MTS Model 815 and 816 Rock Mechanics Test Systems

Fully integrated high-force test systems optimized for carefully controlled characterization of brittle materials

be certain.

FOR NEARLY HALF A CENTURY, GEOLOGICAL TEST PROFESSIONALS HAVE MADE MTS THE INDUSTRY STANDARD FOR HIGHLY ACCURATE AND RELIABLE ROCK TESTING. TODAY, WE CONTINUE TO APPLY MORE THAN FOUR DECADES OF EXPERIENCE AS WE ENGINEER AND MANUFACTURE INNOVATIVE **ROCK MECHANICS TESTING SYSTEMS** THAT ADDRESS AN ARRAY OF APPLICATIONS AND BUDGETS.

Engineered for Accuracy and Reliability

Proven systems for rock mechanics testing

The MTS Model 815 and 816 rock mechanics test systems deliver exactly what geological materials experts need to work with confidence: fully integrated solutions that can be configured to test all types of rock in both basic and highly complex applications.

Designed to test everything from soft sandstone to high-strength brittle rock, these systems combine versatile servohydraulic load frames with precise digital controls, flexible software and specialized accessories for uniaxial and triaxial testing. Expect these complete solutions to help you effectively manage and control the forces, pressures and temperatures required for today's most demanding geological materials evaluations.

MTS Model 815 system

The MTS Model 815 system is ideal for uniaxial and triaxial rock tests that are critical to fossil fuels exploration and production, mining and rock mechanics research. It offers high axial force capacity, with compression ratings up to 4600 kN and tension ratings up to 2300 kN. Overall, its highly stiff load frame, fixed crossheads and single-ended actuators make this system particularly suitable for carefully controlled studies of post-failure behavior.

MTS Model 816 system

The MTS Model 816 system is engineered for rock mechanics research testing that involves smaller samples. It can be configured for uniaxial, triaxial or direct shear testing, and its compact frame is easy to locate in the lab. The 816 system provides lower force capacity than the 815 system, but it offers a significantly more affordable way to add rock testing capabilities to your lab's repertoire.

Flexible, modular design

The MTS Model 815 and 816 test systems include a number of features that help test professionals perform a wider variety of tests with a single system. Spacer plates allow you to choose from a range of specimen sizes. Load frames are pre-engineered for installation of triaxial cells. Other accessories are designed for easy installation in multiple configurations, depending on your needs. Plus, MTS can customize either system to accommodate unique requirements.

MTS Model 815 test system with a Model 656 triaxial load cell

MTS Model 816 test system with the direct shear apparatus

MTS can help you fully characterize rock specimens in the high-temperature, high-pressure extremes common to “downhole” environments.

Unrivaled Experience

Decades of rock testing expertise

MTS has installed more high-force servohydraulic rock testing systems around the world than any other manufacturer. To design these systems, we collaborate with the industry's most respected rock mechanics researchers and geomechanical modeling experts. We also leverage the extensive knowledge and hands-on experience gained through engineering and manufacturing high-quality test solutions for many other materials testing industries, from aerospace to biomechanics.

Servohydraulic specialists

Servohydraulic load frame technology is essential to rock mechanics testing. MTS pioneered this technology decades ago and continues to lead the way in servohydraulic innovation. The 815 and 816 systems represent the culmination of our collective knowledge and experience, which is why they provide the accuracy and reliability test professionals need to perform a diverse and growing number of rock mechanics tests.

Dedicated service and support

To ensure you receive expert assistance, MTS fields the largest, most experienced service, support and consulting staff of any testing solution provider. In addition to essential service and maintenance, we offer expert application engineering from professionals who understand the nuances of rock testing. Our global team also offers complete life cycle management to maximize the return on your technology investment and help you address new test requirements as cost-effectively as possible.

World-class industrial design

The servohydraulic load frames that form the core of the 815 and 816 systems are the result of a world-class industrial design program. No matter which system fits your needs best, you can expect to perform rock mechanics tests safely and efficiently in a tightly controlled environment that emphasizes precision as well as easy operation.

MTS Systems Corporation

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Integrated technology that maximizes precision, reliability and repeatability

MTS rock mechanics test systems provide precise, repeatable and durable performance. Known worldwide for high uptime and dependable results, MTS test systems are designed, improved and fine-tuned as we help customers address tough challenges in many markets. This depth and breadth of practical experience results in a comprehensive product line that enables rock testing professionals to meet all testing objectives with a single, reliable source.

Highly stiff load frames

For the 815 system, the load frame assembly includes a fixed crosshead mounted on two rectangular columns bolted to the base plate, creating an extremely rigid yet free-standing frame. Integrated in the base plate is a single-ended, double-acting actuator with a 100 mm (4 in.) stroke for tests requiring large displacements. The frame assembly includes two feedback transducers – a differential pressure (ΔP) transducer and an internal linear variable differential transformer (LVDT) that provides control and measurement of actuator displacement. An impact-resistant Lexan™ door and sliding back panel retain debris without compromising visibility.

For the 816 system, the load frame assembly includes a fixed crosshead mounted on four columns bolted to the base plate, creating a rigid, free-standing frame that allows easy insertion and removal of a wide range of specimen sizes and fixtures. The system incorporates the same single-ended, double-acting actuator as the 815 system. The test area is enclosed with Lexan panels on all sides, and the frame itself rests on a rigid table for a convenient working height.

Clean, quiet hydraulic distribution

SilentFlo™ hydraulic power units (HPUs) deliver superior performance in a compact footprint with exceptionally low-noise operation. They are small and quiet enough to be installed virtually anywhere in the lab. In fact, SilentFlo HPUs are up to 30 dB(A) quieter than conventional HPUs and require minimal floor space. In addition, the 815 system features remote-mounted hydraulic service manifolds (HSMs) to mitigate interference with acoustic measurements.

Powerful software

MTS Geomechanics Application Software provides a complete set of test templates that follow standard test sequences and analyses described by ASTM and ISRM. These templates guide you through testing, data acquisition and report generation. The software also makes it easy to create your own custom templates. Based on MTS Series 793 Application Software, the MTS Geomechanics package uses a highly flexible, drag-and-drop user interface that simplifies the process of building standard and nonstandard tests. Run-time rate control lets you increase or decrease loading or strain rate during testing for tighter control of post-failure tests and improved throughput. Run-time plotting displays selected feedbacks to monitor test progress continuously.

Digital controls

Versatile FlexTest® digital controllers provide the flexibility you need to address a full spectrum of testing needs and adapt readily to evolving standards. Scalable and easy-to-use, FlexTest controllers provide the high-speed closed-loop control, data acquisition, function generation and transducer conditioning required to conduct reliable single- and multi-channel rock mechanics tests across multiple stations.

Uniaxial accessories

Uniaxial test packages are available for compression, strain measurement, circumferential strain measurement, indirect tension (Brazil Test), direct tension and fracture toughness. These packages include test-specific fixtures and related hardware, plus transducers and application software.

Triaxial accessories

MTS triaxial rock testing assemblies help achieve high-fidelity simulation of in-situ conditions such as high confining pressures, high temperatures, high-pressure pore fluids and various specimen stress states, including extension. Accessories are available to support triaxial testing, including compression, creep, extension and deformational stress pathways.

Rock extensometers

Specifically created for measuring rock strains at high pressures and temperatures, the Model 632.9X family of MTS extensometers provides outstanding accuracy, control and durability for uncovering the deformative characteristics of geological materials.

Direct shear apparatus

Extend the capabilities of the 816 system with an integrated MTS Direct Shear Package that subjects cylindrical, prismatic or irregularly shaped specimens of intact or jointed rock to normal and shearing stresses simultaneously. The package includes a stiff, compact load reaction frame, shearing actuator, load cell optimized for direct shear, and shear box.

Extensive Capabilities

The MTS Model 815 and 816 rock mechanics test systems are designed for a specialized set of demanding applications. They are available in multiple models and force capacities to deliver high accuracy and reliability across a wide range of specific testing needs.

Model 815 system

- Lifting eyes
- Integrated construction ideal for testing brittle materials
- Rigid fixed crosshead
- Rectangular columns
- Precision, parallel alignment between crosshead and actuator surface to ensure proper loading
- Front security door for easy access to test space
- Accessory attachment plates
- Fatigue-rated, single-ended, double-acting actuator with proprietary seal and bearing designs for durability, plus direct-bonded polymer bearings for less friction and maximum heat dissipation
- Differential pressure (ΔP) transducer provides force readout without affecting load frame stiffness and is accurate to within ±1% of calibrated range at loads above 1000 kN
- Internal LVDT calibrated to full-scale actuator travel for complete positioning control
- Remote-mounted hydraulic service manifold to mitigate interference with acoustic measurement equipment
- Large test area for uniaxial and triaxial testing
- Impact-resistant Lexan panels
- Stiff base plate
- Emergency stop button
- Vibration isolation pads

Specifications

		815 Test System		
Load Frame Model		**315.01**	**315.02**	**315.04**
Compression rating				
	kN	1600	2700	4600
	kip	350	600	1000
Tension rating*				
	kN	1050	1350	2300
	kip	240	300	500
Actuator displacement				
	mm	100	100	100
	in	4	4	4
Load frame spring rate				
	N/m	7.0×10^9	9.0×10^9	10.5×10^9
	lb/in	4.0×10^7	5.0×10^7	6.0×10^7
Estimated Weight				
	kg	2614	4218	7590
	lb	5762	9300	16,700
Floor Loading Footprint (width x depth)				
	mm	737 x 432	889 x 521	991 x 610
	in	29 x 17	35 x 20.5	39 x 24

** Although the Load Frame assembly is capable of producing the indicated force in tension, the actual tensile force limit is dependent on the attachment hardware (e.g., threaded connectors) that attach the gripping fixtures to the crosshead and actuator).*

Model 816 system

- Crosshead-mounted actuator
- Close-coupled accumulators
- Servovalve
- Four-column, fixed-crosshead design
- Single-ended, double-acting actuator
- Low-profile, high-stiffness force transducer accurate to within ±0.5% of calibrated range
- Differential pressure transducer (standard on 316.04 load frames) accurate to within ±1% of calibrated range at loads above 1000 kN
- Internal LVDT calibrated to full-scale actuator travel for complete positioning control
- Lexan panels on all sides for easy access to test space
- Emergency stop button
- Stiff base plate
- Rigid support table
- Vibration isolation pads

Specifications

		816 Test System		
Load Frame Model		**316.01**	**316.02**	**316.04**
Compression rating				
	kN	500	1045	2046
	kip	110	235	460
Tension rating*				
	kN	291	667	1374
	kip	65	150	309
Actuator displacement				
	mm	100	100	100
	in	4	4	4
Load frame spring rate				
	N/m	1.1×10^9	2.6×10^9	3.0×10^9
	lb/in	6.2×10^6	1.5×10^7	1.7×10^7
Estimated Weight				
	kg	2380	3252	3822
	lb	5250	7170	8426
Floor Loading Footprint (width x depth)				
	mm	1168 x 813	1168 x 813	1295 x 1168
	in	46 x 32	46 x 32	51 x 46

** Although the Load Frame assembly is capable of producing the indicated force in tension, the actual tensile force limit is dependent on the attachment hardware (e.g., threaded connectors) that attach the gripping fixtures to the crosshead and actuator).*

Uniaxial testing

UNIAXIAL COMPRESSION AND POST-FAILURE COMPRESSION

Compression and deformation tests for cylindrical rock specimens require a compression platen fixture, a force transducer for low-force testing (below 1000 kN/200 kip) or a differential pressure (ΔP) transducer for high-force testing (above 1000 kN/200 kip), signal conditioners and cables, spacers and axial and circumferential strain measurement kits.

The load train for high-force compression is designed to be as stiff as possible to minimize the amount of deformation energy stored in the frame and load train components during tests on brittle materials. This is especially important for testing post-failure behavior, where the integrity of the test depends on preventing the loss of control of a failing specimen.

The force transducer is fatigue-rated for accurate measurement of applied loads (±0.1%), with a one-piece sensing structure that is heat-treated to improve repeatability and linearity and minimize hysteresis. Its multi-column design enhances sensitivity while retaining high axial stiffness, overload capacity and long-term stability. It resists extraneous forces and moments to increase accuracy and allow high lateral and overturning moment stiffness. The transducer also features massive, low-stressed ends to ensure low hysteresis and minimal end attachment effect.

Tests/Standards

- Uniaxial Compressive Strength Test (ASTM D2938-86 and ISRM Suggested Method for Determining the Uniaxial Compressive Strength of Rock)
- Deformability of Rock Materials in Uniaxial Compression (ASTM D3148-86 and ISRM Suggested Method for Determining the Deformability of Rock Materials in Uniaxial Compression)
- Creep of Cylindrical Hard and Soft Rock Specimens in Uniaxial Compression (ASTM 4341-84 and ASTM 4405-84)

INDIRECT TENSION (BRAZIL TEST)

An Indirect Tension Test configuration uses an indirect tension fixture, a force transducer with load frame attachment kit, a signal conditioner, a cable from the force transducer to the load frame and six to eight spacers, depending on specimen size and load frame model.

The indirect tension fixture has a lightweight yet robust aluminum body (>Rc 58) with hardened end caps that are ground flat (less than 0.0005 mm/mm over line of contact) to minimize stress concentrations. These specially designed, size-specific end caps have an arc radius that matches the specimen contact area to further minimize stress concentrations and off-axis loading. In addition, the fixture's self-aligned design does not depend on the alignment of the load train. Instead, it ensures proper alignment over the full travel range of the fixture with large-diameter, chrome-plated columns guided through low-friction bearings. Bending moments are avoided with a retained spherical seated washer at the top of the fixture.

The force transducer is the same fatigue-rated model used for compression testing.

Tests/Standards

- ASTM Standard D3967-86
- ISRM Suggested Methods for Determining Indirect Tensile Strength by the Brazil Test

DIRECT TENSION

Direct tension testing involves a direct tension fixture, a force transducer and spacers. The fixture has robust, orthogonally mounted leaf chains and spherically seated upper and lower joints to ensure alignment of load along the center axis of the specimen. Clevis pin attachment of end caps makes changing specimens fast and easy, and eliminates the need for fixture disassembly. End cap design ensures strong, even distribution of epoxy across specimen end surfaces, as well as around the circumference of the specimen end when greater adhesive strength is required. Alignment hardware is provided to ensure end-cap-to-end-cap alignment when attaching end caps to the specimen. Four sets of specimen end caps are provided. The force transducer is the same fatigue-rated force transducer used for compression and indirect tension testing.

Tests/Standards

- ASTM D-2936-84
- ISRM Suggested Method for Determining Tensile Strength of Rock Materials

Triaxial testing

FRACTURE TOUGHNESS

Fracture toughness testing helps determine the Critical Stress Intensity Factor (K_{Ic}) of chevron-notched core specimens in the three-point bend configuration. This configuration uses a bend fixture, force transducer, three to seven spacers (depending on specimen size, force transducer and load frame), strain measurement kit, clip-on gage, four knife edge sets for mounting the clip-on gage to the specimen, dual LVDTs with averaged output for load point displacement measurement, LVDT mounting fixture and alignment tools, four signal conditioners and cables.

The bend fixture helps locate strain and displacement transducers on the specimen to obtain accurate, repeatable results. It includes a strain measurement kit for accurate measurement of specimen strain. Alignment hardware helps locate the displacement gage and dual LVDTs on the specimen, and correctly orients the specimen on the fixture. The fatigue-rated force transducer is the same model used in compression, indirect and direct tension testing.

Tests/Standards

» Fracture Toughness Test (ISRM Suggested Method for Determining Fracture Toughness of Rock on Chevron Bend Specimens, Level I and Level II)

TRIAXIAL COMPRESSION/TRIAXIAL CREEP

Triaxial compression/creep tests combine the uniaxial compression accessories described previously with a triaxial cell assembly to simulate in situ stresses, temperatures and pore fluid pressures, and then investigate the effects of changes in these conditions on the specimen.

The MTS triaxial cell assembly features a fatigue-rated cell with hydraulically controlled lift and lock cylinders for quick opening and closing. A bolted flange connection at the base plate ensures easy and secure vessel closure. The track and carriage assembly are integrated with the load frame for easier cell installation and removal. The load train itself is designed to accommodate extension testing. Electrical and fluid feed-throughs are rated for high pressure and temperature, and specimen endcaps are available for high-force compression tests, extension tests and pore fluid and permeability tests.

Tests/Standards

» ASTM D2664-86 (Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements)

» ASTM D4406-84 (Creep Test of Rock Core Specimens in Triaxial Compression at Ambient or Elevated Temperature)

» ISRM Suggested Method for Determining the Strength of Rock Materials in Triaxial Compression

TRIAXIAL DEFORMATIONAL STRESS PATHWAYS

It is possible to map deformational stress pathways using MTS rock mechanics test systems, triaxial accessories and FlexTest digital controls. Hydrostatic compression and triaxial compression are performed using standard equipment and direct transducer inputs to the FlexTest controller. The remaining stress pathways use the transducer inputs, as well as the calculated input feature of the FlexTest controller.

The hydrostatic compression pathway enables direct measurement of the bulk modulus. It allows you to obtain Skempton's coefficient B and Biot's coefficient α if the pore fluid volumes and pressure were measured, as well as the hydrostatic compaction point for pore collapse. The triaxial compression pathway provides direct measurement of Young's modulus and Poisson's ratio from the stress/stain curves, along with data useful for determining the shear failure surfaces and ductile yield surfaces.

The uniaxial strain compression pathway involves a test that represents the deformation that occurs when a rock is buried in a depositional basin or deforms as a response to fluid withdrawal during production from oil and gas reservoirs. This pathway provides data representing the approximate deformation of a reservoir rock during production, approximates the deformation of a sediment or rock in a depositional basin, and provides data about the pore collapse region.

Constant K ratio compression represents the deformational pathway followed by a producing reservoir rock. It provides data about the pore collapse region and can generate a constant differential stress pathway or constant mean pressure pathway. The constant differential stress pathway provides data to compare the effect of axial stress σ1 on the material characteristics with similar data obtained from the hydrostatic pathway (equal stress condition).

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