



Rock Triaxial Testing System

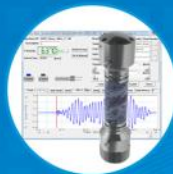
GCTS is committed to designing accurate testing systems by integrating innovative software engineering with advanced hardware.



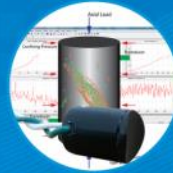
Rock Fracture Toughness



True Triaxial



Ultrasonic Velocity



Acoustic Emissions



Differential Strain Analysis



Direct Shear



Triaxial



Indirect Tension



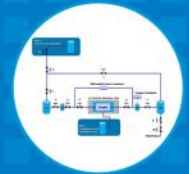
Hydraulic Fracturing



Electrical Resistivity



Direct Tension



Pulse Decay Permeability

Accuracy Is The Underlying Strategy

Rock Triaxial Testing System

RTR Series

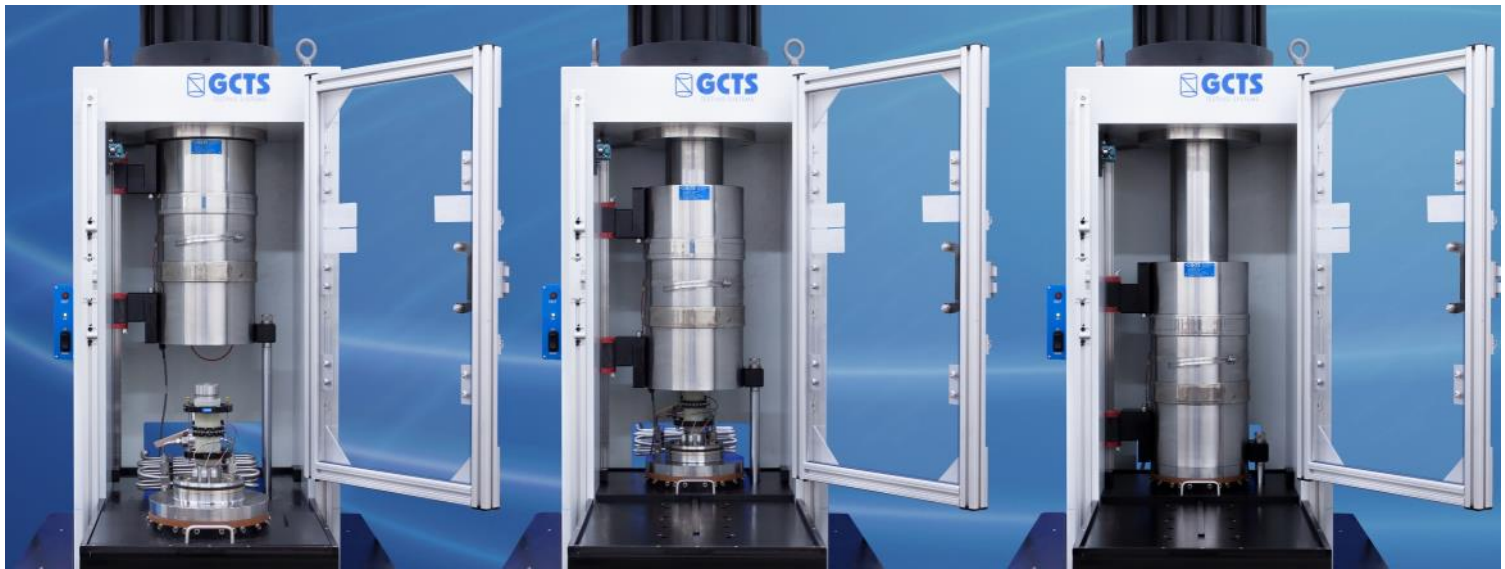


- **Static and dynamic closed-loop servo control**
- **Capable of performing strain or stress controlled & post failure behavior tests**
- **Axial load up to 4,500 kN**
- **Up to 210 MPa cell pressure capacity**
- **Frame stiffness up to 10 MN/mm**
- **Automated cell assembly, no fasteners used!**
- **Direct shear, true triaxial, ultrasonic, hydraulic fracturing, temperature control and many more optional upgrades can be added to the RTR system**
- **Meets all ISRM and ASTM specifications for triaxial testing of rock samples**

DESCRIPTION

We at GCTS are very proud of the RTR Rock Triaxial Systems. They are the most productive and easy to use systems on the market. Their proven design has reached a high level of maturity throughout time. The original design has gone through several iterations allowing our engineers to reach high level of system optimization. This optimization process has allowed for the development of the most advanced triaxial system on the market. At the same time, we have developed economic manufacturing processes making this design simply the best value available.

The GCTS Rapid Triaxial Rock Test System is a closed-loop digitally servo controlled system developed for accurately performing easy and quick triaxial and unconfined tests on rock specimens. In addition, the system is also capable of performing permeability, hydraulic fracturing, indirect tension, and many other advanced rock tests.



Sample Mounted

Cell Base Inserted into Load Frame

Cell Wall Lowered Ready for Testing

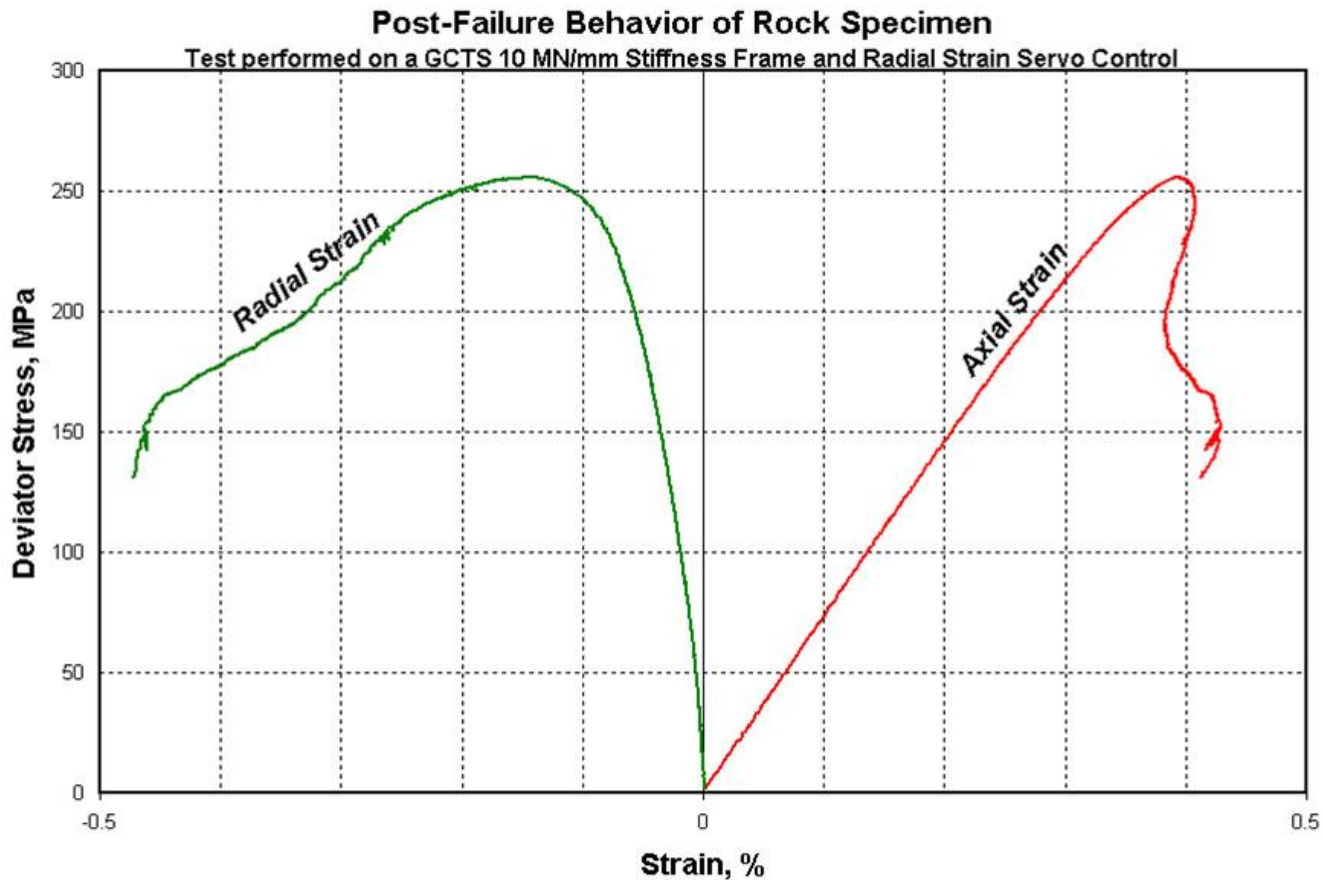
An automatic hydraulic lift and a sliding base for the triaxial cell are included with this system for fast and easy specimen setup as compared to conventional triaxial cells. Fast assembly/disassembly of the cell is achieved with the push of a single button. No bolts or other fasteners are used to assemble the triaxial cell, resulting in more time dedicated to testing.

The triaxial cell is constructed of stainless steel and accommodates cylindrical specimens of up to 75 mm in diameter. The system can be upgraded with a larger triaxial cell for up to 100 mm diameter specimens standard unit features a stiff loading piston and low friction graphite seal. The advantages of the self-contained cell wall are that after the specimen is completely ready for a test, the cell wall is conveniently lowered and is automatically locked into place. An internal load cell can be provided as an option, although the piston friction is typically negligible. Other options include the internal instrumentation and stiff frame upgrades for precise measurement of the deformation modulus and post-failure behavior studies.

The standard RTR system includes two pressure intensifiers for controlling the cell and pore pressures. Each pressure intensifier is housed inside a metal cabinet with casters that also include a 20 liter fluid reservoir, precise analog gages, high pressure valves, flow indicators, etc. making them very convenient and easy to operate. Pressure gauges provide

a visual verification of confining and pore pressures. Convenient “quick-connect” fittings allow for easy connection of pressure lines and filling/draining the fluid reservoirs. Sight tubes are also available to show the available amount of fluid in each fluid circuit. Each pressure intensifier has a pressure transducer and LVDT connected to them allowing for the servo control as a function of pressure, fluid volume control, or any other measured or calculated test parameter. With both pressure intensifiers, advance tests such as stress/strain path, K_0 , permeability, hydraulic fracturing (requires special platens) can be easily performed.

The RTR is operated with our fully integrated SCON digital signal conditioning/controller and the state-of-the-art CATS-TRX-ROCKS software. Conducting Triaxial tests have been greatly simplified by the incorporation of direct user programming of test calculated parameters in the units of interest (stress, strain, etc.) based on the specimen dimensions. Up to 20 test parameters are automatically defined and corrected taking into account such things as piston uplift force from confining pressure application and changes in specimen area during the test. These parameters are calculated in real time and are available for display, graph and/or control. In addition, CATS software allows you to define user defined parameters to obtain multiple sensor averages or corrections as a function of other inputs. Using calculated test parameters directly



Typical Test Results

eliminates complex and lengthy pre-calculations to design test programs. This allows the user to concentrate on the material behavior rather than on the electronics and equipment operation. GCTS offers compatibility with network systems that allows monitoring or sending your test data directly to any computer connected to your network. Any desired unit can be used for display or report test parameters even allowing to combine different unit systems.

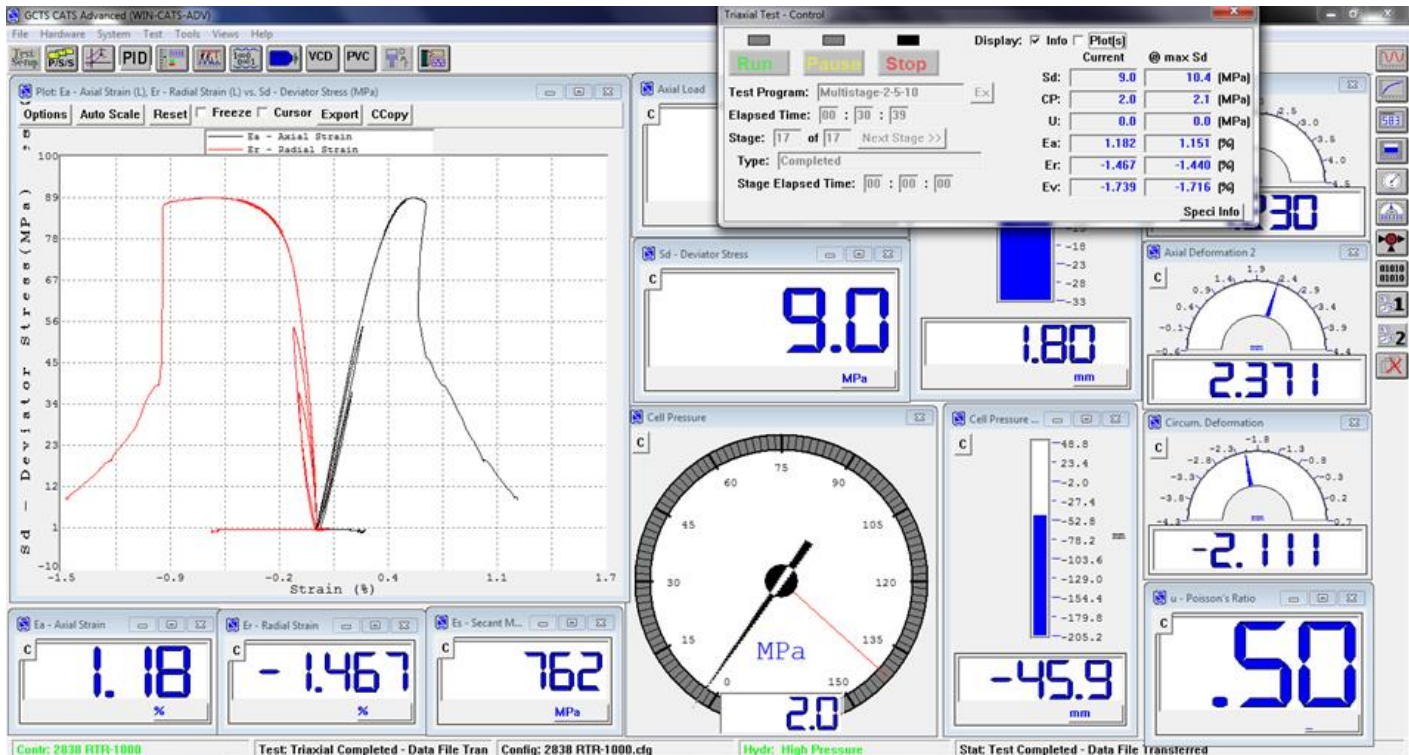
The embedded microprocessor is capable of performing all test functions even if the Windows computer crashes. It provides automatic dynamic control mode switching between any connected transducer or calculated parameter (“bump-less transfer”). This controller also conditions all transducers used for triaxial testing and provides real time linearization of any input using high-order polynomials. This digital controller is capable of updating the control loop at up to 6 kHz required to control the loads for brittle specimens. The SCON has several adaptive compensation techniques to improve the control precision without user intervention.

RTR systems can be supplied with gTest iPhone/iPad app. gTest is a remote monitoring application used to display test status in real time. Current test information can be displayed digitally or graphically from any location. Sensor outputs, hydraulic power supply status, cycle count, and other general test progress can be accessed through your local wireless network or through the internet at remote locations.

This application can be used to facilitate transducer setup where a view of the computer screen might be obstructed as the test specimen may be placed inside an environmental chamber or some other hard to reach place. This application allows the user to move freely around the testing system and check every one of the test sensors to ensure they are properly working and set at their right position. gTest app improves productivity and eliminates requirement for a second person to setup and start a test.

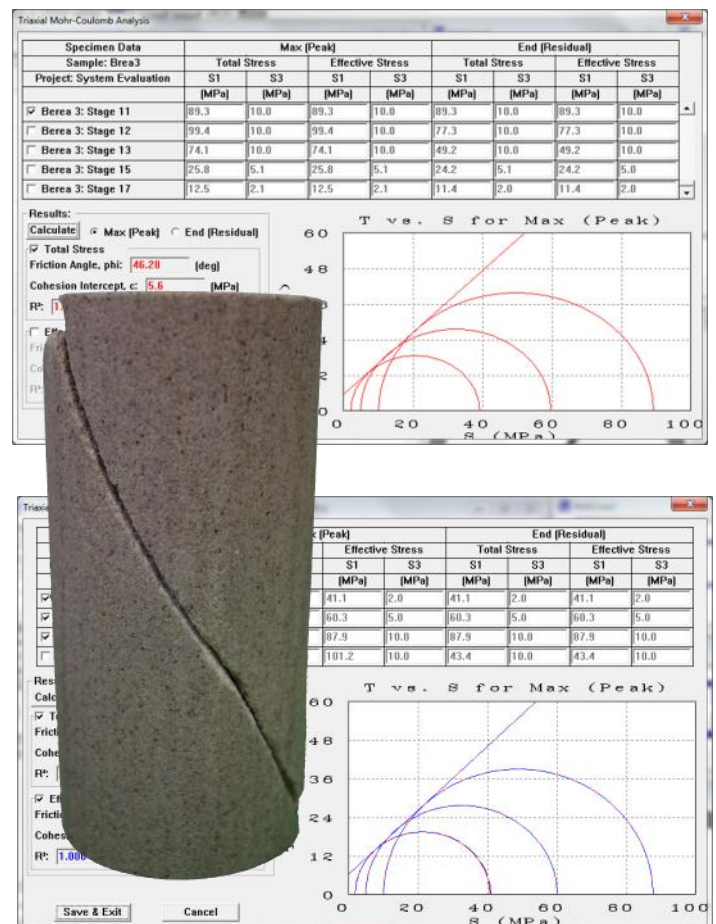
Together with GCTS excellent support from our highly qualified and experienced staff, we are sure to provide the best solution and price-performance value.

RTR Multi Stage Testing



Test Example: RTR systems can be used to conduct multi stage triaxial test with ease. A test program and test results for performing a multistage triaxial test including obtaining residual strength at each different confining pressure are presented. The test was performed on a single Berea Sandstone specimen with 50 mm diameter and 100 mm height. Two axial deformation sensors and one circumferential sensor were mounted onto the specimen.

Three different confining pressures were programmed: 2.0, 5.0 and 10.0 MPa. The end of the stage was detected automatically by CATS software when the Poisson's Ratio reached a value of 0.5. At the end of the last stage the 10 MPa was kept constant and the control switched to radial strain control to subject the sample to large strains while keeping it from exploding after reaching the peak stress. A stiff loading frame was also used to perform this test and observe the post-failure behavior. After the deviator stress applied to the specimen was reduced by more than 25% of the peak stress the test was switched to frame displacement control to ensure stability (the internal instrumentation mounted onto the specimen is susceptible to slide a bit if its holding point coincides with a failure plane). The sample was strained at 1 mm/minute for 0.25 minutes and the resulting deviator stress was considered the residual stress for that confining pressure. Then the confining pressure was reduced to 5 MPa and again the specimen was strained at constant rate for 0.25 minutes. The final deviator stress was considered, then the residual stress for the 5 MPa confining pressure. A similar process was applied for the 2 MPa confining pressure.



Multi stage triaxial test on a Berea specimen

A - Axial Load:

RTR systems can be fitted with loading actuator rated from 1,000 kN to 4,500 kN axial load

B - Frame Stiffness:

RTR load frames are available in three stiffness levels:

- Standard: 2,000 kN/mm
- Medium: 5,000 kN/mm
- High: 10,000 kN/mm

D - Pore Pressure:

70, 140 or 210 MPa

C - Confining Pressure:

70, 140 or 210 MPa

E - Specimen Size:

Maximum specimen diameter with internal instrumentation:

- Model A: 65 mm
- Model L: 100 mm



RTR	A		B		C		D		E	
	A - Axial Load (kN)	B - Frame Stiffness (kN/mm)	C - Confining Pressure (MPa)	D - Pore Pressure (MPa)	D - Maximum Specimen Diameter (mm)					
	1,000	S	2,000	Automatic Control	Automatic Control	A	65			
	1,500	M	5,000	70A	70A	L	100			
	2,000	H	10,000	140A	140A					
	2,500			210A	210A					
	3,000			Manual Control	Manual Control					
	4,000			70M	70M					
	4,500			140M	140M					
				210M	210M					

RTR VERSATILITY

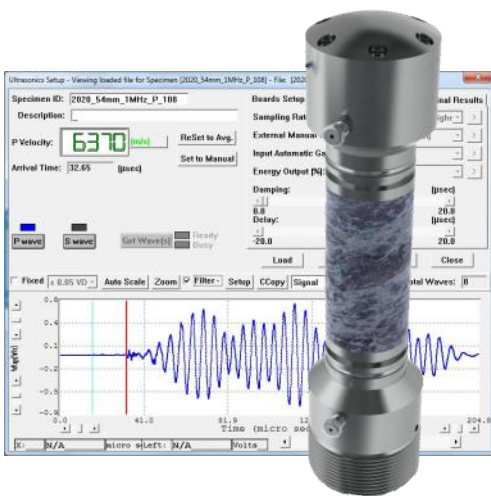


TRIAXIAL TESTING

RTR is an ideal triaxial testing system for any research or commercial rock mechanics laboratory. RTR features automatic locking triaxial cell as well as automatic cell filling and draining which reduces the test preparation significantly and ensures safe test setup. GCTS RTR systems can accommodate up to 100 mm (4 inch) diameter specimens.

- Direct measurement of axial and lateral strains on specimen
- LVDTs used for easy operation
- Very easy to setup and use

ULTRASONIC (ACOUSTIC) VELOCITY MEASUREMENT



RTR can be supplied with the ULT-100 Ultrasonic Measurement System for different specimen types and sizes.

- Measure compressional and shear wave velocity
- Transducer loading platens with 80 to 1000 kHz frequency
- Digitally controlled pulser & receiver
- Automatic readings taken at any stress, strain or other sensor level
- Software for data analysis integrated with RTR software

POLYAXIAL - TRUE TRIAXIAL

RTR can be supplied with the RPX Polyaxial (True Triaxial) fixture for independent control of all principal stresses .

- Perform true triaxial tests
- Independent control of σ_1 , σ_2 and σ_3
- Economical solution for a complex test
- Fits inside standard GCTS triaxial cells



RTR VERSATILITY



DIRECT SHEAR

Direct shear testing is an optional feature within the RTR system. The DSH upgrade can be ordered with the new RTR system or supplied at a later date to be retrofitted to an existing RTR system.

- Measure peak and residual shear strength of rock specimens
- Constant normal stress or normal stiffness control
- Closed loop servo control of shear and normal actuators
- 152 mm (6") inside diameter specimen rings
- ± 500 kN shear load capacity



DIFFERENTIAL STRAIN ANALYSIS

DSA-12 Differential Strain Analysis Device is used for testing cubical rock specimens under hydrostatic conditions to simulate the in-situ stress state. The results with DSA-12 allow for characterization of the distribution of fracture porosity with fracture closure pressure as the fracture orientation as a function of fracture closure pressure amongst other parameters.

- Differential strain analysis
- 12 LVDTs used to measure specimen deformations
- Cubical specimens with 50 mm sides accommodated



TEMPERATURE CONTROL

Temperature control is important for simulating the in-situ environmental conditions. RTR system can be upgraded with temperature control system for both high and low temperatures.

- High Temperature control option up to $+200$ °C
- High Temperature control option up to $+150$ °C
- Low Temperature control option down to -30 °C
- Combined Temperature control option from -30 °C to $+150$ °C

RTR VERSATILITY



INDIRECT TENSION

The GCTS IDT-B Rock Apparatus is used for determining indirect tensile strength by the Brazil test according to the International Society for Rock Mechanics standard.

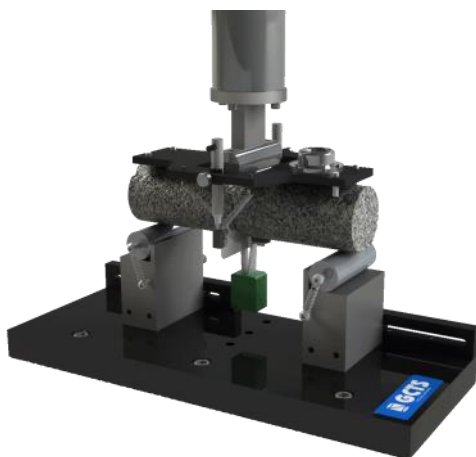
- Fixtures for any specimen size up to 150 mm diameter (Note that ISRM recommends that the diameter should not be less than NX—54 mm)
- Made of hardened stainless steel
- Can be used with GCTS uniaxial, triaxial or point load test frames



DIRECT TENSION

Tensile strength of rock is an important parameter for design and stability analysis for a range of cases including underground structures. Although indirect tension test is used to determine tensile strength a more robust approach is a direct tension test. RTR system can be configured with all the accessories required to conduct the direct tension tests.

- Direct measurement of tensile strength
- Accessories available for any specimen size up to ϕ 150 mm
- Comes with specimen preparation equipment for easy setup

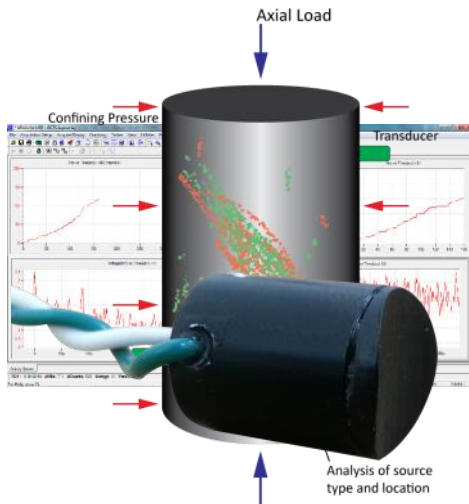


FRACTURE TOUGHNESS

The RTR Rock Fracture Toughness fixture (RFT-V100) is designed for testing cylindrical specimens under unconfined conditions to determine fracture toughness of rock materials. The fracture toughness results allow for classification and characterization of intact rock with respect to its resistance to crack propagation.

- Fixture for determination of rock fracture toughness
- High precision LVDTs and clip gage for strain measurement
- Adjustable base design for different size specimens

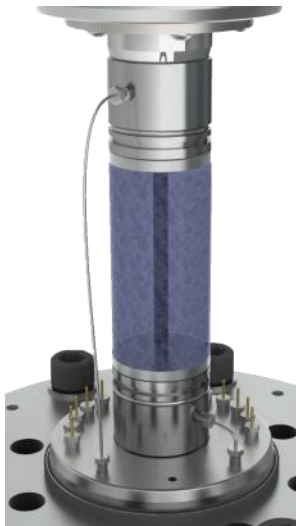
RTR VERSATILITY



ACOUSTIC EMISSIONS

Acoustic emission testing is an optional feature within the RTR system. GCTS has developed AE sensors that can be used inside the triaxial cell mounted on the specimen. The AE upgrade can be ordered with the new RTR system or supplied at a later date to be retrofitted to an existing RTR system.

- Record acoustic emissions
- Can be used inside the triaxial cell
- Available for different specimen sizes



HYDRAULIC FRACTURING (FRACKING)

The GCTS Hydraulic Fracture fixture allows for the performance of fracture tests within any of the standard GCTS Rock Triaxial Cells and the use of a GCTS HPVC pressure intensifier. This fixture is typically used for hydraulic fracture, well bore stability, and permeability tests. Tests can be performed with or without confining pressure.

- Perform hydraulic fracturing, well bore stability, and rock permeability tests within GCTS rock triaxial systems
- Fixtures available for 25 mm to 100 mm diameter specimens

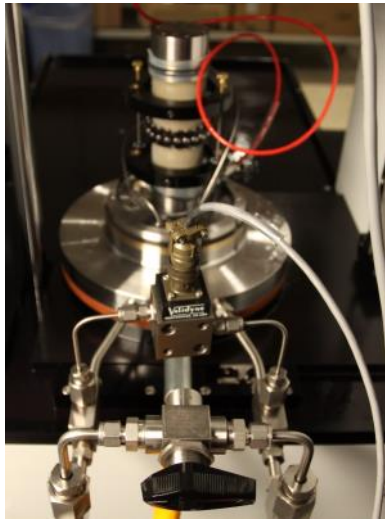


ELECTRICAL RESISTIVITY

The GCTS Rock Resistivity System (RES-100) is designed for measuring electrical resistivity in cylindrical specimens under confined conditions. The electrical resistivity of rock is an important parameter and can be used for variety of application, such as reservoir engineering, determination of oil in place and calibration of resistivity field logs.

- Four electrode system
- Includes two voltage and two current electrodes along with insulation membranes

RTR VERSATILITY



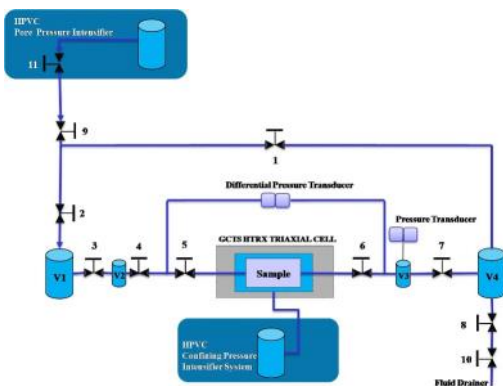
STANDARD PERMEABILITY

RTR systems can be used to measure permeability on medium to high porosity rock specimens. The setup uses an accurate differential pressure transducer to measure low pressure heads while withstanding high absolute pressures.

- Measure permeability under triaxial conditions
- Large volume stroke to measure permeability under continuous flow
- Constant pressure head or constant flow automatic control

PULSE DECAY PERMEABILITY

The GCTS Fast Pulse-Decay Permeability Apparatus (HPPD-20) is designed for measurement of permeability in micro-porous material such as gas shale and other reservoir rocks, in order to determine the capacity and flow characteristics of the rock matrix. HPPD-20 is capable of measuring rock permeability less than $1 \mu\text{D}$ (microdarcy).



- Apparatus for measurement of rock permeability using the Fast Pulse Decay method
- Integrated temperature control system inside the cabinet

TESTING WITH CORROSIVE FLUIDS

Triaxial and permeability testing is usually done with pure water as the pore fluid, however sometimes corrosive fluid which are encountered in the field, such as brine, have to be used. These types of fluids cannot be used with standard materials and have to be handled with specially made components. GCTS Pore Fluid Transfer Cell when used with HPVC pressure intensifiers is ideal for the control of the pore pressure in triaxial tests, head pressure in permeability tests, or fluid pressure in hydro-fracture tests when corrosive fluids are used as the pore fluid.





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