen 2 illustrates a break inside or outside the gauge length - it cannot be determined where the break occurs. The determined strain at break is probably not valid but may be corrected by using the crosshead extension.

Specimen 3 illustrates a break outside the gauge length. The determined strain at break is not valid and is difficult to correct accurately.

Fails to calculate

The algorithm will not report a break location correctly if:

- the extensometer is removed before the specimen breaks.
- the extensometer channel is not selected as the strain source.
- the extensometer gauge length is not correct or the specimen parallel length is wildly in error.
- the extensometer is not set to zero at the beginning of a test.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Coefficient of Friction calculation

This calculation determines the static (motionless) and dynamic (moving) coefficient of friction. Typically, this calculation analyzes data collected from a test that used a friction table and sled.

Parameters

You must specify:

- a sensitivity value as a percentage of the channel's maximum value. A lower sensitivity detects a smaller percent change in the data while a higher sensitivity detects a larger change.
- a start value or channel. This can be a channel or a particular data point such as the first peak.
- a starting value in the units of the start value channel.
- an end value or channel. This can be a channel or a particular data point such as the first peak.
- an end value in the units of the end value channel.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data from the start value to the end value on the specified channel for the maximum value.
- determines the first data point that rises and falls by the percentage of the maximum value and assigns this point as the first peak.
- uses the following equation to determine the coefficient of static friction:

  static friction = first peak/sled weight

- uses the following equation to calculate the average load of the area from the first peak to the end value:

  average load = energy/change in extension

- uses the following equation to determine the coefficient of dynamic friction:

  dynamic friction = average load/sled weight

Example

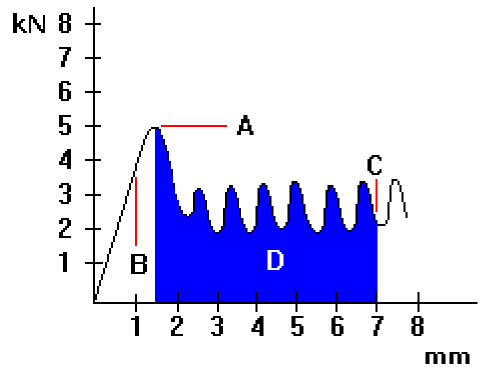
The **Extension** channel is set for a start value of 1 mm and an end value of 7 mm. The sensitivity is 40% of 5 kN which is 2 kN. Static friction is the maximum load point. Dynamic friction is the average load (based on energy and the change in extension) of the data from 1 to 7 mm.

A = Maximum Value

B = Start Value

C = End Value

D = Energy



Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain a first peak.
- the system did not detect a first peak based on the specified parameters.
- the data does not contain either the specified start or end value.

Results

Coefficient of static friction
Coefficient of dynamic friction

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Compliance correction

This calculation is not suitable for use with the Microtester. Compliance correction does work on the Extension channel (actuator data from the motor encoder). It does not work on the Strain channel (actuator data from the Heidenhein gauge).

This calculation provides a way to correct values of extension used in calculations to allow for the compliance, or elastic “give”, of your testing system. First, you run a test using a dummy specimen that will deform very little at the maximum test load. The dummy specimen should be as many times stiffer than the real specimen as possible. During this test the system creates a compliance file containing values of load and extension. When you test the real specimens, the system uses the compliance file to correct values of strain and extension collected during the test.

It is important to understand that compliance is a property of the entire testing system, not only the load frame. When you run the test to create the compliance file you must use exactly the same components in the testing system as you will use in the real tests, including the load cell, grips and couplings.

Parameters

The only required parameter is the name of the compliance correction file. The software assigns a default name of the following form:

- Ccompsav.cmt for tension tests
- Ccompsav.cmc for compression tests

Results

There are no results for the compliance correction calculation.

How to:

Step 1 - Create the Compliance File

1. In the **Calculations Setup** dialog box, highlight **Compliance Correction** in the **Selected Calculation** list. [If you have not used the **Compliance Correction** calculation before, you need to highlight **Compliance Correction** in the **Library** list and click on the **Add** button to add the calculation to the list of **Available Calculations**.]
2. In the **Parameters** area of the dialog box, choose **Create** in the **Type** list box. Choose **Browse…**, type a filename into the **File Name** edit box, and click **OK**.

3. Set up a test in tension or compression using a very stiff dummy specimen. Set the load to a value higher than the maximum test load or to the maximum capacity of the system. This must be done using the same load string that you will use in tests on real specimens. Set the **Control Mode** to **Extension**. Set up the test to apply a small preload, or make sure there is no slack in the specimen. Set up data logging so that one data point is collected approximately every 1-2% of the testing load range. Install the stiff specimen and run the test.

4. During the test a file with extension and load values is created with the name and location specified in the calculation setup. The load values are in newtons, extension values are in millimeters, and the file can be viewed in any text editor such as Notepad.

Step 2 - Apply the Compliance File

1. In the **Calculations Setup** dialog box, highlight **Compliance Correction** in the **Selected Calculation** list.

2. In the **Parameters** area of the dialog box, choose **Apply** in the **Type** list box and use the **Browse…** button to find the file created during the test on the stiff specimen.

3. (Optional) Check the Compliance Correction. Repeat the test using the dummy specimen. The load versus extension graph should plot as a vertical line. This indicates zero extension over the range of applied load and indicates that the compliance correction is valid.

4. Setup the test for the real specimens. As tests are run and results are calculated, the software applies a correction to values of Extension and other channels whose values are derived from Extension.

For more detailed information about the Compliance Correction calculation and how it works, especially which channels are affected by the correction, refer to the “Compliance correction reference” on page 1-41.

Compliance correction reference

Machine compliance is the elastic deflection or “give” of the testing machine when reacting the load supported by the specimen. It is measured in mm/kN or equivalent units. The compliance is determined by running a test using a dummy specimen that will deform very little at the maximum test load. As load is applied to the dummy specimen, load and extension data are collected. The Extension data represents the amount of machine compliance corresponding to the respective load readings. The collected data is written to the Compliance file, which is then used for correction while testing real specimens.

Compliance correction can be applied when the Extension channel is selected as the source for Axial Strain. If an extensometer is removed part way through a test, the Extension channel is automatically selected as the source for Axial Strain after the extensometer has been removed. In both cases, the Tensile Strain and Tensile Extension channels are corrected. These channels can be observed during a test on the live displays. Any results based on Tensile Strain or Tensile Extension will also be corrected.

In the area of test control, channels affected by compliance correction (Tensile Strain and Tensile Extension) no longer have a linear relationship to Extension. This has implications when choosing the criteria by which the system changes from Ramp 1 to Ramp 2. Ramp changeover occurs when an event on the Extension transducer channel in the machine controller is reached, not by setting a trip point on the composite channel in the software. The full list of criteria that use machine controller events rather than software trip points on the composite channels is:

- Precycling - minimum and maximum limits
- Changeover from Ramp 1 to Ramp 2
- TestProfiler Ramp End Points

If you select Tensile Strain or Tensile Extension as the criterion by which the system changes from Ramp 1 to Ramp 2 and compliance correction is applied, the actual ramp changeover may occur at a different value from the one expected.

Creep / Relaxation calculations

The following subsections describe the different types of creep/relaxation calculations.

Delta Creep

This calculation determines the change in a channel value, from the minimum derived extension point in a hold segment to a specified point.

Parameters

You must specify:

- the **Delta Creep** type of creep/relaxation.
- a channel.
- a channel value. This value is the amount of change from the minimum extension point.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the type of relaxation and the channel value in the calculation description. For example, if you select a **Delta Creep** calculation on the **Compressive load** channel with a channel value of 6 N, the description appears as:

Delta Creep (6 N)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the derived extension channel for the minimum value in the hold segment of the data.
- establishes a search value by adding the specified channel value to the channel value at minimum extension.
- searches the specified delta channel for the search value.
- determines the difference between the minimum extension point and the search value point.

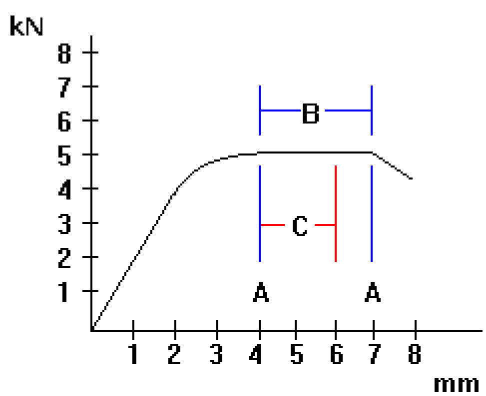
Example

The **Extension** channel is set for a user specified value of 2 mm. The minimum data point within the hold segment is 4 mm. By calculating the difference between these points, the system determines the delta creep as 2 mm.

A = Hold Segment Markers

B = Hold Segment

C = Channel Value



Fails to calculate

The algorithm will not calculate a result if:

- there is no hold data.

- the specified value is not within the data.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Delta Relaxation

This calculation determines the change in a channel value, from the maximum derived load point in a hold segment to a specified point.

Parameters

You must specify:

- the **Delta Relaxation** type of creep/relaxation.
- a channel.
- a channel delta value.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the type of relaxation and the channel value in the calculation description. For example, if you select a **Delta Relaxation** calculation on the **Compressive strain** channel with a channel value of 10 mm/mm, the description appears as:

Delta Relaxation (10 mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the derived extension channel for the data collected during the hold segment for the maximum value.

- establishes a search value by adding the specified channel value to the channel value at maximum load.
- searches the specified delta channel for the search value.
- determines the difference between the maximum load point and the search value point.

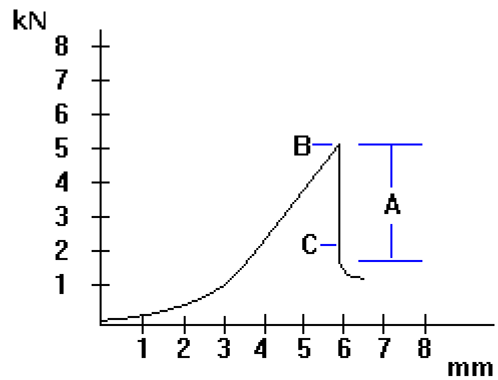
Example

The **Load** channel is selected with a delta value of 2 kN. During the hold segment of the data, the maximum channel value is 5 kN. By calculating the difference between these points, the system determines the delta relaxation as 2 kN.

A = Hold Segment

B = Maximum Value.

C = Channel Value



Fails to calculate

The algorithm will not calculate a result if:

- there is no hold data.
- the specified value is not within the data.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Total Creep

This calculation determines the difference between the channel values at the minimum and maximum derived extension points during the hold segment.

Parameters

You must specify the **Total Creep** type of creep/relaxation.

You have the option to select **Indicate on graph** to indicate the hold segment on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

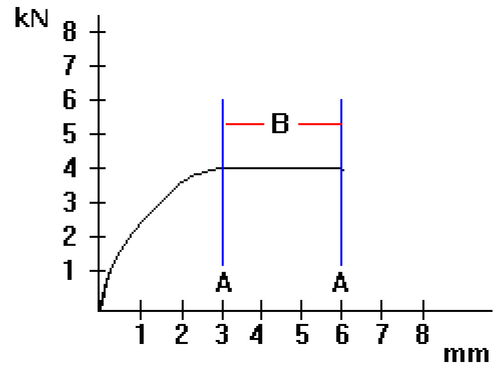
- searches the derived extension channel for the minimum point in the hold segment of the data.
- searches the derived extension channel for the maximum point in the hold segment of the data.
- determines the difference between the channel values of a selected results channel at the derived extension maximum and minimum points.

Example

The maximum value on the **Extension** channel is 6 mm. The minimum value is 3 mm. By calculating the difference between these points, the system determines the total creep as 3 mm.

A = Hold Segment Markers

B = Hold Segment



Fails to calculate

The algorithm will not calculate a result if there is no hold data.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Total Relaxation

This calculation determines the difference between the channel value at the minimum and maximum derived load points during the hold segment.

Parameters

You must specify the **Total Relaxation** type of creep/relaxation.

You have the option to select **Indicate on graph** to indicate the hold segment on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the derived load channel for the minimum and maximum points in the hold segment of the data.
- determines the difference between a selected results channel value and the derived load maximum and minimum values.

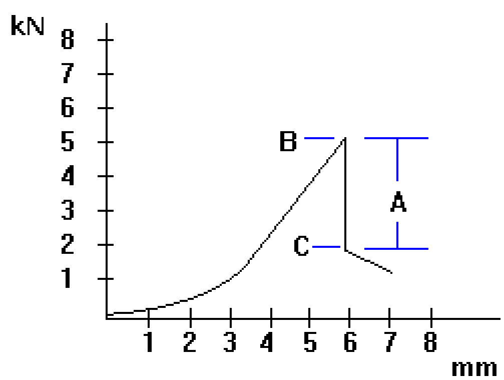
Example

The maximum value on the **Load** channel is 5 kN. The minimum value is 2 kN. By calculating the difference between these points, the system determines the total relaxation as 3 kN.

A = Hold Segment

B = Maximum Value.

C = Minimum Value



Fails to calculate

The algorithm will not calculate a result if there is no hold data.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Hold Preset Point

This calculation is based upon an assigned channel and value within the hold segment of the test curve. For example, you can set a preset point of 20 kN of load, 30 seconds of time, 0.005 mm of strain, pip marks, and so on.

Parameters

You must specify:

- a channel.
- a preset point value. This value must be within the hold segment of the data. If it is not, the system will not calculate the result.

You have the option to select **Indicate on graph** to indicate the preset point on the graph.

The system includes the channel and preset hold value in the calculation description. For example, if you select a preset point of 3 mm on the **Compressive extension** channel, the calculation description appears as:

Hold Preset Point (Compressive Extension 3 mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the hold segment of the test data on the specified channel.

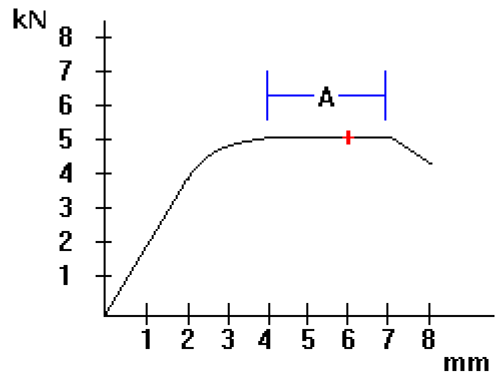
- determines the first occurrence of the specified preset value.
- uses linear interpolation to determine the point if the specified value falls between two data points.

Example

In this example, the preset point is set for 6 seconds on the **Time** channel.

+ = Preset Point Marker

A = Hold Segment



Fails to calculate

The algorithm will not calculate a result if:

- the specified preset point value does not occur within the data.
- you specified a cursor selected point and pressed the **Cancel** button in the **Graph** window.
- you specified a pip point and there are not enough pip marks in the data. For example, if there are 4 pip marks on the curve and 5 are specified, the calculation fails.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

First Peak calculation

This calculation determines the first peak in the test data.

Parameters

You must specify:

- a channel.
- a sensitivity value as a percentage of the channel's maximum value. For example, if the highest value of the **Load** channel is 100 N and you want to detect a rise and fall of 30 N, you would select a peak sensitivity of 30%.

You have the option to select **Indicate on graph** to indicate the first peak on the graph.

The system includes the channel and the percentage change in the calculation description. For example, if you select a first peak on the **Load** channel with a sensitivity of 10%, the description appears as:

First Peak (Load 10% Change)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

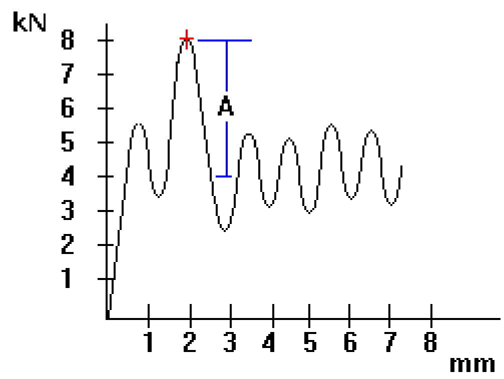
- searches all the data on the specified channel for the maximum value.
- finds the first maximum value.
- if the data before and after a maximum value rises and falls by the specified sensitivity value, the system defines the point as the first peak. If the data does not meet this criteria, the system continues searching the data for the next maximum value.

Example

The channel is set to **Load** with a sensitivity of 50%. The channel's highest value load is 8 kN. The system detects the first peak when the load rises and falls by at least 50% of the maximum load (4 kN).

+ = Marker

A = Sensitivity



Fails to calculate

The algorithm will not calculate a result if the data does not increase and then decrease by the specified sensitivity.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Local Peak calculation

This calculation detects a peak value on a particular channel where the change in value exceeds a preset sensitivity value. The system can detect either a maximum peak, which occurs where the channel values decrease from a previous high value, or a minimum peak, where the channel values increase from a previous low value.

Parameters

You must specify:

- a channel.

- a peak type, either maximum or minimum. Selecting a minimum peak will detect the lowest value. Conversely, a maximum peak detects the highest value.
- a sensitivity as a percentage of the channel's maximum value. For example, if the highest value of the **Load** channel is 100 N and you want to detect a local peak defined as a drop of 30 N, you would select a peak sensitivity of 30%.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the channel, the peak type and the sensitivity in the calculation description. For example, if you select a maximum local peak on the **Tensile Extension** channel with a sensitivity of 1%, the description appears as:

Local Peak Maximum (Tensile Extension 1% Change)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- (for the initial calculation) searches all the data on the specified channel for the maximum value.
- finds the first maximum value.
- if the data before and after a maximum value rises and falls by the specified sensitivity value, the system defines the point as the first peak. If the data does not meet this criteria, the system continues searching the data for the next maximum value.
- (for subsequent calculations) searches from the data point after the first local peak providing there is another local peak calculation with the same channel and peak type settings.

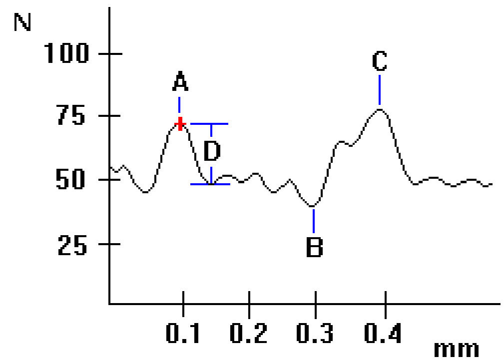
If there is another local peak calculation selected with different channel or peak type settings, the system begins the search from the first data point.

Example

The parameters are set to a maximum peak on the **Load** channel with a 20 N sensitivity. The system detects local peak A because the data following this point drops more that 20 N.

If you select another local peak calculation with the same parameters, the system detects local peak C.

If you change the peak type to minimum, the system detects only peak B because the data after this point rises more than 20 N.



+ = Peak Marker

A= First Maximum Peak

B= Minimum Peak

C = Second Maximum Peak

D = Specified Sensitivity

Fails to calculate

The algorithm will not calculate a result if it does not find a point where the data decreases by the specified sensitivity.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Modulus calculations

These calculations determine the rate of change of stress as a function of strain. Usually this is the slope of the initial linear portion of a stress/strain curve.

Automatic Modulus

This calculation determines the slope of the stress/strain curve by using fixed parameters.

The calculation “E-Modulus” on page 1-59 is recommended for metals testing.

Parameters

You must specify the **Automatic** type of modulus.

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data between the first data point that is greater than or equal to 2% of the maximum load and the maximum load value.
- carries out a zero-slope yield calculation to determine if there is a yield point in the data.
- uses the first data point as the start value.
- uses the yield point or the maximum load point as the end value, whichever occurs first.
- divides the data on the strain axis between the start and end values into 6 equal regions with 0% overlap.
- applies a least square fit algorithm to all of the points in each region to determine the slope of each region.
- determines the pair of consecutive regions that has the highest slope sum.
- from this pair, determines which region has the highest slope and assigns the modulus to that region.

Example

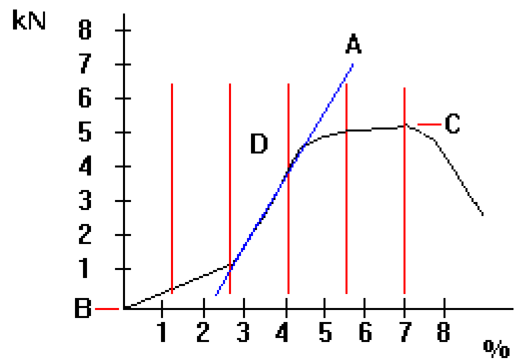
The first data point, 0 kN, is the start value and 5 kN is the end value. The third region within the start and end values has the greatest slope, therefore the system constructs a modulus line along the slope of that region.

A = Modulus Marker

B = Start Value

C = End Value

D = Greatest Slope



Fails to calculate

The algorithm will not calculate a result if there are fewer than seven data points between 2% of maximum load and maximum load.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Automatic Young’s Modulus

This calculation determines the slope of the stress/strain curve by using fixed parameters.

The calculation “E-Modulus” on page 1-59 is recommended for metals testing.

Parameters

You must specify the **Automatic Young’s** type of modulus.

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data between the first data point that is greater than or equal to 2% of the maximum load and the maximum load value.
- carries out a zero-slope yield calculation to determine if there is a yield point in the data.
- uses the first data point as the start value.
- uses the yield point or the maximum load point as the end value, whichever occurs first.
- divides the data on the stress axis between the start and end values into 6 equal regions with 0% overlap.
- applies a least square fit algorithm to all of the points in each region to determine the slope of each region.
- determines the pair of consecutive regions that has the highest slope sum.
- from this pair, determines which region has the highest slope and assigns the modulus to that region.

Example

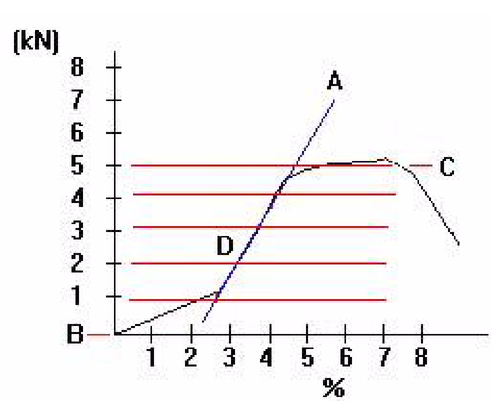
The first data point, 0 kN, is the start value and 5 kN is the end value. The third region within the start and end values has the greatest slope, therefore the system constructs a modulus line along the slope of that region.

A = Modulus Marker

B = Start Value

C = End Value

D = Greatest Slope



Fails to calculate

The algorithm will not calculate a result if there are fewer than seven data points between 2% of maximum load and maximum load.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Chord Modulus

This calculation determines the slope of the stress/strain curve between any two points on the curve. It constructs a straight line between specified lower and upper bounds.

Parameters

You must specify:

- a **Chord** type modulus.
- a channel.
- an end value in the units of the specified channel. This value must be higher than the start value.
- a start value in the units of the specified channel. This value must be lower than the end value.
- If the channel is set to **% Yield**, then specify a yield calculation in the **Parent calculation** field.

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

The system includes the modulus type and the start and end values in the calculation description. For example, if you select a **Chord** modulus on the **Tensile extension** channel with a start value of 5 mm and an end value of 7 mm, the description appears as:

Modulus (Chord 5 mm - 7 mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the channel between the specified start and end values.
- calculates the modulus between the start and end values as follows:

  modulus = {stress at upper value - stress at lower value} / {strain at upper value - strain at lower value}

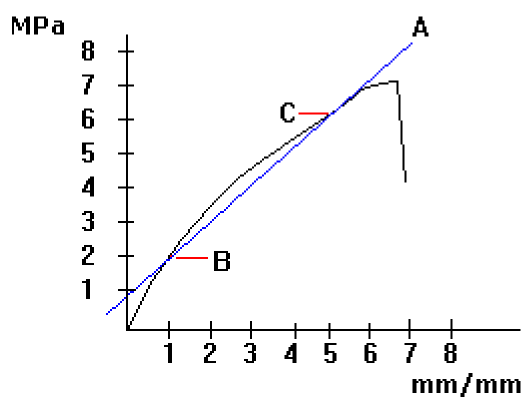
Example

The **Strain** channel is set with a start value of 1 mm/mm and an end value of 5 mm/mm. The system calculates the modulus by dividing the change in stress by the change in strain between the start and end values.

A = Modulus Marker

B = Start Value

C = End Value



Fails to calculate

The algorithm will not calculate a result if the data does not contain either the specified start and end values.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

E-Modulus

This calculation is performed in accordance with the EN10002 and ASTM E8 standards. It determines the elastic modulus of the material by using a standard linear regression technique. The portion of the curve to be used for the calculation is chosen automatically and excludes the initial and final portions of the elastic deformation where the stress-strain curve is non-linear.

Parameters

You must specify the **E-modulus** type of modulus.

You have the option to:

- select **Indicate on graph** to indicate the modulus line on the graph.
- set the modulus value manually (i.e. override the calculation). If the value is set manually, it can be used in another calculation such as offset yield.

If you set the modulus value manually, all results for this calculation are derived from that value, including X-intercept, Y-intercept, and Energy to X-intercept.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- automatically scans the curve from the first recorded stress signal that is greater than 10 MPa. This avoids any noise due to the specimen straightening.

- finds a sample of data points with stress values between 15% and 80% of the current last data point.
- performs a linear regression on the stress-strain curve to calculate the modulus line.
- constructs a line, offset by 0.2%, parallel to the modulus line. A check is made if the offset line crosses the test curve in the yield region. If so, the point of intersection defines the offset yield point and the modulus line is determined. If not, the offset yield point is not yet reached and a new data point is added to the set and the steps are repeated.

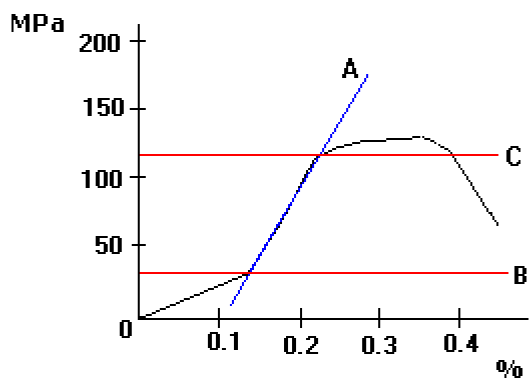
Example

The algorithm has automatically chosen the start and end points as 30 and 120 MPa, defining the linear portion of the curve. A least squares fit algorithm is applied to the region between the start and end values to determine the stress-strain curve slope, the material modulus.

A = Modulus marker

B = Start value (automatically determined)

C = End value (automatically determined)



Fails to calculate

The algorithm will not calculate a result if:

- total elongation is less than 0.2%.
- there are fewer than two data points.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Hysteresis Modulus

This calculation is in accordance with the EN10002 standard. It determines the material modulus from a hysteresis loop generated by a loading and reloading section.

Parameters

You must specify the **Hysteresis** type of modulus.

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- records the stress and strain data during an unloading section.
- records the stress and strain data in the following reloading section.
- uses a least squares fit method to determine the slope of the line through the hysteresis loop, using data points in both the unloading and reloading sections (uses data recorded in the central 15-80% of the hysteresis loop to improve the accuracy of the calculation).

The position of the hysteresis loop is determined by the reversal point value entered in the hysteresis group box in Test Control.

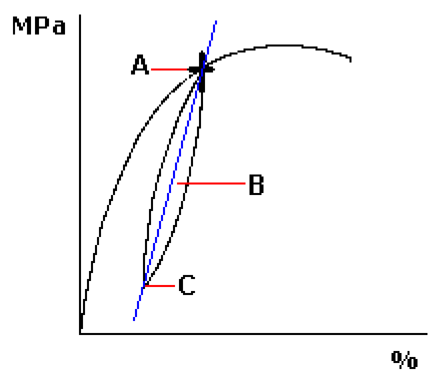
Example

The system starts to unload at the user specified reversal point, which is the start of the hysteresis loop. Then the system reloads at the second reversal point, which is 10% of the stress value at the start of the hysteresis loop. The system calculates the modulus from the line drawn through the hysteresis loop.

A = User Specified Reversal Point

B = Least Squares Fit Line (through Hysteresis Loop)

C = Second Reversal Point



Fails to calculate

The algorithm will not calculate a result if:

- the unloading or reloading sections of the stress-strain curve are not found.
- less than three data points are found in the hysteresis loop.
- the stress at the turnaround point is not less than the start of the unloading section.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Metal Matrix Modulus

The system performs this calculation in accordance with the normative section A.4.9 of the EN10002 standard. It determines the elastic modulus of the material using a technique described in the normative section M bibliography. The portion of the curve to be used for the calculation is chosen automatically and the method is applicable to other metallic material in addition to metal matrix composites.

Parameters

You must specify the **Metal Matrix** type of modulus.

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

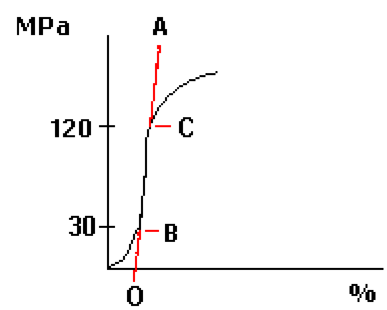
Algorithm

The system:

- fits an initial E-modulus to the stress-strain curve and from this determines the 0.1% offset stress point to define the curve region to be analyzed.
- if an E-modulus calculation cannot be performed, selects all data points up to 0.3% strain or selects the whole curve if the total elongation is less than 0.3%.
- checks that there is no hysteresis loop within the selected region.
- checks that there are sufficient readings for the calculation.
- follows the method of Roebuck et al., and calculates the tangent modulus at each point in the selected region.
- chooses the tangent slope with the least variation about the mean value and estimates the true origin of the stress-strain curve.
- with the new origin defined, calculates a secant modulus at each point in the selected region.
- chooses the secant slope with the least variation about the mean value to determine the material modulus and re-estimates the true origin of the stress-strain curve.

Example

The algorithm automatically chooses the start and end points as 30 and 120 MPa, defining the linear portion of the curve. The region BC contains the most colinear data points in the initial part of the stress-strain curve and this determines the stress-strain curve slope, hence the material modulus.



A = Modulus marker

B = Start value (implicitly determined)

C = End value (automatically determined)

O = True origin of stress-strain curve

Fails to calculate

The algorithm will not calculate a result if:

- there are less than approximately 35 data points in the linear portion of the curve.
- a hysteresis loop is detected in the linear portion of the curve.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Secant Modulus

This calculation determines the slope of a line constructed between zero and any point on the curve. It constructs a straight line between zero and a specified end value.

Parameters

You must specify:

- the **Secant** type of modulus.
- a channel.
- an end value in the units of the specified channel. The system does not include data after the end value in the calculation.
- if the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the modulus line on the graph. This is available only if the graph is plotting a combination of normalized Y (stress) and normalized X (strain) channels or their source.

The system includes the modulus type and the end value in the calculation description. For example, if you select a **Secant** modulus on the **Time** channel with an end value of 1 second, the description appears as:

Modulus (Secant 1 sec)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- uses the zero stress/strain point as the start value.
- searches the data on the channel for the specified end value.
- calculates the modulus between the start and end values as follows:

  modulus = {stress at upper value - stress at lower value} / {strain at upper value - strain at lower value}

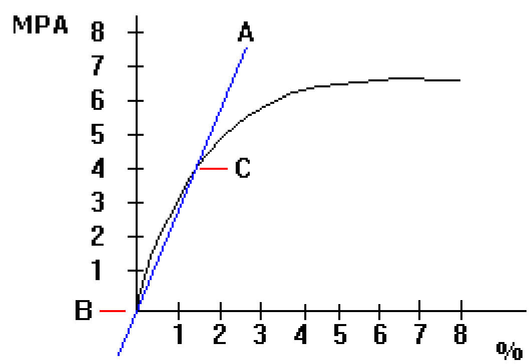
Example

The **Stress** channel is set for a start value of 4 MPa. The start value is fixed at Strain point 0.0%. The system calculates the modulus by dividing the change in stress by the change in strain between the start and end values.

A = Modulus Marker

B = Start Value

C = End Value



Fails to calculate

The algorithm will not calculate a result if the specified end value is not within the data.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Segment Modulus

This calculation determines the slope of the stress/strain curve between specified bounds. The system interpolates the start and end values if the values do not match actual data points. The system uses a least squares fit routine to construct the modulus line.

Parameters

You must specify:

- the **Segment** type modulus.
- a channel.
- an end value in the units of the specified channel. This value must be higher than the start value. The system does not include data after the end value in the calculation
- a start value in the units of the specified channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

The system includes the modulus type and the start and end values in the calculation description. For example, if you select a **Segment** modulus on the **Strain 1** channel with a start value of 0.1% and an end value of 0.5%, the description appears as:

Modulus (Segment 0.1% - 0.5%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data on the channel for the specified start and end values.
- if necessary, uses linear interpolation to define the start and end values.
- calculates the least squares fit on all the points between the start and end values. The modulus line will not necessarily pass through the start and end values or any point in between.

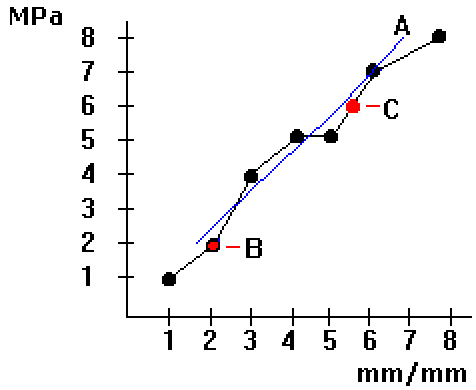
Example

The **Stress** channel is set with a start value of 2 MPa and an end value of 6 MPa. Because no data point is equal 6 MPa, the system uses linear interpolation to define an end value. The system defines the modulus by constructing a straight line using a least squares fit equation.

A = Modulus Marker

B = Start Value

C = End Value (Interpolated)



The modulus line does not intersect the start and end values.

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain either the specified start or end value.
- there are fewer than two data points between the specified start and end values.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Tangent Modulus

This calculation finds the slope of the stress/strain curve at a point on the curve. It constructs a modulus line at a tangent to a specified point.

Parameters

You must specify:

- a **Tangent** type of modulus.
- a channel.
- a channel value (tangent point).
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

The system includes the modulus type and the channel value in the calculation description. For example, if you select a **Tangent** modulus on the **Compressive stress** channel with a value of 11 kPa, the description appears as:

Modulus (Tangent 11 kPa)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches all the data on the specified channel for the first point equal to or greater than the channel value (tangent point).
- uses this data point as the end value.

- uses the first data point before the tangent point as the start value.
- calculates the modulus between the start and end values as follows:

  modulus = {stress at upper value - stress at lower value} / {strain at upper value - strain at lower value}

Example

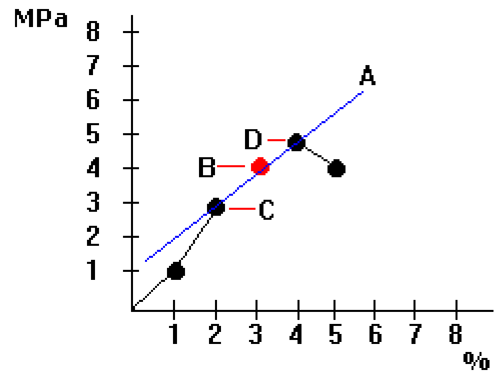
The **Stress** channel is selected with a channel value of 4 MPa. No data point is equal to this point so the system uses 5 MPa as the end value. The start value is 3 MPa, the first point less than the channel value. The system constructs a modulus line through these points.

A = Modulus Marker

B = Channel Value

C = Start Value

D = End Value



Fails to calculate

The algorithm will not calculate a result if the data does not contain the specified tangent value.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Young's Modulus

This calculation determines the slope of the stress/strain curve in the initial linear portion of the curve. It calculates the slopes using least-squares fit on test data for a specified number of regions between the lower and upper bounds, and reports the steepest slope as the modulus.

Parameters

You must specify:

- the **Young's** type of modulus.
- a channel.
- an end value in the units of the specified channel. This value must be higher than the start value. The system does not include data after the end value in the calculation.
- a start value in the units of the specified channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- the number of regions. The available range is between 1 and 100 regions.
- a percentage of overlap between 0 and 99.
- the axis to use for dividing into regions. Select the stress or strain axis.
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to indicate the modulus line on the graph.

The system includes the modulus type and the upper and lower bound values in the calculation description. For example, if you select a **Young's** type of modulus on the **Strain 1** channel with a start value of 0.3 mm/mm and an end value of 0.5 mm/mm with the axis for region division set to **Tensile strain**, the description appears as:

Modulus (Young's Tensile Strain 0.3 mm/mm - 0.5 mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- divides the data between the start and end values into the number of equally spaced regions with the specified percentage overlap.

- assigns the start of each region to the closest data point.
- assigns the end of each region to the closest data point.
- applies a least squares fit algorithm on all the data points in each region.
- calculates the sum of the slopes of each pair of adjacent data regions.
- determines which pair of regions that has the highest slope and assigns the modulus to that region.
- determines the modulus by using the highest slope of the adjacent region that had the highest sum.

Example

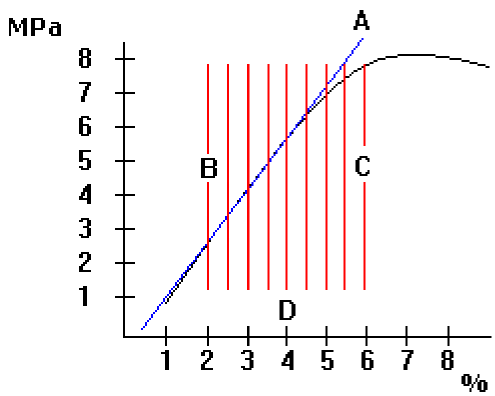
The **Strain** channel is selected with a start value of 2% and an end value of 6%. The number of regions is set to 8 and the axis for region division is set to strain. The system applies the least square fit algorithm to each region between the start and end values and constructs a modulus to the region with the highest slope and the adjacent region.

A = Modulus Marker

B = Start Value

C = End Value

D = Regions



Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain either the specified upper or lower bound.
- the data contains the same number or fewer points than the specified number of regions.

Results

Energy to X-Intercept
X-Intercept
Y- Intercept
Modulus

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

n-value calculations

These calculations meet the requirements of ISO 10275 and ASTM E646 standards. They determine the n-value, also known as the strain hardening exponent, and the strength coefficient in the plastic region.

n-Value (Automatic)

This calculation determines the strain hardening exponent, n, as the slope of the log(true stress) versus log(true strain) curve in the plastic region.

Parameters

You must specify the n-value type as **Automatic**.

You have the option to:

- select **Remove elastic strains** to remove the elastic components of the measured strains. If you select this option, then references to “true strain” in the algorithm section denote “true plastic strain”.
- select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the start point and end point.

  To determine the start point, the system searches for the following points and accepts the first valid point found:

  - end of YPE/A_e
  - upper yield

- 0.2% offset yield

The system calculates the YPE/A_e based on the automatic type with 0.2% offset yield and no end point slope intersection correction.

The end point is the point at tensile strength.

- determines the desired region of the curve between the start and end points.
- calculates the strain hardening exponent, or n-value, and the strength coefficient, which are defined according to the following equation relating the true stress to the true strain during uniaxial force application:

  $\sigma = K\varepsilon^n$

  where:

  σ is the true stress,
  ε is the true strain,
  K is the strength coefficient, and
  n is the strain hardening exponent.

The following steps show how the system calculates the n and K values of the above equation.

For metallic sheet materials, this power curve relationship is only valid during plastic deformation.

The system:

- defines the true stress and strain using the following equations:

  $\sigma = FL / (L_e S_0)$

  $= (F/ S_0)\ (1+e)$

  and $\varepsilon = \ln(L/L_e)$

  $= \ln(1+e)$

  where:

  L is the instantaneous length measurement,
  L_e is the tensile elongation gauge length,
  S_0 is the undeformed specimen cross-sectional area,
  F is the applied load, and
  e is the dimensionless engineering strain (if **Remove elastic strains** is selected, then e is the plastic strain).

- constructs the log(true stress) vs. log(true strain) curve and uses normal linear regression techniques to create a straight line in the desired region.

  This line has the equation:

  $\log \sigma = n\log \varepsilon + \log K$

  where:

  n is the slope of the line, and

  K is a value such that log K is the x intercept of the line.

- obtains the power curve equation by expressing the above equation as an exponential equation:

  $\log \sigma = n\log \varepsilon + \log K = \log K + n\log \varepsilon = \log (K\varepsilon^n)$

  so $\sigma = K\varepsilon^n$

  and hence both n and K can be determined by normal linear regression techniques.

Example

The system finds the start and end points and uses a least-squares fit method to determine the n-value.

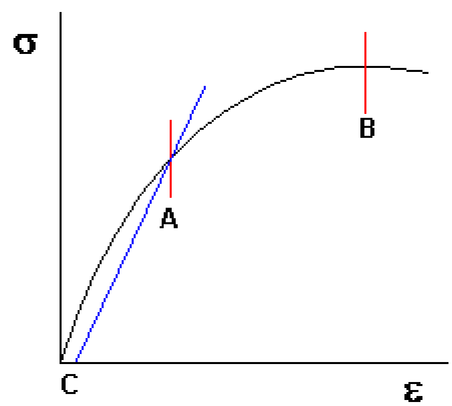
A = Start Point

B = End Point

C = 0.2% Offset

True stress =(F/S_0)(1+e)

True strain = ln(1+e)



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- there are fewer than five points in the selected region.
- a required data channel is missing or empty.
- the elastic strain cannot be calculated because E-modulus does not exist. This failure only occurs if you select **Remove elastic strains** as an option.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Starting Strain
Starting Stress
Ending Strain
Ending Stress
Strain Hardening Exponent
Strength Coefficient
Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
3	Warning: Strain range is less than 1%.
4	Warning: Fewer than 20 data points in selected region.
100	Error: Internal error.
106	Error: There are fewer than five points in the selected region.
107	Error: Specified region has more than one segment ID, or contains a speed change.
108	Error: Specified region contains a hysteresis loop.
110	Error: Required data channel is missing or empty.
112	Error: Required modulus cannot be calculated.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

n-Value (Manual - Automatic Validation)

This calculation determines the strain hardening exponent, n, as the slope of the log(true stress) versus log(true strain) curve in the plastic region. If you require analysis over a particular region of the stress-strain curve, use this calculation to manually enter the start point and the end point. The system automatically validates the specified start and end points.

Parameters

You must specify:

- the n-value type as **Manual (automatic validation)**.
- the **Start type**.
- the **Start value**.
- the **End type**.
- the **End value**.

*For the Start type, select **Delay after speed change** only when there is a speed change in the region where the calculation is performed. This time delay will avoid a calculation failure.*

You have the option to:

- select **Remove elastic strains** to remove the elastic components of the measured strains. If you select this option, then references to “true strain” in the algorithm section denote “true plastic strain”.
- select **Indicate on graph** to place a marker on the graph.

The system includes the start type, start value, end type and end value in the calculation description. For example, if you select extension as a start type, 5.0mm as a start value, extension as an end type and 12.5mm as an end value, the description appears as:

n-Value (Exten 5.0mm, Exten 12.5mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the user specified start and end points.
- validates the start and end points.

  To validate the start point, the system compares the specified start point to the first point found from the following list. The start point is valid if it occurs after any one of these points:

  - end of YPE/A_e, if it exists.
  - upper yield, if it exists.
  - 0.2% offset yield, if it exists

The system calculates the YPE/A_e based on the automatic type with 0.2% offset yield and no end point slope intersection correction.

  To validate the end point, the system compares the specified end point to the point at tensile strength. The end point is valid if it occurs before tensile strength.

- determines the desired region of the curve between the start and end points.
- calculates the strain hardening exponent, or n-value, and the strength coefficient, which are defined according to the following equation relating the true stress to the true strain during uniaxial force application:

  $\sigma = K\varepsilon^n$

  where:

  σ is the true stress,
  ε is the true strain,
  K is the strength coefficient, and
  n is the strain hardening exponent.

The following steps show how the system calculates the n and K values of the above equation.

For metallic sheet materials, this power curve relationship is only valid during plastic deformation.

The system:

- defines the true stress and strain using the following equations:

$\sigma = FL / (L_e S_0)$

$= (F/ S_0)(1+e)$

and $\varepsilon = \ln(L/L_e)$

$= \ln(1+e)$

where:

L is the instantaneous length measurement,
L_e is the tensile elongation gauge length,
S_0 is the undeformed specimen cross-sectional area,
F is the applied load, and
e is the dimensionless engineering strain (if **Remove elastic strains** is selected, then e is the plastic strain).

- constructs the log(true stress) vs. log(true strain) curve and uses normal linear regression techniques to create a straight line in the desired region.

  This line has the equation:

  $\log \sigma = n\log \varepsilon + \log K$

  where:

  n is the slope of the line, and

  K is a value such that log K is the x intercept of the line.

- obtains the power curve equation by expressing the above equation as an exponential equation:

  $\log \sigma = n\log \varepsilon + \log K = \log K + n\log \varepsilon = \log (K\varepsilon^n)$

  so $\sigma = K\varepsilon^n$

  and hence both n and K can be determined by normal linear regression techniques.

Example

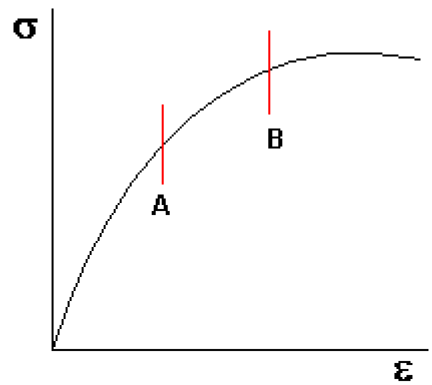
The system finds the user specified start and end points and applies a least-squares fit method to the log of the true stress and true strain data.

A = Start Point

B = End Point

True stress = $(F/S_0)(1+e)$

True strain = $\ln(1+e)$



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- there are fewer than five points in the selected region.
- either the start or end point is not found.
- the start point is not valid as described in the Algorithm section.
- the end point occurs after the point of tensile strength.
- the start point occurs after the end point.
- a required data channel is missing or empty.
- the elastic strain cannot be calculated because E-modulus does not exist. This failure only occurs if you select **Remove elastic strains** as an option.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Starting Strain
Starting Stress
Ending Strain
Ending Stress
Strain Hardening Exponent

Strength Coefficient
Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
1	Warning: Start point replaced by yield or YPE point.
2	Warning: End point replaced by tensile strength point.
3	Warning: Strain range is less than 1%.
4	Warning: Fewer than 20 data points in selected region.
100	Error: Internal error.
101	Error: Start value not found.
102	Error: End value not found.
103	Error: Specified start value occurs after the end value.
104	Error: Specified start value occurs before the yield or YPE point.
105	Error: Specified end value occurs after the tensile strength point.
106	Error: There are fewer than five points in the selected region.
107	Error: Specified region has more than one segment ID, or contains a speed change.
108	Error: Specified region contains a hysteresis loop.
110	Error: Required data channel is missing or empty.
112	Error: Required modulus cannot be calculated.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

n-Value (Manual)

This calculation determines the strain hardening exponent, n, as the slope of the log(true stress) versus log(true strain) curve in the plastic region. If you require analysis over a particular region of the stress-strain curve, use this calculation to manually enter the start point and the end point. You can also manually set the validation rules for the specified start and end points.

Parameters

You must specify:

- the n-value type as **Manual**.
- the **Start type**.
- the **Start value**.
- the **End type**.
- the **End value**.
- the **Parent calculation** field if any of the following conditions exist:
  - if the start type is set to **yield point**, **end of YPE region** or **percent of plastic strain**.
  - if **Compare Start Value to Yield or YPE** is selected.
  - if the end type is set to **percent of plastic strain**.

  The parent calculation can be any Yield or YPE calculation.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

*For the Start type, select **Delay after speed change** only when there is a speed change in the region where the calculation is performed. This time delay will avoid a calculation failure.*

You have the option to:

- select **Compare Start Value to Yield or YPE** when you select any start type except yield point, end of YPE region or percent of plastic strain. This option verifies that the specified start value is valid when compared to a specific yield or YPE result. In order to calculate the desired yield or YPE result, you must add the desired calculation to the **Selected Calculations** list, and then select it as a parent calculation. If you select this option, you must also specify what the system should do if the specified start value occurs first. The options are in **If Start Value occurs first**. To keep the specified start value regardless of where it occurs on the curve, do not enable **Compare Start Value to Yield or YPE**.
- select **Compare End Value to Tensile Strength** when you select any end type except percent of plastic strain or percent of tensile strength. This option verifies that the specified end value is valid when compared to tensile strength. If you select this option, you must also specify what the system should do if the specified end value occurs last. The options are in **If End Value occurs last**. To keep the specified end value regardless of where it occurs relative to tensile strength, do not enable **Compare End Value to Tensile Strength**.
- select **Remove elastic strains** to remove the elastic components of the measured strains. If you select this option, then references to "true strain" in the algorithm section denote "true plastic strain".
- select **Indicate on graph** to place a marker on the graph.

The system includes the start type, start value, end type and end value in the calculation description. For example, if you select extension as a start type, 5.0mm as a start value, extension as an end type and 12.5mm as an end value, the description appears as:

n-Value (Exten 5.0mm, Exten 12.5mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the user specified start and end points.
- validates the start and end points based on the parameter choices you made.
- determines the desired region of the curve between the start and end points.
- calculates the strain hardening exponent, or n-value, and the strength coefficient, which are defined according to the following equation relating the true stress to the true strain during uniaxial force application:

$$\sigma = K\varepsilon^n$$

where:

σ is the true stress,
ε is the true strain,
K is the strength coefficient, and
n is the strain hardening exponent.

The following steps show how the system calculates the n and K values of the above equation.

For metallic sheet materials, this power curve relationship is only valid during plastic deformation.

The system:

- defines the true stress and strain using the following equations:

  $\sigma = FL / (L_e S_0)$

  $= (F/ S_0) (1+e)$

  and $\varepsilon = \ln(L/L_e)$

  $= \ln(1+e)$

  where:

  L is the instantaneous length measurement,
  L_e is the tensile elongation gauge length,
  S_0 is the undeformed specimen cross-sectional area,
  F is the applied load, and
  e is the dimensionless engineering strain (if **Remove elastic strains** is selected, then e is the plastic strain).

- constructs the log(true stress) vs. log(true strain) curve and uses normal linear regression techniques to create a straight line in the desired region.

  This line has the equation:

  $\log \sigma = n\log \varepsilon + \log K$

  where:

  n is the slope of the line, and

  K is a value such that log K is the x intercept of the line.

- obtains the power curve equation by expressing the above equation as an exponential equation:

  $\log \sigma = n\log \varepsilon + \log K = \log K + n\log \varepsilon = \log (K\varepsilon^n)$

so $\sigma = K\varepsilon^n$

and hence both n and K can be determined by normal linear regression techniques.

Example

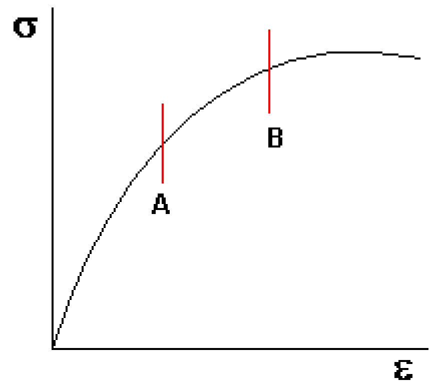
The system finds the user specified start and end points and applies a least-squares fit method to the log of the true stress and true strain data.

A = Start Point

B = End Point

True stress =(F/S_0)(1+e)

True strain = ln(1+e)



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- there are fewer than five points in the selected region.
- either the start or end point is not found.
- the start point is not valid based on the user defined parameters.
- the end point is not valid based on the user defined parameters.
- the start point occurs after the end point.
- a required data channel is missing or empty.
- a required parent calculation is not selected or failed to calculate.
- the elastic strain cannot be calculated because E-modulus does not exist. This failure only occurs if you select **Remove elastic strains** as an option.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Starting Strain
Starting Stress
Ending Strain
Ending Stress
Strain Hardening Exponent
Strength Coefficient
Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
1	Warning: Start point replaced by yield or YPE point.
2	Warning: End point replaced by tensile strength point.
3	Warning: Strain range is less than 1%.
4	Warning: Fewer than 20 data points in selected region.
100	Error: Internal error.
101	Error: Start value not found.
102	Error: End value not found.
103	Error: Specified start value occurs after the end value.
104	Error: Specified start value occurs before the yield or YPE point.
105	Error: Specified end value occurs after the tensile strength point.
106	Error: There are fewer than five points in the selected region.
107	Error: Specified region has more than one segment ID, or contains a speed change.
108	Error: Specified region contains a hysteresis loop.

Status Number	Status
110	Error: Required data channel is missing or empty.
111	Error: Required parent calculation is not selected or failed to calculate.
112	Error: Required modulus cannot be calculated.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Non-Proportional Elongation calculations

These calculations meet the requirements for EN10002 and ASTM E8 standards. They determine the plastic portion of elongation at tensile strength and break.

Non-Proportional Elongation (% Maximum Load)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is defined as a percentage of the maximum load.

Parameters

You must specify:

- the **% Maximum load** type of non-proportional elongation.
- the value. Typically the value is a percentage of maximum load between 0 and 100.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the value in the calculation description. For example, if the maximum load is 100 N and the specified value is 60%, the system detects a break when the load falls to 60 N after the maximum load. The description appears as:

Non-Proportional Elongation (% Maximum load 60%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

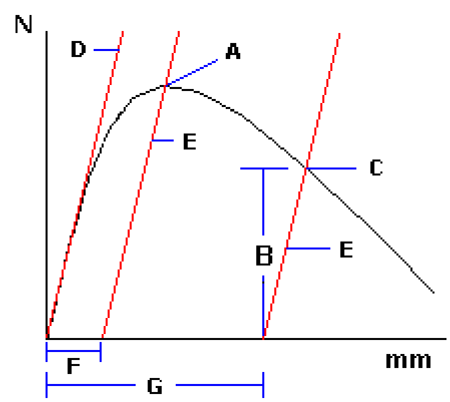
Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches all the data on the load channel for the maximum load point.
- searches the data beyond the maximum load point for the first point where the load is less than or equal to the specified percentage of the load. If the value falls between two points, the system interpolates the value.
- assigns that point as the break.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system finds the user-specified percentage of maximum load and assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.



A = Maximum Load and Tensile Strength

B = % of Maximum Load

C = User-Specified Break Point

D = Modulus Line

E = Line Drawn Parallel to Modulus Line

F = Non-proportional (plastic) Elongation at Tensile Strength

G = Non-proportional (plastic) Elongation at Break

Fails to calculate

The algorithm will not calculate a break result if:

- the load does not drop below the specified percent of maximum load after the maximum load point.
- if the maximum load is the last data point.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Non-Proportional Elongation (EN Standard)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is the point at which stress is lower than 3% of the maximum measured stress.

Parameters

You must specify the **EN standard** type of Non-proportional elongation.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches all the data on the stress channel for three consecutive data points such that the stress drop between the second and third points is more than five times the stress drop between the first and second points. If so, assigns the second point as a potential break point.

- if a potential break point is found, searches the rest of the data on the stress channel for a value less than 3% of the maximum recorded stress and assigns that point as the break point.
- if no potential break point is found, assigns the last data point as the break point, provided that its stress value is less than 3% of the maximum recorded stress.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system finds the required stress point and assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.

A = Maximum Stress and Tensile Strength

B = Potential Break Point where b>5a

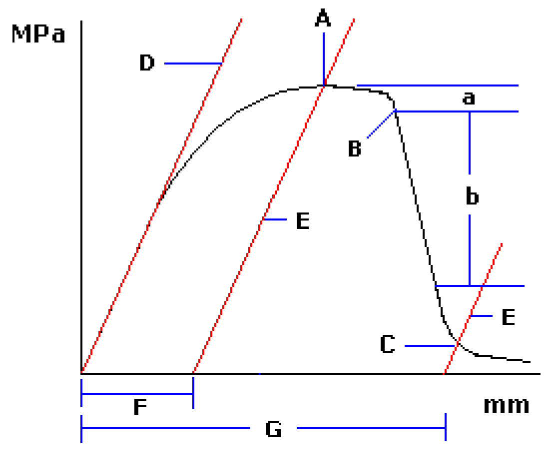
C = Calculated Break Point at or <3% of A

D = Modulus Line

E = Line Drawn Parallel to Modulus Line

F = Plastic Portion of Elongation at Tensile Strength

G = Plastic Portion of Elongation at Break



Fails to calculate

The algorithm will not calculate a break result if the recorded stress never falls to less than 3% of the maximum stress.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Non-Proportional Elongation (Load)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is defined as a specified load value.

Parameters

You must specify:

- the **Load** type of Non-proportional elongation.
- the value. The value must be less than the maximum load point.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the value in the calculation description. For example, if the value is 10 N, the description appears as:

Non-Proportional Elongation (Load 10 N)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

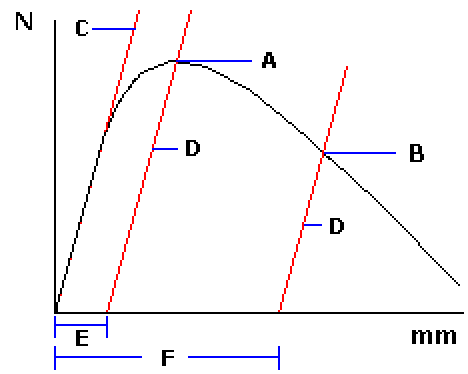
Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches all the test data on the load channel for the maximum load point.
- searches the data beyond the maximum load point for the first point where the load is less than or equal to the specified load value.
- assigns that point as the break.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system finds the first point, beyond maximum load, where the load is less than or equal to the user-specified load value and assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.



A = Maximum Load and Tensile Strength

B = User-Specified Break Point

C = Modulus Line

D = Line Drawn Parallel to Modulus Line

E = Non-proportional (plastic) Elongation at Tensile Strength

F = Non-proportional (plastic) Elongation at Break

Fails to calculate

The algorithm will not calculate a break result if:

- the load does not drop to the specified value.
- the maximum load is the last data point.
- the maximum load is less than the specified value.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Non-Proportional Elongation (Load/Tensile Extension Rate)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is defined as a drop in load at a specified rate. The rate of the drop is derived from the change in load divided by a change in extension.

Parameters

You must specify:

- the **Load/tensile extension rate** type of Non-proportional elongation.
- the value.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the value in the calculation description. For example, if the value is 20 N/mm, the description appears as:

Non-proportional elongation (Load/tensile extension rate 20 N/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

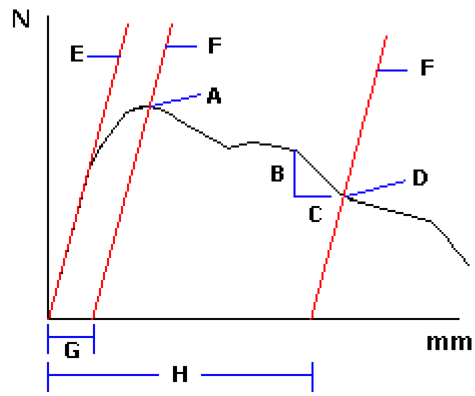
Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches all the data on the **Load** channel for the maximum load point.
- searches the load and extension data beyond the maximum load point for the first point where the slope of the load/tensile extension curve is equal to or greater than the specified rate.
- assigns that point as break.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system finds the maximum load and searches from that point to the end of the data for the first occurrence of the load dropping at the user-specified rate. The rate of the drop is derived from the change in load divided by a change in extension. The system assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.



A = Maximum Load and Tensile Strength

B = Load Change

C = Extension Change

D = User-Specified Break Point

E = Modulus Line

F = Line Drawn Parallel to Modulus Line

G = Plastic Portion of Elongation at Tensile Strength

H = Plastic Portion of Elongation at Break

Fails to calculate

The algorithm will not calculate a break result if:

- the data does not contain a slope that is equal to or less than the specified rate.
- the maximum load is the last data point.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Non-Proportional Elongation (Load/Tensile Strain Rate)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is defined as a drop in load at a specified rate. The rate of the drop is derived from the change in load divided by a change in strain.

Parameters

You must specify:

- the **Load/tensile strain rate** type of Non-proportional elongation.
- the value.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the value in the calculation description. For example, if the value is 20 N/mm/mm, the description appears as:

Non-Proportional Elongation (Load/Tensile Strain Rate 20 N/mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

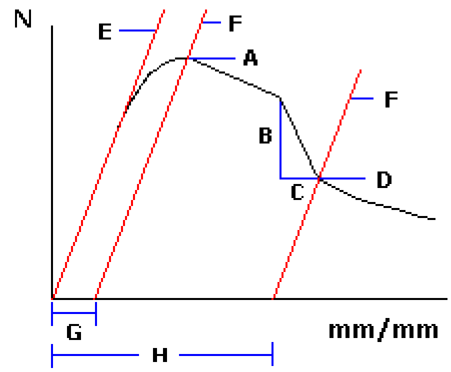
Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches all the data on the **Load** channel for the maximum load point.
- searches the data beyond the maximum load point for the occurrence when the slope of the curve is equal to or greater than the specified rate.
- assigns that point as break.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system finds the maximum load and searches from that point to the end of the data for the first occurrence of the load dropping at the user-specified rate. The rate of the drop is derived from the change in load divided by a change in strain. The system assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.



A = Maximum Load and Tensile Strength

B = Load Change

C = Strain Change

D = User-Specified Break Point

E = Modulus Line

F = Line Drawn Parallel to Modulus Line

G = Plastic Portion of Elongation at Tensile Strength

H = Plastic Portion of Elongation at Break

Fails to calculate

The algorithm will not calculate a break result if:

- the data does not contain a slope that is equal to or less than the specified rate.
- the maximum load is the last data point.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Non-Proportional Elongation (Standard)

This calculation determines the plastic portion of elongation at tensile strength and break. The break point is defined as the highest load in the last 100 ms of data.

Parameters

You must specify the **Standard** type of non-proportional elongation.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

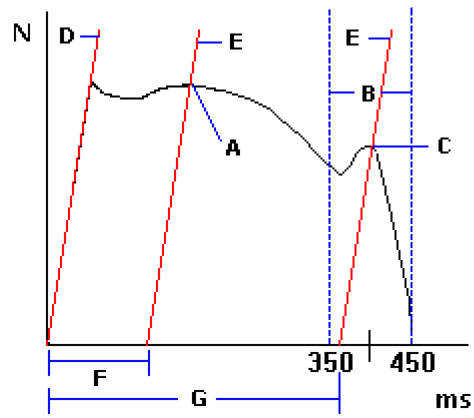
Algorithm

The system:

- finds the tensile strength using the algorithm described under the tensile strength calculation.
- searches the last 100 ms of the load channel data.
- sequentially compares each point with the next to determine the maximum value.
- assigns the maximum point as the break.
- through both the tensile strength point and assigned break point, draws lines parallel to the modulus line then calculates the distance between the intercepts of the line and modulus line on the strain axis.

Example

The system searches the last 100 ms for the maximum load and assigns that point as the break. Through both the tensile strength point and the break point, it draws lines parallel to the modulus line to calculate the non-proportional elongation.



A = Tensile Strength

B = 100 ms

C = Break Point

D = Modulus Line

E = Line Drawn Parallel to Modulus Line

F = Non-proportional (plastic) Elongation at Tensile Strength

G = Non-proportional (plastic) Elongation at Break

Fails to calculate

The algorithm will not calculate a break result if there is less than 100 ms of data.

The algorithm will not calculate a tensile strength result if there are less than 50 data points collected.

Results

Percentage Elongation at Break
Elongation at Break
Percentage Elongation at Tensile Strength
Elongation at Tensile Strength

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Poisson's Ratio calculations

Poisson's Ratio is the negative of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material. Transverse strain is measured in a direction perpendicular to the applied load and axial strain is measured in a direction of the applied load. The ratio is a material constant for stresses in the region below the proportional limit; that is in the region where stress and strain are proportional.

The axial strain always comes from the axial strain source, and the transverse strain always comes from the transverse strain source 1.

Poisson's Ratio (Chord)

Poisson's Ratio is the negative of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material. Transverse strain is measured in a direction perpendicular to the applied load and axial strain is measured in a direction of the applied load. The ratio is a material constant for stresses in the region below the proportional limit; that is in the region where stress and strain are proportional.

The axial strain always comes from the axial strain source, and the transverse strain always comes from the transverse strain source 1.

This calculation determines the slope of the transverse strain/tensile strain curve between any two points on the curve. It constructs a straight line between the specified lower and upper bounds.

Parameters

You must specify:

- the **Chord** type of Poisson's Ratio
- a channel.
- an **End Value** in the units of the specified channel. This value must be higher than the start value. The system does not include data after the end value in the calculation.
- a **Start Value** in the units of the specified channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

The system includes the **Poisson's Ratio** type in the calculation description. For example, if you select a **Chord** type of Poisson's Ratio on the **Strain 1** channel with a start value of 0.3 mm/mm and an end value of 0.5 mm/mm, the description appears as:

Poisson's Ratio (Chord 0.3 mm/mm - 0.5 mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- defines the start point by finding the first place in the test data where the start value occurs between two points. Interpolate the transverse strain and the axial strain at the start value.
- defines the end point by finding the first place in the test data, after the start value, where the end value occurs between two points. Interpolates the transverse strain and the axial strain at the end value.
- calculates the slope of the straight line between the two interpolated points as follows:

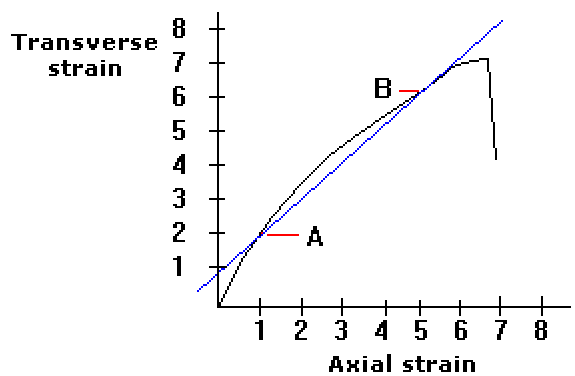
  Poisson's ratio = {transverse strain at upper value - transverse strain at lower value} / {tensile strain at upper value - tensile strain at lower value}

A transverse extensometer produces a positive signal as the extension decreases.

Example

In a tensile test, transverse strain generally decreases as axial strain increases. The value of Poisson's Ratio is therefore the negative of the ratio of the two strains in order to produce a positive number. You define limits between which the system constructs a straight line. Poisson's Ratio is the slope of that line.

In this example, the **Strain** channel is set with a start value of 1 mm/mm and an end value of 5 mm/mm. The system calculates Poisson's Ratio by dividing the change in transverse strain by the change in axial strain between the start and end values.



A = Start Value

B = End Value

Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain either the specified upper or lower bound.
- no yield calculation is selected when the channel is % of Yield Load.

Results

Poisson's Ratio
X-Intercept
Y-Intercept

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Poisson's Ratio (Least Squares Fit)

Poisson's Ratio is the negative of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material. Transverse strain is measured in a direction perpendicular to the applied load and axial strain is measured in a direction of the applied load. The ratio is a material constant for stresses in the region below the proportional limit; that is in the region where stress and strain are proportional.

The axial strain always comes from the axial strain source, and the transverse strain always comes from the transverse strain source 1.

This calculation determines the slope of the transverse strain/tensile strain curve between the specified limits using least squares fit on test data.

Parameters

You must specify:

- the **Least Squares Fit** type of Poisson's Ratio
- a channel.
- an **End Value** in the units of the specified channel. This value must be higher than the start value. The system does not include data after the end value in the calculation.

- a **Start Value** in the units of the specified channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

The system includes the **Poisson's Ratio** type in the calculation description. For example, if you select a **Least Squares Fit** type of Poisson's Ratio on the **Strain 1** channel with a start value of 0.3 mm/mm and an end value of 0.5 mm/mm, the description appears as:

Poisson's Ratio (Least Squares Fit 0.3 mm/mm - 0.5 mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- defaults to a single data region with no overlap.
- defines the start point by finding the first place in the test data where the start value occurs between two points. Then it selects one of these two points, whichever is closer to the specified value.
- finds the end value in the same way, starting the search after the start point.
- using this data, calculates a least squares fit for transverse strain vs. axial strain. Does not interpolate. Reports this value as Poisson's Ratio.

A transverse extensometer produces a positive signal as the extension decreases.

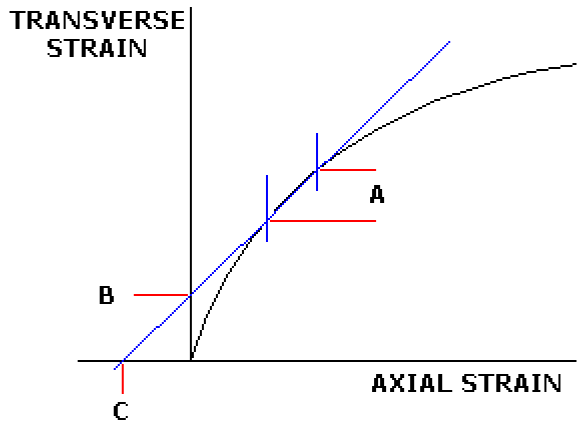
Example

In a tensile test, transverse strain generally decreases as axial strain increases. The value of Poisson's ratio is therefore the negative of the ratio of the two strains in order to produce a positive number. You define limits between which the system constructs a straight line. Poisson's ratio is the slope of that line.

A = Limits

B = Y-intercept

C = X-intercept



Fails to calculate

The algorithm will not calculate a result if:

- the data does not contain either the specified upper or lower bound.
- no yield calculation is selected when the channel is % of Yield Load.

Results

Poisson's Ratio
X-Intercept
Y-Intercept

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Preset Point calculation

This calculation is based upon an assigned channel and value. For example, you can set a preset point of 20 kN of load, 30 seconds of time, 0.005 mm of strain, cursor selected points, pip marks, and so on.

Parameters

You must specify:

- either a channel, a cursor-selected point, or a pip point.
- a preset point value for a channel, or a pip number for a pip point.
- If the channel is set to **% Yield**, specify a yield calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the channel and preset point value in the calculation description. For example, if you select a preset point of 3mm on the Compressive extension channel, the description appears as:

Preset Point (Compressive extension 3mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

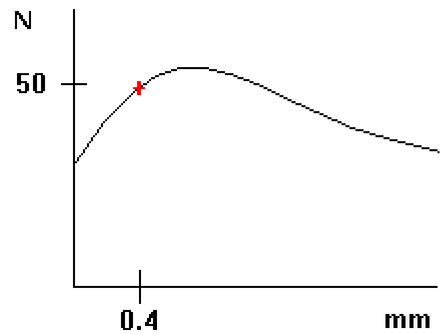
The system:

- searches all the test data on the specified channel.
- determines the first occurrence of the specified preset value.
- uses linear interpolation to determine the value if the point falls between two data points.

Example

The preset point is set for 50 N on the **Load** channel. The **Time** result at the first occurrence of the preset point is 0.4 seconds.

+ = Preset Point Marker



Fails to calculate

The algorithm will not calculate a result if:

- you specified a cursor-selected point for the calculation but have not selected the point in the **Edit Cursor-Selected Points** dialog.
- the preset point value does not occur within the data.
- you specified a pip point and there are not enough pip marks in the data. For example, if there are 4 pip marks on the curve and 5 are specified, the calculation fails.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

r-value calculations

These calculations meet the requirements of ISO 10113 and ASTM E517 standards. They determine the ratio of the true width strain to the true thickness strain. These calculations are also known as plastic strain ratio.

The axial strain always comes from the axial strain source, and the transverse strain always comes from the transverse strain source 1.

r-value (Automatic)

This calculation determines the plastic strain ratio, r, as the ratio of the true width strain to the true thickness strain.

Parameters

You must specify the r-value type as **Automatic**.

You have the option to:

- select **Remove elastic strains** to remove the elastic components of the measured strains.
- specify **Modulus**. Modulus of elasticity is greater than zero.
- specify **Poisson's Ratio**. Poisson’s Ratio value ranges from 0.1 to 0.9.
- select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the start point and end points.

  To determine the start point, the system searches for the following points and accepts the first valid point found:

  - end of YPE/A_e
  - upper yield
  - 0.2% offset yield

The system calculates the YPE/A_e based on the automatic type with 0.2% offset yield and no end point slope intersection correction.

  The end point is the point at tensile strength.

- determines the desired region of the curve between the start and end points.

- calculates the true width strain and true thickness strain at each point within the region by using the following equations:

  $\varepsilon_w = \ln(w_f/w_0)$

  $\varepsilon_t = \ln(t_f/t_0)$

  where:

  ε_w = true width strain,
  ε_t = true thickness strain,
  w_f = instantaneous width measurement,
  w_0 = entered specimen width,
  t_f = instantaneous thickness measurement, and
  t_0 = undeformed thickness of the metal.

  In practice, the thickness strain is very difficult to measure and so the equation can be rewritten, assuming constant volume:

  $\varepsilon_t = \ln(l_0 w_0 \,/\, l_f w_f)$

  where:

  l_f is the instantaneous measured length in mm, and
  l_0 is the gauge length of the axial extensometer in mm.

- uses a least-squares fit method to calculate the ratio of the true width strain to the true length strain over the selected region, which determines the r-value.

  To allow comparison with manually calculated r-values where the specimen is unloaded from the testing machine before measurements are taken, the system provides an option to remove the elastic strains prior to calculating the plastic strain ratio.

  Specifically, if elastic strains are removed, the true length and width strains are modified as follows:

  $\varepsilon_l' = \varepsilon_l - \ln(1+\sigma_l \,/\, E)$

  $\varepsilon_w' = \varepsilon_w - \ln(1+\nu\,\sigma_l \,/\, E)$

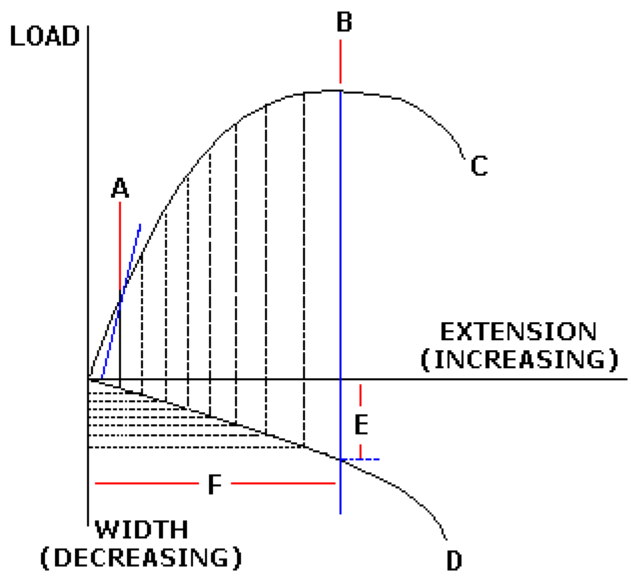
  where:

  ε_l' = true length strain without elastic component,
  ε_l = true length strain with elastic component,
  ε_w' = true width strain without elastic component,
  σ_l = true axial stress,
  E = nominal modulus of elasticity,
  ν = nominal Poisson's Ratio.

Example

The system finds the start and end points, and uses a least-squares fit method to determine the r-value.

A = Start point
B = End point
C = Load versus Extension curve
D = Width versus Extension curve
E = Change in width
F = Change in length



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- transverse or axial strain is zero or a negative value.
- you do not use two extensometers: one measuring axial strain and one measuring transverse strain.
- a required data channel is missing or empty.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Axial Length
Transverse Length
Starting Strain
Ending Strain
Plastic Strain Ratio

Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
100	Error: Internal error.
107	Error: Specified region contains a speed change so it has more than one segment ID.
108	Error: Specified region contains a hysteresis loop.
109	Error: Transverse or axial strain is zero or a negative value.
110	Error: Required data channel is missing or empty.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

r-value (Manual - Automatic Validation)

This calculation determines the plastic strain ratio, r, as the ratio of the true width strain to the true thickness strain. If you require analysis over a particular region, use this calculation to manually enter the start point and the end point. The system automatically validates the specified start and end points.

Parameters

You must specify:

- the r-value type as **Manual (automatic validation)**.
- the **Start** type.

- the **Start value**. Typically the Start value is 12-15%.
- the **End** type.
- the **End value**. Typically the End value is 12-15%.

*For the Start type, select **Delay after speed change** only when there is a speed change in the region where the calculation is performed. This time delay will avoid a calculation failure.*

To calculate the r-value based on a single point, enter the same information for both the start and end points.

You have the option to:

- select **Remove elastic strains** to remove the elastic components of the measured strains.
- specify **Modulus**. Modulus of elasticity is greater than zero.
- specify **Poisson's Ratio**. Poisson’s Ratio value ranges from 0.1 to 0.9.
- select **Indicate on graph** to place a marker on the graph.

The system includes the start type, start value, end type and end value in the calculation description. If you select tensile strain as a start type, 12% as a start value, tensile strain as an end type and 15% as an end value, the description appears as:

r-Value (Strain 12% Strain 15%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the user specified start and end points.
- validates the start and end points.

  To validate the start point, the system compares the specified start point to the first point found from the following list. The start point is valid if it occurs after any one of these points:

  - end of YPE/A_e, if it exists.
  - upper yield, if it exists.
  - 0.2% offset yield, if it exists.

The system calculates the YPE/A_e based on the automatic type with 0.2% offset yield and no end point slope intersection correction.

To validate the end point, the system compares the specified end point to the point at tensile strength. The end point is valid if it occurs before tensile strength.

- determines the desired region of the curve between the start and end points.
- calculates the true width strain and true thickness strain at each point within the region by using the following equations:

$$\varepsilon_w = \ln(w_f/w_0)$$

$$\varepsilon_t = \ln(t_f/t_0)$$

where:

ε_w = true width strain,
ε_t = true thickness strain,
w_f = instantaneous width measurement,
w_0 = entered specimen width,
t_f = instantaneous thickness measurement, and
t_0 = undeformed thickness of the metal.

In practice, the thickness strain is very difficult to measure and so the equation can be rewritten, assuming constant volume:

$$\varepsilon_t = \ln(l_0 w_0 / l_f w_f)$$

where:

l_f is the instantaneous measured length in mm, and
l_0 is the gauge length of the axial extensometer in mm.

- uses a least-squares fit method to calculate the ratio of the true width strain to the true length strain over the selected region, which determines the r-value.

To allow comparison with manually calculated r-values where the specimen is unloaded from the testing machine before measurements are taken, the system provides an option to remove the elastic strains prior to calculating the plastic strain ratio.

Specifically, if elastic strains are removed, the true length and width strains are modified as follows:

$$\varepsilon_l' = \varepsilon_l - \ln(1+\sigma_l / E)$$

$$\varepsilon_w' = \varepsilon_w - \ln(1+\nu\, \sigma_l / E)$$

where:

ε_l' = true length strain without elastic component,
ε_l = true length strain with elastic component,

ε_w' = true width strain without elastic component,
σ_l = true axial stress,
E = nominal modulus of elasticity,
ν = nominal Poisson's Ratio.

Examples

Multiple Points

The system finds the user specified start and end points and uses a least-squares fit method to calculate the r-value.

A = User-specified start point

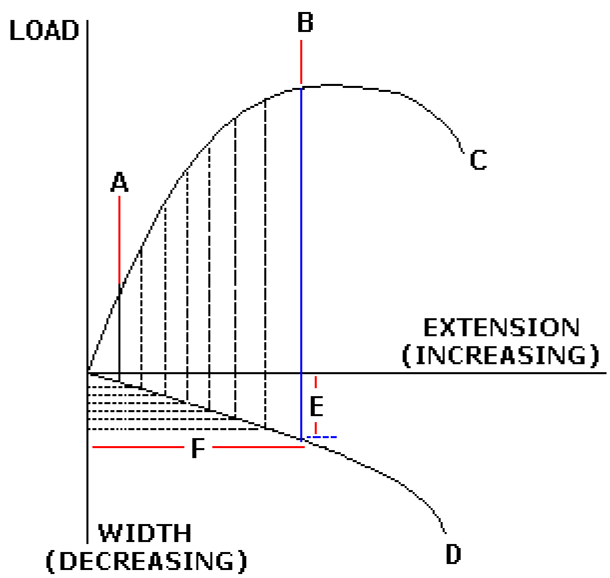
B = User-specified end point

C = Load versus Extension curve

D = Width versus Extension curve

E = Change in width

F = Change in length



Single Point

The system finds the user specified point, for example 15%, and uses the data at that point to calculate the r-value.

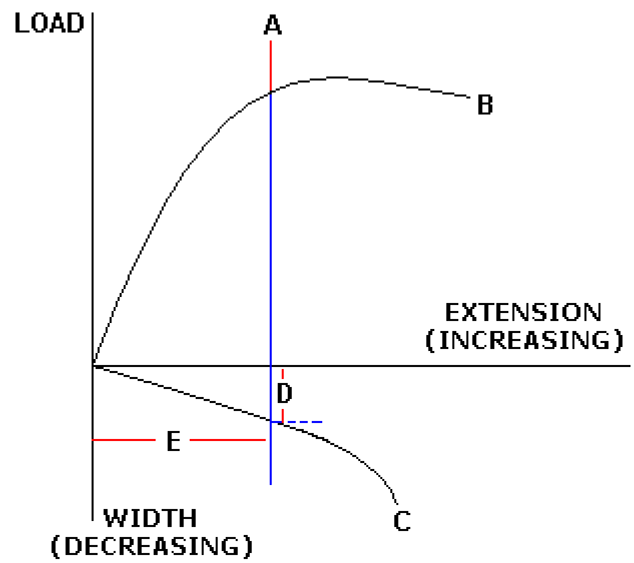
A = User-specified point

B = Load versus Extension curve

C = Width versus Extension curve

D = Change in width

E = Change in length



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- transverse or axial strain is zero or a negative value.
- you do not use two extensometers: one measuring axial strain and one measuring transverse strain.
- either the start or end point is not found.
- the start point is not valid as described in the Algorithm section.
- the end point occurs after the point of tensile strength.
- the start point occurs after the end point.
- a required data channel is missing or empty.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Axial Length
Transverse Length
Starting Strain
Ending Strain
Plastic Strain Ratio
Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
1	Warning: Start point replaced by yield or YPE point.
2	Warning: End point replaced by tensile strength point.
100	Error: Internal error.
101	Error: Start value not found.
102	Error: End value not found.
103	Error: Specified start value occurs after the end value.
104	Error: Specified start value occurs before the yield or YPE point.
105	Error: Specified end value occurs after the tensile strength point.
107	Error: Specified region contains a speed change so it has more than one segment ID.
108	Error: Specified region contains a hysteresis loop.
109	Error: Transverse or axial strain is zero or a negative value.
110	Error: Required data channel is missing or empty.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

r-value (Manual)

This calculation determines the plastic strain ratio, r, as the ratio of the true width strain to the true thickness strain. If you require analysis over a particular region of the curve, use this calculation to manually enter the start point and the end point. You can also manually set the validation rules for the specified start and end points.

Parameters

You must specify:

- the r-value type as **Manual**.
- the **Start type**.
- the **Start value**. Typically the Start value is 12-15%.
- the **End type**.
- the **End value**. Typically the End value is 12-15%.
- the **Parent calculation** field if any of the following conditions exist:
  - if the start type is set to **yield point**, **end of YPE region** or **percent of plastic strain**.
  - if **Compare Start Value to Yield or YPE** is selected.
  - if the end type is set to **percent of plastic strain**.

  The parent calculation can be any Yield or YPE calculation.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

*For the Start type, select **Delay after speed change** only when there is a speed change in the region where the calculation is performed. This time delay will avoid a calculation failure.*

To calculate the r-value based on a single point, enter the same information for both the start and end points.

You have the option to:

- select **Compare Start Value to Yield or YPE** when you select any start type except yield point, end of YPE region or percent of plastic strain. This option verifies that the specified start value is valid when compared to a specific yield or YPE result. In order to calculate the desired yield or YPE result, you must add the desired calculation to the **Selected Calculations** list, and then select it as a parent calculation. If you select this option, you must also specify what the system should do if the specified start value occurs first. The options are in **If Start Value occurs first**. To keep the specified start value regardless of where it occurs on the curve, do not enable **Compare Start Value to Yield or YPE**.
- select **Compare End Value to Tensile Strength** when you select any end type except percent of plastic strain or percent of tensile strength. This option verifies that the specified end value is valid when compared to tensile strength. If you select this option, you must also specify what the system should do if the specified end value occurs last. The options are in **If End Value occurs last**. To keep the specified end value regardless of where it occurs relative to tensile strength, do not enable **Compare End Value to Tensile Strength**.
- select **Remove elastic strains** to remove the elastic components of the measured strains.
- specify **Modulus**. Modulus of elasticity is greater than zero.
- specify **Poisson's Ratio**. Poisson's Ratio value ranges from 0.1 to 0.9.
- select **Indicate on graph** to place a marker on the graph.

The system includes the start type, start value, end type and end value in the calculation description. If you select tensile strain as a start type, 12% as a start value, tensile strain as an end type and 15% as an end value, the description appears as:

r-Value (Strain 12% Strain 15%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the user specified start and end points.
- validates the start and end points based on the parameter choices you made.
- determines the desired region of the curve between the start and end points.
- calculates the true width strain and true thickness strain at each point within the region by using the following equations:

$\varepsilon_w = \ln(w_f/w_0)$

$\varepsilon_t = \ln(t_f/t_0)$

where:

ε_w = true width strain,
ε_t = true thickness strain,
w_f = instantaneous width measurement,
w_0 = entered specimen width,
t_f = instantaneous thickness measurement, and
t_0 = undeformed thickness of the metal.

In practice, the thickness strain is very difficult to measure and so the equation can be rewritten, assuming constant volume:

$\varepsilon_t = \ln(l_0 w_0 / l_f w_f)$

where:

l_f is the instantaneous measured length in mm, and
l_0 is the gauge length of the axial extensometer in mm.

- uses a least-squares fit method to calculate the ratio of the true width strain to the true length strain over the selected region, which determines the r-value.

  To allow comparison with manually calculated r-values where the specimen is unloaded from the testing machine before measurements are taken, the system provides an option to remove the elastic strains prior to calculating the plastic strain ratio.

  Specifically, if elastic strains are removed, the true length and width strains are modified as follows:

  $\varepsilon_l' = \varepsilon_l - \ln(1+\sigma_l / E)$

  $\varepsilon_w' = \varepsilon_w - \ln(1+\nu\,\sigma_l / E)$

  where:

  ε_l' = true length strain without elastic component,
  ε_l = true length strain with elastic component,
  ε_w' = true width strain without elastic component,
  σ_l = true axial stress,
  E = nominal modulus of elasticity,
  ν = nominal Poisson's Ratio.

Examples

Multiple Points

The system finds the user specified start and end points and uses a least-squares fit method to calculate the r-value.

A = User-specified start point

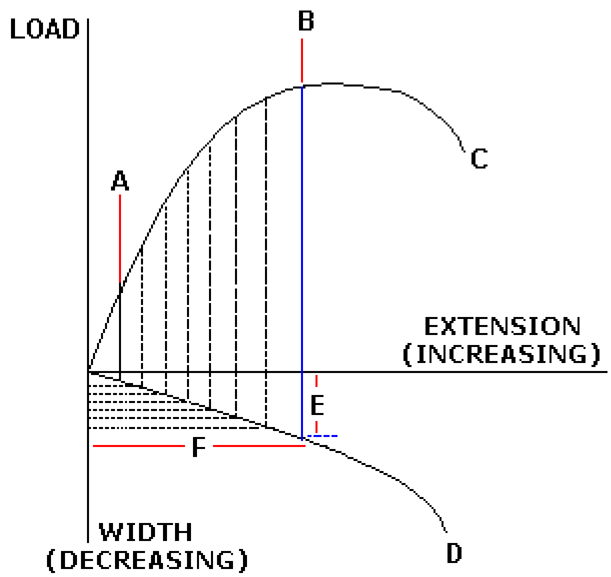
B = User-specified end point

C = Load versus Extension curve

D = Width versus Extension curve

E = Change in width

F = Change in length



Single Point

The system finds the user specified point, for example 15%, and uses the data at that point to calculate the r-value.

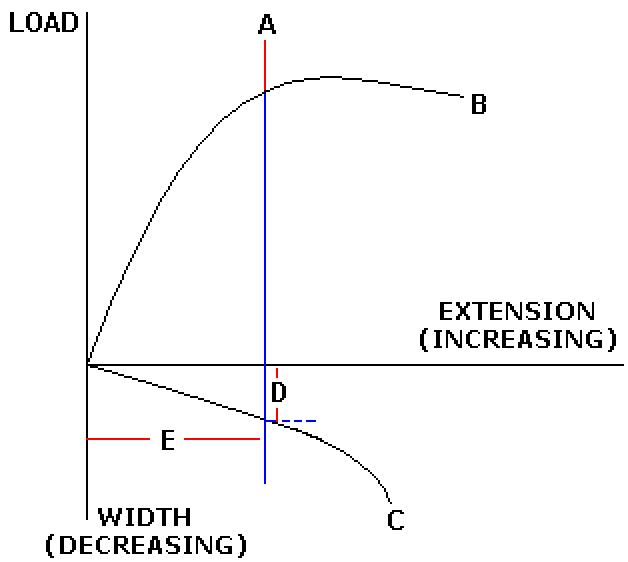
A = User-specified point

B = Load versus Extension curve

C = Width versus Extension curve

D = Change in width

E = Change in length



Fails to calculate

The algorithm will not calculate a result if:

- there is a hysteresis loop or change in speed between the start and end points.
- transverse or axial strain is zero or a negative value.
- you do not use two extensometers: one measuring axial strain and one measuring transverse strain.
- either the start or end point is not found.
- the start point is not valid based on the user defined parameters.
- the end point is not valid based on the user defined parameters.
- the start point occurs after the end point.
- a required data channel is missing or empty.
- a required parent calculation is not selected or failed to calculate.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Axial Length
Transverse Length
Starting Strain
Ending Strain
Plastic Strain Ratio
Status Number
Status

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status Number	Status
0	Success. No errors or warnings.
1	Warning: Start point replaced by yield or YPE point.
2	Warning: End point replaced by tensile strength point.
100	Error: Internal error.
101	Error: Start value not found.
102	Error: End value not found.
103	Error: Specified start value occurs after the end value.
104	Error: Specified start value occurs before the yield or YPE point.
105	Error: Specified end value occurs after the tensile strength point.
107	Error: Specified region contains a speed change so it has more than one segment ID.
108	Error: Specified region contains a hysteresis loop.
109	Error: Transverse or axial strain is zero or a negative value.
110	Error: Required data channel is missing or empty.
111	Error: Required parent calculation is not selected or failed to calculate.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Seam Slippage

Seam slippage is the load required to produce a specified amount of seam opening in a fabric in a given direction. Use the seam slippage calculation to determine whether a woven fabric is suitable for seaming. Test the specimen in whichever direction the yarns move most easily.

To calculate seam slippage, test pairs of specimens and produce load versus extension curves for each test. Each pair of specimens consists of one seamed and one unseamed specimen.

For Warp over Weft Slippage the specimens might be made up of three pieces of fabric each with a warp measurement of 100 mm and a weft measurement of 350 mm. These specimens would have been cut from one piece of fabric with a warp measurement of 300 mm and a weft measurement of 350 mm.

For Weft over Warp Slippage the specimens might be made up of three pieces of fabric each with a warp measurement of 350 mm and a weft measurement of 100 mm. These specimens would have been cut from one piece of fabric with a warp measurement of 350 mm and a weft measurement of 300 mm.

Parameters

You must specify:

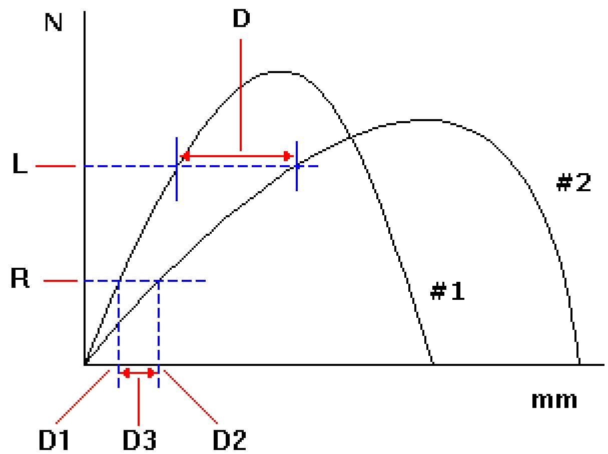
- the **Seam Slippage** calculation.
- the **Load Reference Point**. This is the initial load applied to take up any slack in the specimen (load value at which the “compensation” is measured).
- the **Target Seam Opening**. This is the seam opening required.
- the **Type**. Choose between ASTM and EN/ISO. The algorithm for calculating seam slippage is slightly different between these standards.

The calculation description appears as:

Seam Slippage (ASTM) or **Seam Slippage (EN/ISO)**

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm and Example



The Seam Slippage calculation is shown schematically in the diagram.

This seam slippage calculation conforms with ASTM standards D434 and D4034 or to EN ISO 13936-1, depending on which type you choose.

Each pair of specimens produces two test curves. D1 is the displacement on Curve 1 where load is equal to the Load Reference Point (R). D2 is the displacement on Curve 2 where the load is equal to that at D1 on Curve 1. D3 is the absolute value of the difference between D1 and D2 (called the “compensation” in D434). D is then given by the sum of D3 and the Target Seam Opening value. The load at L is the load value where the separation between the pair of curves, parallel to the displacement axis, is equal to the value of D.

For the ASTM type, the Load at Seam Slippage is the value of load where seam slippage occurs minus the load at the load reference point. This is (L – R) in the diagram above.

For the EN/ISO type, the Load at Seam Slippage is the value of load where seam slippage occurs. This is L in the diagram above.

Fails to calculate

The algorithm will not calculate a result for Load at Seam Slippage if:

- the **Load Reference Point** is greater than the maximum load of one of the specimens.
- there are not enough points in data, where N <= 1 (refer to Algorithm description above).
- it failed to find load data for specimen A.

- it failed to find load data for specimen B.
- it failed to find extension data for specimen A.
- it failed to find extension data for specimen B.
- it failed to identify one of the specimens.
- it failed to access test data of specimen A.
- it failed to access test data of specimen B.

Each failure and warning condition has an equivalent **Status** and **Status Number**. You can include one, or both, on the **Results** screen to indicate the status of the calculation in your results. Refer to the Results section for additional information.

Results

Load at Seam Slippage

For the ASTM type of calculation, Load at Seam Slippage is the value of load where seam slippage occurs minus the load at the load reference point. This is (L – R) in the diagram above.

For the EN/ISO type of calculation, Load at Seam Slippage is the value of load where seam slippage occurs. This is L in the diagram above.

A value of Load at Seam Slippage is reported whether or not seam slippage occurs. If no seam slippage occurs, the value reported is the lesser of the two maximum loads for the seamed and unseamed specimens; which would normally be the value for the seamed specimen.

Status and Status Number

If you choose **Status** as a result, a text description of the calculation status displays with your results.

If you choose **Status Number** as a result, a numerical code corresponding to the status of the calculation displays with your results.

Status numbers 0 and 1 indicate legitimate tests. Other status numbers indicate errors in the data.

Status Number	Status
0	Seam slippage occurred. The system reports Load at seam slippage.
1	Seam slippage did not occur. Lesser of the two maximum loads of seamed and unseamed specimens is reported.
2	The Load Reference Point is greater than the maximum load of one of the specimens.
4	Not enough points in data, where N <= 1 (refer to Algorithm description above).
5	Failed to find load data for specimen A.
6	Failed to find load data for specimen B.
7	Internal error: Failed to find extension data for specimen A.
8	Internal error: Failed to find extension data for specimen B.
9	No result for odd-numbered specimen (A). This displays for an odd-numbered specimen because the calculation requires a pair of specimens. Results only display for even-numbered specimens.
10	Internal error: Failed to identify one of the specimens.
11	Internal error: Failed to access test data of specimen A.
12	Internal error: Failed to access test data of specimen B.

Slack Correction calculations

These calculations apply a correction to the specimen to compensate for any slack in the specimen. Slack correction is always the first calculation and subsequent calculations use the corrected gauge length.

Slack Correction (Automatic)

This calculation applies a correction to the specimen to compensate for any slack in the specimen. Slack correction is always the first calculation and subsequent calculations use the corrected gauge length.

Parameters

You must specify the **Automatic** type of slack correction.

You have the option to select **Correct Gauge Length** to correct the gauge length.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data from the first point to the maximum load point.
- determines the start value by finding the first data point equal to or greater than 2% of the maximum load.
- defines the end value as the maximum load point.
- divides the data on the strain axis between the start and end values into 6 equal regions with no overlap.
- applies a least squares fit algorithm on all the data points in the regions.
- calculates the sum of the slopes of each pair of adjacent data regions.
- determines which pair of regions that has the highest slope sum.
- from this pair, determines which region has the highest slope and assigns the modulus to that region.
- determines the slack correction at the point where the modulus line intersects the zero-stress strain axis.
- applies the correction to the derived strain and extension channels.

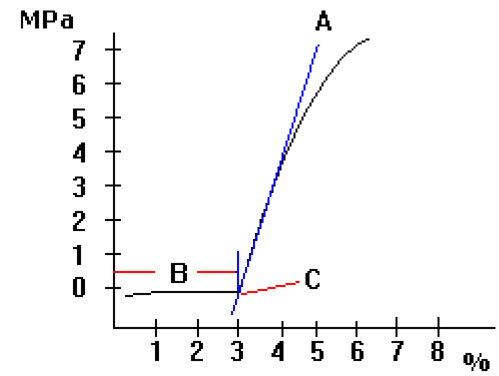
Example

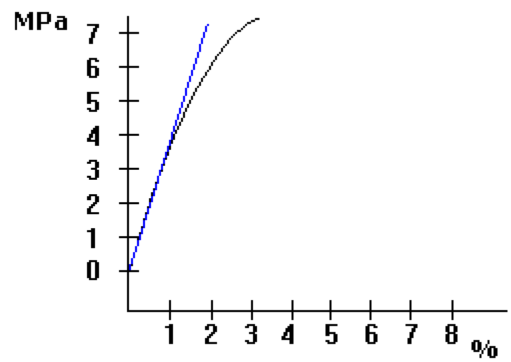
The system constructs a modulus line along the initial linear portion of the data. The modulus line intersects the Strain channel at 3% strain. This point is the calculated slack that the system uses to correct the gauge length. Applying the calculation to the same data on the Tensile strain channel produces the graph below. Notice that there is no slack.

A = Modulus Marker

B = Slack

C = Modulus/Strain intersect





Fails to calculate

The algorithm will not calculate a result if there are fewer than seven data points between 2% of maximum load and maximum load.

Results

Extension Offset
Strain Offset
Corrected Gauge Length

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Slack Correction (Automatic Young’s)

This calculation applies a correction to the specimen to compensate for any slack in the specimen. Slack correction is always the first calculation and subsequent calculations use the corrected gauge length.

Parameters

You must specify the **Automatic Young’s** type of slack correction.

You have the option to select **Correct Gauge Length** to correct the gauge length.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data from the first point to the maximum load point.
- determines the start value by finding the first data point equal to or greater than 2% of the maximum load.
- defines the end value as the maximum load point.
- divides the data on the stress axis between the start and end values into 6 equal regions with no overlap.
- applies a least squares fit algorithm on all the data points in the regions.
- calculates the sum of the slopes of each pair of adjacent data regions.
- determines which pair of regions that has the highest slope sum.
- from this pair, determines which region has the highest slope and assigns the modulus to that region.
- determines the slack correction at the point where the modulus line intersects the zero-stress strain axis.
- applies the correction to the derived strain and extension channels.

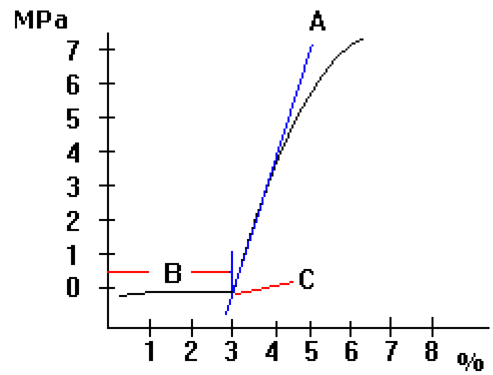
Example

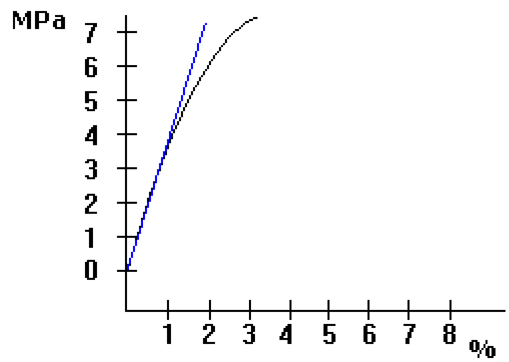
The system constructs a modulus line along the initial linear portion of the data. The modulus line intersects the Strain channel at 3% strain. This point is the calculated slack that the system uses to correct the gauge length. Applying the calculation to the same data on the Tensile strain channel produces the graph below. Notice that there is no slack.

A = Modulus Marker

B = Slack

C = Modulus/Strain intersect





Fails to calculate

The algorithm will not calculate a result if there are fewer than seven data points between 2% of maximum load and maximum load.

Results

Extension Offset
Strain Offset
Corrected Gauge Length

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Slack Correction (Channel Value)

This calculation determines the point on the stress/strain curve at which any slack is removed from the specimen. The system must reach a minimum load or stress value. You have the option of correcting the gauge length at the specified point. This action corrects the derived strain and extension.

Parameters

You must specify:

- the **Channel Value** type of slack correction.
- the channel to determine the slack correction point.
- a value in the units of the specified channel.

You have the option to select **Correct Gauge Length** to correct the gauge length.

The system includes the slack correction type and the channel value in the calculation description. For example, if you select a **Channel Value** type of slack correction on the **Compressive strain** channel with a value of 2mm/mm, the description appears as:

Slack Correction (Channel Value 2mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

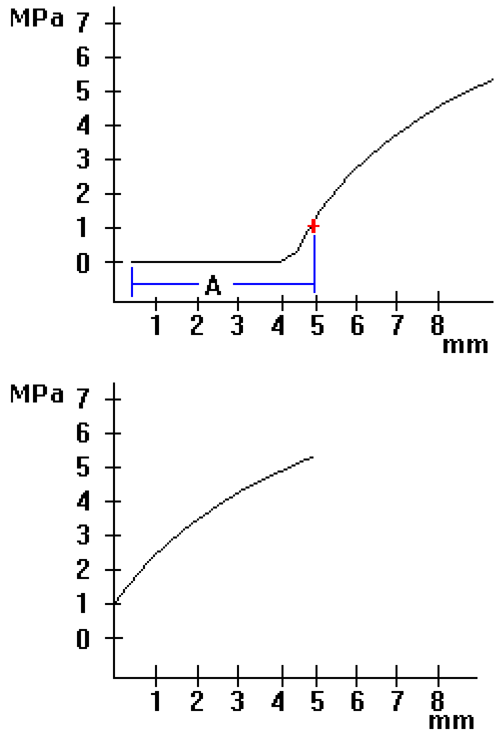
- searches the data on the specified channel.
- finds the first point that is equal to or greater than the specified channel value. If the value does not fall on a data point, the system interpolates between the points on either side of the value.
- determines the slack correction as the strain value corresponding to the channel value.

Example

The Extension channel is set with a channel value of 5 mm. Applying the calculation to the same data on the Tensile extension channel produces the graph below. Notice that there is no slack.

+ = Channel Value Marker

A =Slack



Fails to calculate

The algorithm will not calculate a result if the data does not contain the specified channel value.

Results

Extension Offset
Strain Offset
Corrected Gauge Length

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Slack Correction (Young's)

This calculation determines the point on the stress/strain curve at which load is fully applied to the specimen.

Parameters

You must specify:

- the **Young's** type of slack correction.
- a channel.
- a start value in the units of the specified channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- an end value in the units of the specified channel. This value must be higher than the start value. The system does not include data beyond the end value in the calculation.
- number of regions. You can specify 1 to 100 regions. The more regions specified, the higher the accuracy and processing time.
- Overlap as a percent value from 0 to 99%. The greater the number, the more overlap between regions.
- the axis to use for dividing into regions. Select the stress or strain axis.

You have the option to select **Correct Gauge Length** to correct the gauge length.

The system includes the slack correction type and start and end values in the description. For example, if you select a Young's type of slack correction on the **Compression extension** channel with a start value of 0 mm and a end value of 10 mm with the axis for region division set to **Compressive Stress**, the description appears as:

Slack Correction (Young's Compressive Stress 0mm - 10mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- searches the data for the specified lower and upper bounds.
- divides the data between the start and end values into the number of equally spaced regions with the specified percentage of overlap.

- assigns the start of each region to the closest data point.
- assigns the end of each region to the closest data point.
- applies a least squares fit algorithm to all the data points in each region.
- calculates the sum of the slopes of each pair of adjacent regions.
- determines which pair of regions that has the highest slope sum.
- from this pair, determines which region has the highest slope and assigns the modulus to that region.
- determines the slack correction from the point where the modulus line intersects the strain axis.
- applies the correction to the derived strain and extension channels.

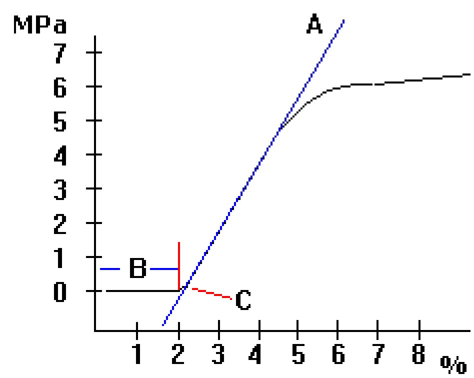
Example

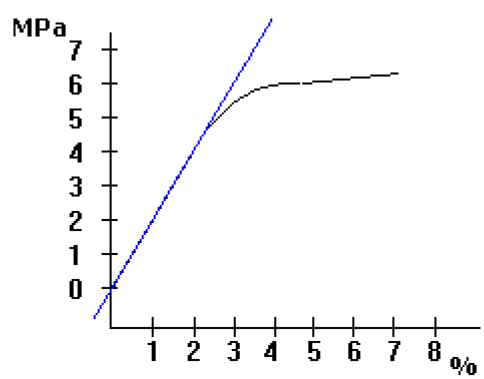
The system constructs a modulus line along the initial linear portion of the data. The modulus line intersects the Strain channel at 2% strain. The system uses this point to correct the gauge length. Applying the calculation to the same data on the Tensile strain channel produces the graph below. Notice that there is no slack.

A = Modulus Marker

B = Slack

C = Modulus/Strain intersect





Fails to calculate

The algorithm will not calculate a result if the data contains the same number or fewer points than the specified number of regions.

Results

Extension Offset
Strain Offset
Corrected Gauge Length

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Slope calculations

These calculations are very similar to their equivalent modulus calculations. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

Automatic Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The automatic slope calculation determines the slope of a specified curve using fixed parameters.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Automatic** type slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- the slope criteria as **Maximum** or **Minimum**.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The algorithm is almost identical to that of Automatic Modulus, except for the end point of the data used for the calculation.

Automatic Modulus performs a zero-slope yield calculation to determine if there is a yield point in the data that occurs before the maximum load point.

You can apply Automatic Slope to a curve plotted using any two channels in the system, so the zero-slope yield calculation is not performed. The end point for the data is therefore always the maximum point on the y-axis.

The slope calculation lets you choose minimum slope as an alternative to maximum slope.

Results

X-Intercept
Y- Intercept
Slope

Automatic Young's Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The Automatic Young's Slope calculation determines the slope of a specified curve using fixed parameters.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Automatic Young's** type slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- the slope criteria as **Maximum** or **Minimum**.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The algorithm is almost identical to that of Automatic Young's Modulus, except for the end point of the data used for the calculation.

Automatic Young's Modulus performs a zero-slope yield calculation to determine if there is a yield point in the data that occurs before the maximum load point.

You can apply Automatic Young's Slope to a curve plotted using any two channels in the system, so the zero-slope yield calculation is not performed. The end point for the data is therefore always the maximum point on the y-axis.

The slope calculation lets you choose minimum slope as an alternative to maximum slope.

Results

X-Intercept
Y- Intercept
Slope

Chord Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The chord slope calculation determines the slope of a specified curve between any two points on the curve. It constructs a straight line between the specified lower and upper bounds.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Chord** type slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- a search channel.
- an end value in the units of the specified search channel. This value must be higher than the start value.

- a start value in the units of the specified search channel. This value must be lower than the end value.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the slope type and the start and end values in the calculation description. For example, if you select a **Chord** slope and **Tensile extension** for the search channel with a start value of 5 mm and an end value of 7 mm, the description appears as:

Slope (Chord 5 mm - 7 mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Results

X-Intercept
Y- Intercept
Slope

Secant Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The secant slope calculation determines the slope of a line constructed between zero and any point on the curve. It constructs a straight line between zero and a specified end value.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Secant** type of slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- a search channel.
- the upper value in the units of the specified search channel.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the slope type and the end value in the calculation description. For example, if you select a **Secant** slope and **Time** for the search channel with an end value of 1 second, the description appears as:

Slope (Secant 1 sec)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Results

X-Intercept
Y- Intercept
Slope

Segment Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The segment slope calculation determines the slope of a specified curve between specified bounds. The system interpolates the start and end values if the values do not match actual data points. The system uses a least squares fit routine to construct the slope.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Segment** type slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- a search channel.
- an end value in the units of the specified search channel. This value must be higher than the start value. The system does not include data after the end value in the calculation.
- a start value in the units of the specified search channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the slope type and the start and end values in the calculation description. For example, if you select a **Segment** slope and **Strain 1** for the search channel with a start value of 0.1% and an end value of 0.5%, the description appears as:

Slope (Segment 0.1% - 0.5%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Results

X-Intercept
Y- Intercept
Slope

Tangent Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The tangent slope calculation finds the slope of the specified curve at a point on the curve. It constructs a slope at a tangent to the specified point.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- a **Tangent** type of slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- a search channel.
- a value (tangent point) in the units of the specified search channel.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the slope type and the start and end values in the calculation description. For example, if you select a **Tangent** slope and **Compressive stress** for the search channel with a value of 11 kPa, the description appears as:

Slope (Tangent 11 kPa)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Results

X-Intercept
Y- Intercept
Slope

Young's Slope

This calculation is very similar to its equivalent modulus calculation. Modulus is a specific form of slope; that is, the slope of the stress/strain curve in the elastic region. The slope calculations let you:

- choose the axes for the calculation from the list of channels available
- choose a Search channel which is the channel that is used to define the limits of the slope calculation - this does not have to be one of the axis channels

The slope calculations determine the slope of a curve plotted using any two channels in the system.

The modulus equivalent of this calculation, Young's modulus, determines the slope of the stress/strain curve. It calculates the slopes using least-squares fit on test data for a number of specified regions between specified lower and upper bounds, and reports the maximum slope as the modulus.

The Young's slope calculation uses the same algorithm to determine the maximum slope of a specified curve. You should only use it, therefore, if the specified curve follows the same type of shape as the stress/strain curve, with an initial linear portion.

The slope calculation provides two criteria: minimum slope and maximum slope.

The following sections describe only the parameters and results for this calculation. Refer to the description of the equivalent modulus calculation for more detail and examples.

Parameters

You must specify:

- the **Young's** type of slope.
- a channel and units for the x axis of the curve.
- a channel and units for the y axis of the curve.
- the slope criteria as **Maximum** or **Minimum**.
- a search channel.
- an end value in the units of the specified search channel. This value must be higher than the start value. The system does not include data after the end value in the calculation.
- a start value in the units of the specified search channel. This value must be lower than the end value. The system does not include data before the start value in the calculation.
- the number of regions. Specify between 1 and 100 regions.
- a percentage of overlap between 0 and 99.
- the axis to use for dividing into regions. Specify the y-axis or x-axis.

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the slope type and the upper and lower bound values in the calculation description. For example, if you select a **Young's** slope with maximum slope criteria and **Strain 1** for the search channel with a start value of 0.3 mm/mm and an end value of 0.5 mm/mm and the axis for region division set to **Y-Axis**, the description appears as:

Maximum Y-Axis Slope (Young's 0.3 mm/mm - 0.5 mm/mm)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Results

X-Intercept
Y- Intercept
Slope

Tensile Strength calculation

This calculation meets the requirements of the EN10002 and ASTM E8 standards. It determines the percentage of total elongation at the maximum force and the value of all data channels at that point, which includes the tensile strength of the material.

Parameters

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

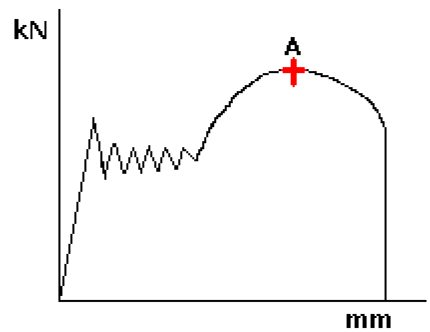
- smoothes the raw stress data after the upper yield point (if any) by using a moving average of the recorded stress readings and records the highest value seen as an approximate position of the total elongation at maximum force.
- after all the data has been analyzed, selects an interval around the approximate total elongation at maximum force and smoothes the raw stress data by using a smoothing cubic spline.

- selects the data point where the slope of the smoothed data changes from positive to negative.
- assigns that point as the total elongation at maximum force.
- returns the value of all data channels at this point, including the tensile strength.

Example

The system detects an ultimate tensile stress point at A because this point is the highest (smoothed) stress value after the yield point.

A = Ultimate Tensile Stress (UTS) point



Fails to calculate

The algorithm will not calculate a result if there are less than 50 data points collected.

The approximate value of the total elongation at maximum force will be used if the total elongation of the material is less than about 4%

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

User calculations

User calculations are equations that you build to perform computations on the test data.

Refer to the “User Calculations” chapter for more detailed information.

Yield calculations

The following subsections describe the different types of yield calculations.

Lower Yield

This calculation determines the point on the stress/strain curve at which the slope increases to zero after a zero slope yield point.

For metals testing, lower yield should not be used. Use the Yield (EN/ISO Lower) calculation, which is a more reliable version relevant to metals tests.

Parameters

You must specify:

- the **Lower** type of yield.
- a number of regions. Specify 1 to 100 regions. The more regions, the higher the accuracy and processing time.
- percentage of overlap between 0 and 99.
- a yield slope criteria. This is the number of consecutive regions with a zero or positive slope the system must detect to establish the yield point. Specify 1 to 99.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

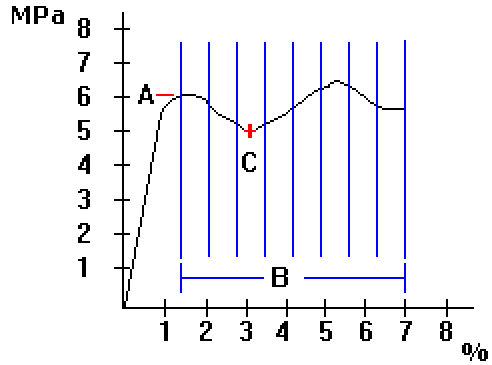
The system:

- searches all the data for the initial zero slope yield.
- uses the initial yield as the starting point.
- divides the data into the number of regions with the specified percent overlap.

- finds the number of consecutive regions that have a slope greater than or equal to zero.
- assigns the point of the minimum load, from the initial yield to the end of the regions that have a slope equal to or greater than zero, as the lower yield.

Example

The system finds the upper yield point at 6 MPa. From that point, the system divides the remaining data into 8 regions and begins calculating the slope for each region. The third region is the first to have a zero slope, the point where there is an increase in strain and no increase in stress. The system assigns the lower yield point at 5 MPa.



+ = Yield Point Marker

A = Upper Yield Point

B = Regions

C = Lower Yield Point

Fails to calculate

The algorithm will not calculate a result if:

- the data contains the same number or fewer points than the specified number of regions.
- the data does not contain a zero or negative slope.
- the data beyond the zero slope point does not contain a positive slope.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Lower Yield (EN/ISO)

The system performs this calculation in accordance with the EN10002 and ASTM E8 standards. It determines the point on the stress/strain curve at which the slope increases to zero after an upper yield point. Optionally, the transient (first low peak) can be included.

Parameters

You must specify:

- the **EN/ISO Lower** type of yield.
- the **EN/ISO Upper Yield** calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to:

- select **Indicate on graph** to place a marker on the graph.
- select **Include transient** to include the transient.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- finds the upper yield point.
- uses the upper yield point as the starting point.
- determines the EN\ISO lower yield by finding the lowest point on the stress-strain curve between the upper yield point and the end of the yield point elongation that has a slope increasing to zero. Optionally it can include the transient lower yield point if it is the lowest value.

Example

The system finds the upper yield point and uses this point as the starting point to find the lower yield point.

Graph 1 - Include transient is checked

The system finds the lowest point on the stress-strain curve and assigns it as the EN/ISO lower yield.

Graph 2 - Include transient is unchecked and there are three or less potential lower yield points.

If there are three or less potential lower yield points (points where the slope changes from negative to positive), the system assumes these points are valid results and includes the transient.

Graph 3 - Include transient is unchecked and there are more than three potential lower yield points.

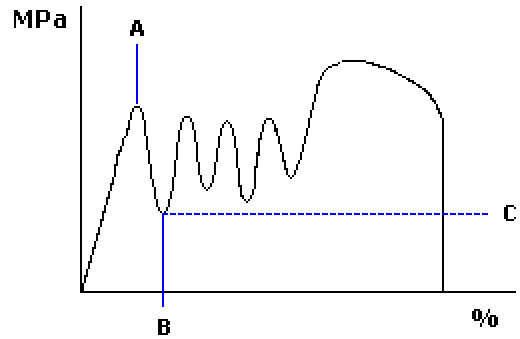
If there are more then three potential lower yield points, the system finds the lowest point on the stress-strain curve, excluding the transient, and assigns it as the EN/ISO lower yield.

A = Upper Yield Point

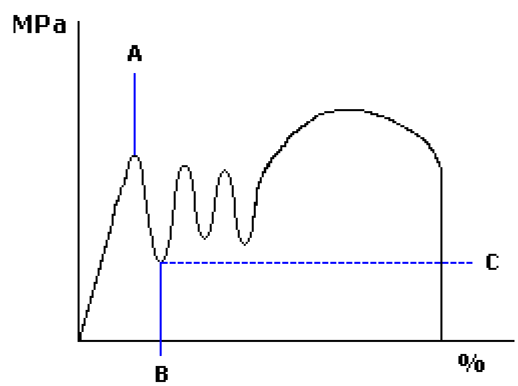
B = Lower Yield Point

C = Transient

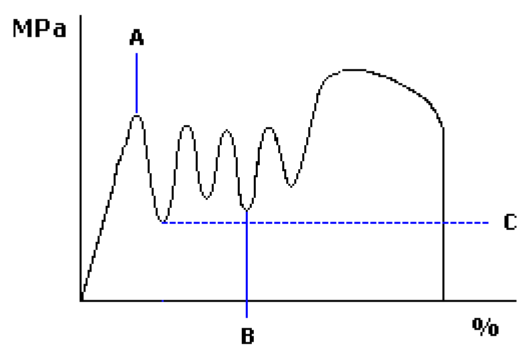
Graph 1



Graph 2



Graph 3



Fails to calculate

The algorithm will not calculate a result if:

- no upper yield point is detected.
- the curve does not have a yield point elongation.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Offset Yield

This calculation determines the point on the stress/strain curve at which yield is assumed to have occurred. Offset yield is a dependent calculation that requires a result from a modulus calculation. The offset yield calculation constructs a line parallel to the modulus and is offset from it by a specified amount. The offset yield point is where the offset line intersects the curve.

Parameters

You must specify:

- the **Offset Yield** type of yield.
- either the derived extension or strain channel.
- a modulus calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the type of yield and the offset value in the calculation description. If you select an **Offset Yield** with a 30% offset on the **Tensile Strain** channel, the calculation description appears as:

Yield (Offset 30%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- uses a modulus line determined by a previous calculation as a starting point.
- searches the channel, either strain or extension, specified for the point of intersection of a line parallel to the modulus but offset by a specified channel value.
- assigns an interpolated point of intersection as the yield point.

Example

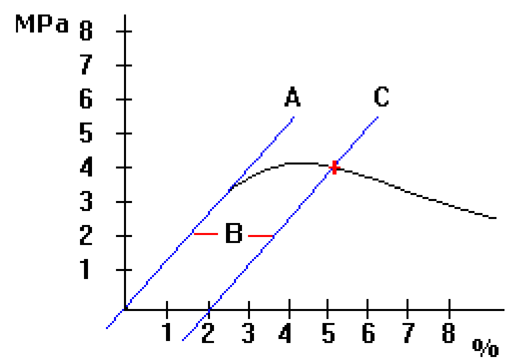
The **Tensile strain** channel is set to an offset yield value of 2%. The system draws a line parallel (but offset by the specified value) to the line created by a previous modulus calculation. The yield point is where this line intersects the data, in this case a stress point of 4 MPa.

+ = Yield Point Marker

A = Initial Modulus

B = Offset Value

C = Offset Line



Fails to calculate

The algorithm will not calculate a result if:

- the data never intersects the offset line.
- there is no modulus line.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Slope Threshold Yield

This calculation determines the point on the stress/stain curve at which yield is assumed to have occurred. Slope threshold yield is a dependent calculation that requires a result from a modulus calculation. The slope threshold yield calculation searches for the point at which the slope of the stress/strain curve has decreased to a specified percentage of the modulus slope.

Parameters

You must specify:

- the **Slope Threshold** type of yield.
- a percentage of the initial modulus slope.
- a number of regions. Specify 2 to 999 regions. The more regions, the higher the accuracy and processing time.
- a percentage of overlap between 0 and 99.
- a modulus calculation in the **Parent calculation** field.

*The parent calculation must be in the **Selected** list for it to appear in the **Parent calculation** field.*

You have the option to select **Indicate on graph** to place a marker on the graph.

The system includes the type of yield and the value in the calculation description. If you select a **Slope Threshold** yield with a 50% value, the calculation description appears as:

Yield (Slope Threshold 50%)

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- divides the curve into the number of regions with the specified percent overlap.
- calculates the slope of each region.

- finds the first region with a slope that is less than or equal to the specified percentage of the modulus' slope.
- assigns the center point of this region as the yield point.

Example

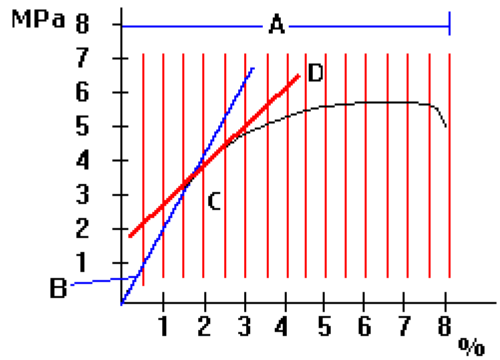
The specified threshold slope is set for 75% of the modulus. The data in the fifth region is the first point where the slope drops to 75% of the modulus.

A = Regions

B = Modulus

C = Region of percent change

D = 75% slope marker



Fails to calculate

The algorithm will not calculate a result if:

- the system does not find a region with a slope that is less than or equal to the specified percentage of the modulus' slope.
- the data contains the same number or fewer points than the specified number of regions.
- the modulus calculation fails.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Upper Yield (EN/ISO)

This calculation lets you define the search range to find the upper yield point on the stress/strain curve.

Parameters

You must specify:

- the **EN/ISO Upper** type of yield.
- the upper limit for the search range.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- starts searching at 5 MPa stress.
- smoothes the raw stress data by using a moving average of the recorded stress readings.
- finds three consecutive stress drops on the smoothed stress data.
- once the third stress drop is found, the search ends and assigns the upper yield to the maximum stress found. The stress drops must be found before the system reaches the specified upper limit for the search range.

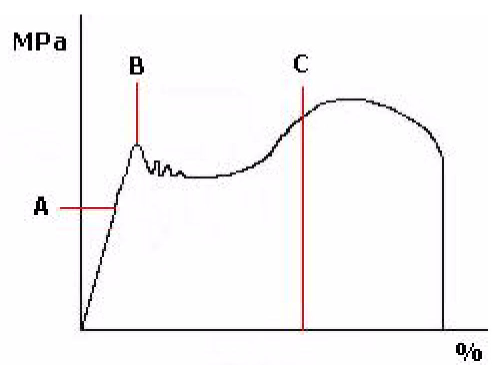
Example

The system starts searching the data at 5 MPa on the stress channel and continues searching the data until the system finds three consecutive stress drops on the smoothed stress data or reaches the specified upper limit for the search range.

A = Starting point for search range

B = Upper yield point

C = Upper limit for search range



Fails to calculate

The algorithm will not calculate a result if:

- the data never reaches 5 MPa.
- the system does not detect an upper yield before reaching the specified upper search limit.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Zero Slope Yield

This calculation finds the first point on the stress/strain curve at which the slope decreases to zero.

For metals testing, zero slope yield should not be used. Use Yield Point Extension/Elongation (YPE\Ae) using UYS results, which is a more reliable version relevant to metals tests.

Parameters

You must specify:

- the **Zero Slope** type of yield.
- a number of regions. Specify 1 to 100 regions. The more regions, the higher the accuracy and processing time.
- percentage of overlap between 0 and 99.
- the upper limit. This is the maximum value that can be determined for the upper yield.
- a yield slope criteria. This is the number of consecutive regions with a negative slope the system must detect to establish the yield point. Specify 1 to 99.

You have the option to select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

The system:

- divides the data, based on extension and any percent overlap, into the specified number of regions.
- using the least squares fit method, calculates the slope of each region.
- finds the number of consecutive regions that have a slope equal to or less than zero.
- assigns the point of the highest load within the regions as the yield point.

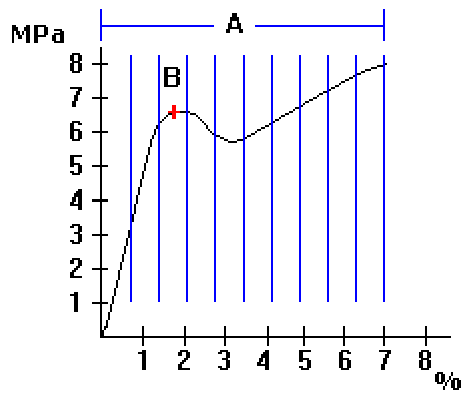
Example

The data is divided into 10 regions. The slope is less than zero in the third region, the stress does not increase while the strain does.

+ = Yield Point Marker

A = Regions

B = First region with zero slope



Fails to calculate

The algorithm will not calculate a result if:

- there is no data with a zero or negative slope.
- the system did not detect a zero slope based on the specified parameters.
- the data contains the same number or fewer points than the specified number of regions.

Results

All channels in the system are available.

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Yield Point Extension calculations

The Yield Point Extension/Elongation (YPE / A_e) calculations meet the requirements for EN10002 and ASTM E8 standards. These calculations measure the extension on a stress-strain curve.

Yield Point Extension (Automatic)

The Automatic Yield Point Extension/Elongation (YPE/A_e) calculation measures the extension from the upper yield point to the end of discontinuous yielding.

Parameters

You must specify:

- the **Automatic** type of YPE/A_e.
- the **Offset Yield** for a type 2 curve and a type 3 curve. The default value is 0.2%.

You have the option to:

- select **End point slope intersection correction**, which calculates the YPE/A_e for ASTM E8 and EN10002:2003 standards. If you do not enable this option, the YPE/A_e is calculated according to versions of EN10002 prior to EN10002:2003.
- select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

EN10002 (versions prior to EN10002:2003)

If you do not enable the **End point slope intersection correction**, the system performs the calculation according to versions of EN10002 prior to EN10002:2003.

The system:

- finds the upper yield point.
- uses the upper yield point as the start point.
- finds the last point of inflection on the curve.
- calculates the extension between the upper yield point and the last point of inflection to determine the YPE/A_e.

ASTM E8 and EN10002:2003

If you enable the **End point slope intersection correction**, the system performs the calculation according to ASTM E8 and EN10002:2003.

The system:

- finds the upper yield point.
- uses the upper yield point as the start point.
- finds the last point of inflection on the curve.
- draws a tangent at the last point of inflection.
- draws a horizontal line at the last lower yield point. The intersection of the two lines is the end point slope intersection correction.
- calculates the extension between the upper yield point and the intersection of the lines constructed above to determine the YPE/A_e.

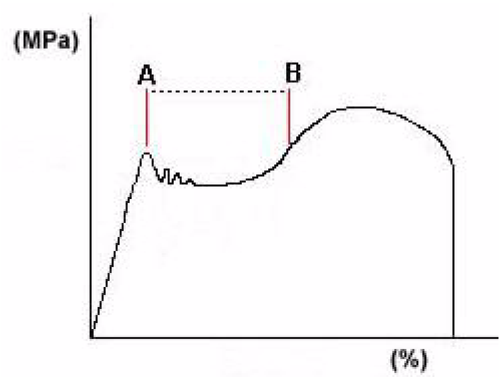
Examples

EN10002 (versions prior to EN10002:2003)

The system finds the upper yield point and the last point of inflection on the curve. The system calculates the extension between the upper yield point and the last point of inflection.

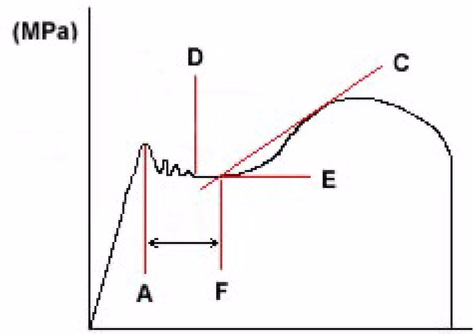
A = Upper yield point

B = Last point of inflection



ASTM E8 and EN10002:2003

The system finds the upper yield point and the last point of inflection on the curve. The system determines the end point slope intersection correction. The system calculates the extension between the upper yield point and the end point slope intersection correction.



A = Upper yield point

B = Last point of inflection

C = Tangent at Inflection Point

D = Last Lower Yield Point

E = Horizontal Line at Lower Yield Point

F = End Point Slope Intersection Correction

Fails to calculate

The algorithm will not calculate a result if:

- no upper yield point is found.
- the stress-strain curve contains no points of inflection.
- the difference between the measured upper yield point and lower yield strength is less than 2.5 MPa (i.e. the upper yield point is insignificant).
- the YPE/A_e is beyond the point of maximum load.
- there is a hysteresis loop or change in speed.

Results

YPE\ Ae
Starting Strain
Ending Strain
Ending Stress
Ending Extension
Ending Load
UYS or Proof Strength
UYS
Curve Types:

Curve Type 1
Curve Type 2
Curve Type 3

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to "Channels used as inputs for calculations" on page 3-1.

Yield Point Extension (Cursor)

The Cursor Yield Point Extension/Elongation (YPE/A_e) calculation measures the extension from the upper yield point to the specified cursor point. This calculation is useful for unusual stress-strain curves. You specify the end of the region on the graph of the stress-strain curve.

Parameters

You must specify:

- the **Cursor** type of YPE/A_e.
- the **Offset Yield** for a type 2 curve and a type 3 curve. The default value is 0.2%.

You have the option to:

- enable **End point slope intersection correction**, which calculates the YPE/A_e for ASTM E8 and EN10002:2003 standards. If you do not enable this option, the YPE/A_e is calculated according to versions of EN10002 prior to EN10002:2003.
- select **Indicate on graph** to place a marker on the graph.

If desired, edit the calculation description in the **Description** field. Changes to the description appear in the **Selected Calculation** list and also in the **Available Results** list under **Setup Results Table - Column** screen.

Algorithm

EN10002 (versions prior to EN10002:2003)

If you do not enable the **End point slope intersection correction**, the system performs the calculation according to versions of EN10002 prior to EN10002:2003.

The system:

- finds the upper yield point.
- uses the upper yield point as the start point.
- finds the specified cursor point.

- calculates the extension between the upper yield point and the specified cursor point to determine the YPE/A_e.

ASTM E8 and EN10002:2003

If you enable the **End point slope intersection correction**, the system performs the calculation according to ASTM E8 and EN10002:2003.

The system:

- finds the upper yield point.
- uses the upper yield point as the start point.
- finds the specified cursor point.
- draws a tangent at the specified cursor point.
- draws a horizontal line at the last lower yield point. The intersection of the two lines is the end point slope intersection correction.
- calculates the extension between the upper yield point and the intersection of the lines constructed above to determine the YPE/A_e.

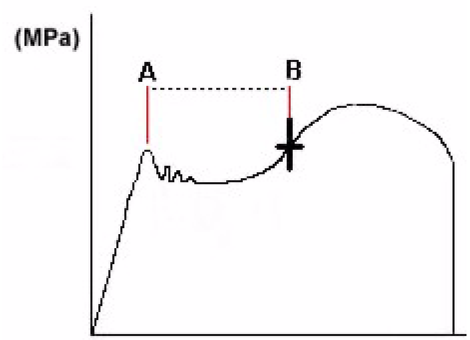
Examples

EN10002 (versions prior to EN10002:2003)

The system finds the upper yield point and the user specified cursor point. The system calculates the extension between the upper yield point and the user specified cursor point.

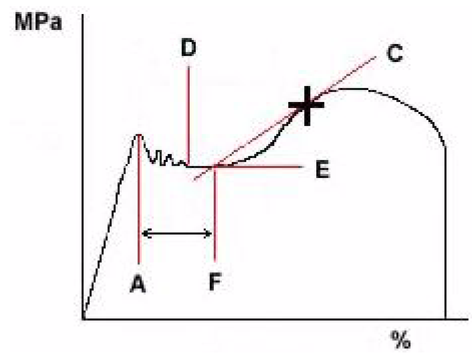
A = Upper yield point

B = User-specified cursor point



ASTM E8 and EN10002:2003

The system finds the upper yield point and the user specified cursor point. The system determines the end point slope intersection correction. The system calculates the extension between the upper yield point and the end point slope intersection correction.



A = Upper yield point

B = User-specified cursor point

C = Tangent at Inflection Point

D = Last Lower Yield Point

E = Horizontal Line at Lower Yield Point

F = End Point Slope Intersection Correction

Fails to calculate

The algorithm will not calculate a result if:

- no upper yield point is found.
- the difference between the measured upper yield point and lower yield strength is less than 2.5 MPa (i.e. the upper yield point is insignificant).
- there is a hysteresis loop or change in speed.

Results

YPE\ Ae
Starting Strain
Ending Strain
Ending Stress
Ending Extension
Ending Load
UYS or Proof Strength
UYS
Curve Types:

Curve Type 1
Curve Type 2
Curve Type 3

Channels used as inputs for the calculation

The channel designated for Stress, Load, Strain and Extension varies according to the test type. Refer to “Channels used as inputs for calculations” on page 3-1.

Chapter 2
User Calculations

This section describes user calculations and how to create them. It includes the following sections:

What are user calculations?

User calculations are equations that you build to perform computations on the test data. The equations are built from variables, functions and numbers. Each user calculation produces a single result. You can display the result in a column of the results table.

User calculations use variables as the base for their computation. Variables are similar to results in that they return the result of a calculation. Calculations used as a base for a variable may be either a standard installed calculation such as maximum load, a test parameter such as rate or specimen width, or a previously built user calculation. Thus a variable used in one user calculation may be dependent upon the result of another user calculation.

Dependencies within user calculations

Variables

If a variable is used in a user calculation, you cannot remove that variable from the **Variable List**.

Standard calculations

If a standard calculation is used as a variable in a user calculation, you cannot delete that standard calculation from the available calculations list in the **Calculations Setup** dialog box.

User calculations

If user calculation A is used as a variable in another user calculation B, you cannot delete user calculation A from the available calculations list in the **Calculations Setup** dialog box.

Creating user calculations

The process falls into three parts, as follows:

- Defining variables
- Building equations
- Validating equations

Refer to the following subsections for more detail regarding the above process.

Defining variables for user calculations

User calculations use variables as the base for their computation. Variables are similar to results in that they return the result of a calculation. Calculations used as a base for a variable may be either a standard installed calculation such as maximum load, a test parameter such as rate or specimen width, or a previously built user calculation.

You can only use alphanumeric characters and the underscore character in the variable name. The name must begin with an alphabetic character and can be up to 32 characters long.

Defining variables

Before you can use a variable in a user calculation, you must define it.

You must first add a user calculation to the **Selected Calculations** list in the **Calculations Setup** dialog box. When you highlight the **User Calculation** in the list, you see the Parameters for that calculation.

To open up the dialog where you define variables and build equations, click the **Setup...** button in the Parameters area to open the **User Calculation Setup** dialog.

Click on the **Variable Definition** tab.

There are two lists beneath the **Variable Definition** field, which you use to define a variable from its two component parts.

1. Scroll the list on the left-hand side to see the different calculations and parameter categories and click on one of the items to select it. The calculations in this list are only those that you have previously added to the **Selected Calculations** list. Your selection appears immediately in the **Variable Definition** field above the lists.

   When you select an item from this list, a default selection is made in the list on the right-hand side. The next step in the procedure allows you to change this.

2. Scroll the list on the right-hand side to see the different parameters and click on one of the items to select it. Your selection is added immediately to the **Variable Definition** field above the lists to complete the definition of the variable. If you have selected a previously-defined user calculation in the list on the left-hand side, the variable must always be the result of that calculation.

3. Type a name for your variable into the **Variable Name** field.

4. Click the **Add** button to add the variable to the list.

Example

As a basis for establishing a safe working load on a cable, you wish to find the load that corresponds to 2/3 of the load reached at the 0.2% offset yield point. Thus load at 0.2% offset yield is the variable that your user calculation will use. This example assumes that you have already established a standard 0.2% Offset Yield calculation in the **Selected Calculations** list.

To define the variable:

1. Select **Yield (Offset 0.2%)** calculation from the left-hand list.
2. Select **Load** from the corresponding channel list on the right.
3. Type the name Yield_Load in the **Variable Name** edit field.
4. Click the **Add** button to add the variable to the **Variable List**.

Modifying variables

You can modify any variable in the **Variable List**. When you select an existing variable, the **Modify** button becomes available. If you change the Variable name, the **Add** button also becomes available to let you add the new variable. If you change the Variable name and click the **Modify** button, you will overwrite the original variable name and definition.

Removing variables

You can remove a variable in the **Variable List**, provided that the variable is not being used by any user calculation. When you select an existing variable, the **Remove** button becomes available. If the variable is being used by another user calculation, the **Remove** button grays out when you select that variable.

Building equations for user calculations

To build an equation, you use the **Insert** variable button and the calculator to assemble the equation components. The calculator provides numbers, functions, and numeric operators. The **Variables List** contains variables that you have previously defined.

As you build the equation, it appears in the **Equation** field above the calculator.

You can type directly into this field except for variable names, which you must add from the list using the **Insert** button, and the Pi constant, trigonometric and logarithmic functions which you must add using the calculator. You can highlight and delete characters using the cursor as well as using the Delete and Backspace keys to remove individual characters. You can also use the **Clear** button on the calculator to remove the whole equation string.

Example

As a basis for establishing a safe working load on a cable, you wish to find the load that corresponds to 2/3 of the load reached at the 0.2% offset yield point. You have established your Yield_Load variable already.

To build the equation:

1. Highlight the Yield_Load variable in the **Variables** list and click the **Insert** button. The variable appears in the **Equation** field.
2. Select in turn from the calculator buttons the characters (2 / 3) or type them directly from the keyboard.
3. Click the **OK** button
4. In the **Calculations Setup** dialog, type a calculation description such as Safe Working Load and set the units.
5. Click the **Add** button to add the new user calculation to the **Calculation List**.

List of functions and operators

The calculator provides the following:

Calculator key	Shortcut key	Result
Ln	n	Natural log()
Log	l	Log to base 10()
Sqrt	q	Square root()
Sin	s	Sine()
Cos	c	Cosine()
Tan	t	Tangent()
Pi	p	Pi
Sin-1	Shift + s	Inverse Sine() or Arcsin()
Cos-1	Shift + c	Inverse Cosine() or Arccos()
Tan-1	Shift + t	Inverse Tangent() or Arctan()
ex	e	inverse of natural log()
EXP	x	Exponential

Symbol	Function
( )	Precedence operators
x(y)	Function calls
^	Power function
* , /	Multiply, divide
+ , -	Add, subtract

For example, the equation 3+4*5 resolves to 23, but the equation (3+4)*5 resolves to 35.

Modifying equations

You can modify a user calculation as required.

You should be aware that if user calculation A is used as a variable in another user calculation B, then modifying user calculation A may change the operation of user calculation B. Furthermore, you cannot change the name of user calculation A.

Validating equations for user calculations

When you select the **OK** button in the **User Calculation Setup** dialog box, the program checks the syntax of the equation.

The syntax checker ensures the following:

- All variables referenced in the equation are defined.
- Functions have an opening parenthesis.
- Functions have a number or a variable as a parameter.
- Opening and closing parentheses match.
- Function numeric values are legal. A variable parameter is accepted as a deferred evaluation. For example, Sqrt(-9) is rejected but Sqrt(Load) is deferred for calculation after the test.

If the equation is incorrect, the program displays an error message and places the cursor as close as possible to the position that the error was detected.

If a deferred calculation cannot produce a result, the relevant column in the **Results Table** will show dashes in the cells in the place of values.

If you select the **Cancel** button, the program discards all changes to equations and variables made since the dialog was opened.

Chapter 3
Channel Reference

This section provides greater detail about channels and how the system handles them. This section contains the following topics:

Channels used as inputs for calculations

The channel designated for Stress, Load, Strain and Extension varies according to the test type as follows:

Test Type	Stress Channel	Load Channel	Strain Channel	Extension Channel
Tension, Tension Creep Relaxation, Tension Profile, Asphalt,	Tensile Stress (or Tenacity for fiber specimens)	Load	Tensile Strain	Tensile Extension
Compression, Compression Creep Relaxation, Compression Profile	Compressive Stress	Compressive Load	Compressive Strain	Compressive Extension
Flexure, Flexure Relaxation	Flexure Stress	Flexure Load	Flexure Strain	Flexure Extension
Peel, Tear and Friction	Load/Width (or Load for Friction tests)	Load	Peel Extension (or Extension for Friction tests)	Peel Extension (or Extension for Friction tests)

How does the system handle channels?

The factors that affect the number of channels available in various parts of the user interface are:

- the connected transducers
- the test type
- the controller type
- the Enhanced Test Control Option
- the VersaChannel Option

Real channels

Real channels supply data from physical transducers connected to your testing system. These are Extension (Electromechanical Systems only), Position (Servohydraulic Systems only), Load, Strain 1, Strain 2 and Video Strain. Extension, Position and Load are always available, Strain 1, Strain 2 and Video Strain are only available when the appropriate strain card is installed. Time is also considered to be a real channel.

Derived channels

The following description assumes a Tension test type. Refer to "Types of channels" on page 3-5 for details of how other test types differ from this.

Derived channels supply data about the specimen that is calculated mathematically from the measurements made from real channels. For example, stress is derived by dividing the readings of the load channel by the cross-sectional area of the specimen. If you do not have an extensometer connected to your system, the system derives values of strain by dividing measurements from the extension channel by the gauge length of the specimen. Other derived channels include average strain and differential strain; these are available only if you have both Strain 1 and Strain 2 cards installed.

The derived channels available in the Tension test are the following:

Derived Channel	Derivation/Explanation
Tensile Stress	Load/specimen cross-sectional area
Tenacity	Load/linear density
Transverse Strain	Transverse Strain Source * Source Gauge Length/Transverse Gauge Width Value

Derived Channel	Derivation/Explanation
Transverse Extension	Transverse Strain * Transverse Gauge Width Value
Displacement (Strain 1)and Displacement (Strain 2)	Strain 1 * Strain Source Gauge Length Strain 2 * Strain Source Gauge Length
Average Strain	(Strain 1 + Strain 2)/2
Differential Strain	Strain 1 - Strain 2
True Strain	ln(1 + tensile strain)
True Stress	Load(1 + tensile strain)/initial specimen cross sectional area
Cycle Count	A count of all triangles run during the current block. Each time a new triangle block is executed in profiler, the cycle count is reset to zero. Cycle count counts the number of precycles too.
Total Cycle Count	A running count of all triangles run during the current test. Total cycle count is set to zero when a new test is started and does not include precycle cycles.
Repetitions Count	Counts the repetitions of the profile.

Composite channels

The following description assumes a Tension test type. Refer to "Types of channels" on page 3-5 for details of how other test types differ from this.

A composite channel is one that can change the source of its information during a test. There are two composite channels in the Tension test; Tensile Strain and Tensile Extension.

Tensile Strain is a channel that you define in the Setup Control - Strain screen within the **Method** tab.

If you assign the Extension channel to Tensile Strain, then values of strain are calculated for the entire duration of the test by dividing values of crosshead/actuator extension by the specimen gauge length.

If you assign a channel with an extensometer connected to it (Strain 1, for example) as Tensile Strain and you do not remove the extensometer during the test, then values of strain are derived directly from the extensometer for the entire duration of the test.

If you assign a channel with an extensometer connected to it as Tensile Strain and you choose to remove that extensometer at a specified point in the test, the system must change the method of calculating Tensile Strain during the test. The system operates as follows:

1. Up to the point of extensometer removal, values of Tensile Strain are derived directly from readings from the extensometer assigned to it.
2. After the removal point, the system uses extension measurements from crosshead/actuator movement. The extension readings are corrected and normalized using the "Extensometer removal correction algorithm" on page 3-12.

Tensile Extension is calculated from Tensile Strain. If you choose to assign the Extension channel to Tensile Strain, you would expect Tensile Extension to be the same as extension measured from movement of the crosshead/actuator. This is the case provided that:

- you have not enabled Auto Balance in the Setup Control - Strain screen
- you have not chosen a slack correction calculation which corrects the gauge length in the Setup Results Columns screen

If you choose to assign Tensile Strain to a channel with an extensometer connected, then Tensile Extension is the extension of the specimen within the extensometer gauge length. In the same way as for Tensile Strain, values of Tensile Extension are corrected and normalized if you decide to remove the extensometer at a specified point during the test.

You cannot choose to remove the extensometer during preload or precycling.

Availability of channels

The list of channels offered to you in any particular screen varies depending upon the function involved. For example, the list offered for the live displays contains more choices than that offered for precycling channels.

Enhanced test control channels

In a testing system that does not have the Enhanced Test Control software module installed, the Extension channel controls the crosshead/actuator movement. If you install and enable the Enhanced Test Control module, and if the controller supports it, the system can use any of the three types of real channel source transducers to control the crosshead/actuator movement. In addition to the real channels, the software allows you to specify some derived and composite channels as test control modes.

The following are the real channel source transducers:

- Extension channel - motor encoder
- Load channel - load cell
- Strain channel - extensometer (not video extensometer)

VersaChannel channels

The VersaChannel option lets you specify additional channels. These are real channels and can be one of three types; load, strain and user-defined. For every Strain channel that you create, the system creates an additional, derived Displacement (Strain) channel.

Types of channels

A channel can be one of three types; real, derived or composite, as described in the following sections.

Real channels

Definition

A real channel is a test data channel measured directly from the transducers that monitor the specimen. For example, load from the load cell, strain from the extensometer.

A real channel can be a source of data for a derived channel. For example, Stress is derived from Load divided by the specimen cross-sectional area.

List

Extension	The location of the crosshead/actuator relative to the point where the gauge length is reset. Extension is a real channel on an electromechanical system. Extension is derived from position on servohydraulic systems.
Load	The force the testing system exerts on the specimen. Load is a real channel. The testing system uses a load cell to measure force.
Position	Records the absolute position of the actuator. Position is a real channel. This channel is available in servohydraulic systems only.
Strain	The change in specimen length divided by the original length. Strain is a real channel. You normally use an extensometer to measure strain, where the extensometer has a specific gauge length.

Derived channels

Definition

A derived channel is a test data channel calculated using data from the transducers that monitor the specimen. For example, stress is derived using load data from the load cell, average strain is derived by dividing the sum of two strain channels.

Some derived channels are specific to the test type. For example, flexure stress is derived from load divided by an outer fiber stress factor.

List

Average Strain	Average strain is a derived channel. Calculated as the average value of the output from two extensometers. (Strain 1 + Strain 2)/2
Compressive Load	Compressive load is a derived channel calculated as the standard load with the sign inverted. Compressive load is reported using positive values for increasing compression. The compressive load channel is available in the following test types: • Compression • Compression Creep Relaxation • Compression Test Profile Load with sign inverted
Compressive Stress	Compressive stress is a derived channel calculated as compressive load divided by the cross-sectional area of the specimen. Compressive stress increases as the compressive load on the specimen increases. The compressive stress channel is available in the following test types: • Compression • Compression Creep Relaxation • Compression Test Profile Compressive load/cross-sectional area
Cycle Count	A count of all triangles run during the current block. Each time a new triangle block is executed in profiler, the cycle count is reset to zero. Cycle count counts the number of precycles too.
Differential Strain	Differential strain is a derived channel calculated as the difference between the output of two extensometers. Strain 1 - Strain 2.

Displacement (Strain 1) and Displacement (Strain 2)	Displacement (Strain 1 or Strain 2) is a derived channel, calculated by taking the value of the real strain channel and multiplying it by the gauge length of the device. For every Strain sensor that the system contains (except for Automatic or Video extensometers), the system creates an equivalent Displacement (Strain) sensor. In most systems this would be Strain 1 and Strain 2, but there may be additional strain sensors created using the VersaChannel feature. If you want to report values from a device connected to a strain input in terms of displacement, you should select the appropriate Displacement (Strain) channel.
Flexure Load	Flexure load is a derived channel calculated as the standard load with the sign inverted. Flexure load is reported using positive values for increasing compression. Flexure load channel is available in the following test types: • Flexure • Flexure Creep Relaxation Load with sign inverted
Flexure Stress	Flexure stress is a derived channel calculated as flexure load divided by an outer fiber stress factor. Flexure load is reported using positive values for increasing compression. Flexure stress channel is available in the following test types: • Flexure • Flexure Creep Relaxation *For rectangular specimens in a 4-point bend test:* Flexure stress = Flexure load * 1.5 *(1 - load span/support span) * (support span)/(width * thickness^2) *For rectangular specimens in a 3-point bend test:* Flexure stress = Flexure load * 1.5 *(support span)/(width * thickness^2) *For cylindrical specimens in a 4-point bend test:* Flexure stress = Flexure load * 8 *(1 - load span/support span) * (support span)/(π * diameter^3) *For cylindrical specimens in a 3-point bend test:* Flexure stress = Flexure load * 8 *(support span)/(π * diameter^3)
Load/Width (Peel, Tear and Friction test type only)	Load/Width is a derived channel calculated by dividing the readings of the load channel by the width of the specimen.
Peel Extension (Peel, Tear and Friction test type only)	Peel extension is a derived channel calculated as extension divided by a peel factor. The value of the peel factor varies according to specimen geometry. For 90° peel specimens and friction specimens, the peel factor is 1. For 180° peel specimens, T-peel specimens and tear specimens, the peel factor is 2.
Repetitions Count	Counts the repetitions of the profile.

Tenacity	Load divided by linear density. Tenacity is a derived channel. The testing system calculates tenacity using the measured load and the value of linear density that you enter into the test application. Tenacity is a measure used in the testing of fibers and is therefore only available in those test types where fibers can be tested. Tenacity channel is available in the following test types: • Asphalt • Tension • Tension Creep Relaxation • Tension Test Profile
Tensile Stress	Tensile stress is a derived channel. calculated as load divided by the cross-sectional area of the specimen. Tensile stress increases as the load increases on the specimen. The tensile stress channel is available in the following test types: • Asphalt • Tension • Tension Creep Relaxation • Tension Test Profile • Metals
Total Cycle Count	A running count of all triangles run during the current test. Total cycle count is set to zero when a new test is started and does not include precycle cycles.
Transverse Strain	Transverse strain is a derived channel. It is measured in a direction perpendicular to the applied load. Transverse Strain = Transverse Strain Source * Source Gauge Length/Transverse Gauge Width Value. For example, if Strain 1 is the source channel for Transverse Strain then: Transverse Strain = Strain 1 * Strain 1 Gauge Length/Transverse Gauge Width Value. The transverse gauge width value can be set to a specimen dimension (e.g. width, thickness) or a manually entered value. The transverse strain channel is available in the following test types: • Asphalt • Compression • Compression Creep Relaxation • Compression Test Profile • Metals • Tension • Tension Creep Relaxation • Tension Test Profile

Transverse Extension	Transverse extension is a derived channel. The extension is calculated from the transverse strain sensor by multiplying the transverse strain by transverse gauge width value. The transverse extension channel is available in the following test types: • Asphalt • Compression • Compression Creep Relaxation • Compression Test Profile • Metals • Tension • Tension Creep Relaxation • Tension Test Profile
True Strain	True strain is a derived channel that is available with the Enhanced Test Control Module. The system derives true strain from composite channels in different test types as follows: • Tension test types (including Asphalt) and the Metals test type use Tensile Strain • Compression test types use Compressive Strain It is assumed that composite strain is equivalent to engineering strain. The system calculates the true strain channel value by applying the appropriate composite strain channel in the following formulas: *Tension and Metals Test Types (including Asphalt)* True Strain = ln (1 + composite strain) *Compression Test Types* True Strain = -ln (1 - composite strain) You can specify the true strain channel as a control mode in the Metals, Asphalt, Tension, Tension Creep Relaxation, Compression and Compression Creep Relaxation test types.
True Stress	True stress is a derived channel that is available with the Enhanced Test Control Module. The system derives true stress from the load cell and a composite strain channel in different test types as follows: • Tension test types (including Asphalt) and the Metals test type use Tensile Strain • Compression test types use Compressive Strain It is assumed that composite strain is equivalent to engineering strain. The system calculates the true stress channel value by applying the appropriate composite strain channel in the following formulas: *Tension and Metals Test Types (including Asphalt)* True Stress = (load * (1 + composite strain))/(initial specimen cross-sectional area) *Compression Test Types* True Stress = (load * (1 - composite strain))/(initial specimen cross-sectional area)

Composite channels

Definition

A composite channel is a test data channel that can change its information source during a test. For example, the composite channel Tensile Strain lets you measure strain directly from an extensometer during the first part of a test, then calculate strain from the extension of the crosshead for the remainder of the test. Thus the total strain measurement is a composite of the real strain channel and the derived strain from extension channel.

List

Compressive extension	Compressive extension is a composite channel calculated from compressive strain multiplied by the anvil height. Compressive extension is reported using positive values for increasing compression. The compressive extension channel is available in the following test types: • Compression • Compression Creep Relaxation • Compression Test Profile
Compressive strain	Compressive strain is a composite channel. You can choose any strain channel as a source channel for compressive strain. If your source channel is an extensometer, you can choose to remove the extensometer during a test; from this point compressive strain measurement continues using the extension channel as the source. The extension readings are corrected and normalized using the Extensometer Removal Correction Algorithm. Refer to “Extensometer removal correction algorithm” on page 3-12 for more detail. Compressive strain increases as the specimen compresses. The compressive strain channel is available in the following test types: • Compression • Compression Creep Relaxation • Compression Test Profile
Flexure extension	Flexure extension is a composite channel calculated from flexure strain multiplied by an outer fiber strain factor. Flexure extension is reported using positive values for increasing compression. The flexure extension channel is available in the following test types: • Flexure • Flexure Creep Relaxation

Flexure strain	Flexure strain is a composite channel. You can choose any strain channel as a source channel for flexure strain. If your source channel is an extensometer, you can choose to remove the extensometer during a test; from this point flexure strain measurement continues using the extension channel as the source. The extension readings are corrected and normalized using the Extensometer Removal Correction Algorithm. Refer to "Extensometer removal correction algorithm" on page 3-12 for more detail. Flexure strain is reported using positive values for increasing compression. The flexure strain channel is available in the following test types: • Flexure • Flexure Creep Relaxation **Note:** *When using a 4-point bend fixture for flexural testing, you should use a deflectometer to measure the specimen deflection directly at the mid-span point on the specimen. You must set up the method to use output from the deflectometer as the Axial Strain Source. If you don't use a deflectometer, the software uses the crosshead extension at the point of contact of the fixture, which may be significantly different from the specimen deflection at mid-span.* *For rectangular specimens in a 4-point bend test:* Flexure strain = Deflection * thickness * 12/(support span^2*(3 - (1 - load span/support span)^2)) *For rectangular specimens in a 3-point bend test:* Flexure strain = Deflection * thickness * 6/support span^2 *For cylindrical specimens in a 4-point bend test:* Flexure strain = Deflection * diameter * 12/(support span^2*(3 - (1 - load span/support span)^2)) *For cylindrical specimens in a 3-point bend test:* Flexure strain = Deflection * diameter * 6/support span^2

Tensile extension	Tensile extension is a composite channel calculated from tensile strain multiplied by the specimen gauge length. The tensile extension channel is available in the following test types: • Asphalt • Tension • Tension Creep Relaxation • Tension Test Profile • Metals
Tensile Strain	Tensile strain is a composite channel. You can choose any strain channel as a source channel for tensile strain. If your source channel is an extensometer, you can choose to remove the extensometer during a test; from this point tensile strain measurement continues using the extension channel as the source. The extension readings are corrected and normalized using the Extensometer Removal Correction Algorithm. Refer to “Extensometer removal correction algorithm” on page 3-12 for more detail. Tensile strain increases as the specimen stretches. The tensile strain channel is available in the following test types: • Asphalt • Tension • Tension Creep Relaxation • Tension Test Profile • Metals

Extensometer removal correction algorithm

The extension readings made after the removal of the extensometer are corrected and normalized using the following algorithm.

The extension value written into the raw data file after the point of extensometer removal is calculated as follows:

1. A correction value is determined by checking the last data point “p” before removal of the extensometer. At point “p”, both crosshead extension and strain are read.
2. Strain measured from the extensometer at point p is:

   $\varepsilon p = EXTp / Le$

   where εp is the strain and EXTp is the extension at point “p” for the section of specimen between the extensometer knife edges, and Le is the extensometer gauge length.
3. Strain measured from crosshead extension at point p is:

   $\varepsilon(XHD)p = Dp / Lo$

where $\varepsilon(XHD)p$ is the strain, Dp is the crosshead extension and Lo is the specimen gauge length.

4. To conserve consistency in what is written into the data file, for all points after extensometer removal, the extension read from crosshead (D) is normalized to that section of the specimen between the extensometer knife edges. That is, a scaling factor of (Le / Lo) is applied to any extension reading from the crosshead.

5. For an ideal specimen, strain is the same throughout, so it follows from steps (2) and (3) that:

   $\varepsilon p = \varepsilon(XHD)p$

   which means that EXTp / Le = Dp / Lo
   and so rearranging, this becomes EXTp = Dp x (Le /Lo)

6. Since the specimen is not likely to be ideal, the software defines an offset correction as:

   Correction value = EXTp – [Dp x (Le / Lo)]
   which is applied to the extension value for all data points after point “p”.

7. Therefore, the extension data for the section of the specimen between the extensometer knife edges is given by:

   Extension = [D x (Le / Lo)] + correction value
   that is,
   Extension = (D - Dp) x (Le / Lo) + EXTp
   where D is the extension read from the crosshead.

Note that adding the correction value to the normalized crosshead extension at point “p” yields the extension at “p” which is actually calculated from the strain value obtained from the extensometer, so the test curve is connected through that point.

Appendix A
Glossary

A

absolute peak: Typically, the highest value reached by the assigned channel during a test. For example, if load is assigned to the absolute peak calculation, then the highest value of load reached during a test is the absolute peak load. You can monitor for either a maximum peak, which occurs where the channel values decrease from a previous high value, or a minimum peak, where the channel values increase from a previous low value.

actuator: A rod, mounted on the load frame that is driven up or down using servohydraulic force. The force required to drive the actuator is transferred to the specimen through the grips. Actuator applies to servohydraulic systems only. Note that the crosshead is fixed during a test on a servohydraulic system.

analog meters: Show an analog representation of their associated parameters on the live display area of console. You can set the scale of each analog meter to increase the resolution of the parameter level.

anvil height: The distance between the upper and lower components of a compression fixture.

ASCII raw data: A file, saved at the end of the sample, of the measured data points relevant to each specimen. The data is in the standard ASCII text format, which means that you can open the file into a text editor or spreadsheet and read, print, or further analyze the details of the data. The ASCII raw data file name is of the form filename.raw.

ASCII results data: A file, saved at the end of the sample, of the results data calculated for each specimen using the calculations that you have currently set up in the Results Table. The data is in the standard ASCII text format, which means that you can open the file into a text editor or spreadsheet and read, print, or further analyze the details of the result data. The ASCII results data file name is of the form filename.rlt.

average value: Group of calculations that test properties such as adhesion, fabric and paper tear resistance, and surface friction. Calculations available are average peaks, average troughs, average peaks and troughs, first peak, and interval peaks.

axial strain: Strain measured in a direction parallel to the applied load.

B

balance:	Balance resets the current transducer value of load or strain to zero by removing offsets due to minor electrical or mechanical changes. For example, the change in weight of a new upper grip can cause slight changes in the load signal. The load balance procedure resets the load signal to zero.
binary raw data:	A file, saved at the end of the sample, of the basic data relevant to each specimen. The data is in binary format, which means that you cannot open the file into a text editor or spreadsheet and read or print the details of the data.
bounds:	The term “bounds” is used to describe limits that you set for a particular parameter. These bounds must lie within system limits set by the software. For example, you know that the width of all the specimens in a particular sample should be between 10 and 15mm. If you set bounds for width of 10 and 15 and an operator accidentally enters 100mm, an error message is generated. If bounds were not set, no error would result because 100mm is a valid value for the testing system.

C

calculation:	A computation carried out on the test data. Calculations are used to find points in the test data from which you can take results. For example, you can perform a peak calculation to find the maximum load during a test. You can then obtain various results from that point, such as load, strain, or time.
calibration:	Calibration ensures that the transducer is sending the correct output voltage signals throughout its range of measurement. For example, a calibrated 100 kN load cell has an output signal of 10 V at a load of 100 kN, - 10 V at a load of - 100 kN, and 0 V at a load of 0 kN.
channel:	A source of test data. Typical channels of information are measurements of physical properties such as load, strain, and temperature. Channels may be real, derived, or composite.
compliance:	The ability of an object to yield elastically when a force is applied.
composite channel:	A composite channel is a test data channel that can change its information source during a test. For example, the composite channel Tensile Strain lets you measure strain directly from an extensometer during the first part of a test, then calculate strain from the extension of the crosshead for the remainder of the test. Thus the total strain measurement is a composite of the real strain channel and the derived strain from extension channel.

console: The top region of the software display that lets you setup and monitor a test. The console comprises the hardware icons and the live displays.

context menu: Also known as the right-click menu. Right-click on the screen to show the context menu for that screen component, if there is one available.

control loop: The testing machine operates on a closed-loop control system. In extension control, the Master Controller board generates a command signal which dictates a required position for the crosshead. An encoder in the load frame has an associated feedback signal that details the current position of the crosshead. If the required position and the actual position are not equal, the system generates an error signal that drives the motor in the direction necessary to reduce the error signal to zero.

control mode: The transducer feedback signal that controls the system. The normal mode of control is extension. Under extension control, the system requests a specific extension of the crosshead. If the current extension is different to that requested, the system generates an error signal to drive the crosshead in the direction necessary to achieve the requested extension. With the optional Enhanced Test Control module, you can specify other modes of control such as load, strain or true strain.

control panel: On some load frames, the control panel contains dedicated keys to control the most repeated test actions and those actions that take place close to the test area. The keys let you (1) start and stop a test, (2) manually move the crosshead between tests at a selectable speed using jog keys, (3) use preassigned soft-keys on the control panel to carry out actions between or during tests, (4) select the Specimen Protect function, (5) reset the gauge length.

controller: The controller is the hardware that controls the frame and any ancillary equipment connected to the testing system. Different controllers have different testing capabilities. Examples are the 5900, 5500, 5500A, 3300, 4400, 5800, 8800 and IS02 controllers.

creep: Deformation that occurs over time when a material is subjected to constant stress at a constant temperature.

crosshead: A stiff beam, mounted on the load frame, that is driven up or down using electromechanical force. The force required to drive the crosshead is transferred to the specimen through the grips. Crosshead applies to electromechanical systems only.

D

data point: A result that is available for any calculation that identifies a single point on the test curve (e.g. peak, break, yield). This result reports the index number of the calculated point in the array of logged data. For interpolated points, where the system uses two points to perform the interpolation, the result reports the index number for the first point.

default specimen: Values of parameters for the default specimen are the values that are saved in a test method file. Take width and thickness as examples. When you start testing real specimens in a sample, they are assigned the default values of width and thickness. In the Test Inputs area on the test workspace, you can then enter different values of width and thickness for each specimen.

delete a specimen: When you delete a specimen, the specimen is permanently destroyed. All the data from that specimen is removed from the sample data file. This is very different from excluding a specimen, where the specimen data is retained but is not included in statistics calculations. The ability to delete specimens can be permitted or denied to an operator using security settings.

demonstration mode: Demonstration mode is distinguished from standalone mode by the ability to run tests. Standalone mode lets you do everything except run tests on specimens. Demonstration mode uses test data to simulate running tests on specimens. It is primarily a tool for sales personnel.

dependent calculation: A calculation carried out on the test data that is dependent upon the completion of a previous calculation. For example, an offset yield calculation may be dependent upon results obtained from a prior modulus calculation.

derived channel: A derived channel is a test data channel calculated using data from the transducers that monitor the specimen. For example, stress is derived using load data from the load cell, average strain is derived by dividing the sum of two strain channels. Some derived channels are specific to the test type. For example, flexure stress is derived from load divided by an outer fiber stress factor.

displacement Displacement (Strain 1 or Strain 2) is a derived channel, calculated by taking the value of the real strain channel and multiplying it by the gauge length of the device.

double shear round: When this geometry is selected, specimen diameter is required. The specimen cross section is calculated as the area of two circles. This affects all computations based on area, including stress (and stress control rates if entered prior to test start).

E

elongation: Increase in the original gauge length at the end of the test.

energy A measurement of the work done on a specimen during a test. The energy expended between any two points in a test is measured as the area under the load - extension curve between those points. Note that extension is calculated from the axial strain source.

In a Peel, Tear, Friction test method, the energy expended between any two points is measured as the area under the load - peel extension curve between those points.

engineering strain: The change in specimen length divided by the original length. Refer to the definition for strain.

engineering stress: Load applied to a specimen in a tension or compression test divided by the cross-sectional area of the specimen. The change in cross-sectional area that occurs with increases and decreases in applied load, is disregarded in computing engineering stress. Refer to the definition for stress.

enhanced test control module: Allows you to specify various system channels, such as Load or Strain to control the crosshead/actuator's movement. During a test, the system uses a real channel transducer to control the crosshead's movement.

exclude a specimen: When you exclude a specimen, the data from that specimen is excluded from statistics calculations. The data is not destroyed and the specimen can be included again at any time, even after the sample is finished.

extension: The location of the crosshead/actuator relative to the point where the gauge length is reset. Extension is a real channel on an electromechanical system. Extension is derived from position on servohydraulic systems.

extension (calculated rate): **Metals test type only**

When you select **Extension (calculated rate)** as a control mode, the system calculates an extension rate at the end of the preceding ramp so that there is no speed change after the ramp change. While the test is running, the system switches to extension control and maintains the speed at the calculated extension rate for the duration of the ramp.

extensometer: A transducer that converts a value of displacement into a proportional electrical signal. There are two main types of extensometer; contacting, such as the strain gauge and automatic extensometers, and non-contacting, such as the video extensometer.

F

freeform test:	If a test method is not set up to run as a prompted test, it runs as a freeform test. There are no prompts for the operator to enter values and the entire test workspace is visible to the operator at all times during testing, allowing entry of values at any time and in any sequence.
full-scale:	The maximum capacity of a load cell or extension of an extensometer.

G

gauge length:	The distance along the specimen upon which extension calculations are made. The gauge length is sometimes taken as the distance between the grips.
gauge width:	The separation of the transverse extensometer knife edges at the start of a test.

H

hold:	A test segment that holds the crosshead at the current value of the selected channel. Thus, when the Start of Hold criteria are met with load as the hold channel, the crosshead maintains the specimen at the current load value.
hysteresis loop:	The closed curve representing the successive stress-strain status of the material during a cyclic deformation.

I

include a specimen:	This is the reverse of exclude a specimen.

J

jog controls:	Buttons and a thumbwheel on the control panel that move the crosshead up or down manually. You use the jog keys and thumbwheel to manually position the crosshead; for example, when you install a specimen.

L

limits:	The selected boundaries to which the system can drive the crosshead. You can set physical limit stops on the load frame to limit crosshead travel, and you can set electrical limits in the software for each transducer. Limits are set as safety measures to prevent overtravel or overloading.
linear interpolation:	Method of estimating a value that falls between two data points by extending a straight line between those points.
live displays:	The numeric displays in the console show current values for the selected channel in the selected units.
load:	The force the testing system exerts on the specimen. Load is a real channel. The testing system uses a load cell to measure force.
load cell:	A transducer which converts a value of force into a proportional electrical signal.
load frame:	A high stiffness support structure against which the test forces can react. The load frame comprises a base beam, two columns, and a moving crosshead.
load string:	The complete test setup between the moving crosshead and the load frame table (or fixed crosshead). The load string normally comprises a load cell, grip adapters, grips, and the specimen.
loop shaping:	Loop-shaping is the process of tuning the control loop such that the movement of the crosshead closely follows the requirements of the command signal without any significant lag or overshoot.

M

method:	The set of values of all the parameters in the system that are saved to define a test setup.
modulus:	Rate of change of stress as a function of strain. Usually the slope of the straight-line portion of a stress/strain curve.

N

nominal modulus:	A Nominal modulus value is required only when you select Stressing Rate as a control mode in a Metals test. The nominal modulus is your estimate of the modulus value of the material that you are testing. It is used in conjunction with the specified stressing rate to calculate the speed at which the test runs.

O

offset yield: Calculation of the point on the stress/strain curve at which yield is assumed to have taken place. Offset yield is a dependent calculation that requires the result from a modulus calculation. The offset yield calculation constructs a line parallel to the modulus and separated from it by an amount that you specify. The offset yield point is where the new line intersects the curve.

outer fiber strain factor: For rectangular specimens in a 4-point bend test:

Outer fiber strain factor = (support span^2 * (3 - (1 - load span/support span)^2))/(thickness * 12)

For rectangular specimens in a 3-point bend test:

Outer fiber strain factor = support span^2/(thickness * 6)

For cylindrical specimens in a 4-point bend test:

Outer fiber strain factor = (support span^2 * (3 - (1 - load span/support span)^2))/(diameter * 12)

For cylindrical specimens in a 3-point bend test:

Outer fiber strain factor = support span^2/(diameter * 6)

outer fiber stress factor: For rectangular specimens in a 4-point bend test:

Outer fiber stress factor = (width * thickness^2)/(1.5 *(1 - load span/support span) * (support span))

For rectangular specimens in a 3-point bend test:

Outer fiber stress factor = (width * thickness^2)/(1.5 *(support span))

For cylindrical specimens in a 4-point bend test:

Outer fiber stress factor = (π * diameter^3)/(8 *(1 - load span/support span) * (support span))

For cylindrical specimens in a 3-point bend test:

Outer fiber stress factor = (π * diameter^3)/(8 *(support span))

P

parallel length:	Parallel portion of the reduced section of the test piece or specimen.
parent calculation:	A calculation that is required by another, dependent calculation. The dependent calculation requires the result of its parent calculation in order to calculate its own result. For example, an offset yield calculation may be dependent upon results obtained from a prior modulus calculation, which is the parent.
peel extension:	Peel extension is a derived channel calculated as extension divided by a peel factor. The value of the peel factor varies according to specimen geometry. For 90 degree peel specimens and friction specimens, the peel factor is 1. For 180 degree peel specimens, T-peel specimens and tear specimens, the peel factor is 2.
peel factor:	The value of the peel factor varies according to specimen geometry. For 90 degree peel specimens and friction specimens, the peel factor is 1. For 180 degree peel specimens, T-peel specimens and tear specimens, the peel factor is 2. This factor is used to calculation peel extension and peel length.
peel length:	Peel length is the value of peel extension relative to the first peak. The first peak detector searches for a 10% drop in load from peak. The load must first attain a value of at least 1% of the full-scale of the load cell.
pip:	On some load frames, you can connect an external marking device to the rear of the electrical compartment to the 1/4 in. phone jack marked PIP. When you select PIP as the source channel for a preset point result, you can display a result item in the Results column whenever you press the button on the pip marker. For example, if you set up a result of Extension at Preset Point PIP 1, the specimen extension is displayed in the Results table the first time that you press the button during a test. You can set up to 99 pip results, and capture data from all available channels on each one.
poisson's ratio:	The ratio of the lateral contraction to the axial elongation.
position:	Records the absolute position of the actuator. Position is a real channel. This channel is available in servohydraulic systems only.
precycling:	A test segment where the crosshead moves to cycle the specimen between specified bounds before a test starts. Data is captured during the precycle segment, but is not used for subsequent analysis.
preload:	A test segment where the crosshead moves to load the specimen to a specified value before a test starts. Data is not captured during the preload segment.

prompt workspace: The version of the screen within the Test tab that displays during a prompted test.

prompted test: To simplify testing, test methods can be set up to direct you through setting up and running a test. If a method is set up to run as a prompted test, the procedure constructed by the method designer automatically runs, displaying the steps and prompting you for the required inputs.

proof strength: The stress at the point of offset yield.

R

ramp: A test segment where the crosshead moves at a constant speed in a constant direction. Some test types such as tension relaxation have a single ramp segment while others such as tension have two ramp segments with a changeover point during the test.

rationalized transducer: A rationalized transducer contains code resistors which are recognized by the testing system. When you connect a rationalized transducer to the testing system, the type and the full-scale value of the transducer is registered into the system.

real channel: A real channel is a test data channel measured directly from the transducers that monitor the specimen. For example, load from the load cell, strain from the extensometer. A real channel can be a source of data for a derived channel. For example, Stress is derived from Load divided by the specimen cross-sectional area.

relaxation: The rate of reduction of stress in a material due to creep.

result: A measured value at a point in the test data found using a calculation. For example, you can perform a peak calculation to find the maximum load during a test. You can then obtain various results from that point, such as load, strain or time.

reverse polarity: When the reverse polarity checkbox is enabled, the transverse strain channel applies a factor of -1 to the source signal received.

S

sample:	A group of material specimens. whose properties are studied and compared to gain statistical or quality assurance information. For example, you could take a specimen from different parts of a single manufacturing run of a material to form a sample of the material. The sample is then representative of the complete run and you can test it to ensure that the material quality has remained stable over the complete run. You perform the same test on each specimen in a sample.
sample file:	File that contains the set of test parameters that were used to test the specimens AND all of the test data for each of the specimens. Test parameters that are the same for all specimens are stored as global parameters, test parameters that may be different for each specimen (specimen width, for example) are stored for each individual specimen.
self-identification:	A self-identifying transducer contains code resistors which are recognized by the testing system. When you connect a self-identifying transducer to the testing system, the type and the full-scale value of the transducer is registered into the system.
slack:	Typically, the distance the crosshead must travel before load is fully applied to the specimen.
soft-keys:	Buttons on the control panel to which you can assign certain test functions from the software.
specimen:	A single piece of a material for testing.
standalone mode:	When you start the software, it detects any frame that is connected to the computer. If no frame is connected, the software runs in “standalone” mode. This lets you do everything except run tests on specimens.
strain:	The change in specimen length divided by the original length. Strain is a real channel. You normally use an extensometer to measure strain, where the extensometer has a specific gauge length. The testing system uses the deflection of the extensometer divided by the gauge length to calculate the strain.
strain hardening exponent:	The slope of the log (true stress) versus log (true strain) curve in the region specified.

straining rate:

Metals test type only

Straining rate is a specified rate of strain of the parallel section of the specimen. It is run in extension control.

The specified straining rate converts into an equivalent crosshead speed by multiplying the strain rate by the gauge (parallel) length of the specimen. For example, a rate of 1% per minute on a specimen having 100mm parallel length results in a crosshead speed of 1mm/min. The Metals test type calculates an appropriate position rate that is in close proximity to the target strain rate and controls the crosshead movement at that rate throughout the ramp in which it applies. The actual strain rate that is achieved is affected by the specimen compliance.

The calculation for straining rate is:

Strain rate * Parallel length = Position rate

This calculation is only valid in the plastic region (or yielding region) of the stress-strain curve, where the majority of crosshead displacement translates into permanent specimen deformation. Because the position rate is fixed for the entire ramp and is calculated without accounting for possible compliance factors, it is not recommended for the elastic portion of the test. Since straining rate is only appropriate in the plastic region of a test, it should only be selected as the control mode in either Ramp 2 or Ramp 3.

If you use straining rate during the elastic portion of the test, it is strongly recommended that you instead use strain rate (Adaptive) with an extensometer on electromechanical systems or use strain control on servohydraulic systems.

The main advantage of the straining rate is that gain value settings are unnecessary since it is essentially in position control and it does not require an extensometer. However, if you need very accurate strain rates, you should use either Strain Rate (Adaptive) or Strain 1/Strain 2 control. Both of these control modes rely on feedback from an extensometer.

Note: Since the test is in extension control, the gauge length used to calculate the strain is the parallel length of the specimen and not the gauge length of the extensometer.

strain pacing:

Metals test type only

Strain pacing is an outer loop software algorithm that monitors the current data and alters the position rate to achieve a user defined tensile strain rate as determined from the tensile strain sensor. The pacing facility within the software allows the straining rate of the specimen to be controlled to a pre-defined level. It is intended for use with materials that show smooth, continuous deformation characteristics in the elastic region, such as metals and rigid or semi-rigid plastics. Many such materials are sensitive to the straining rate applied during the materials test and it is therefore desirable (and sometimes mandatory) to control, or at least limit, the strain rate. The actual maximum strain rate that can be controlled depends upon the characteristics of the specimen to be tested and the strain rate accuracy requirements. The lower the specimen stiffness and the more gradual the yield, the higher the strain rate that can be used.

Instron® electromechanical testing machines normally run at a constant rate of crosshead displacement (i.e. crosshead speed) by using a position controlled servo-loop. The characteristics of the testing system and specimen are such that a constant rate of crosshead displacement may not result in a constant strain at the specimen, particularly in the yielding region. Hence the need for controlling the straining rate.

In pacing mode, the software constantly alters the crosshead speed to achieve the demanded rate. The extensometer monitors the actual rate on the specimen, and the software computes the crosshead speed required to maintain the demanded rate as the test proceeds. The crosshead speed slows down as the material yields in order to maintain a constant straining rate due to the fact that most of the crosshead displacement is translated into permanent specimen deformation.

The pacing mode is intended for monotonic (unidirectional) tests only and is not suitable for controlling the straining rate during transient effects such as upper and lower yield or discontinuous yield phenomena.

strain rate (adaptive):

Metals test type only

Outer loop strain rate control while in position control. It is a strain pacing technique that remains active throughout the ramp in which it applies. An outer loop software algorithm monitors the current data stream and alters the position rate to achieve a user defined tensile strain rate as determined from the tensile strain sensor in the software.

Strain rate (Adaptive) requires an extensometer attached to the specimen throughout the ramp in which the mode is specified. In the event that the strain exceeds the maximum limit of the extensometer during the test, the mode defaults to Straining rate and uses a fixed crosshead speed.

Strain rate (Adaptive) mode of control differs from Straining rate in that the crosshead speed constantly updates to maintain the demanded strain rate. Straining rate calculates a single position rate based on the target strain rate and the gauge (parallel) length of the specimen. This rate remains constant throughout the entire ramp.

Strain rate (Adaptive) mode differs from Straining Rate in that you enter the target strain rate directly, rather than having the software calculate the target strain rate. However, the standards often require that metals testing operate within specified stress rate limits. As a result, you must manually calculate the stress rate after testing to verify that the test(s) complied with the standard requirements.

Since Strain rate (Adaptive) uses a strain pacing algorithm, it is not a true strain control mode (i.e. responding directly to feedback from the strain device) and thus you should check your data to confirm that it complies with the stress requirements of the standard to which you are testing. Determine the stress/time curve and calculate the linear portion of the curve to verify that the test(s) stayed within the stress rate requirements of the standard.

Strain Rate (Adaptive) mode is compatible with the HRD extensometer. It only applies to 5900 and 5500 Series testing machines.

Note: The HRD extensometer should not be used directly in closed loop control as it is highly unstable. If the Tensile Strain Source in Bluehill® is set to HRDE then inappropriate control modes are grayed out to prevent selection.

strength coefficient:

Stress-strain power curve coefficient, K, numerically equal to the extrapolated value of true stress at a true strain of 1.00.

stress: Load divided by the specimen cross-sectional area. Stress is a derived channel. The testing system calculates stress using the measured load and the specimen dimension values that you enter.

stressing rate: **Metals test type only**

Stressing rate is a rate specified in terms of a stress rate, but run under position control. The initial speed is calculated by dividing the value of the stressing rate by the nominal modulus of elasticity, then multiplying this quotient by the specimen gauge length.

Initial speed = (Target Stress Rate / Nominal Modulus of Elasticity) * Specimen Gauge (Parallel) Length

Note: The Nominal Modulus for the material you are testing should be available. If you do not know the nominal modulus of the material you are testing, you should run a test on a specimen to determine a modulus.

The desired stressing rate is converted into an equivalent strain rate using the above calculation. The strain rate is controlled using the Straining Rate algorithm.

The modulus is only effective in the linear elastic region, where stress is proportional to strain. When the linear relationship between stress and strain breaks down (which occurs during yielding), this control mode is no longer capable of maintaining the desired stress rate. As a result, the stressing rate control mode should only be used in the elastic region prior to yielding, typically in Ramp 1 of the test.

If you need to maintain a constant and precise stress rate(s), you should use Tensile Stress control, which is the fully closed-loop load control version.

Since Stressing rate uses the Straining rate algorithm, it is not a true stress control mode and thus you should check your data to confirm that the data complies with the standard to which you are testing. Determine the stress/time curve and calculate the linear portion of the curve to verify that the test(s) stayed within the stress rate requirements of the standard. Although you enter the target stress rate, the actual stress rate may be incorrect if either the nominal modulus or specimen gauge (parallel) length is incorrect.

T

tensile stress then position:

Metals test type only

When you select **Tensile Stress then Position**, the system calculates a position rate during the test that maintains the specified tensile stress rate. While the test is running, it converts the control mode from tensile stress to its equivalent position rate, thus allowing the crosshead to maintain the required speed throughout the ramp in which it applies.

If you run the test in **Tensile Stress** control mode, the crosshead may speed up as a result of feedback received during the test. This occurs when the specimen is no longer responding in a linear elastic fashion, as occurs when yielding begins. The stress-strain response of the specimen may no longer be able to maintain the rate of stress increase specified in the method. If the crosshead speeds up, the data results may be invalidated.

When running in **Tensile Stress** control mode, the test runs on tensile stress feedback. When the specimen enters its yielding region, Bluehill® adjusts the speed of the crosshead to maintain the tensile stress rate, which forces the crosshead to increase in speed. As the specimen's yield increases, the crosshead must continuously increase in speed. This could lead to the frame shutting down as a safety response to a runaway condition. The adjustment in crosshead speed violates the EN10002 standard requiring that the crosshead movement rate be as constant as possible until the upper yield point, and can also invalidate the test data.

When you select **Tensile Stress then Position**, the test starts out using tensile stress feedback. Once Bluehill determines that the tensile stress rate has stabilized at the target stress rate, it calculates the equivalent position rate and converts from tensile stress control mode to position control mode at the calculated rate. When running in position rate, the test continues at the calculated speed, maintaining a constant speed regardless of changes to the specimen in the yielding region.

Maintaining a constant speed enables the Metals test type to determine the upper yield point, and also complies with the EN10002 standard requiring that the crosshead movement rate be as constant as possible until the upper yield point.

There are two reasons for changing from tensile stress to position control mode:

1. It is not always possible to know what position rate will generate a desired tensile stress rate for a given material.
2. Running into yield in tensile stress control is not recommended because the crosshead will tend to speed up in order to maintain the appropriate rate.

Tensile Stress control is a valid control mode only if the transition to the next ramp will occur before yielding begins.

test data: Data points read from the testing system as each specimen is tested.

test director: Refer to the definition for a prompted test. The Prompted Test is the new version of the Test Director that existed within Merlin software.

test method: A file containing all the parameters needed by the testing system to run a test, analyze the test data and produce calculated results. It may be linked to other files; a report template to format a printed report from the testing and a test profile file, if test profiler software is being used.

test parameter: A test parameter is any value, numerical or alphabetic, that the testing software uses to run a test on a specimen and produce some kind of output. Examples are test speed, specimen geometry, and the list of results that are to be calculated. A group of test parameters can be saved as a test method.

test profile: A file containing a sequence of waveforms and ramps. You apply the test sequence to a specimen by using the optional Tension or Compression Test Profile test types.

test profiler: An optional software program for creating, editing and saving a Test Profile.

test segment: A single portion of a test, such as preload, precycle, ramp, and hold. You link individual test segments to create a complete materials test. If the system is equipped with the optional Test Profiler, you can specify the system to graph or apply calculations to segments of test data.

test type: Bluehill® software consists of a number of test types, allowing you to run different types of materials tests within the software. Examples of test types include Tension, Compression and Peel, Tear and Friction.

test workspace: The area of the screen comprising one or more runtime graphs, a result table, and an area for specimen parameters. It is the dynamic content of the screen during testing of a sample.

transducer: A device which converts a physical property such as force, motion, temperature, and so on, into a proportional electrical signal which is used to measure the property. A load transducer, or load cell, converts load into an electrical signal, and an extensometer converts specimen extension into an electrical signal.

transverse strain: Transverse strain is a derived channel. It is measured in a direction perpendicular to the applied load.

true strain: Instantaneous % of change in length of a specimen in mechanical test. It is equal to the natural logarithm of the ratio of length at any instant to original length.

true stress: Applied load divided by actual area of the cross section through which load operates. It takes into account the change in cross section that occurs with changing load.

U

undo test: Undo Test is available when running a prompted test. It is not the same as Delete Specimen. Delete Specimen removes all the information about a specimen, including any parameters such as dimensions and specimen notes that you may have entered. Undo Test only deletes test data and calculated results, it does not delete any parameters that you may have entered in earlier prompted test screens, such as specimen dimensions.

V

VersaChannel: Instron® name for the feature that lets you create more channels for your testing system. It requires additional hardware to let you connect extra transducers to these channels. [Previously known as Multichannel in custom versions of Merlin software].

Y

yield point extension (YPE): In materials that have a yield point, the yield point extension is the difference between the extension (elongation) at the completion and at the start of discontinuous yielding.

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