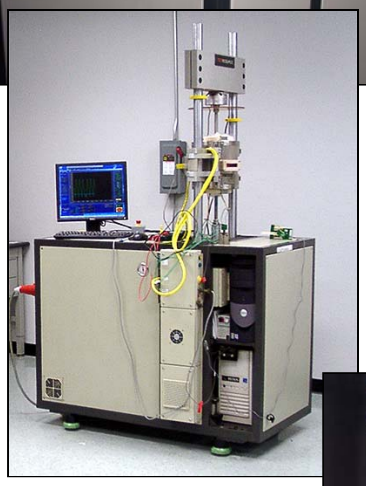
900L Servohydraulic Test Systems

Forces to 300 kN (66 Kip)
Frequencies from Static to 100 Hz

Servo-hydraulic dynamic test systems consist of a load frame with servo-actuator, grips or fixtures, transducers, hydraulic power to apply forces, displacements or strains, a digital controller, data acquisition and computer. The purpose of this application note is to assist you as a project manager, laboratory head or research engineer with a step-by-step procedure to configure a machine to your requirements.



Model LX11

Rated 50 kN (11000 LB) High Temperature Test System

About TestResources

As you can see by visiting our web site at www.testresources.com, our roots are firmly planted in servohydraulic testing applications. After more than 20 years experience in developing systems for customers around the world, TestResources was founded a decade ago with our name reflecting our vision – to offer alternative and creative solutions and resources to test engineers and customers -- in Fortune 500 companies, government labs, and universities and specializing in the engineering of test systems. This application note is meant to serve customers who want to configure standard affordable test systems for single channel materials and product test applications.

TestResources also offers affordable and high resolution servoelectric dynamic test systems that employ linear motors and other actuators to test at low loads – below a gram. These systems are now available for applications up to 11,000 pounds and have their place alongside servohydraulic test systems. Call us to discuss your needs.

Axial Torsional System

Model LX3

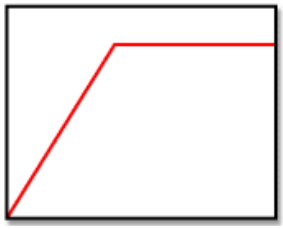
Rated 15 kN (3300 LB) Biomedical Test System

TESTRESOURCES

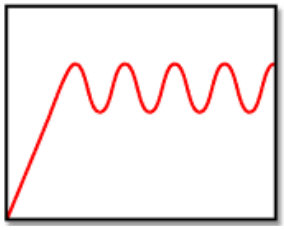
Best Value in Testing

Perform any mechanical test – standard or custom!

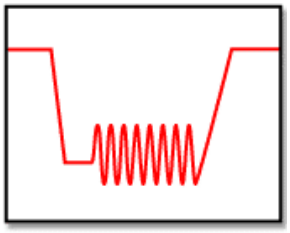
Tensile, Compressive, Bend, Stress Relaxation, Indentation and Creep
Generate slow or fast ramps and collect force, strain, and displacement data for materials characterization, stress – strain curves, strength analysis or yield properties.



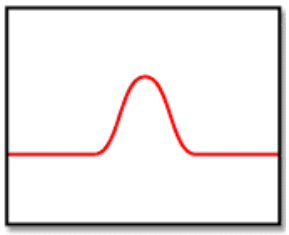
Fatigue
Run load or position controlled cyclic tests to determine how many cycles to failure or to prove your device meets endurance requirements. Adaptive control adjusts amplitude to handle different sample responses.



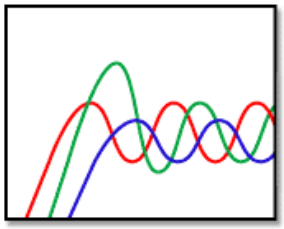
Dynamic Properties
Sweep multiple test frequencies and gather accurate stress and strain data to characterize time dependent characteristics. Analyze and report viscoelastic properties of rubber, polymers, gels and biomaterials.



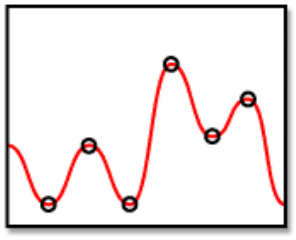
Dynamic Impact or High Strain Rate
Generate quick impact loads and capture high speed data characterizing force, strain, and displacement for materials characterization or product performance.



Multi-Axial tests
Synchronize control of multiple channels, in-phase or out of-phase, and perform biaxial, triaxial, multiaxial, and axial-torsional tests.



Customize Point by Point loading - Create Your own Test
Generate custom waveforms point by point, or customize the data collection process by narrowing in on the area of interest.



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Step 1 – Size the load frame

Load frames and pumps can last well over ten years, so it's important to set long-term objectives for the test system. To begin, identify the nature of materials and specimens likely to be tested on the machine, and from these, establish the maximum load capacity.

> Example: Static tensile tests of steels lead you to review ASTM E8 test method as one source to determine specimen gage dimensions. From the test cross-section area and expected maximum tensile properties of your test materials, you can determine required (static in this case) load capacity.

Typically, test systems rated for dynamic loads of 50 or 100 kN meet most requirements of materials testing. Actuators are available with a wide choice of stroke (50, 100, 150 or 200 mm). Long strokes provide more flexibility to mount specimens, but proportionately lower quality stroke measurement. This may not be a problem if testing is under load or strain (extensometer) control. However, if you plan to do tests in stroke control, you are better off with a shorter stroke actuator. Some performance improvement is also available with shorter stroke actuators due to higher oil column stiffness. Finally, longer stroke actuators offer a marginal improvement in angular alignment, which is critical in special tests – such as metal low cycle fatigue tests (ASTM E466).

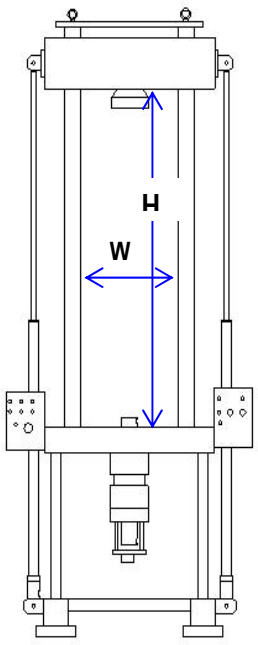
Our load frames are free standing, self-reacting, precision aligned, free from self induced shocks and vibrations and do not require special groundwork for installing. Frames are rated for static and dynamic loads and available with actuators baseplate (most common) or crosshead mounted actuator configurations. The load cell then placed on upper crosshead which can be moved and locked to various positions. Mechanical clamps lock the crosshead on the B01-100 (37 kN static rated load frame). Load frames rated above 50 kN feature hydraulic lifts and include clamps to move and lock the crosshead to desired positions.

Actuators

Actuators operate over a wide range of loads and displacements and include an integral service manifold with a safety dump/cutoff solenoid valve. They are capable of mounting one or two servo-valves. Servo-valves feature exceptional linearity of response and near-zero hysteresis. Servovalve flow rating is selected to match the power pack. In some applications, a lower flow higher resolution servovalve may be best. Internal threading matches metric adapters for interconnection with the accessories of the load train. Total stroke of actuator includes hydraulic cushioning at both ends to avoid accidental damage to the actuator. A built in co-axial LVDT matches the actuator stroke.

Load Cells

Shear web load cells avoid errors in the presence of side loads or bending moments, and ensure insensitivity to side loads. All load cells are fatigue rated to 10^7 cycles at maximum rated dynamic load. Their durability under nominal working conditions may be assumed to be indefinite. Load cells include circuitry for auto-calibration against internal shunt reference, obviating the need for on-site calibration during installation. Load cells are internally threaded for coaxial mounting at the other end.



Load Frame selection guide

Static rating (kN)	Dynamic rating (kN)	Model	Column Clearance, **W** (mm)	Vertical Daylight **H** (mm)	Hydraulic lifts & clamps	Overall dimensions (mm)
37	25	B01-100	400	1000	No	600x500x2100
70	50	B01-101	400	1000	Yes	600x500x2100
150	100	B01-102	600	1500	Yes	800x600x2750
300	200	B01-103	600	1500	Yes	1000x600x2750

Step 2 – Power Pack selection

Pump capacity sets machine performance and power consumption. The matrix below provides a qualitative comparison for different load frames and pumps. A graph with normalized performance curves confirms the selected components are suited to your needs. As a measure of reserve in performance, one can select the next higher Index. The combinations suggested in the matrix below are designed for optimum combination of performance, quality and economy of operation.

<table>
<tr><th></th><th>4 LPM (1 GPM)</th><th>11 LPM (3 GPM)</th><th>21 LPM (5.5 GPM)</th></tr>
<tr><td>Static 37 kN (8 kip)
Dynamic 25 kN (5.5 kip)</td><td colspan="3">Soft Materials - Static, Fatigue & Fracture</td></tr>
<tr><td>Static 75 kN (17 kip)
Dynamic 50 kN (11 kip)</td><td>All Metals - Static, Fatigue & Fracture</td><td colspan="2">Soft Materials - Static, Fatigue & Fracture</td></tr>
<tr><td>Static 150 kN (34 kip)
Dynamic 100 kN (22 kip)</td><td>Static
LCF & Creep-fatigue</td><td>All Metals - Static, Fatigue & Fracture</td><td>Soft Materials - Static, Fatigue & Fracture</td></tr>
<tr><td>Static 300 kN (65 kip)
Dynamic 150 kN (44 kip)</td><td>Static</td><td>Static
LCF & Creep-fatigue</td><td>All Metals - Static, Fatigue & Fracture</td></tr>
</table>

Our pumps are quiet, economical, energy efficient and reliable packages. Interlocks switch off the pump in case of emergency:

- Sensors for monitoring oil temperature
- Oil level indicator to indicate the oil level inside the tank
- Filter clogging to monitor the cleanliness of the filter cartridge.
- Phase failure sensor to monitor any phase failure in electrical supply
- Motor overload safety interlock to protect the motor from higher current
- Software interlock feature

Direct drive servo valves are insensitive to contamination, so special pressure line filters are not needed.

Step 3 – Select grips/transducers and application software

Static Tensile Tests

For tensile tests, the test frame requires the addition of tensile grips, an extensometer to measure sample strain, and application software to analyze and report test results – generally to ASTM E8 in the case of metals tests. Mechanical manual grips are suitable for tensile tests on flat and round specimens. Quick and easily changeable jaw faces to accommodate flat specimen thickness of 6 to 13 mm and round specimens of 7 to 12 mm diameter. A variety of grips is available.

Static Tensile Tests with Low Cycle Fatigue (strain controlled through zero fatigue tests)

Require the addition of an extensometer matched to specific sample size and test, plus software matched to the industry standard test method (ASTM E606) and typically hydraulic action grips. Extensometers for low cycle fatigue tests are normally not the same as those used for high elongation tensile tests – contact us for the details. Self aligning and hydraulic locking grips ensure accurate alignment of the specimen with load axis. The hydraulic pressure to operate the grips is tapped from the hydraulic system. A dedicated specimen and wedge clamping manifold with electrically operated valve, accumulator to hold pressure, pressure is provided to activate, lock and release the grips. Grip action can be controlled through the software.

Fracture Tests
Clevis grips are available for C(T) specimens of different geometries like LLD and MOD specimens, with thickness of 12.5 mm and 25 mm. Grips are designed to ensure there is no interference between the grips and COD gages, and machined per ASTM E399 standard. Again, COD gages are matched to test specifics – FCP tests typically require displacements of -1 to 4 mm and J1c gages from -1 mm to 7 mm travel. Fatigue crack growth software matches ASTM E647 and a software bundle handles K1C, J1C, JR and CTOD per ASTM 1820. COD gages are used for fracture mechanics applications using compact tension, arc shaped, disc shaped, bend specimens or other specimen geometries in compliance with ASTM and other standards. Knife-edges ensure firm mounting of the gage on to the specimen with out any slip and can be used up to a frequency of 100Hz. Grooves machined as per ASTM E399 standards

Flexural Tests

Three point bend fixtures are designed for SE(B) specimens of width 25 mm and include a set of three rollers.

Step 4 – Controller Selection

900L Test Systems include a 2350 Digital Controller, with a high-performance Digital Signal Processor (DSP) for direct digital servocontrol. The DSP computes control correction signals to the servohydraulic actuator. The value is output to the servo-valve thousands of times a second (speeds up to 20,000 per second). Any available transducer can provide the servo-feedback, making it possible to perform precise tests under stroke, force, strain or other modes of control. Control modes are transferred before or during a test in a bump-less manner - meaning there will be no damaging jerk on the specimen.

Controller test and measurement quality is normally promoted to be related to the number of bits per readout with a controller's response time or loop update rate. Since our controller is currently the fastest loop update in the industry, no further discussion is needed on that topic.

Most digital controllers offer 16-bit measurement resolution and may claim up to 32-bit resolution in control. One can be easily misled by these numbers, as evidenced by the obvious fact that you cannot control anything better than you can measure it. Even if you could achieve the impossible, you can't prove so unless you can confirm (e.g. measure) it with the same resolution claimed. So no useful purpose is served by having control resolution better than measurement resolution. That said, resolution remains important when part of a discussion that includes electrical noise.

A Bit of Resolution . . .

Twelve bit resolves a transducer to +/-0.05% of a 100% range. Sixteen bits resolves to +/-0.003% of full scale and nineteen bits extends that by a factor of 2^3 and so delivers +/- 0.0004%. It takes twenty one bits to resolve one part in a million.

Some Noise .,…,,

However, true data quality is limited by electronic quality rather than resolution. The bits specified means little unless backed up by matching electronic quality. Both industrial and laboratory electronic signals are 10VDC or less. Electronic noise can easily interfere with data. An electronic engineer knows how challenging it is to guarantee signal noise less than 5 mV (equivalent to 12 bit resolution). So, unless the signal being measured has noise less than 5 mV, 12-bit measurement resolution is adequate. This is particularly true with strain bridge transducers such as load cells and extensometers which use signal conditioning where bridge output is mV level and then amplified more than 100 times. Noise is then amplified 100 times as well. So – notice equipment specifications that proclaim high measurement resolution (bits) without specifying noise.

Our research conducted on actual field measurements of 2350 controllers at customer sites around the world indicate *effective test data resolution* of raw data ranges between 12-bits and 16-bits on load cell outputs. *This is in spite of multiple noise abatement strategies the 2350 employs.*

The 2350 controller includes the ability to over-sample data and average multiple readouts – because of the high DSP performance. Oversampling is proven -- random noise can be reduced by the square root of sample size, so

noise reduces 64 times at a sample size of 4096. Over-sampling applies to measurement, but cannot be used in the control loop which is updated thousands of times per second.

Digital filtering, combined with 24-bit measurement hardware, is now available on *2350 Resolution Plus* controllers, which improve measurement quality 4 to 8 times better than the standard 2350 controller. *Resolution Plus* improves quality of servo-control and measurement, and especially important when operating over a small part of transducer range.

Digital transducers also deliver great quality because they are practically noise-free. A digital linear encoder guarantees zero noise at high (0.1 micron) resolution.

Depending on the variety in measurement range as a fraction of transducer range and depending on your budget, you can choose one of the following standard controller configurations. Note that the 24-bit version offers about 4 times to 8X improvement in signal measurement quality.

Typical Controller configuration for materials testing includes

- Motherboard with DSP interface and USB communication
- Signal conditioners for LVDT and load channel
- Signal conditioners for two channels of strain
- Power pack control card
- Firmware and basic software

2350 Control System Attributes (see comments above regarding expected noise)

Control System Attributes	• Flexible open architecture software (GDS) • Modular expandable hardware (2350) • Compatible with linear motors, screw driven actuators, servohydraulic and others • High performance and high resolution
2350 Controller Hardware	
PC with Microsoft OS	Yes – requires USB port
Enclosure options	• Tower style enclosure • 19 inch rack mount - optional
Max update rate	20 kHz (DSP is on card – future upgradeable)
Digital IO	User settable – 16 in & 16 out
Control Modes	• Connected transducers (e.g. load cell, extensometer, LVDT) • Real time calculations or calculated channels • Load-limited displacement for sample loading
Control Resolution	16 bit (± 32768 parts) – 0.003% of full scale (load, strain, position)
Control Channels	Up to 8 actuators
Backplane Expansion Slots	Six
Expansion Cards	Digital 2 ch Signal Conditioners (SC) – AC for LVDT's (16 bit) Digital 2 ch SC – DC for load cells & extensometers (16 bit) Digital 2 ch SC – AC and DC (16 bit) Digital 4 ch SC – strain bridges, LVDT or Hi-level signals (24 bit) Analog 1 ch SC for LVDT (16 bit) Analog 4 ch SC for LVDTs (16 bit) Analog IN 8 ch diff'l and Analog OUT 4 ch (16 bit)
Other options	BNC box for analog IO – 8 ch BNC 19 inch panel for analog IO – multiple channel Remote Pod Control
Encoders	Up to 4 channels (2 per card)
Signal Conditioners – Maximum	Up to 8 channels (16 bit) Up to 24 channels (24 bit – Fall 2006)
Signal Conditioner Ranges	User settable ranges implemented in software (no hardware required)

	• Lowest sensor range: 1% of full scale in SAV pipe (60 samples/sec) • Lowest sensor range: 5% of full scale in SCH pipe (dynamic tests)

MTL Windows Single Channel Software

Setup Tasks	
Setup, store, recall machine settings	Yes
Setup, store, recall test settings	Yes
Setup, store, recall waveforms & commands	Yes
User assignable sensors	Yes
Real time PID servotuning	Yes - 7 variables available
Adaptive (amplitude) control	Yes
Set limits	Yes
Calibration access	Yes
Auto Zero	Yes
User selectable units	English, metric or SI
Data Acqusition	Performance specifications from 16 bit hardware
Data acquisition modes or 'pipes'	
Continuous - High resolution - pseudo 24 bit	Yes - 4 ch to 60 samples/sec max (SAV pipe)
Continuous 16 bit	Yes - 4 ch to 2 kHz (SCH pipe)
Peak Valley Mode	Yes - 4 Ch to 600 Hz (PKV pipe)
High speed transient	Yes - 2048 points to 20 kHz (SCH pipe)
Logging multiple channels continuously	Yes – 76 ch (min/max or average), cycle count (LOG pipe)
Data Display	
Display Scope	Yes
Display Meters	Yes
Autozoom & autoscaling	Yes
Data Storage & Export	
Binary file format	Yes
Export to ASCII	Yes
Select and Link large files	Yes
Test Creation with test editor	
Define sine, triangular, square, ramp, dwell	Yes
Define rate, frequency, amplitude, mean	Yes
Turn segment data acquisition recording on/off	Yes
User defined calculated channel	Yes
Monitor and modify test in real time	Yes