FRACTURE DIAGNOSTICS, INC.

DIGITAL DISPLACEMENT RISING STEP LOAD™ *LRA / RSL*™ TEST EQUIPMENT

BACKGROUND AND PRODUCT DESCRIPTIONS

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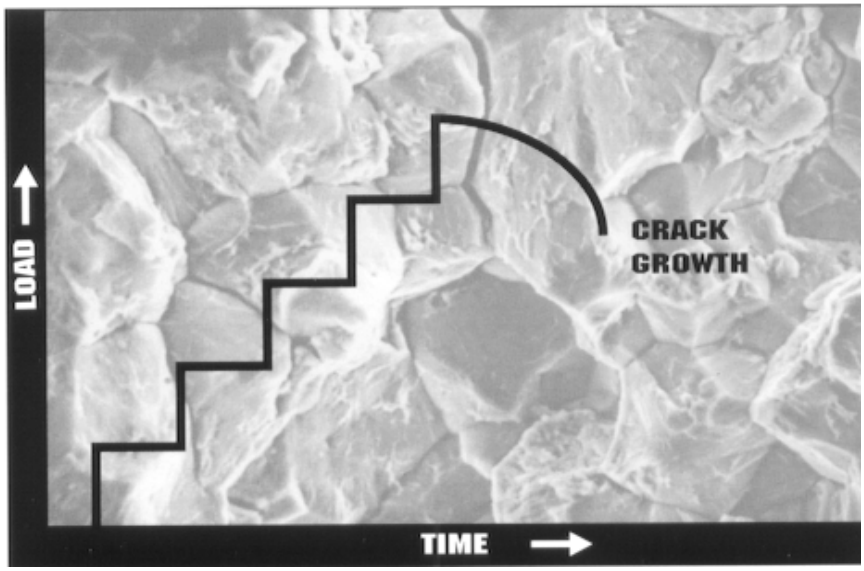
FRACTURE DIAGNOSTICS, INC.

Fracture Diagnostics provides state-of-the-art test equipment, utilizing the Rising Step Load™ testing technique. The RSL™ method has been recognized as the only reliable and quantitative method for detecting the existence of, or susceptibility to, hydrogen embrittlement in high-performance materials.

RISING STEP LOAD TEST METHOD



The RSL™ testing method was developed by Dr. L. Raymond, a noted scientist, lecturer and investigator in the area of failures due to hydrogen embrittlement. Fracture Diagnostics has developed a total system to allow research facilities, production operations, failure investigators, universities and any other interested party to be able to detect the presence of hydrogen embrittlement in a material in a reliable, reproducible fashion. The simplicity of the equipment combined with a most advanced software system requires a minimal of training for proper operation.

This testing procedure has been incorporated into ASTM F 519-97 "Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating Processes and Service Environments", ASTM F1940-99 "System for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners" and is described in detail in ASTM F 1624 "Standard Test Method for Measurement of Hydrogen Embrittlement in Steel by Incremental Loading Technique".

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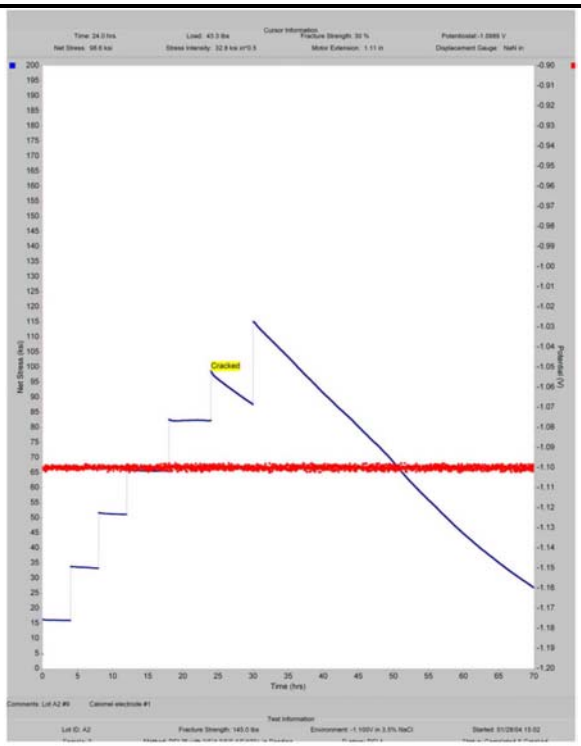
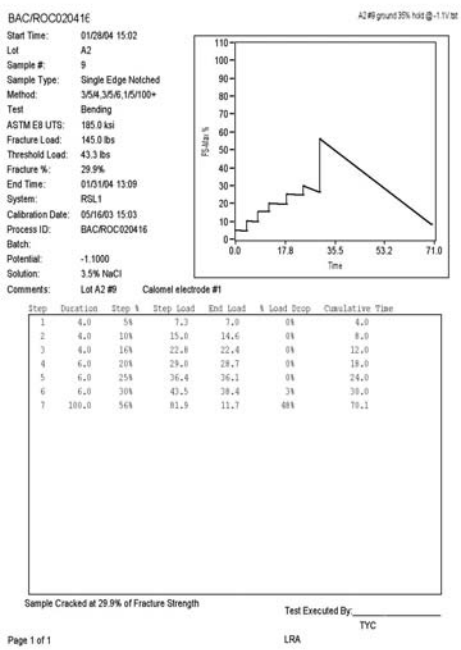
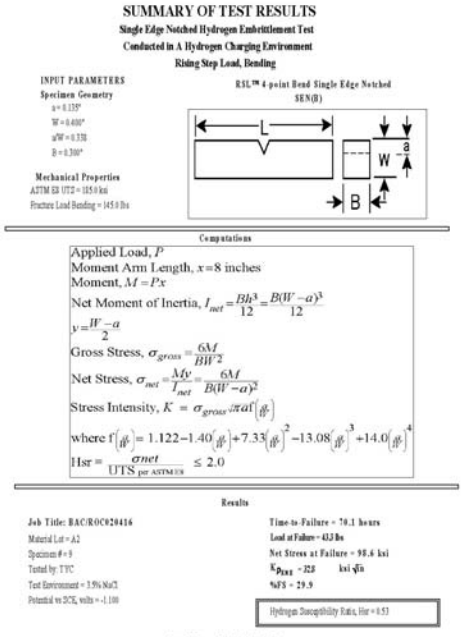
Typical RSL™ Data Sheet and Analysis of Standard 0.4 W SEN(B) Specimen



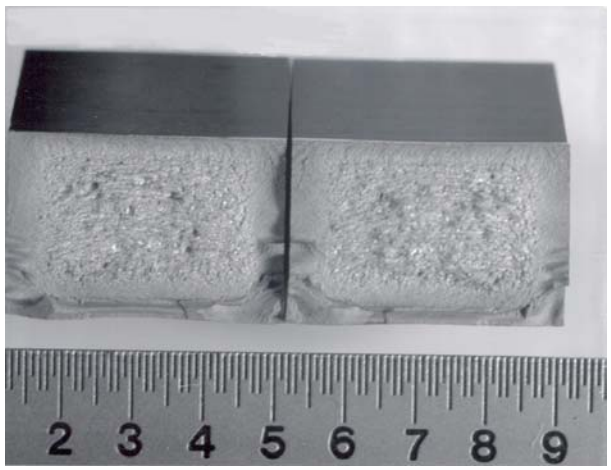
RSL™ Window



RSL™ Test Data Report



RSL™ Analysis Report



Specimen Fracture Face

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ABOUT RSL™ TESTING EQUIPMENT

RSL test equipment is based on:

- Utilizing the most advanced concepts of hydrogen embrittlement detection in a reliable and proven combination of testing equipment and software.
- Maintaining precise control of displacement, whether in a sustained load or over a broad variety of loading rates.
- Measuring the applied load accurately with precision load cells.
- Specially designed software that provides a graphical interface that allows both simplicity of operation and a broad variety of testing parameters.
- Testing units that are essentially desktop. They require very little space and can be configured so as to be portable for demonstration purposes.
- Requiring only standard electric wall outlets for operation and no water cooling or waste disposal.
- Are modular in nature in that up to eight testing units can be operated from the same PC.
- Can be adapted to advanced research and product performance evaluations through the addition of the Scientific Investigation Package which includes special software, the Scientific Control Unit and the solution reservoir, a potentiostat, a platinum electrode and a Saturated Calomel Electrode.
- Can be used as everyday quality control units or used for the most sophisticated research investigations.
- Providing data and solutions to hydrogen embrittlement problems. that can not be accomplished with any other equipment.

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COMPONENT OVERVIEW

The RSL™ line of Digital Displacement testing equipment is modular in concept and is made up of the following individual units.

TENSILE FRAME: This unit is designed for testing test specimens or threaded parts in tension using either the **RSL** method or standard tensile loading parameters. It is capable of exerting tensile forces up to 25,000 pounds. It can also be used in conjunction with the Scientific Controller to provide tests with an imposed potential in a reservoir containing an aqueous solution.

BENDING FRAME: This unit uses 4 point bending to put stress on either a standard single notch square bar specimen or an actual threaded specimen. It can be used in air as a quality monitoring tool or can be used in conjunction with the Scientific Controller to provide tests with an imposed potential in a reservoir containing an aqueous solution.

MOTOR CONTROLLER: This controlling unit takes the output from the specially designed software and converts it to a digital signal that operates the precisely controlled and stable stepper motor. This provides the constant displacement required for the multiple test designs. This unit monitors load and/or extension through a second electronic input.

SCIENTIFIC CONTROLLER: This unit contains an extraordinarily stable potentiostat as well as a micro voltage processor that can take input from any standard electronic extensometer or clip gauge and integrate the real time results through the Scientific Software to provide an extensive amount of experimental parameters and measurements. It also can monitor load/extension through an additional electronic input.

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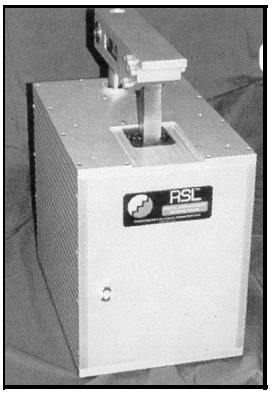
4 POINT BENDING FRAME



Model FD 1200-B - Rising Step Load™ Test System for Quality Monitoring Using a Bending Moment:

This unit utilizes a four point bending mode to put stress on a test specimen or actual part. It utilizes a constant displacement bending arm that is precisely controlled through software developed especially for this equipment and the broad variety of testing that it can perform. The standard test specimen is a modified single edged notched square bar. However, fixtures are readily available to allow the testing of threaded fasteners and other product forms. This unit is designed to operate in air and is the basic unit used by platers to provide quality monitoring of the plating process. It is often used in concert with the Certified Test Specimens to provide a quantitative measure of the hydrogen generating potential of any specific plating process. It can provide up to 9600 in-lb of bending stress.

The software uses a graphical interface with the testing unit providing a unique control of testing parameters and simplicity of operation. Data generated can be filed into and analyzed by many standard data base programs.

The actual bending frame is designed as a desk top unit and can be provided with several units custom mounted in a single cabinet.

This unit comes with a motor controller, a calibrated load cell, the operating software, a powerful computer and a 2 day installation and operating instruction course. The computer provided can operate up to eight of the bending frames.

Test Capability: Rising Step Load - ASTM F1624/F1940
Sustained Load - ASTM F519
Constant Displacement
All other standard bend tests .

Construction: Stainless Steel and Aluminum Housing
Height - 12"" x Width - 9.5" - Weight: 75lbs
Power Requirements 110/125 Volt AC 50/60Hz Single Phase

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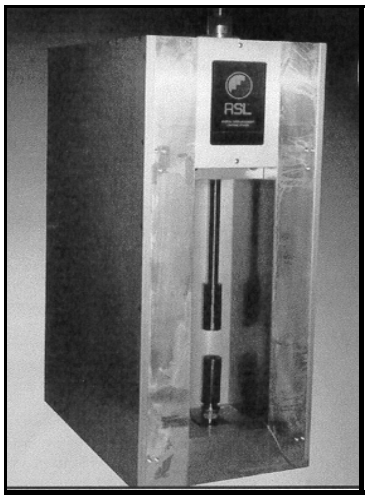
TENSILE FRAME

Model FD 25000-T - Rising Step Load™ Test System for Quality Monitoring Using a Tensile Force:



This unit is designed for testing standard test specimens or threaded parts in tension using either the **RSL™** method or standard tensile loading parameters. It uses the same constant displacement method controlled by the digitally actuated stepper motor. This provides abilities for a broad variety of testing parameters including sustained load, constant extension rate, Rising Step Load and traditional constant stress rate such as ASTM E8. It provides a tensile force capability of 25,000 pounds, which allows testing of many standard test specimens as well as actual parts of significant size.

The software uses a graphical interface with the testing unit providing a unique control of testing parameters and simplicity of operation. Data generated can be filed and analyzed into many standard data base programs. Stress/ strain curves can be generated high-lighting desired testing parameters when used in conjunction with the Scientific Controller

The tensile frame is designed as a desk top unit and can be provided with gripping adapters to accommodate a broad variety of test specimen configurations. It can be mounted on a mobile stand for use as a demonstration unit. It needs only normal wall outlet power and requires no cooling or waste disposal.

The unit comes with a motor controller, a calibrated load cell, the operating software, a powerful computer and a 2 day installation and operating instruction course, The computer provided can operate up to eight of the tensile frames.

Test Capability: Sustained Load per ASTM F519
Constant Extension Rate per ASTM G 129
Rising Step Load per ASTM F1624/F1940
Constant Stress Rate as per ASTM E8

Construction: Stainless Steel and Aluminum Housing
Height – 42" x Width – 12" x Depth – 24" – Weight 420lbs

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SCIENTIFIC INVESTIGATION MODELS

4 POINT BENDING FRAME

Model FD 1200SI-B - Rising Step Load™ Test System Using a Bending Moment for Scientific Investigation and R & D:

This unit is identical to Model FD 1200-B with regard to the Bending Frame itself, but comes with additional Scientific Software, a Scientific Controller and the solution reservoir with a Platinum Electrode and a Saturated Calomel Electrode. This allows the Bending Frame to become a powerful research and investigative tool in that it can measure the response of materials to conditions that emulate field applications. With this equipment it is possible to determine not only if a material is already embrittled by hydrogen, but also if it would be susceptible to embrittlement when used in exposure to a corrosive media.

This unit comes with a Motor Controller, a calibrated load cell, the operating software, a powerful computer and an optional 2 day installation and operating instruction course. The computer provided can operate up to four of the Bending Frames that also have a Scientific Controller.

TENSILE FRAME

Model FD 25000SI-T Rising Step Load System Using Tensile Force for Scientific Investigation and R & D:

This unit is the same as Model FD 25000-T with regard to the Tensile Frame itself, but comes with additional Scientific Software, a Scientific Controller and the solution reservoir with a Platinum Electrode and a Saturated Calomel Electrode. This allows the Tensile Frame to become a powerful research and investigative tool in that it can measure the response of materials to conditions that emulate field applications. With this equipment it is possible to determine not only if a material is already embrittled my hydrogen, but also if it would be susceptible to embrittlement when used in exposure to a corrosive media.

This unit comes with a Motor Controller, a calibrated load cell, the operating software, a powerful computer and an optional 2 day installation and operating instruction course. The computer provided can operate up to four of the Tensile Frames that also have a Scientific Controller.

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MOTOR CONTROLLER

Model FD 1200- MC Rising Step Load™ System Motor Controller for use with both Bending and Tensile frames:

The Motor Controller is the hub between the Loading Frames and the operating software. Fracture Diagnostic's components incorporate distributed processing rather than relying on a dedicated computer to run the system. This enables the Motor Controller's computer chip to focus on digital data acquisition, closed loop load control, signal conditioning and system diagnostics, while a non-dedicated PC will act as the operator **in**terface and maintains its multitasking abilities.

Real-time functions include high speed control of the loading frame and other components. It performs algorithms that enable the test system to automatically adjust loading. The controller utilizes a dedicated computer that allows for precise digital rates to reach an exact load in seconds. With the digital Motor Controller, loading profiles can be added by just modifying the RSL software.

The Motor Controller utilizes a 20 bit A to D strain gauge to digitized the load cell's measured force. The Load Cells are independently recognized and identified by the operating software and then integrated into the control system.

Up to eight Motor Controllers can be operated independently by the PC provided with either of the loading frames.

Construction: Encased in a Corrosion Resistant Aluminum Housing
Height – 3" x Width – 8" x Depth – 10" – Weight 12 lbs.
Power Requirements – 110/125 Volt AC 50/60Hz Single Phase

Interface: RS 232 9 Pin Closed Loop Drive Command Interface.

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SCIENTIFIC CONTROLLER

Model FD 1200- SC Rising Step Load System Scientific Controller for use with both Bending and Tensile Frames:

The Scientific Controller is an electronic signal generator and detector for utilizing the advanced functions of the Scientific Investigation Software. It provides capabilities as an extremely stable potentiostat for the imposition of a potential through a platinum electrode in relation to a Saturated Calomel Electrode of from 0 to -2.0 Volts. In this mode it is used with the solution reservoir and the two electrodes that are provided in the Scientific Investigation (SI) models of the loading frames. This feature is used to generate information relative to the performance of a test specimen or part in actual field applications and can be used with either the Tensile or Bending Frames.

The same device can be used as the detector for a variety of electronic extensometors or clip gauges that are available in the market place. With this unit, the Tensile Frame can provide data output recording the elongation of materials during tensile testing and crack opening displacement during fracture toughness testing, therefore providing a broad capability tensile testing unit with the most sophisticated software available.

Up to eight Scientific Controllers can be operated independently by the PC provided with either of the loading frames.

Construction: Encased in a Corrosion Resistant Aluminum Housing
Height - 3" x Width - 8" x Depth - 10" - Weight 12 lbs.
Power Requirements - 110/125 Volt AC 50/60Hz Single Phase

Interface: RS 232 9 Pin Closed Loop Drive Command Interface.

Applied Potential:
Range: 0 to -2.0Volts
Accuracy: ± 0.1% of reading
Resolution: ±0.2% mV

Measured Potential:
Range: 0 to -4 Volts
Accuracy: ±0.1% if reading
Resolution: ±0.2% mV:

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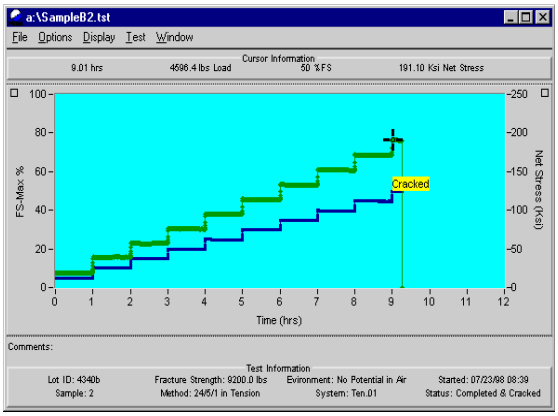
ABOUT *RSL*™ SOFTWARE

RSL Software was designed to complement the advanced features of the *RSL* test equipment. It is a graphical interface, user friendly system with capabilities to effectively and simply perform tests of substantial technical complexity. The figure below shows the test screen for a traditional *RSL* test which includes tracking of any two of seven parameters offered, including %Fracture Stress, Load, Net Stress, Potential, Displacement Gauge, Motor Extension and Stress Intensity against Time. Ordinate values are easily changed to accommodate appropriate ranges. A "Flag" will display at a pre-desribed % change in prescribed parameter.



Test window for standard *RSL profile*

Some Additional features of this powerful software:

- Test window displays all testing parameters, sample identification and real time test performance.
- Test window, as well as test data and data analysis, are available as convenient printed reports.
- Able to accommodate a variety of sample geometries and configurations, including all F 519 and F 1940 specimen types.
- Data is retained for re-plotting of test performance with alternate ordinates.
- Built in standard test profiles plus ability to create any desired test profile and keep as available file.
- Ease of installing and checking calibration data, with date of calibration recorded.
- Special windows to estabish and measure imposed potential from Scientific Controller potentiostat.
- A variety of test methods available including bend or tension test controlled by *RSL* profile, Constant Extension Rate, Constant Load Rate, Constant Stress Rate and Constant Stress Intensity Rate.
- Data are stored under test identity and can be transferred to standard spreadsheet programs.
- Flags signaling critcal points in data curve can be defined for any measured parameter.
- Test curve can be zoomed for critical response analysis.
- PC and monitor can run up to four machines and track the data simultaneously.
- Test reports calculate stress, stress intensity and Hydrogen Embrittlement Ratio automatically.
- Procedures can be learned by competent lab technician in very short time.

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