Dynamic Testing Machines

ibertest
ADVANCED TESTING SOLUTIONS

Servohydraulic Testing Machines for Dynamic Testing UFIB Series

Capacity: 15 - 500 kN

Since 1970
Made in Spain (EU)

www.ibertest.com

Universal Servo hydraulic Dynamic Testing Machines - UFIB series.

Designed for the configuration and performing of static and dynamic tests on a wide range of materials (specimens, subassemblies or finished parts) by incorporating the appropriate tools for each application.

Typical applications

- Dynamic tests on all type of materials
- Fatigue tests on finished parts or subassemblies.
- Lifespan tests on elastic elements and lift.
- Tests on springs and set of dampers.
- Pre-cracking tests for mechanics fracture.

Testing frame

With high structural stiffness, 2 columns, a mobile crosshead and a lower steel plate, which function as a base and closure of the testing frame.

The baseplate is perforated to allow the hydraulic piston movement.

The upper mobile crosshead is steel manufactured, precision machining, which allows a linear movement along the columns with adequate thickness to guarantee the specified rigidity value.

Furthermore the crosshead can be positioned to the desired height: raised or lowered by the simultaneous action of two synchronized lateral hydraulic actuators. The position of the crosshead is adjustable via a screen of movements in WinTest testing software or via the remote control.

Load cell is mounted under the upper crosshead, specially designed for fatigue testing with a nominal capacity equal to the testing frame capacity. Over the load cell in series, is the assembly which allows the interchangeability of testing devices using clamping bolts.

These testing devices can be gripping heads, compression plates, bending device, etc.

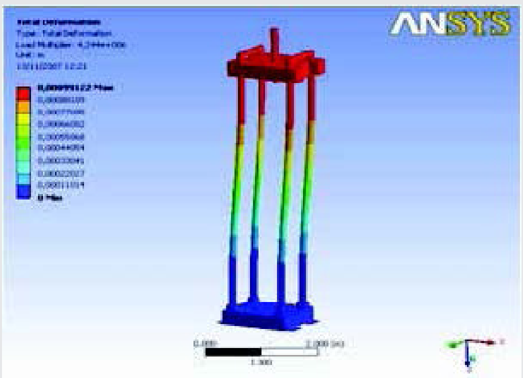
The lower steel plate is mounted over a metallic frame composed by UPN steel profiles.

The double effect hydraulic servo cylinder and double piston rod with symmetric chambers is mounted under the plate.

The entire testing frame is resting over the metallic frame which contains the hydraulic piston and sleeves of lateral lifting jacks, making it possible to work at a comfortable height.

The testing frame has been designed to have less than 1 mm deformation when the machine operates at maximum load.

The mechanical design of testing frame is made with finite elements analysis using the design ANSYS software to determine, in addition to the analysis that guarantee the specified rigidity, those important parameters for the correct operation of the machine without resonance under dynamic conditions.



EXAMPLES OF APPLICATIONS IN UFIB MACHINES:

Tensile tests

- For these tests gripping heads are used, with lateral clamping jaws and mechanical fastening, pneumatic and hydraulic, or wedge clamping jaws with hydraulic clamping.
- Typically testing are performed on fastening elements such as bolts and screws, weldings, elastomers, adhesives, rebars, etc.

Compression tests

- Compression plates are used for these tests. If the compression plates are jointed, the joint must be locked in a position in order to prevent that the specimen can leave the plate during the movement.
- Typically tested elements are dampers, elastomers, rubber-metal elements, silent-blocks, etc.
- If the purpose of the test is to verify the behavior of springs, the compression plates must have a restraint system.

Bending tests.

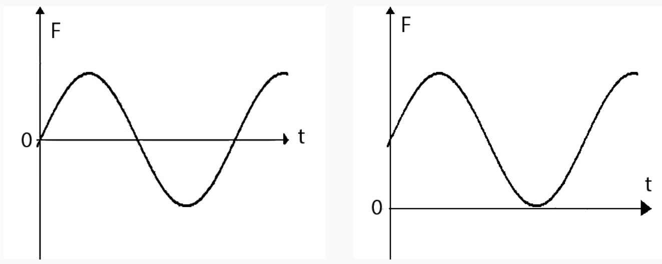
- Bending tests consist in the application of force by one or two loading points while the specimen is resting on two supports.
- Fracture mechanics tests on metals and fiber reinforced concrete, and tests for welding homologation are typical applications.

Fracture Mechanics.

- To carrying out the crack propagation process (pre-cracking).
- On specimens types: CT, SEB, etc.

Consult for specific technical information.

Gripping heads, wedge type and hydraulic closure



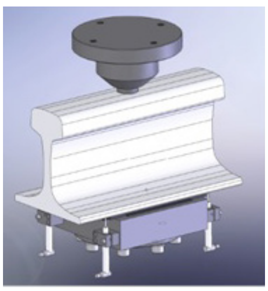
A **B**

A: Tensile-compression test with zero crossing. The dynamic solicitation consists in the application of a tensile load over a specimen with specific amplitude to immediately apply a compression force with same amplitude, starting a new cycle.

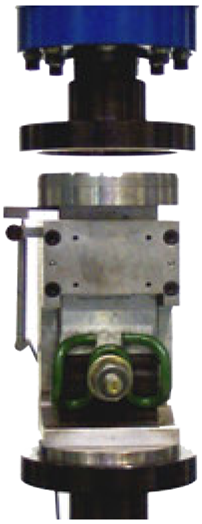
B: Tensile-compression test without zero crossing. The dynamic solicitation consists in the application of a tensile load with specific amplitude and a subsequent controlled release of the force until zero (or a particular preloaded value), starting a new cycle.

IBERTEST uses the following criteria:

- Positive force: tensile load
- Negative force: compression load.



Rigidity test over elastic plates for a high speed rail



Fatigue tests under lateral loads for sleepers light fastening plates

Technical specifications for testing frames UFIB

MODEL	UFIB-15	UFIB-25	UFIB-50	UFIB-100	UFIB-250	UFIB-500
Maximum load tensile-compression	± 15 kN	± 25 kN	± 50 kN	± 100 kN	± 250 kN	± 500 kN
Load measurement	Strain gauge high performance load cell HBM or INTERFACE for static and dynamic tests.					
Measuring calibrated range	1 % to 100 % of the load cell nominal capacity					
Class	0,5 according to EN-ISO 7500					
Resolución en fuerza	5 digits with floating coma					
Columns	2 chromed plated and grounded columns					
Mobile Crosshead	Can be freely positioned in height by means of side jacks. Guided by columns. With hydraulic stop.					
Free horizontal distance (distance between columns)	420 mm	420 mm	520 mm	520 mm	620 mm	720 mm
Free vertical distance between standard gripping heads [1]	0-540 mm	0-500 mm	0-800 mm	0-950 mm	0-950 mm	0-950 mm
Max. free vertical distance between load cell and pistom stem.	800 mm	800 mm	1220 mm	1570 mm	1600 mm	1650 mm
Measurement of piston position.	Magnetostrictive displacement transducer Resolution: 0,5 micron					
Displacement resolution, shown in software WinTest	5 digits (3 integers and 2 decimals)					
Piston stroke	100 mm (± 50) [2]				150 mm (± 75) [2]	
Power supply	Three-phase 400 V + N + T, 50/60 Hz (Power to define according to hydraulic group)[3]					
Dimensions testing frame [4] (Width x Depth x Height)	750 x 600 x 2100 mm	750 x 600 x 2100 mm	900 x 600 x 2500 mm	1100 x 800 x 2800 mm	1250 x 900 x 2900 mm	1350 x 900 x 3200 mm
Approx. weight without testing devices	680 kg	720 kg	980 kg	1300 kg	1600 kg	1950 kg

NOTES:

(1) .Free vertical distance between standard gripping heads model IB-HYDY. Greater distance is possible on demand.
(2) Other piston strokes available: 150 mm (± 75); 200 mm (± 100) y 250 mm (± 125).
(3) The characteristics of the hydraulic unit are specific to the application and the needs of each client.
(4) IIERTEST can design and manufacture larger testing frames, according to your testing needs.

Please contact our Sales Department.

S.A.E. IBERTEST reserves the right to modify the present technical information without prior notice

Hydraulic systems for the application of dynamic loads.

To apply the load on the specimen a set of servo cylinder, servo valve and hydraulic group is used, as detailed below.

Servo cylinder

The servo cylinders are mounted below the bottom plate of the testing frame, using a standard fastening flange. The piston sleeve crosses through the plate (front flange).

The servo cylinders for dynamic applications have the following main specifications:

- Double effect and dual rod with symmetric chambers to ensure an accurate dynamic response when operating at high frequencies.
- High rigidity design, with grounded and chromed piston and rods.
- Joints, slides and bearings with low friction and minimum wear. According to the application, the cylinder can be equipped with polymer, hydrostatic (pressurized oil joint) or semi-hydrostatic joints .

The servo cylinders for dynamic applications can also include accumulators (high and low pressure), if necessary, to ensure accurate dynamic response when working at high frequencies.

Servo valve.

The servo valve is the element which regulates the piston movement, adjusting the hydraulic flow (input-output) in the servocylinder chambers.

The selection of the appropriate servo valve depends on the flow to adjust, which can be calculated according to:

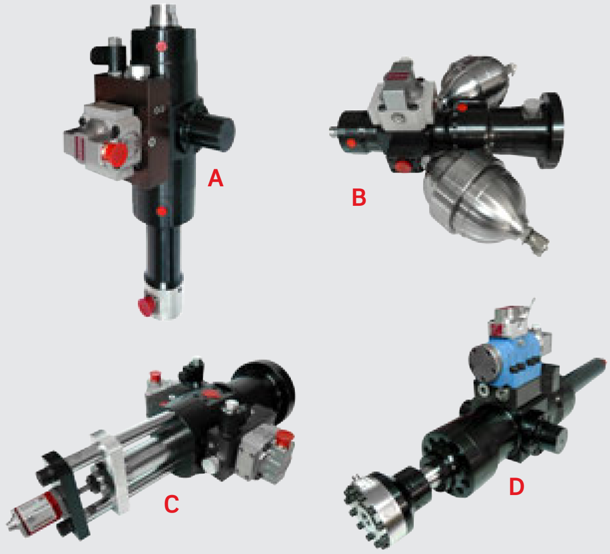
- Work pressure of the hydraulic group
- Speed of the piston
- Amplitude of movement

The servo valve must be selected with a rated flow higher than the estimated value.

The servo valves for dynamic applications have the following main specifications.

- High response pilot signal.
- Flow controlled by a high speed spool.
- The spool is moved by a permanent magnet motor. This type of motor acts on the spool with a force 2 times greater than a conventional solenoid.
- Integrated electronics, with emergency failsafe positioning: in case of voltage drop or emergency stop, the main spool will move to its central position with a default and safe flow condition.

Examples of servocylinders for dynamic loads



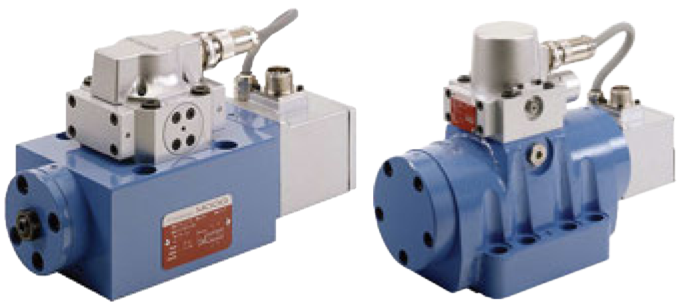
A: With servo MOOG 761.

B: With servo MOOG 761 and pressure accumulators

C: With double servo MOOG 761 and anti rotating system

D: With pilot operated servo MOOG 792, high flow (in the picture, with load cell assembled on the top of the piston.)

Two steps servovalve MOOG Series 761.
Rated flow Q up to 63 l/min at 315 bar.



Three steps servo valves MOOG 791 and 792
Rated flow Q up to 250 l/min and 1000 l/min

Hydraulic systems

Their function is to provide pressure and hydraulic flow required for the movement of the actuators.

The electric drive motor pump generates pressure in the hydraulic system and flow is regulated by a servo valve or a high performance servo distributor.

The oil flow in the circuit is restricted through the manifold and the servovalve, increasing oil temperature.

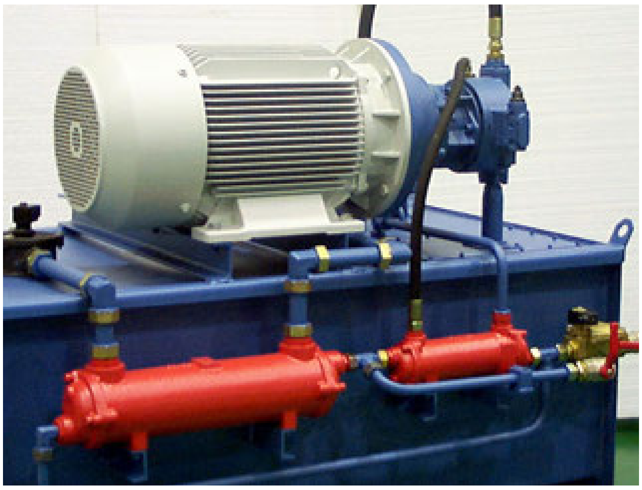
In order to maintain an ideal temperature of oil and to avoid problems of low viscosity or lamination, the group must have an adequate cooling system. The most common systems are heat exchangers water-oil or air-oil. The temperature is monitored by a thermostat which activates the system if necessary.

It is also necessary to use clean oil free of water and particles. To achieve this, the circuit incorporates oil filters with interchangeable cartridge for necessary replacements.

Other common elements are the pressure switches, inlet flow regulators, pressure accumulators, return pumps, monitoring elements, etc.

Hydraulic group with soundproof enclosure

Medium flow hydraulic group Q: 40-65 l/min



Cooling system water-oil

High-flow hydraulic group Q > 200 l/min

Cooling system air-oil

Determination of dynamic performance

The performances of the hydraulic group are always calculated according to the needs and indications of the customer.

For static and quasi-static tests, the use of high pressure motor pump units with slightly elevated constant flow is enough (up to 10 l/min).

However, for dynamic tests the group requires higher flow rates.

To assess approximately, the hydraulic flow required for a dynamic solicitation with a determined frequency and amplitude, the following relation can be used:

$$\boxed{Q\ (l/min) = 3{,}7 \cdot 10^{-2} \cdot a_0 \cdot A}$$

Where

- a_0 = amplitude (mm)
- A = piston active cross section area (cm²)

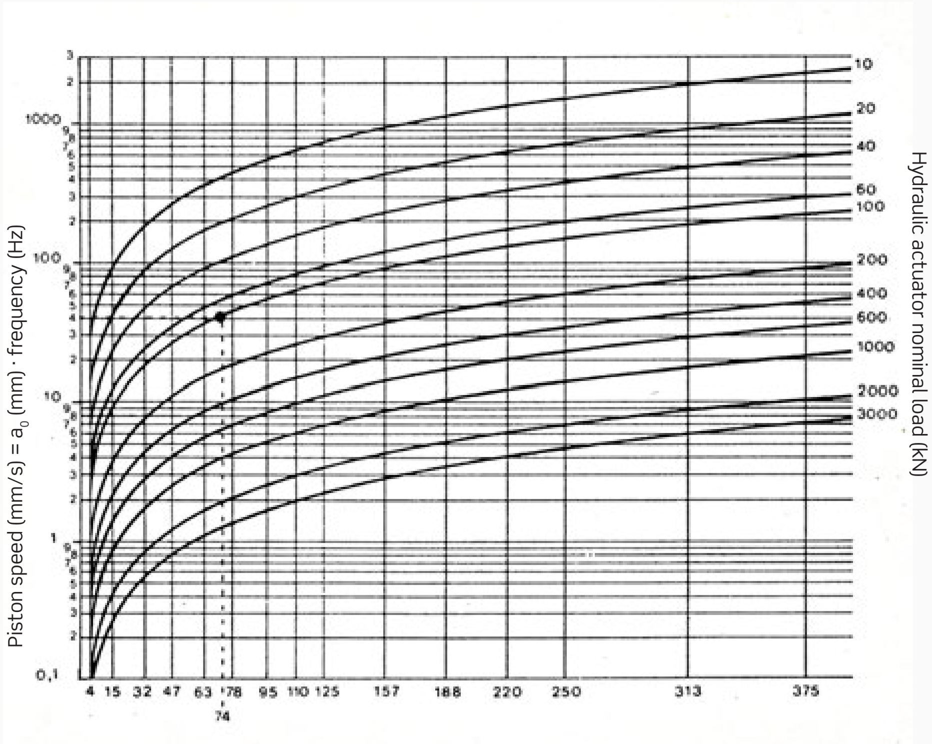
Note:

The formula is an approximation to the real needs, since it does not take into account factors such as oil compressibility of oil, the pressure drop in the pipes or the servo valve, the beneficial effect of hydraulic accumulators, etc.

For a more realistic calculation, graphics as the figure below are usually used, in which the necessary flow is extrapolated according to the test frequency and amplitude of the motion. These graphs are made for each particular type of actuator

Example: Calculation of the flow required for a double effect actuator of ± 100 kN nominal load

- › a_0: Amplitude: ± 2 mm
- › f: Frequency of sollicitation: 20 Hz
- › $a_0 \cdot f$: Piston speed: 40 mm/second
- › Q: Flow required: 74 litres/minute



Q: Flow (l/minute)

LOAD TRANSDUCER
Load cells for dynamic applications

High performance load cells HBM or INTERFACE (depending on the application) for the measurement of tensile and compression static and dynamic loads:

› Universal application: for tension and compression, suitable for static and dynamic tests.

› Low profile robust measuring body: strictly symmetrical design with multi-shear network technology.

› Individual compensation of bending moment: thanks to a special electrical adjustment procedure, the interference of parasitic loads is minimized, even in the double bridge version.

› High resistance to fatigue tests, even with extreme oscillation amplitudes of up to 200 %.

› Manufactured in materials highly resistant to corrosion.

› Connection and coupling flanges highly resistant to corrosion, with the possibility of integrated cable for difficult environments (climate chambers).

Example: Load cell ±250 kN

HBM U10M			250 kN
Nominal force	F_{nom}	kN	250
Rated characteristic value	C_{nom}	mV/V	2 ... 2.5
Accuracy class			0,05
Relative repeatability without modification of position	b_{rg}	%	0,025
Zero signal relative error	$d_{s,0}$	%	1
Linearity relative error	d_{lin}	%	< ± 0.04
Temperature effect on characteristic value / 10 K	TK_C	%	< ± 0.015
Effect of temperature on the zero signal / 10 K	TK_0	%	< ± 0.015
Influence of bending moment (at 10% · F_{nom} · 10 mm)	d_Q	%	< 0.01
Reference temperature	T_{ref}	°C	+ 23
Nominal temperature range	$B_{T,nom}$	°C	- 10 ... + 45
Operating temperature range	$B_{T,G}$	°C	- 30 ... + 85
Maximum operating force	(F_G)	% F_{nom}	240
Breaking force	(F_B)	% F_{nom}	> 400
Lateral force limit (relative to the center of the cell)	(F_Q)	% F_{nom}	100
Limit bending moment	$M_{b\ perm}$	N · m	5715
Torque limit	M_L	N · m	5715
Nominal displacement	S_{nom}	mm	0.05
Fundamental resonance frequency	f_G	kHz	6,6
Rigidity	F/S	10^5 N/mm	50,0
Relative permissible oscillatory stress (oscillation amplitude DIN 50100)	F_{rb}	% v. F_{nom}	200
Weight (without cable) · With adapter · Without adapter		kg	60 28

DISPLACEMENT TRANSDUCER

Magnetostrictive, digital transducer.

Located inside the dynamic servo cylinder, it is aimed to control at any moment the piston position enabling to obtain the set parameter when the machine works with “displacement” servo control.

- Maximum stroke: 200 mm (+ 100 mm)
- Resolution: 0,0005 mm.
- Linearity: + 0,05% full scale.
- Repeatability: + 0,01% full scale.
- Hysteresis:< 0,07 mm.
- Operating temperature: from -10° C to +70° C.
- Estimated lifespan: More than 4 million hours.
- Communication protocol: SSI (digital)

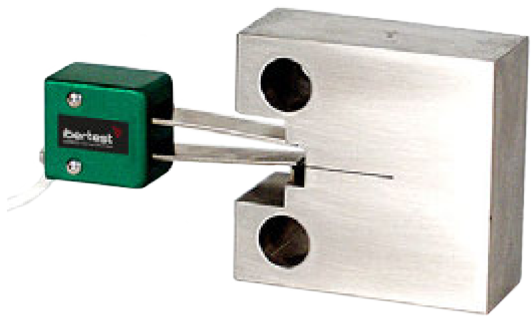
DEFORMATION TRANSDUCERS (Extensometers)

They allow for the measurement of deformation of the specimen while it is under dynamic solicitation.

For dynamic tests, the most usual types of extensometers are as follows:

A: Axial, clip-on, extensometer.

The extensometer can be clipped on the specimen by means of a system of adjustable springs.



Appropriate for performing tensile and compression dynamic tests, with or without zero crossing.

Its excellent design and strength ensure a high level of reliability and long lifespan.

B: Measurement of crack propagation, clip-on type, for fracture mechanics.

Used for the measurement of crack propagation in fracture mechanics of metallic materials, on metallic materials with CT (Compact Tension) type or SEB (three point bending) specimens.

Used to perform tests with constant strain speed (crack opening: CMOD), to determine the tenacity of composite materials such as, for example, fiber reinforced concrete

MD5i Electronic system
For control and data acquisition

System fully automatic and independent from the computer used for dynamic testing with test frequencies up to 500 Hz.

This high performance modular system MD5i, enables closed loop control of IBERTEST hydraulic machines (with servo valve) or electromechanical (with servomotor), performing static, dynamic or fatigue tests.

The unit manages the acquisition and synchronization of data from each of the transducers (force, stroke, deformation channels, etc.) as well as the interpretation and correction of the control signal according to the specified set point (closed loop servo control)

The control can be done by closing the loop against any channel (force, stroke or deformation control).

The MD5i electronic unit can operate in standalone mode (with the MD52i) or in remote mode (connected to a computer).

To work in standalone mode, the front side of the unit has an LCD screen to display the different menus of parameter setting, a" Digi-poti " digital control to browse the menu and alphanumeric keyboard to enter data.

These elements are embedded in the UCRD-6i, UCRD-7i or UCRD-8i remote control therefore, in case of purchase, the MD5i control unit would be delivered without these elements (blind front).

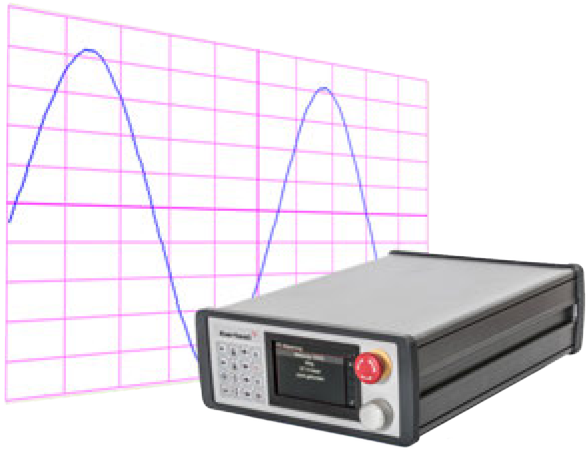
In the remote mode, the control unit is connected to a computer via USB or Ethernet, using application software for configuration, presentation and process of test results. In this case the MD5i unit is also supplied with blind front.

The user can then operate in standalone mode even if the computer does not work, recording the basic parameters of the test in the MD52i unit (force and stroke max and min values, number of cycles, etc.), without waiting to repair the computer or application software.

The MD5i control unit includes advanced technology using digital feedback via 32-bit DSP, able to control the system in real-time at 10 KHz data acquisition control frequency (simultaneous channel), which enables to follow highly accurately the control function imposed by the operator to carry out the tests. As well as an A/D conversor with 24 bits resolution.

The use of an appropriate digital signal processing enables total control, thus obtaining characteristics of highly effective work which are the best technical solution to ensure obtaining reliable, comparable and reproducible results.

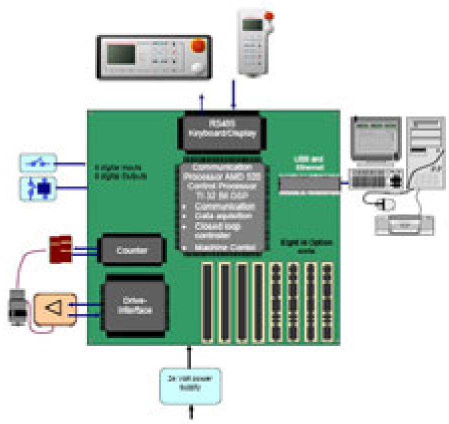
The system has the possibility of PID adjustment in high and low pressure modes. The system automatically adjusts the PID according to the working pressure, chosen depending on the type of test (low or high dynamic range)



MD52i standalone module

UCRD-7i remote control

UCRD-8i remote control



This function is highly important as the dynamic response of the servo valve is optimized and it enables to reduce the electric consumption of the installation without quality control is affected

Specifications of MD5i control system

- Digital output for servo valve command through an internal amplifier with rated current up to 300 mA.
- Adjustable "dither" signal
- It supports incremental type position measurement (SSI digital protocol).
- It has eight slots to connect data acquisition cards, which amplify and condition the transducer signal, allowing reading load cells, encoders, extensometers, etc.
- The data acquisition cards vary according to the type of transducers (strain gauges, potentiometers, magneto restrictive, LVDT, digital incremental, digital SSI, etc.).
- System for recognition and automatic adjustment of the transducers connected in each channel by means of "sensor-plug" connectors with EEPROM memory chip, which store the calibration and linearization data of the transducer. This enables to connect alternatively same type transducers on the same channel. The system recognizes the connected transducer and adjusts automatically the reading channel depending on the characteristics of the transducer (measure unit, zero, maximum, minimum, linearization, etc.).

MD5i control module

MD52i

Main features

- **Frequency** (Closing loop time): up to **10 kHz** (0,1 ms (10.000 times per second).
- **Sampling frequency**: Up to **10 kHz** (10.000 readings per second and per channel.
- Resolution in measurement (conversion A/D) per channel.
- **24 bits** resolution.
- ±10.000.000 steps.
- Maximum test frequency: **500 Hz**.
- All channels are synchronous and simultaneous.
- Connexions to PC: USB 2.0 or Ethernet 10/100.
- **Up to 14 (slots)** for data acquisition of transducers.

Rear view of the MD5i module

The **MD5i** unit is delivered with the standard following configuration:

- Slot 1: Card for reading of the load transducer (load cell)
- Slot 2: Card for reading of the position transducer (SSI displacement transducer), 500 Hz data acquisition frequency.
- Slot 3: For data acquisition cards of strain gauge transducers
- 2 free channels: for the future possible installation of other transducers data acquisition cards.

Side view of the MD5i module

ADVANCED HAND-HELD REMOTE UNITS UCRD-7i, UCRD-8i AND UCRV.

Basic features

Features	UCRD-7i	UCRD-8i
Handling	Operation by alphanumeric keypad, function keys, touch screen and digital potentiometer control.	
Keys	UP/DOWN /STOP keys and programmable keys (machine control) to control the moving piston or crosshead. More precise movements are possible with the Digi-poti potentiometric control.	
N° of keys	19	16
Graphic screen	OLED, mono-chromatic 128 x 64 pixels.	Touchable TFT, color 480p x 272p
Base	Magnetic base, which allows the control to be placed on the machine or other metal support.	
Emergency stop	Yes (according to CE marking requirements)	
Other features	• Remote control activation or deactivation for software operation. • Extensometer positioning keys for automatic models. • Jaw opening and closing. Independent keys for upper and lower head (for hydraulic heads).	

UCRD-7i remote control

UCRD-8i remote control

Advanced features

The **UCRD-7i** and **UCRD-8i** controls have the ability to **run tests independently** without the need for a computer or software. Examples of tests that can be configured and run directly:

› General tension/compression
› Pressure
› Bending cycles
› Bending
› Creep test (creep) (*)
› Indirect tensile test (Brazilian)

(*)*Optional, on request.*

Test configuration

› **Preload**: value and speed until it is reached.

› **Maximum load speed** in the elastic zone.

› **Maximum extension velocity** in the yield zone.

› **Specimen definition**: thickness, width, diameter, initial section, initial length, calibrated length, etc.

Available control types

› Force and position.

› Force, position and deformation (with extensometer).

› Change of control between zones of the material.

The end of the elastic zone, the end of the yield zone and rupture can be detected with the following criteria:

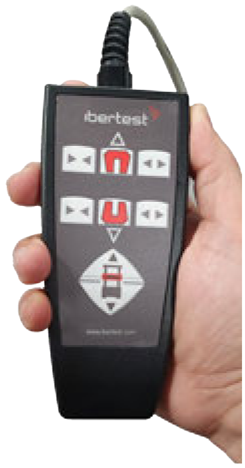
› **Specific values**: MPa, kN/mm2,kN, N

› **Relative drops** to Fm: %.

› **Absolute drops**: N, kN

NEW UCRV: Remote control with virtual version included.

Wired remote control for cross-head movements. Independent opening and closing of hydraulic(*) gripping heads and piston move-ment. *(*) Options for machines that have this feature.*



In addition to the wired controller, it is included a virtual version, installable on a mobile phone or tablet (Android or IOS) for wireless operation via the integrated WIFI network (terminal not included).

The virtual version, besides the basic functions of the cable version, includes the following:

› Real-time display of force and stroke data.
› Start and stop the test.

WINTEST DW SOFTWARE

FOR DYNAMIC TESTING

Application software package WinTest, DW version, specifically designed by the I+D Ibertest department, for the performing of dynamic wave or alternated tests (with or without zero crossing) with machines and dynamic installations from Ibertest and/or other manufacturers.

Compatible with Operating systems Microsoft 32 and 64 bits (Windows® 7, Windows® 8, Windows® 10, etc.)

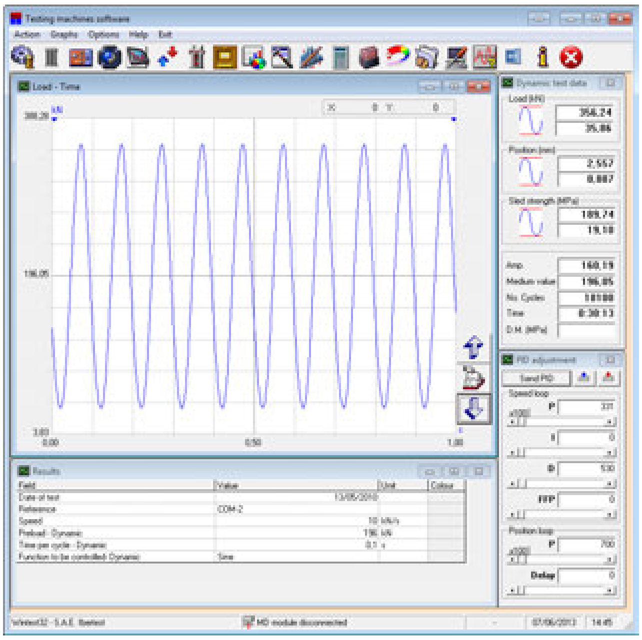
It is possible to adapt effectively the WinTest software to each testing necessity thanks to its high flexibility and power.

This testing system has been designed to be designed by the user according to the main international testing standards (UNE, EN, ASTM, ISO, ... etc). Moreover, for a small fee, IBERTEST can adapt the WinTest to te particular or special end user necessities.

During design phase, IBERTEST has specially focused on a easy use interface, so that it can be used by a person with little experience using computers.

The main screen of the WinTest software includes a simple selection menu and an intuitive icon bar, so it is possible to use the program without consulting the using manual.

WinTest shows the user the available options in each moment (as well as the setting options) guiding the user step by step, interactively, till the complete configuration of the test.



WinTest allows you to get the most out of your test machine, both in the execution of the tests and in the interpretation of the results.

(*) NOTE:

This technical information is of a general nature. The specific characteristics would be fixed, depending on the actual applications that the machine should perform.

Creation of test methods using user profiles

In the "user" menu of the main menu, you can create independent users that can correspond to both test methods and different people.

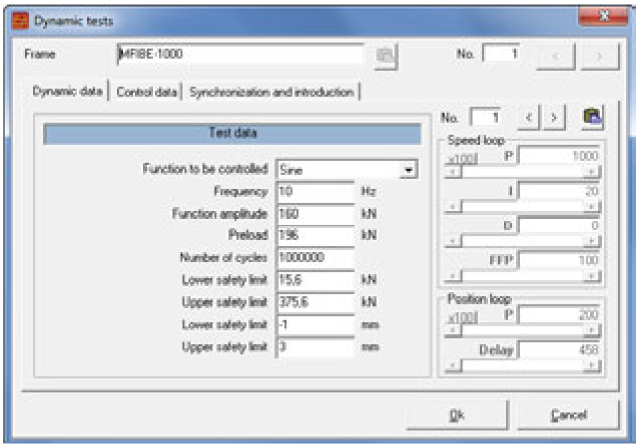
In this way it is possible to save the information of preprogrammed trials, being able to recover it when deemed appropriate.

This possibility is very useful since, once a test has been configured, the user does not need to configure it again if he wishes to repeat the same type of test, it being sufficient to recover the test carried out to execute it in the same way.

Test setup

For the configuration of tests, depending on the dynamic capabilities of the machine, the following parameters can be set:

- Type of test: alternating or wavy (with or without zero crossing)
- Variable to control:
    - > Force to be applied on the specimen
    - > Actuator stroke
    - > Deformation of the specimen
- Section or test block: it is possible to create up to 6 sections, in each of which you can select:
    - > Function type: ramp, sine, triangular or square
    - > Test frequency in Hz
    - > Function amplitude (in mm or kN)
    - > Initial preload
    - > Safety limitations for the test piece or for the machine
    - > Number of total cycles to perform
    - > Control settings via PID (see table)



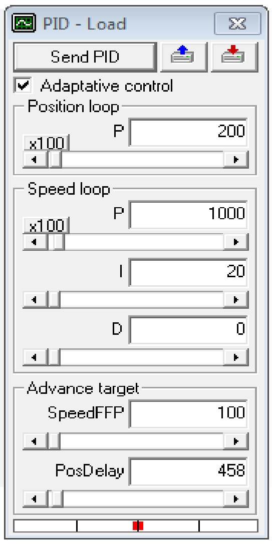
CONTROL FEATURES:

Sampling rate up to 10 kHz, in all channels

Closing frequency of the control loop: 10 kHz

Multivariable control, composed of two simultaneous systems of PIDs and Adaptive Control:

- **PIDs with two loops:** one for speed and one for the position of the signal of the variable to be controlled. The window is always enabled and manual adjustments can be made at any time during the test.
- **Adaptive control,** to guarantee the amplitude and the average value of the programmed wave, with accuracy of 1% in the whole bandwidth of the system



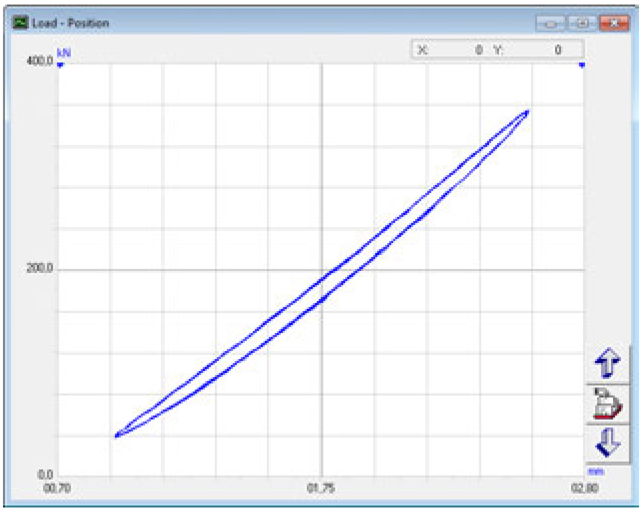
Data on screen in real time

During the test the following data and parameters will appear on the screen:

- Maximum, minimum force and average value (kN) represented in their corresponding digital indicators.
- Maximum, minimum and average stroke (mm) represented in their corresponding digital indicators.
- Signal amplitude (mm or kN).
- Average amplitude value
- Number of cycles performed.
- Elapsed time (s)

Optionally, if the appropriate extensometers are available, it is possible to display on the screen:

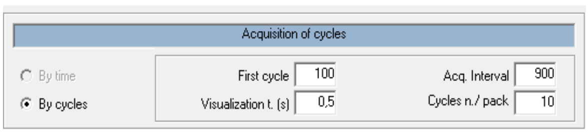
- Maximum, minimum longitudinal deformation and average value (mm) represented in their corresponding digital indicators
- Maximum, minimum and average transverse deformation (mm) represented in their corresponding digital indicators

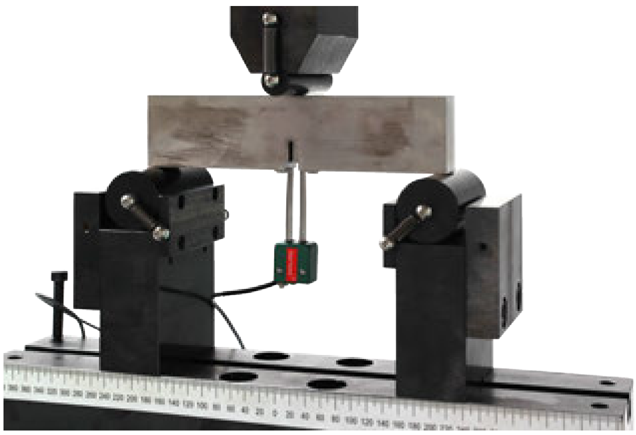


Data capture

To save the test data, the software allows you to save a data acquisition file with up to 10,000 consecutive captures.

You can program the interval of each capture (in time or in number of cycles) as well as its duration (in time or by number of cycles).





Results management

After the test, the final results and the complete graphic representation are displayed. At this time it is possible to perform the following actions:

- Expanded selection of chart areas (zoom)
- Location and search of significant points.
- Change the type of diagram: it is possible to represent the following relationships:

  > Strength - Time

  > Race - Time

  > Strength - Race

  > Strength - Deformation (*)

  > Career - Deformation (*)

  > Deformation - Time (*)

* If there are deformation channels

It is also possible to draw multidiagram graphics, showing the relationship between one channel and several of the other channels that are enabled.

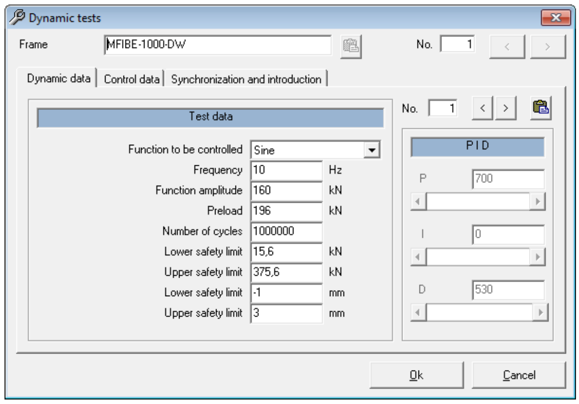
Once these operations have been carried out, the test can be validated to be stored in the computer's memory.

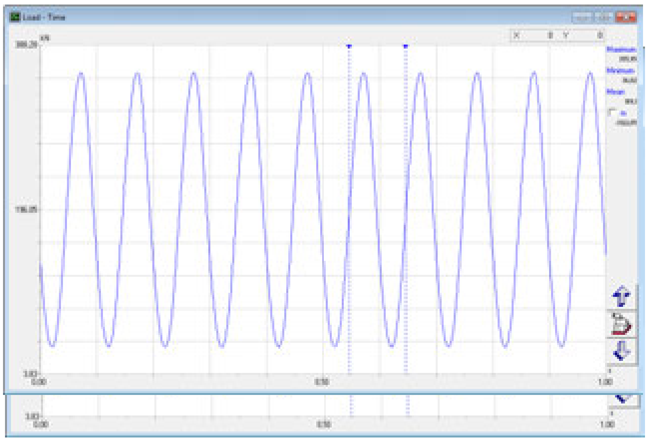
If the user discards the test, the results of the test will not be stored.

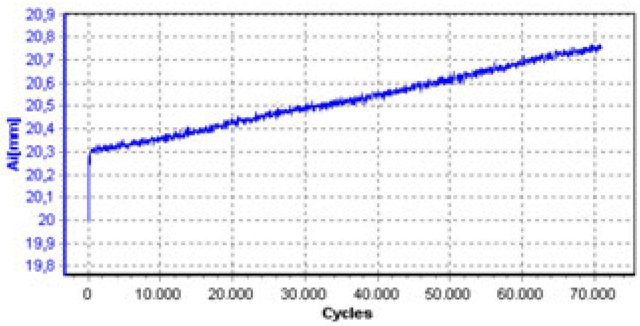
The Test Management menu allows you to recover previous tests to work on them.

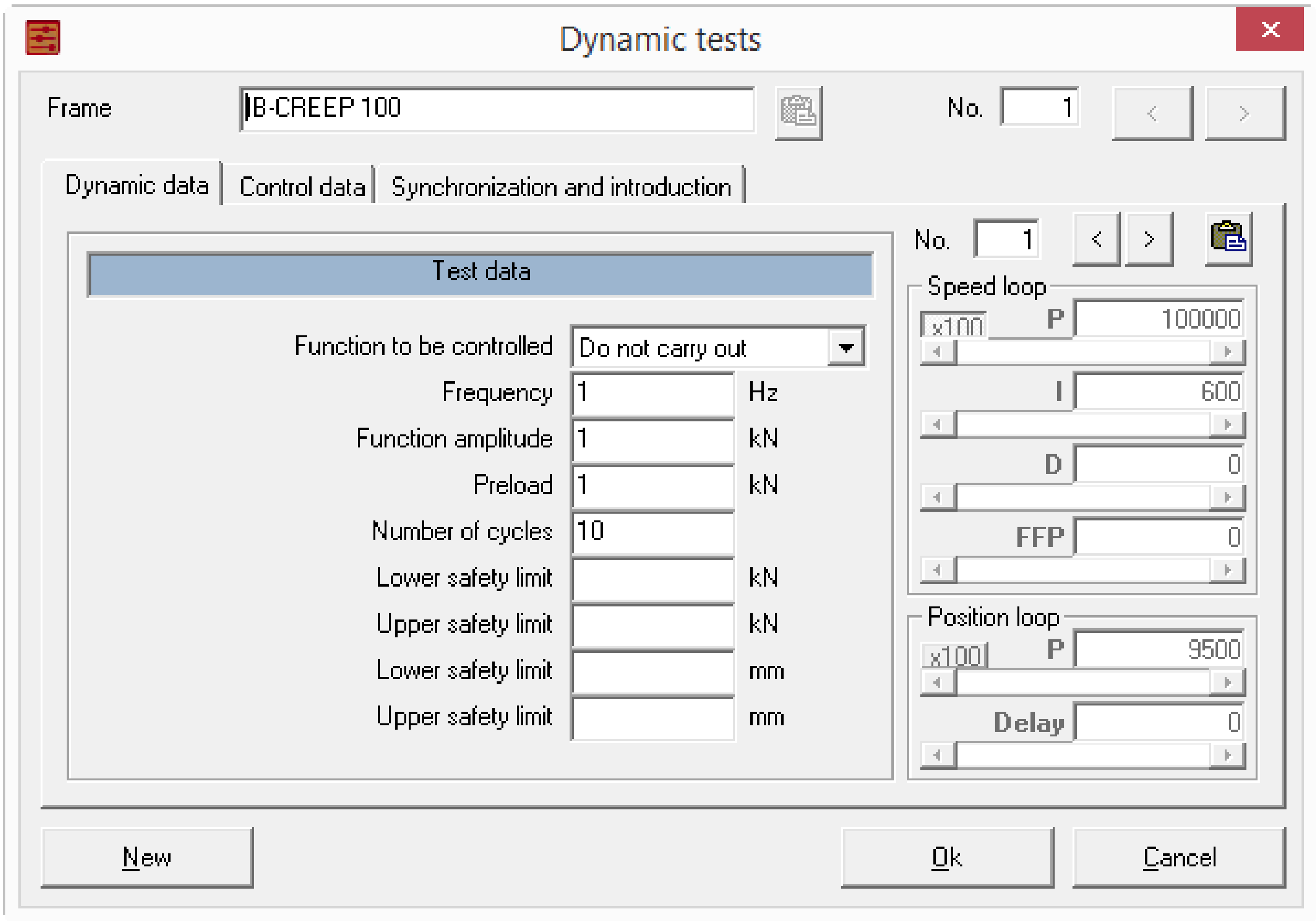
In this way it is possible to re-graph tests, create images (bmp or jpeg) of the test graphs and issue reports, as well as performing statistical calculations (comparison of curves, histogram, distribution level, sampling of results, surface and volume diagrams etc.)

The results files can be converted to ASCII or CSV formats for export to other programs (for example MS Excel) or laboratory management systems (LIMS).









Frame

Name of the area where the test is done.

Copy Data area button

It copies all the dynamic data of the current area to the selected by the user.

N°

Current area's number.

Displacement arrows between areas

It allows the displacement between the different areas configured in the machine.

Dynamic data

Test data

Function to control

It defines the type of wave to be used on the test (sinewave, triangular and square). When it is desired not to perform a step, the option "Do not perform" is chosen. In this case, the following steps must have this option chosen.

Frequency

Frequency of the periodical wave measured in Hz.

Function's amplitude

Amplitude of the periodical wave's shape, defined from its average value to its maximum or minimum value.

Preload

Average value of the periodical wave.

N° of cycles to be done

Number of programmed cycles by the user.

Security limits

It is the maximum and minimum limits within which the test should be done. If the test goes out the selected limits, the c trol stops the test.

N°

It shows the dynamic step number of the six possible.

Displacement buttons

With these buttons it is possible to move along the configuration of the dynamic test steps.

Copy step button

Copy the data of the current step, indicated by the user.

Speed loop

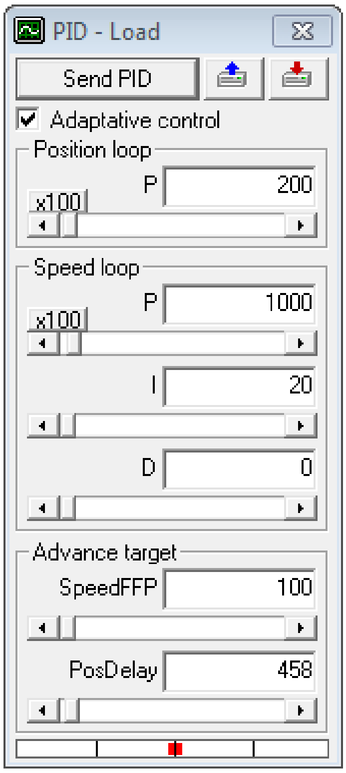
PID

P
Control loop's proportional coefficient for dynamic tests

I
Control loop's integral coefficient for dynamic tests.

D
Control loop's derivative coefficient for dynamic tests.

FFP
Target forwarding for the speed loop.



Position loop

P
Proportional coefficient of the position loop for dynamic test.

Delay
Target delay for the position loop.

The PID parameters depend on the type of control and on the tested specimen's mechanical characteristics and on the working frequency. These parameters may be modified during the test and should not be changed abruptly. The modifications are carried out through a window enabled with that purpose on the main panel shown when the dynamic data display is enabled.

If the control electronic is a MD unit, the initial values are those given by the MD unit. Thus, the values given by this windows will override the unit values for every step of the dynamic test.

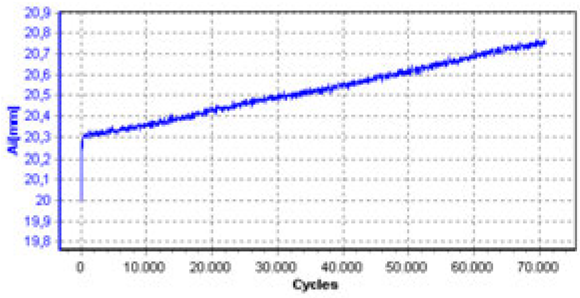
Pre-cracking Software Module and K_{Ic}

1. Pre-cracking

During the last years, research on fatigue crack propagation and fracture toughness has become more significant, for metallic materials, polymers or composites as well.

This software module for Fatigue Strength Testing Machines allows the creation of a fissure or initial crack (pre-cracking) by the application of load cycles on standard test specimens, provided with a crack starter notch.

The crack propagation is measured using an axial extensometer specially designed for this purpose.



Stages of the test

The software allows the creation of precracked specimens with a controlled size before performing the static test to determinate the fracture toughness.

The full test has up to three stages.

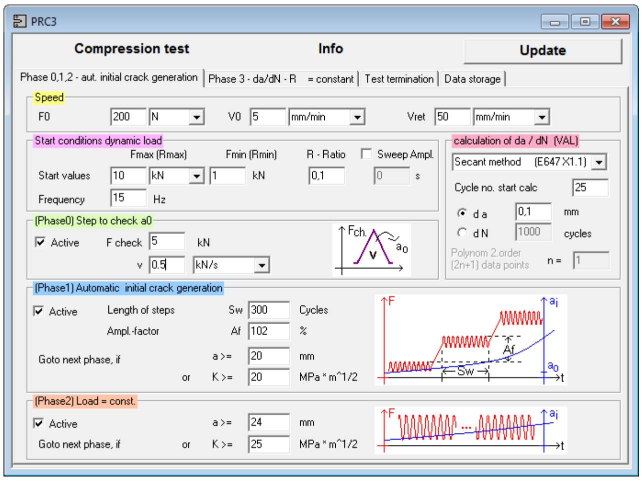
- Stage 1: Crack formation
- Stage 2: Observation of the crack growth
- Stage 3: Approximation to the crack length required

Performing the first two stages is optional. If there is already a cracked specimen through fatigue, it is possible to go directly to the crack test.

Specimen type
Three types of specimen geometry can be selected

- CT. Compact Tension.
- SEB. Standard Bending.
- SEN.

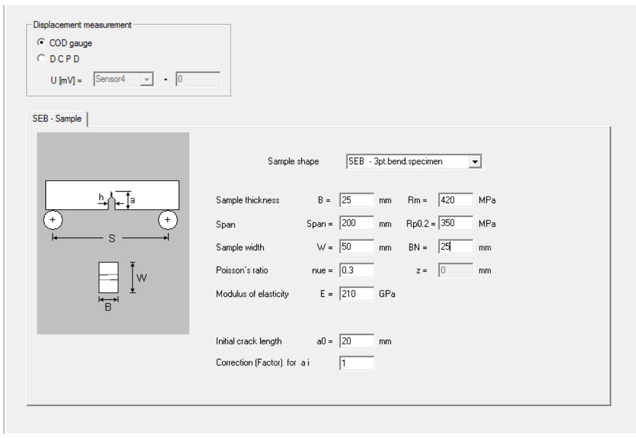
The user has a selection menu to enter the type and size of specimens.



Fatigue crack measurement method.
The fatigue crack growth can be determined using a displacement gage (extensometer), located on the crack starter notch mouth: direct measure of COD (Crack Opening Displacement).

Crack growth can be calculated by the formulas indica-ted in the test method using the extensometer measure, the specimen dimensions and instantaneous measurement of the crack opening.

As option it is possible to determine the crack size with an electric potential difference procedure.

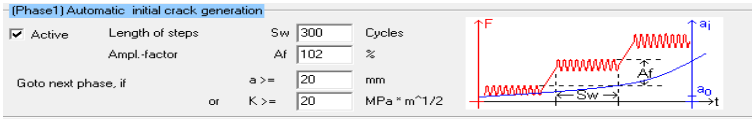


Stage 1: Automatic generation of the initial crack applying series of load cycles.

On the test specimen, charge cycles are performed at a defined load value, increasing the load on each series of cycles. The shape of the cyclic wave is sinusoidal type.

The initial values are:

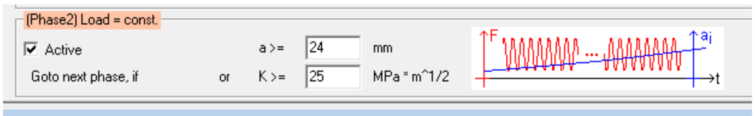
- Initial load value (f)
- Number of cycles (Sw)
- Load increase factor (percentage). (Af)
- Maximum crack length.
- Maximum stress intensity factor (Kmax)



The program continuously calculates the values of **a_i** (crack length) and **K_i**(stress intensity factor).
If the predefined number of cycles Sw is reached, the program starts a new series of cycles, applying a load increment Af according to a predefined percentage.
When the **a_i** value is greater than the predefined maximum or when the calculated Ki value exceeds the maximum **K_{max}**, we move to stage 2 or 3.

Stage 2: Observation of the crack growth with constant load.

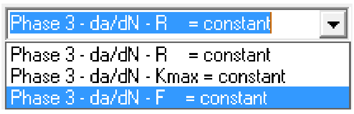
The program performs one series of cycles on the precracked specimen and allows to check the behavior of the crack with more detail, calculating **a_i** and **K_i**.

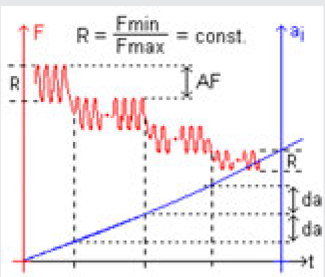


When the **a_i** value exceeds a predefined maximum or when the calculated value of **K_i** exceeds the maximum value **K_{max}**.
We move to stage 3.

Stage 3: Approximation to the crack length required.

On the test specimen, charge cycles are performed at a defined load value, decreasing the intensity on each series of cycles.

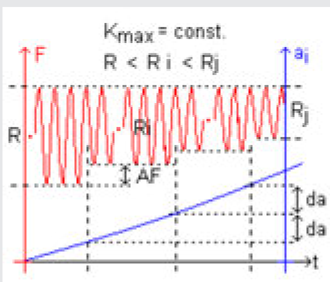




R constant

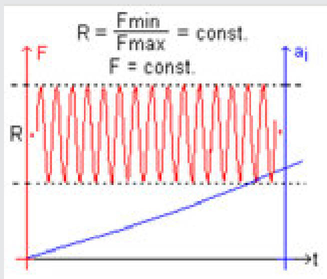
Where R =F_{min}/$F_{max.}$

Perform decreasing cycle load series, in which **F_{max}** and **F_{min}** are decreasing proportionally as they are multiplied by the same factor **Af**.



K_{max} constant

Perform cycle load series keeping constant **F_{max}** and decreasing the **F_{min}** value



F constant

Perform only one cycle load serie.

All initial values for **F_{max}** and **F_{min}** remain constant

2. Crack test: K_{Ic} test, determination of fracture toughness.

Prior to the determination of $\mathbf{K_{Ic}}$ it is necessary to determine $\mathbf{F_Q}$ corresponding to the critical value of the stress intensity factor at point $\mathbf{F_Q}$.

$\mathbf{K_Q}$ value is obtained from:

- Load force ($\mathbf{P_Q}$)
- Specimen dimensions
- Nominal crack length (**a**).

The test consists in a precracked specimen subjected to an increasing force until fracture.

The values required for the calculation are determined as follows:

- Tangent line slope of the load-line displacement curve is determined.
- A secant line is drawn with a slope of 95% the previous value and adjusted in the coordinate origin. The intersection between this line and the curve is $\mathbf{F_d}$ (see figure on the right)
- $\mathbf{F_Q}$ is defined as the highest force that precedes Fd. Depending on the type of curve there are three possibilities to determine $\mathbf{F_Q}$.

Curve type I. $\mathbf{F_Q}$ and $\mathbf{F_{max}}$ are equal

Curve type II. $\mathbf{F_{max}}$ is over $\mathbf{F_d}$, then $\mathbf{F_Q}$ would be $\mathbf{F_d}$, but there is another maximum point before, so $\mathbf{F_Q}$ is this maximum value.

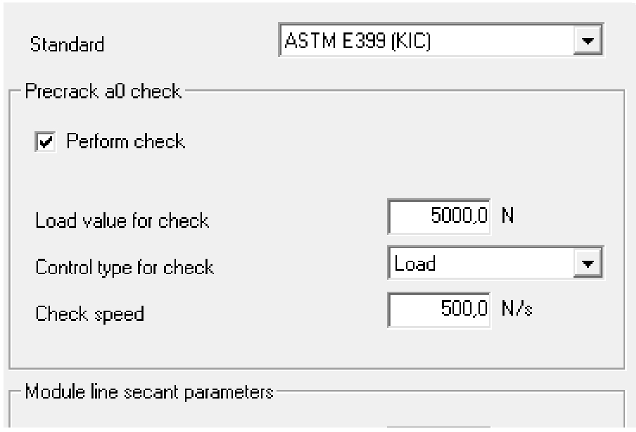
Curve type III. $\mathbf{F_{max}}$ is over $\mathbf{F_d}$, and there is no other maximum point before, so $\mathbf{F_Q}$ and $\mathbf{F_d}$ are equal.

The program automatically calculates the value of $\mathbf{F_d}$ but it is possible to make manual adjustments with the function: **define modulus**.

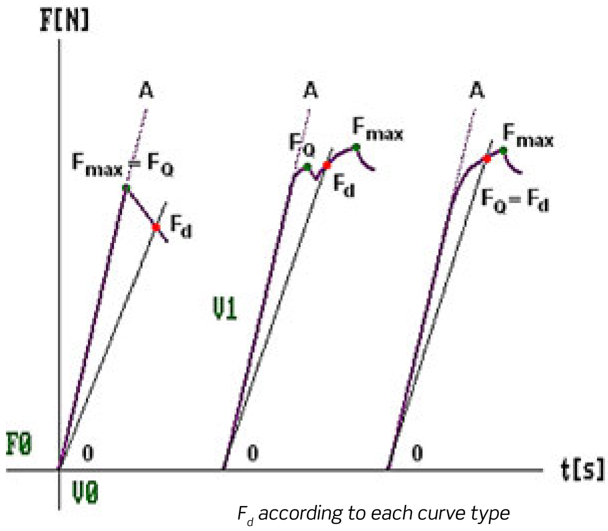
When the specimen reaches fracture, the test results are automatically calculated (see table on the right).

If the crack length is known, you can calculate the stress-intensity factor **K**.

All calculations are performed following the approximations and indications of the test method ASTM E399 Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness $\mathbf{K_{Ic}}$ of Metallic Materials



Test K_{Ic}



F_d according to each curve type

Symbol	Parameter	Unit
$\mathbf{F_{max}}$	Maximun force	N
A	Modulus: slope for the drawn line over a range of $\mathbf{F_{max}}$ / 5 Linear regression: y= **A**x + **n**	N/mm
n	See previous expression	mm
dLh	Elongation at maximum load	mm
$\mathbf{F_d}$	Intersection point between the secant line and graph, with a slope of 5% less than the slope of the tangent **0 - A** to the initial part of the record	N
$\mathbf{F_Q}$	Is the highest force that precedes $\mathbf{F_d}$	N
$\mathbf{K_Q}$	Stress intensity factor calculated with $\mathbf{F_Q}$	MPa $m^{1/2}$

Results table

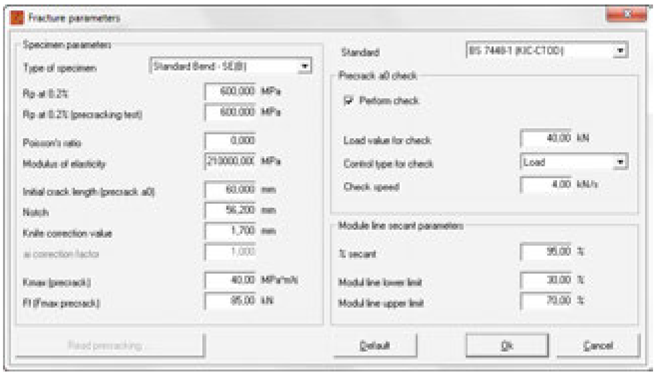
NOTE:
In order for a result of KQ as KLC to be considered valid according to standard test method ASTM E399, is necessary to carry out a numerical verification related to the crack length and the thickness of the specimen.
For more information, see the test method *ASTM E399*

3. KIc. Determination of the CTOD value.

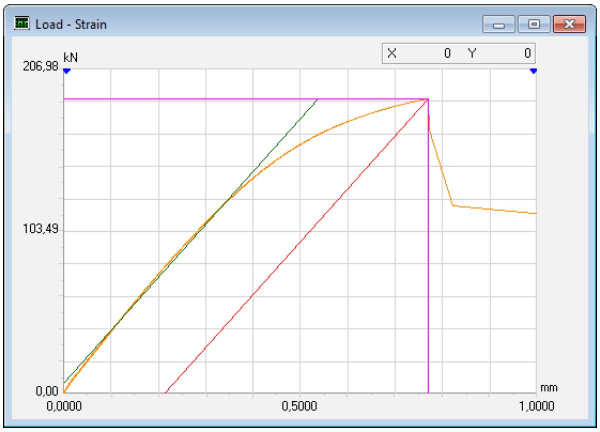
Sometimes the material shows a behavior that makes the KIC determination not valid. For these materials the CTOD value can be determined. It is equal to the distance between both sides of the crack tip opening the moment the crack starts propagating critically. The result is expressed in mm.

Unlike KIC test, the CTOD value cannot be considered a property of the material, since it depends on the width of the sample under test.

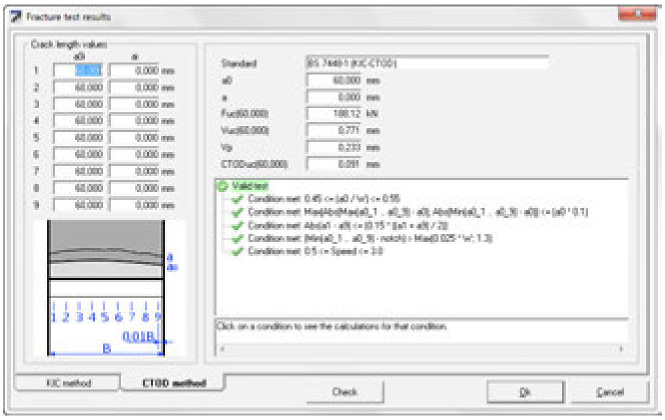
On the other side, the validity conditions only depend on the crack front geometry and the test speed, so the validation is more relaxed



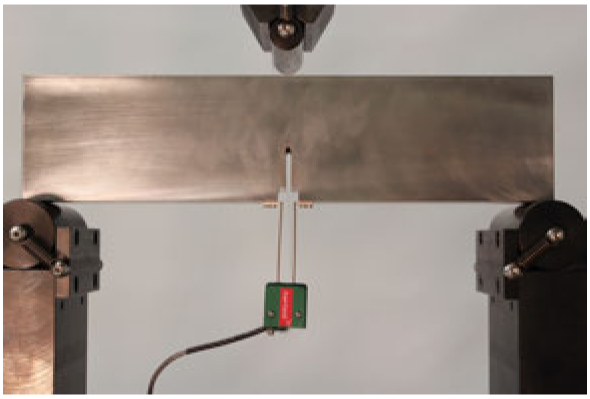
CTOD test



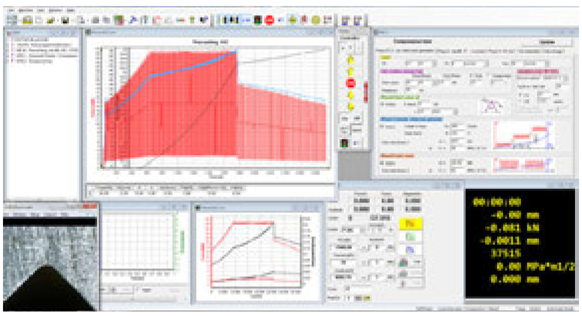
Typical curve for a CTOD test



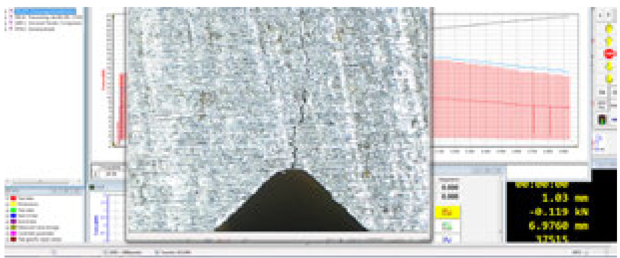
CTOD test validity conditions



Fatigue three point bending test with fracture mechanics extensometer



Pre-cracking software



Visualisation of the precrack with image capture system

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TELEDIAGNOSIS is a remote diagnostic service and maintenance support, available for all IBERTEST equipment and testing machines equipped with data acquisition system by computer.

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During a TELEDIAGNOSIS session, the following actions can be performed:

› **Software revision and correction.** IBERTEST technicians can inspect the software file system, looking for wrong configurations, lost files and directories, corrupted files, viruses or others. Once the errors are detected, only the appropriate libraries and changes are transferred, without reinstalling complete programs.

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› **Videoconference.** Through webcam a videoconference between client and our technicians can be mantained, thus we can get visual-information about the correct operation of the machine's mechanical and hydraulic systems. Also, by written or voice messages, it is possible to exchange views and comments, and give appropriate instructions to the user, when necessary, to perform some physical action in the machine.

› **Updates.** The software can be easily updated to its latest version, which allows enjoying the advantages resulting from the continuing work of review and program development.

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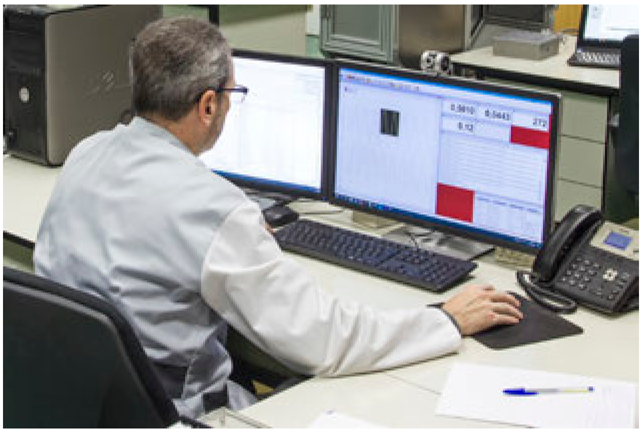
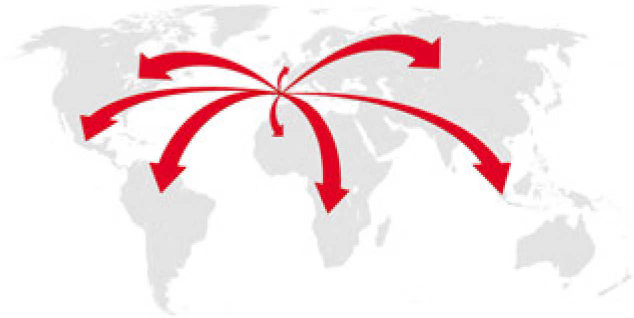
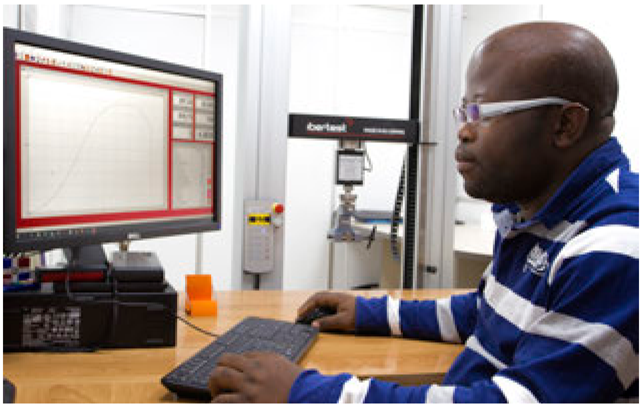


IBERTEST Spain - Madrid Technical Services



Real time TELEDIAGNOSIS link



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