Rocks

45 Rock mechanics

According to the "Committee on Rock Mechanics, National Academy of Sciences", rock mechanics is a theoretical and applied science concerning the physical behaviour of rocks subjected to stress conditions of different origin. In general terms, rock mechanics involves the study of underground works such as tunnels and surface construction such as open quarries or dam foundations.
When a rock sample is subjected to defined stress conditions in the laboratory, the stress-strain diagram can show behaviours of non linearity also for very small strains, hysteresis, anisotropy, fluage conditions, etc. All these phenomena can be mathematically described.
This section proposes a complete range of testing equipment including Automatic test systems for the determination of Elastic Modulus and strength characteristics of rock specimens in uniaxial and triaxial conditions.

45 Rock mechanics

Behaviour of joints

The behaviour of joints is of particular interest: joints originate from geological failures; a break in the rock mass continuity along which no visible displacement has occurred.
From a rock mechanics point of view, the discontinuities are characterized by a mechanical strength lower than the original rock matrix and require detailed test investigations summarized as follows:

Tilt test Performed with the Tilt test apparatus, 45-B0096.
Surface roughness of the joint Performed with the Profilometer (Barton comb), 45-D0566 or 45-D0566/A.
Shear strength of the joint Performed with the Rock shear box apparatus, 45-D0548 or 45-D0548/D.

45-B0096
Tilt test. apparatus

This device is used to calculate the JRC (Joint Roughness coefficient) of a rock joint. It consists of an adjustable inclined plate, on which the rock sample (maximum 100 mm diameter) is placed, separated along the surface where the roughness is to be measured. The plate is then slowly tilted until the upper part of the sample starts to slide over the lower one. From the measured inclination angle it is possible to evaluate the roughness index.

Inclination angle: 0 to 50°
Overall dimensions: 265 x 170 x 260 mm
Weight: 4 kg (approx.)

45-B0096

Profilometers (Barton comb)

Used for measuring the roughness profile of rock samples.

45-D0566

Profilometer (Barton comb), 300 mm length. Weight 1 kg (approx.).

45-D0566/A

Profilometer (Barton comb), 150 mm length. Weight 0.5 kg (approx.).

Rock shear box apparatus

Standards

ASTM D5607 | ISRM Suggested method

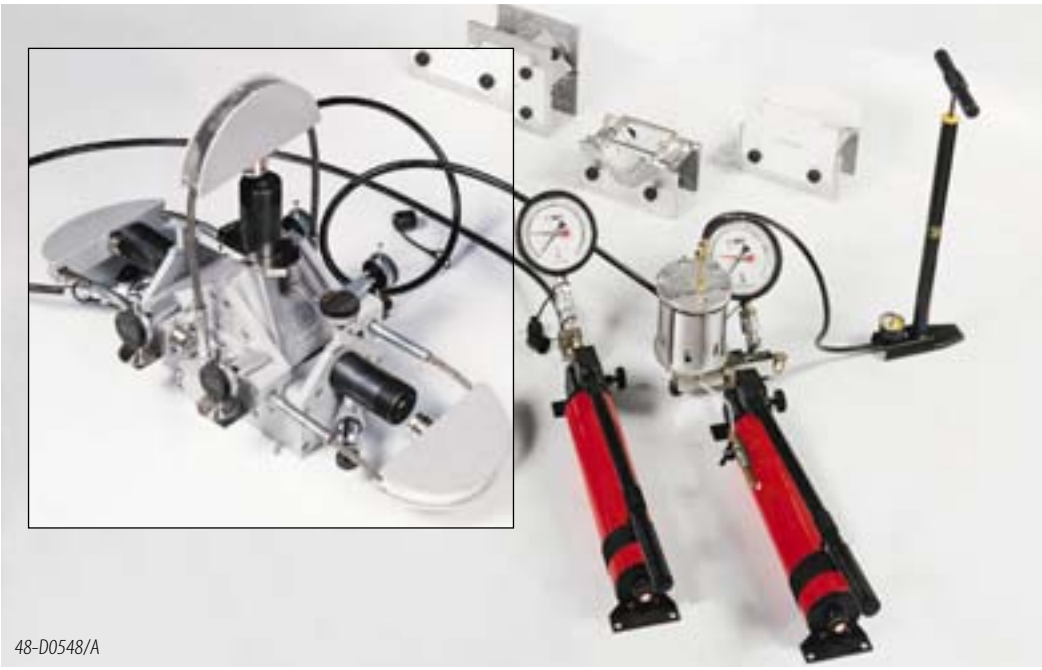
The test method offers a simple and practical way of determining the strength and slope stability of rock, both in the field and in the laboratory. The apparatus consists of a shear box designed to accept samples measuring no larger than 115x 125 mm, or alternatively, cores up to 102 mm diameter. The shear box is in two halves, the upper being connected to two rams for reversible shearing action and the lower connected to a ram for normal load application. The loads are recorded by Bourdon tube load gauges.

The normal loading system comes with an adjustable low-friction pressure maintainer to absorb any changes in the specimen volume during the shearing process and to ensure a constant vertical stress is maintained.

Two versions are available:

- **45-D0548/A**, supplied complete with two 50 kN pumps and manometers, five digital gauges (25 x 0.01 mm), and two mould forms used to ensure correct alignment of the sample before the test with cementation.
- **45-D0548/D (digital version)** comprises: 5 potentiometric transducers with 25 mm travel (4 vertical and 1 horizontal), 2 hand-operated pumps fitted with Bourdon gauges for applying lateral and vertical load, 2 pressure transducers for the direct acquisition of the load values on the external datalogger model 82-P9008 (see page 552)

Note: *High alumina cement for cementation of the sample is not included and has to be ordered separately - see Accessories.*



48-D0548/A

Specifications

Gauge range: 50 kN x 1 kN
Overall dimensions (loading frame only): 460 x 250 x 600 mm
Weight: 45 kg (approx.)

Classification tests

45-D0548/D: Detail of the shear box apparatus fitted with 5 displacement transducers

Ordering information

45-D0548/A
Rock shear box apparatus conforming to ASTM and ISRM suggested method.

45-D0548/D
Digital rock shear apparatus to ASTM and ISRM suggested method.

Accessories and spares

45-D0548/9
High alumina cement for the cementation of the sample in the shear box. 50 kg bag.

82-P9008
Datalog, 8 channel general purpose data acquisition device.
110-240 V, 50-60 Hz, 1 ph.

45-D0548/8
Spare shear box

45-P0070/6
Excel® template for data processing according to ASTM D5607.

45-D0561

Rock classification hammer

Standards

ASTM D5873 | ISRM Suggested method

Used to measure the rebound index on rock cores and samples. It is similar to the one used for testing concrete, but has a different level of impact energy: 0.74 Nm. Rock cores are positioned horizontally and the rebound index is obtained from the average of several measurements performed perpendicularly to the longitudinal axis, using the ASTM Rock cradle (45-D0562/A - see Accessories) as shown in the picture.

Weight: 1.5 kg (approx.)

45-D0561 with 45-D562/A

Accessories

45-D0562/A

ASTM rock cradle
This universal cradle can hold rock core samples with diameters from EX (21.46 mm) to NX (54.74 mm) size and greater. The cradle comprises a vertical hammer guide fitted to a steel plate of minimum mass conforming to ASTM D5873.

Dimensions: 220 mm diameter x 420 mm height (approx.)
Weight: 27 kg (approx.)

58-C0184

Calibration anvil

Standards

EN 12504-2 | ASTM C805 | ASTM D5873

Made from special alloy steel and supplied complete with a traceable hardness certificate, the anvil is essential for the periodical laboratory verification of the rock classification hammer.

Dimensions: dia. 150 mm x 230 mm
Weight: 16 kg (approx.)

58-C0184

Rock picks

Used for preliminary rock identification.

45-D1710
Rock pick with pointed tip.
Weight: 650 g (approx.).

45-D1711
Rock pick with chisel edge.
Weight: 550 g (approx.).

45-D1710, 45-D1711

Mohs hardness scale set

45-D0529
Mohs hardness scale. Set of 9 mineral specimens.

45-D0529

Rock strength index apparatus

Standards ASTM D5731 | ISRM Suggested method

45-D0550/E

Digital rock strength index apparatus (Franklin press).

This apparatus consists of a 60 kN capacity load frame with a hydraulic loading ram worked with a hand pump. The frame is adjustable, for testing samples measuring up to 102 mm diameter. A ruler mounted on the frame allows for direct measurement of the distance D between the conical platens before and after the test. The compression load is measured by a pressure transducer with an advanced digital display unit, assuring the best accuracy and resistance to failure shocks. The machine, when fitted with the accessory 45-D0550/D5, can also be used for compression tests on small cores or cylindrical specimens. The apparatus is contained in an easily transportable metal case and is supplied complete with clear safety goggles.

Specifications

- Load range: 0 to 60 kN
- Digital display: 2 x 16 characters
- Resolution: 32,000 divisions
- Load pacer: included
- Load units: kN and MPa
- PC connection: serial port
- Accuracy: ±1%
- Case dimensions: 800 x 500 x 280 mm
- Weight: 15 kg (approx.)
- Battery charger: 110-240V, 50-60 Hz, 1 ph

main features

- Light and portable unit
- Sample sizes up to 102mm diameter
- Accepts irregularly shaped samples
- High resolution digital display, battery operated
- Resistant to failure shocks
- Serial port for PC connection included
- Compression platens option for compression test on small cores and cylinder
- Safety goggles included

45-D0550/E

45-D0550/E during operation

45-D0550/E fitted with set 45-D0550/D5 for compression test

Accessories and spare parts

45-D0550/D5

Set of lower and upper platens, 52 mm diameter, with spherical seat.

45-D0550/D5

45-D0550/A7

Set of hardened conical points.

45-D0550/A8

Set of gaskets for cylinder and pump.

Specimen preparation

Laboratory coring machine and bits

This machine is specifically used in the laboratory for cutting core samples from hard materials such as rock and concrete. A clamp is provided to firmly secure the material during the cutting cycle. The coring area is protected with a transparent cylinder. A special clamping device for preparing rock samples from core pieces is also available - see Accessories.

Note: drill bits are not included.

Technical specifications

- Power unit: 1800 W
- Coring speed: 1485/2720 rpm
- Coring range: from 8 to 60 mm diameter
- Dimensions of the base tray assembly: 600 x 500 x 200 mm
- Weight: 80 kg (approx.)

Ordering information

45-C0330

Laboratory coring machine, 2-speed, complete with water inlet.
230 V, 50-60 Hz, 1 ph.

45-C0330/Z
As above but 110 V, 60 Hz, 1 ph.

Accessories

Drill bits with spigot adaptors

Code	Description	Specimen diameter		Effective length	D.C.D.M.A. reference
		mm	inches	mm	
45-C0342	Diamond core bit for	21.46	0.850	110	EX
45-C0343	Diamond core bit for	30.10	1.185	110	AX
45-C0344	Diamond core bit for	38.10	1.500	110	1.5 in.
45-C0345	Diamond core bit for	42.04	1.655	120	BX
45-C0346	Diamond core bit for	54.74	2.155	140	NX
45-C0347	Diamond core bit for	63.5	2.5	150	HQ

Clamping device

45-C0331

Clamping device for cores with a maximum diameter of 100 mm, complete with transparent guard.

45-C0331

45-C0330 with core bit, taking sample from a large rock core

45-C0330 with core bit and clamping device 45-C0331

45-D0343, 45-D0344, 45-D0345

Cutting saw

Description

This universal saw, when completed with suitable accessories, can be used to cut concrete and rock cores and irregular rock samples in order to obtain geometrically defined samples. It can be fitted with 300 to 450 mm diameter blades.

The head is adjustable in height and the tilting motor head permits cutting at an inclination of up to 45°. The tank and the trolley are zinc-plated to avoid corrosion. A water pump with double-filtering system for cooling the blade is included.

Note: *cutting blade and accessories to cut cores, rock and other building materials are not included - see Accessories.*

Specifications

Maximum cutting height: 115 mm with the 350 mm diameter blade and 165 mm with the 450 mm diameter blade
Maximum blade diameter: 450 mm
Power: 3 kW
Overall dimensions: 1300 x 700 x 700 mm (w x d x h)
Weight: 92 kg (approx.)

Ordering information

55-C0210/D
Rock, concrete and masonry saw. 380 V, 50 Hz, 3 ph.
55-C0210/DZ
As above but 220 V, 60 Hz, 3 ph.

Accessories

45-C0211/4
Diamond blade, 350 mm diameter, for hard rock.

55-C0211/1
Diamond blade, 350 mm diameter, for concrete.

55-C0210/1
Diamond blade, 450 mm diameter, for concrete.

55-C0210/5
V-shaped support for cylinders and cores up to 160 mm diameter.
Weight: 4 kg (approx.).

45-C0210/6
Locking clamp device for irregular pieces.

Note: *for more information about using the machine for cutting concrete core specimens, see page 297*

55-C0210/D with 55-C0210/1 blade and 55-C0210/5 V-shaped support for cylinders and cores.

55-C0210/D with 45-C0210/6 and 55-C0210/4

Core trimmer and cut-off machine

Standards ASTM D4543

This machine is used to obtain perfectly machined rock samples (cubes, prisms, etc.) from irregular rock or core pieces. It is supplied complete with a standard vice to hold irregular pieces (up to approx. 70 x 140mm) firmly in place, and a "V" device for cores up to 75mm diameter x 140 mm height. Longer cores can be machined by turning the sample upside down in the device. The machine also includes a cooling water inlet and transparent cover, conforming to CE requirements, with a switch that automatically stops the machine when it's opened.

The machine can be fitted with either a cutting blade or a double-faced cup wheel for surfacing the ends of cylindrical specimens.

Note: *blade, cup wheel and water pump are not included and have to be ordered separately - see Accessories.*

Specifications

Power: 1100 W
Blade speed: 3000 rpm
Dimensions:
730 x 1050 x 590 mm (approx.)
Weight: 100 kg (approx.)

Ordering information

45-D0536/A

Laboratory core trimmer and cut-off machine complete with water inlet.
230 V, 50 Hz, 1 ph.

45-D0536/AY
As above but 220 V, 60 Hz, 1 ph.

45-D0536/AZ
As above but 110 V, 60 Hz, 1 ph.

45-D0536/A, detail of spindle with clamping mechanism and cutting blade 45-D0536/2

45-D0536/A, detail of spindle with clamping mechanism and double-faced cup wheel 45-D0536/A3 during surface grinding of cylindrical specimen ends

45-D0536/A with cutting blade 45-D0536/2

Accessories

Cooling recirculating pump

45-D0536/1

Cooling recirculating pump complete with reservoir.
230 V, 50 Hz, 1 ph.

45-D0536/1Y
As above but 220 V, 60 Hz, 1 ph.

45-D0536/1Z
As abovebut 110 V, 60 Hz, 1 ph.

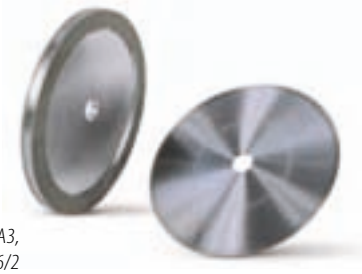
Cutting blade and cup wheel

45-D0536/2

Diamond cutting blade, 230 mm diameter x 2.8 mm thick. Maximum cutting area 110 x 70 mm.

45-D0536/A3

Double-faced diamond cup wheel, 230 mm diameter x 16 mm thick.
Used for finishing/grinding sample ends parallel and at right angles to the axis.



45-D0536/A3, 45-D0536/2

Specimen grinding machine 55-C0201 series

Standards

EN 12390-2 | ASTM D4543

This machine is used to grind and polish rock and concrete specimens, natural stones, ceramic materials, etc.
Two versions are produced:

- 55-C0201/B Standard: in this version the radial displacement of the grinding head is motor operated and activated with a push button.
- 55-C0201/C Automatic: in this version the radial displacement is fully automatic and controlled by travel limit switches.

All the other characteristics are identical.

The machine is supplied complete with a safety chip-guard (which, when removed, automatically stops the machine), a coolant tank, motor pump, and one set of abrasive sectors. Diamond grinding sectors are available on request (see Accessories).

The 45-D0534/B Core face preparation jig can be easily fitted using the clamping element supplied with the machine.

Note: *for more details and information about using these machines for grinding concrete specimens,* *see page 296*

55-C0201/B

Ordering information

55-C0201/B
Specimen grinding machine.
220-380 V, 50Hz, 3 ph.

55-C0201/BZ
As above but 220 V, 60 Hz, 3 ph.

55-C0201/C
Specimen grinding machine with automatic radial displacement of the grinding head. 230-380 V, 50 Hz, 3 ph.

55-C0201/CZ
As above but 220 V, 60 Hz, 3 ph.

Accessories and spares

55-C0201/B2
Set of 10 diamond impregnated sectors.
Weight: 4,6 kg (approx.).

55-C0201/B1
Spare set of 10 abrasive sectors.
Weight: 2 kg (approx.).

45-D0534/B
Core face preparation jig, for preparation of parallel and flat core faces using horizontal surface grinders (e.g. 55-C0201/B). Consisting of a 4-place locking device capable of clamping core samples from 20 to 55 mm diameter, it can be mounted on most grinding machines with or without a magnetic chuck.
Weight: 6 kg (approx.).

45-D0534/C
As 45-D0534/B but consisting of a 2 place docking device capable of clamping core samples from 50 to 100 mm diameter.

45-D0534/C

45-D0534/B

Strength and deformability tests

UNIAXIAL AND TRIAXIAL TESTS

Most of the information obtained from laboratory tests on rock are substantially related to the stress and strain characteristics of the tested materials. The tests most generally performed on cylindrical rock samples are the following:

- Evaluation of the compressive strength and strain under uniaxial conditions
- Evaluation of the compressive strength and strain under triaxial conditions

Uniaxial test

Standards

ASTM D2938 | ASTM D3148

Recommended by ISRM: Suggested methods for determining the uniaxial compressive strength and deformability of rock materials

The uniaxial test is performed by applying increasing vertical stress at a constant rate of between 0.5 and 1.0 MPa/s. Axial and radial strains are measured with high precision (about $5x10^{-6}$). Subsequent load-unload cycles are also carried out to obtain an accurate evaluation of the compressibility properties.

Triaxial test

Standards

ASTM D2664 | ASTM D5407

Recommended by ISRM: Suggested methods for determining the strength of rock materials in triaxial compression

The triaxial test is performed on prepared rock specimens which are contained in a rubber sealing membrane and placed within a triaxial chamber. They are then subjected to a constant isotropic confining pressure (generally between 5 and 60 MPa). A vertical stress is subsequently applied; tests and measurements are carried out in the same way as for uniaxial tests.

From the measurements recorded during the tests the following information is obtained:

- Rate of stress versus axial and radial strain
- Maximum stress / failure stress
- Tangent and secant Young's modulus measured from the stress-axial strain curve
- Poisson's ratio, obtained from the change in radial and axial strain
- Maximum stress versus applied cell pressure (in the triaxial tests) to define the failure envelope and the corresponding properties (cohesion and friction).

Other significant parameters investigated in the triaxial test are the permeability characteristics of rocks, and rock behaviour, when subjected to high water pressure, especially important for the study of dam foundations, and generally for underground tunnels and cavities.

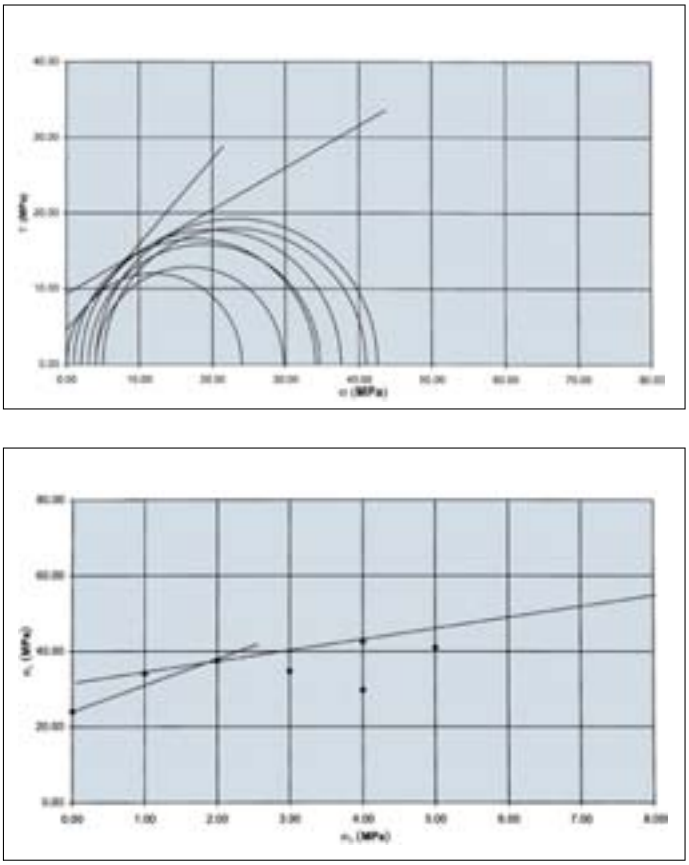
Testing systems

We produce three systems which differ for sophistication and automation:

ADVANCED Automatic system for Uniaxial and Triaxial tests on rock specimens (see page 180)

Triaxial test is carried out automatically at a multiple failure stages, the strength envelope is obtained with a single test by a stepwise procedure, from a single specimen it is possible to plot the complete failure path.

The system is based on ADVANTEST ROCK and SERCOMP 7 ROCK Servo-hydraulic units and it features the full automation of triaxial testing including stress path (multi - stage) and post-peak softening analysis.



Triaxial test on rock material. Typical failure envelopes, diagrams σ vs τ and σ_1 vs σ_3.

Automatic system for Uniaxial and Triaxial tests on rock specimens (see page 187)

Based on the AUTOMAX E MODULUS for axial load and SERCOMP 7 for confining pressure. The whole system performs either uniaxial or triaxial automatic tests under load/stress control.

The 2 consoles are operated independently and the failure envelope is obtained by few individual tests (single - stage) with automatic application of axial load and confining pressure at different levels.

Semi-automatic system for Uniaxial and Triaxial tests on rock specimens (see dedicated web page for details and ordering information).

Based on a standard compression machine for axial loading and a manually-operated pump for confining pressure. It performs either uniaxial or triaxial tests under load/stress control. Failure envelope is obtained by few individual tests (single - stage) with manual application of axial load confining pressure at different levels.

Advanced automatic uniaxial and triaxial test system

Standards

ASTM D2664 | ASTM D3148 | ASTM D5407 | EN 14580 | EN 1926

ADVANTEST

ADVANTEST ROCK

- For determining elastic and Poisson modulae and strength characteristics of rock specimens under uniaxial and triaxial conditions.
- Automatic performance of triaxial tests with individual but combined control of axial load and confining pressure including stress-path procedure.
- Fully customizable test procedure including axial and later pressure combining laws.
- Fully integrated data acquisition and results elaboration including strength envelope diagrammimg.

ADVANTEST ROCK: an advanced testing system specifically designed for rock testing

Our Automatic Rock Mechanics test systems are designed for testing various materials, from soft sandstone to high-strength basaltic samples.
Triaxial tests with multiple failure stages are carried out automatically, making it possible to plot the entire failure path from a single specimen.
The complete test system includes:

ADVANTEST Rock Servo-hydraulic control console

For Uniaxial and Triaxial tests

For application of load in conformance with the relevant standards.

The ADVANTEST Rock (45-C9842/RCK) manages strain-controlled load-unload ramps automatically and includes a dedicated software module for testing rock under triaxial conditions, applying confining pressures at definable values. When the specimen approaches failure, the system automatically and instantaneously increases the confining pressure to the next defined value to increase the specimen's strength.

It is therefore possible to build the complete failure path using a single specimen (multi-stage triaxial tests).

The ADVANTEST Rock can also be used for load, stress, displacement and strain-controlled testing of concrete, fibre-reinforced concrete and Shotcrete etc.

Sercomp 7 Rock Servo-hydraulic control console

For Triaxial tests

For control of confining pressure.

The Sercomp unit (45-C7022/RCK) has been specifically designed for triaxial rock testing and works as a remotely-controlled pressure unit, managed by the ADVANTEST Rock control console.

With the tests carried out under displacement controller conditions the cell pressure is maintained constant and axial stress is increased. When the sample approaches peak strength, the cell pressure is automatically increased up to a defined level.

Cell pressure is again maintained constant and axial stress is increased. When the sample again approaches peak strength, the cell pressure is further increased.

The above procedure is automatically repeated several times.

When maximum peak strength is reached, the test is continued.

Cell pressure is reduced in steps and, for each step, the residual strength is measured.

All the peak strengths are plotted against the corresponding values of cell pressure, thus building the complete failure path.

High-stiffness compression testing frame

For Uniaxial and Triaxial tests

Several different frames are available - the appropriate one should be selected according to the size and expected strength of the test specimens. Due to the typical high strength and fragility of rocks we recommend using the higher capacity frames (4000 kN or 5000 kN).

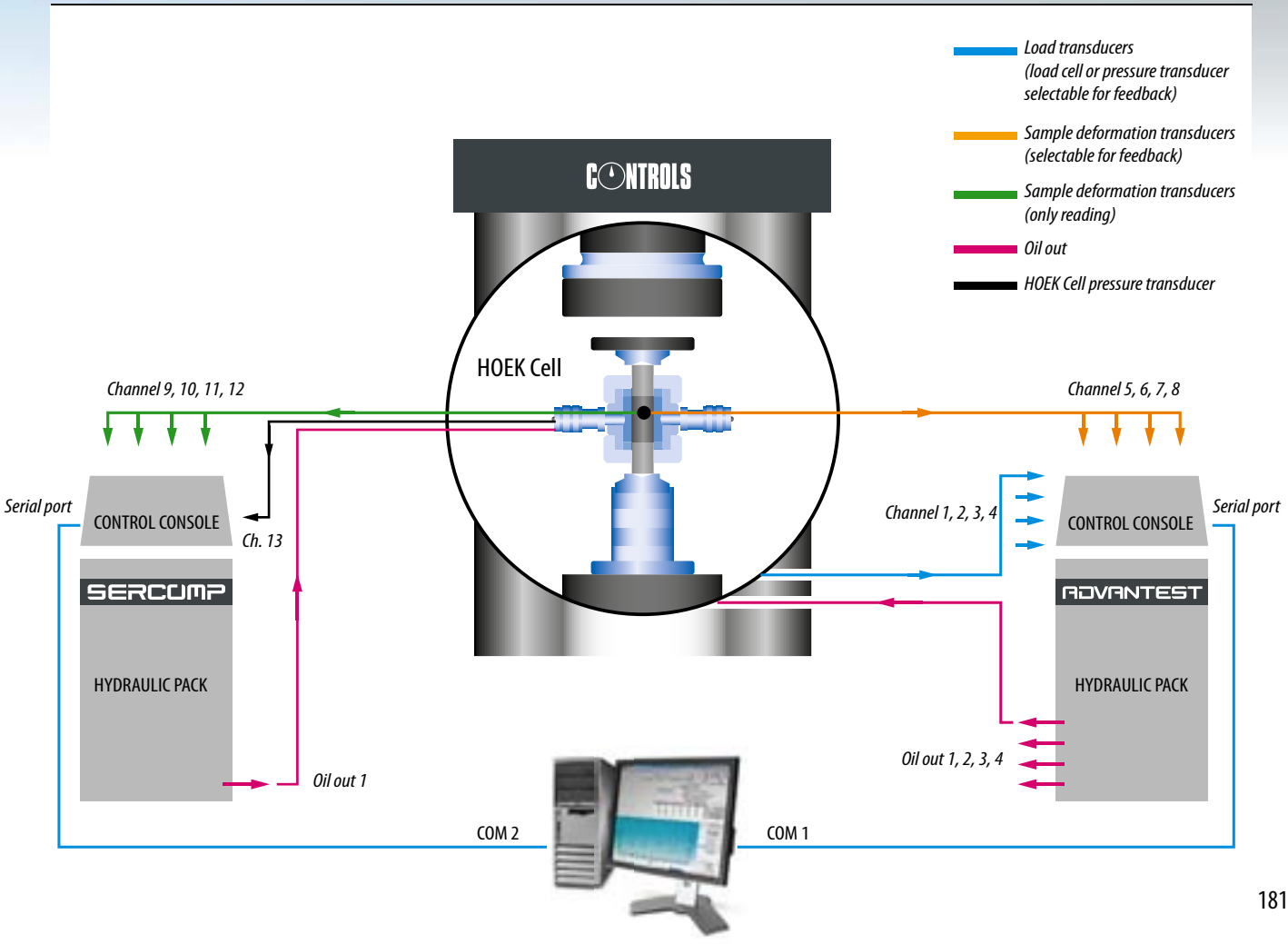
For more information see page 216 EN 12390-4 compression frames.

Accessories

Hoek cells (for triaxial tests), see page 184
Strain gauges and accessories (for uniaxial and triaxial tests), see page 185
Sample extruders, see page 185
Compression device (for Uniaxial tests) see page 186
For a typical configuration of an Automatic triaxial test system, see page 186,187

3000 kN compression frame 50-C86Z00 with Hoek cell, 45-C9842/RCK ADVANTEST Rock, 45-C7022/RCK Sercomp Rock and 82-D2999 PC cabinet

ADVANTEST Rock Triaxial tests. Layout of the system



ADVANTEST

ADVANTEST Rock

Technical specifications

Hydraulics

- Maximum working pressure: 700 bar
- Maximum oil delivery: 2 litres/min at low pressure, 0.7 litres/min at high pressure
- Hydraulic ports for connection of test frames: 4
- Flow control: via servo-controlled proportional valve
- Cooling system: oil, with forced ventilation
- ON/OFF valves: 4, with electronic control

Hardware and onboard software

- Maximum resolution: 1/524,000 divisions
- 8 input channels:
  - 4 for load sensors (load cells or pressure transducers)
  - 4 for displacement transducers (potentiometric, LVDT amplified or analogue) and deformation transducers (clip gauge, strain gauge)
- Electrical characteristics of the conditioners:
  - Input signal from -2.5 to +2.5 V DC
  - Single/dual-ended input selected by jumper
  - Output signal from 1 to 10 V DC, calibrated by trimmer
- Zeroa nd gaina djustable vias oftware
- Data acquisition synchronized on all channels
- 8 analogue outputs corresponding to each channel for possible use of an external data acquisition system
- Test execution with control of:
  - Load/specific load
  - Displacement
  - Strain
- Diagnostic system to detect possible system malfunctions including oil level and oil filter
- 320 x 240 pixel display
- Storage of multiple calibration curves for immediate connection of different sensors
- Low frequency dynamic tests: maximum frequency 0.1 Hz (depending on the wave amplitude)

PC and software

PC and printer of latest generation
Software modules:

- Performs the remote control of the system. Manages the graphical and numerical display of the data including the overlay of various curves on the same axis (e.g. 3 different deformation curves with respect to a single time axis)
- Performs tests and sequences of steps/cycles programmable by the user
- Print out of test reports
- Real time variation of all test parameters during the test, including active control channel
- Language selection: English, French, Spanish, Italian, plus another language which can be input by the user overwriting messages of the desired language.

Physical specifications

- Power rating 750 W
- Voltage: 230V, 50Hz, 1ph (other voltages are available - see below)
- Dimensions:
  470 x 410 x 1000 mm (d x w x h)
- Weight: 120 kg (approx.) excluding PC and printer

Ordering information

45-C9842/RCK

ADVANTEST Rock Servo-hydraulic unit for controlling up to four test frames for compression, flexure and indirect tensile tests with load, displacement and deformation control.Complete with PC, printer and software, including dedicated software module for rock testing under triaxial conditions (requires also the Sercomp7 Rock unit). 230 V, 50 Hz, 1 ph.

45-C9843/RCK
As above but 220 V, 60 Hz, 1 ph.

45-C9844/RCK
As above but 110 V, 60 Hz, 1 ph.

Sercomp 7 Rock

The Sercomp 7 Rock is a hydraulic unit remotely managed by the ADVANTEST Rock to provide and control lateral pressure inside the Hoek cell for triaxial testing. A cooling device is incorporated into the unit, for better control and uniformity of pressure throughout the test.

The control console includes 4 additional channels for sample strain / displacement transducers (acquisition only).

Specifications

- Maximum working pressure: 700 bar
- Maximum oil delivery: 0.7 litres/min
- Flow control: by servo-valve system
- Hydraulic ports: 2
- Power: 750 W
- Voltage: 230 V, 50 Hz, 1 ph (other voltages are available - see below)
- Dimensions: 470 x 410 x 1000 mm (d x w x h)
- Weight: 120 kg (approx.)

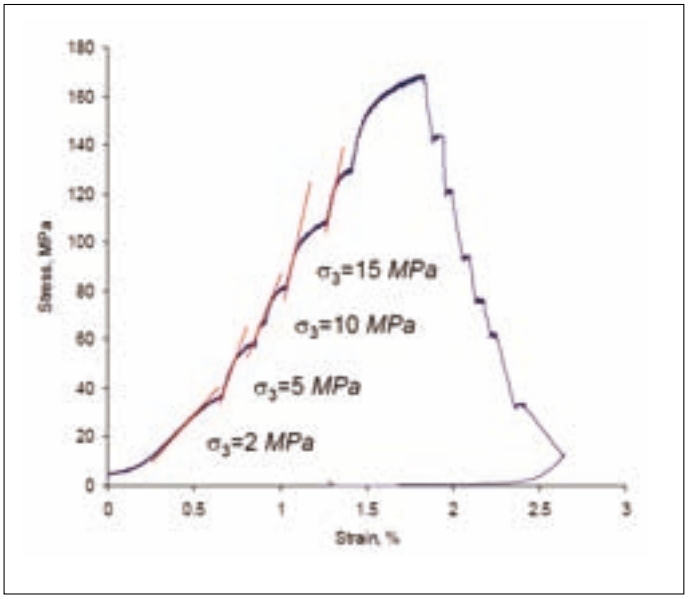
Ordering information

45-C7022/RCK

Sercomp 7 Rock Servo-hydraulic control unit for lateral pressure control. Can be used as a remotely controlled pressure unit, managed by the ADVANTEST Rock. 230 V, 50 Hz, 1 ph.

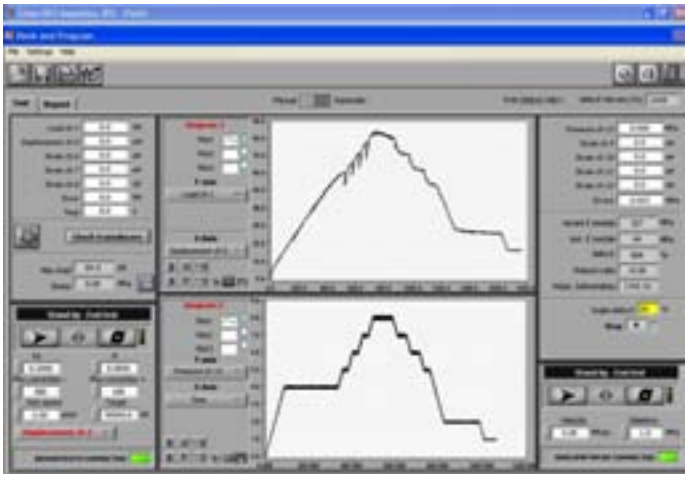
45-C7023/RCK
As above but 220 V, 60 Hz, 1 ph.

45-C7024/RCK
As above but 110 V, 60 Hz, 1 ph.



Stress-path triaxial test on rock performed under strain control for post peak evaluation.

ADVANTEST, virtual gauges indicating the real-time readings of the sensors both in engineering units and as a percentage of the full scale. An excellent tool for transducer positioning.



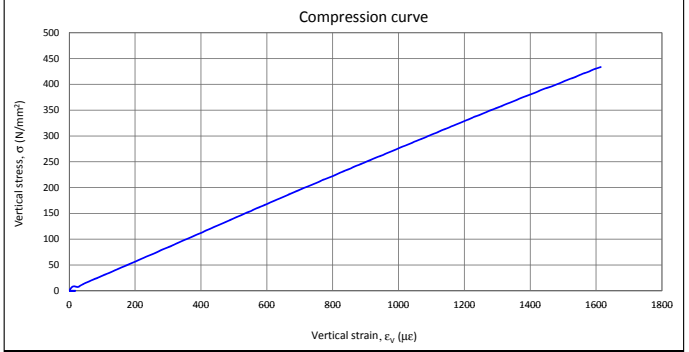
ADVANTEST, main screenshot of software showing a stress-path triaxial test.

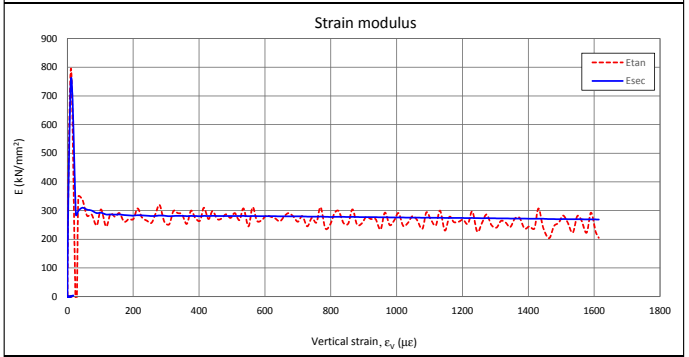
Examples of Excel® data sheets for uniaxial tests

UNIAXIAL COMPRESSION TEST ON ROCK SAMPLES (ISRM Suggested Method)

TEST DETAILS

Certificate:	Specimen height:	*110,00*	mm
Test date:	Specimen area:	*42,41*	cm^2
Client:	Maximum strength:	*433,59*	N/mm^2
Site:	E_{tan}*:	*311,94*	kN/mm^2
Location:	E_{sec}*:	*279,02*	kN/mm^2
Specimen label:	$E_{average}$:	*295,48*	kN/mm^2
Specimen type:	* Calculated at a vertical stress of 215 N/mm^2		



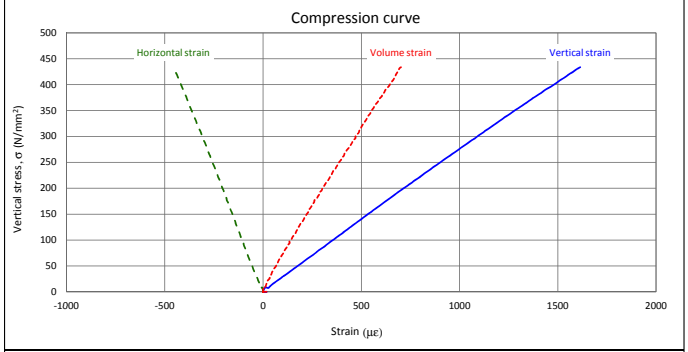


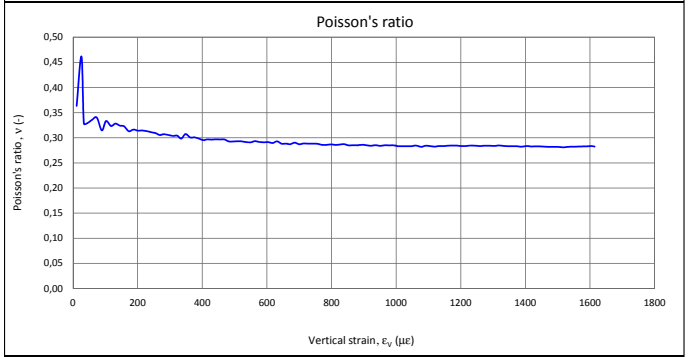
Technician	Laboratory Manager

UNIAXIAL COMPRESSION TEST ON ROCK SAMPLES (ISRM Suggested Method)

TEST DETAILS

Certificate:	Specimen height:	*110,00*	mm
Test date:	Specimen area:	*42,41*	cm^2
Client:	Maximum strength:	*433,59*	N/mm^2
Site:	Poisson's ratio at failure:	*0,283*	
Location:	Poisson's ratio at vertical stress of 215 N/mm^2 :	*0,286*	
Specimen label:			
Specimen type:			





Technician	Laboratory Manager

Hoek cells for triaxial tests

Four different sizes of Hoek triaxial cells are produced; each one consisting of the following: (please refer to the drawing below)

- A cell body (1), complete with two quick-release self-sealing couplings: one for the introduction of hydraulic oil and cell pressure, and one for air out
- Two end caps (2)
- An upper (3) and a lower loading cap (4) with spherical coupling
- Two female spherical seats (5) for correct transmission of the axial load
- A rubber sealing sleeve (6)

Measurements of axial and radial strain are taken using electric strain gauges (7) glued directly onto the cylindrical surface of the specimen in both vertical and horizontal directions. Each strain gauge must be connected through a proper interface device (see 82-P0398) to complete and balance the Wheatstone bridge. The strain gauge measurements can be acquired by automatic testing systems such as the ADVANTEST Rock control system or by the Semi-automatic systems.

The cells can also be used for permeability tests. See the Rock permeability equipment on page 188.

It is recommended that a specimen extruder is used to extrude the rock sample from its sleeve.

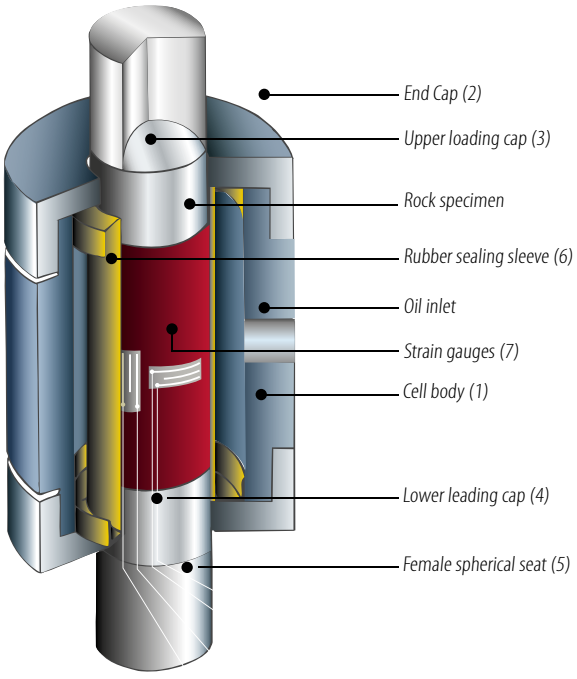
Hoek cells for triaxial tests

Hoek cells. Specifications and ordering information

Code	D.C.D.M.A. reference	Specimen size (dia. x h) (mm)	Total height (mm)	Total height[(1)] (mm)	Weight (kg)
45-D0553	AX	30.10 x 60	193	248	2.5
45-D0554	1.5 in.	38.10 x 75	247	302	4.0
45-D0555	BX	42.04 x 85	246	301	6.5
45-D0556	NX	54.74 x 108	271	326	13.0
45-D0557	HQ	63.5 x 130	300	355	15.0

(1) *Including also 45-D0556/A and 45-D0556/B*

Note: *other Hoek cell dimensions, example H type, dia. 63.5 mm, available on request*



Accessories

45-D0556/A

Pair of load spreaders for uniform load distribution. Thickness 15 mm (each).

45-D0556/B

Distance pad to reduce the vertical clearance of the compression machine. Thickness 25 mm.

45-D0556/H

Hoek cell holder

Spare rubber sleeves

45-D0553/1

Spare rubber sleeve, AX, for specimens 30.10 mm diameter x 60 mm height.

45-D0554/1

Spare rubber sleeve, 1.5 in., for specimens 38.10 mm diameter x 75 mm height.

45-D0555/1

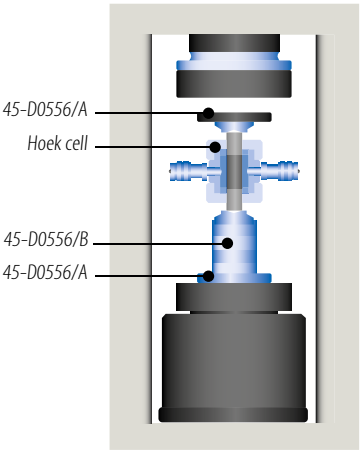
Spare rubber sleeve, BX, for specimens 42.04 mm diameter x 85 mm height.

45-D0556/1

Spare rubber sleeve, NX, for specimens 54.74 mm diameter x 100 mm height.

45-D0557/1

Spare rubber sleeve, HQ, for specimens 63.5 mm diameter x 130 mm height.



Schematic view of the Hoek cell with load spreaders and distance pads within the testing chamber of the compression frame

45-D0556/A, 45-D0566/B

Hoek cell 45-D0556 supported by cell holder model 45-D0556/H

45-D0577/A

Rock sample extruder

The extruder is used to extrude the rock sample from its sleeve thus avoiding having to empty the confining fluid. It consists of a steel frame with a rack and pinion mechanism and has to be used with an adapter set suitable for the cell size. See the following table. Weight:11 kg (approx.)

45-D0577/A with adapter

Extruder adapter sets, comprising adapter plate, support cell body and shaft head.

Code	D.C.D.M.A. reference	For use with cell	Weight (kg)
45-D0577/1	AX	45-D0553	1.7
45-D0577/2	1.5 in.	45-D0554	1.7
45-D0577/3	BX	45-D0555	1.5
45-D0577/4	NX	45-D0556	1.5
45-D0577/5	HQ	45-D0557	1.5

Strain gauges for uniaxial and triaxial tests

Strain gauges provide a very accurate electrical signal which is directly proportional to deformation. When attached to the surface of a specimen submitted to an application of load, the measurements can be used to determine the elastic modulus and strength characteristics of the specimen. The gauges can be applied to the specimen surface using a special adhesive-catalyst agent and other accessories, which are all included in the Strain gauge application kit (82-P0399/B).

Up to four ¼ bridge strain gauges and eight ½ bridge gauges can be connected, via interface 82-P0398, to the ADVANTEST Rock control console. In the same way other additional strain gauges can be connected to the Sercomp 7 Rock (for triaxial tests).

In the Semi-automatic systems, the gauges can be connected, via one or two interfaces (82-P0398), to a suitable data logger. See page 552

Specifications

Code	82-P0390	82-P0391	82-P0392	82-P0393
Gauge width, mm	0.9	1.2	2.3	1
Gauge length, mm	10	20	30	60
Resistance, ohm	120	120	120	120
Bridge	¼	¼	¼	¼
No. of gauges per pack	10	10	10	10

Ordering information

82-P0390

Strain gauge, 10 mm gauge length. Pack of 10.

82-P0391

Strain gauge, 20 mm gauge length. Pack of 10.

82-P0392

Strain gauge, 30 mm gauge length. Pack of 10.

82-P0393

Strain gauge, 60 mm gauge length. Pack of 10.

82-P0399/1

Connecting terminals, 50-pair sheet.

82-P0399/B

Strain gauge application kit comprising: conditioner, neutralizer, acetone, two tweezers, adhesive and catalyst agent, 100 m of bipolar cable, solder, electric welder and carrying case.

82-P0398

Compensation device for up to 4 Wheatstone bridge gauges with ¼ or ½ bridge setup.

Spare parts

82-P0399/P22

Adhesive and catalyst agent for gluing strain gauges to the specimen.

Detail of rock sample fitted with 3 strain gauges

82-P0399/B Application kit

82-P0398

Compression device for uniaxial tests

Standards

ASTM D2938

The apparatus consists of a two-column frame fitted with an upper platen with a spherical seat that moves vertically, sustained by a spring. The lower platen is fitted to the base. It is suitable for use with a compression frame, as part of the Automatic or Semi-automatic testing systems for rock uniaxial tests.

45-D9035

45-D9035

Compression device for rock core specimens with dia. 50 to 55 mm and with height 100 to 110 mm.

Specifications

- Maximum load capacity: 800 kN
- Platen dimensions:
  55 mm diameter x 28 mm thick
- Platen minimum hardness: 58 HRC
- Vertical clearance: 112 mm
- Overall dimensions:
  145 mm diameter x 280 mm height
- Weight: 15 kg (approx.)

82-D1260 with 82-P0331/C

82-P0331/2

Typical configuration of the advanced automatic stress path system for uniaxial and triaxial tests on rock specimens

Code	Description	Q.ty Uniaxial	Q.ty Triaxial
Axial load system			
45-C9842/RCK	ADVANTEST Rock servo-hydraulic control console	1	1
86-D2999	PC cabinet (optional)	1	1
50-C68Z00	Compression frame, 4000 kN capacity	1	1
50-C0050/CAL	Special calibration of digital load unit assuring Class 1 from 1% of full scale	1	1
50-Q0050/P8	Upgrading of the 50-C68xxx series compression frame with bottom platen anti-fall safety system	1	1
50-C9086/P	Distance piece, 200 x 100 mm (dia. x h with threaded centering pin	2	1
50-C9083/P	As above but 200 x 68 mm	3	2
50-C9082/P	As above but 200 x 50 mm	1	1
Confining pressure system			
45-C7022/RCK	Sercomp 7 Rock control unit	-	1
Triaxial components			
45-D0556[(1)]	Hoek cell, NX, 54.7 mm diameter	-	1
45-D0556/A	Pair of load spreaders	-	1
45-D0556/B	Distance pad	-	1
45-D0556/1[(1)]	Spare rubber sleeve	-	5
45-D0577/A	Rock sample extruder	-	1
45-D0577/4[(1)]	Extruder adapter set for NX samples	-	1
45-D0556/H	Holding device for Hoek cells	-	1
Uniaxial components			
45-D9035	Compression device for samples up to 55 mm diameter x 110 mm height	1	-
Strain measurement (Select suitable strain gauges from the models listed below)			
82-P0398	Electrical compensation device	1	1
82-P0399/B	Strain gauge application kit	1	1
82-P0399/1	Connecting terminals, 50 pairs	1	1
82-P0390	10 mm strain gauge, 10 pieces	1	1
82-P0391	20 mm strain gauge, 10 pieces	1	1
82-P0392	30 mm strain gauge, 10 pieces	1	1
82-P0393	60 mm strain gauge, 10 pieces	1	1
82-P0070/3	Excel template for uniaxial tests, with stress-strain analysis, elastic modulus and Poisson's ratio processing	1	1
82-P0070/4	Excel template for triaxial tests, with stress-strain analysis and failure envelope processing	-	1
Post-peak evaluation (The following items are required, in displacement-controlled testing under triaxial conditions, to perform automatic failure path test (multi-stage) and to evaluate the post-peak behavior of the specimen)			
82-P0331/C1	High-precision LVDT transducer, 10 mm travel	-	3
82-P0331/2	Electrical averaging device for 2 or 3 transducers	-	1
82-D1260	Magnetic transducer holder	-	3

(1)Other models are available. See Hoek cells and Rock sample extruder on page 184,185

Automatic uniaxial and triaxial test system

For determining the elastic modulus and strength characteristics of rock specimens under uniaxial and triaxial conditions.

Standards

ASTM D2664 | ASTM D3148 | ASTM D5407 | EN 14580 | EN 1926

The Automatic configuration including AUTOMAX E MODULUS and SERCOMP 7 performs stress path test by few individual tests (single - stage) with automatic application of axial load and confining pressure at different levels.

The confining pressure into the Hoek cell, applied by SERCOMP 7 is also measured by AUTOMAX E for simultaneous plot of all test quantities, e.g. stress, strain and cell pressure.

AUTOMAX E MODULUS

The AUTOMAX E-Modulus, fully described on page 252 , consists of an ergonomic control console which houses the power unit and the PC.

Specifications

Hydraulics
See pag 252

Hardware
See page 252 except:
- 4 channels for load sensors (pressure transducers/load cells)
- 1 channel for confining pressure (acquisition only)
- 6 channels for strain/displacement transducers (potentiometers, magnetostrictive, LVDTs)
- 3 channels for strain gauges

Ordering information

50-C20E82

AUTOMAX E-Modulus stand alone power and control console. 230 V, 50-60 Hz, 1 ph

50-C20E84
Same as above but 110 V, 60 Hz, 1 ph

SERCOMP 7

The hydraulic unit SERCOMP 7 controls the lateral pressure in the Hoek cell in case of triaxial testing. A cooling device is incorporated, for superior control and uniformity of pressure throughout the test. The control console includes a large graphic display with a membrane keyboard allowing easy setting and test monitoring.

Specifications

See pag 182

Ordering information

45-C7022/S

SERCOMP 7 Servo-hydraulic control console for lateral pressure to perform triaxial rock testing. 230V, 50 Hz, 1ph.

45-C7023/S
As above but 220 V, 60 Hz, 1 ph.

45-C7024/S
As above but 110 V, 60 Hz, 1 ph.

3000 kN compression frame 50-C56Z00 with Hoek cell, 50-C20E82 AUTOMAX E-Modulus and 45-C7022/S SERCOMP 7

Typical configuration of an automatic system for uniaxial and triaxial tests on rock specimens

Code	Description	Q.ty Uniaxial	Q.ty Triaxial
Axial load system			
50-C20E82	Automax E modulus control console	1	1
50-C56Z00	Compression frame, 3000 kN capacity	1	1
50-Q0050/HRD	Upgrading of the 50-C46xxx and C56xxx Series compression frames with upper and bottom platens dia. 300 mm, min. hardness 58 HRC	1	1
50-C0050/CAL	Special calibration of digital load unit assuring Class 1% from 1% of full scale	1	1
50-Q0050/P6	Upgrading of the 50-C46xx and 50-C56xx series compression frames with bottom platen anti-fall safety system	1	1
50-C9086/P	Distance piece, 200 x 100 mm (dia. x h) with threaded centering pin	1	-
50-C9083/P	As above but 200 x 68 mm	2	1
Confining pressure system			
45-C7022/5	Sercomp 7 servo hydraulic control console	-	1
45-R0023	Three way connector	-	1
82-P0700	Pressure transducer, 700 bar capacity	-	2
82-P0349/ELT	Connection cable	-	2
Triaxial components			
45-D0556[(1)]	Hoek cell, NX, 54.7 mm diameter	-	1
45-D0556/A	Pair of load spreaders	-	1
45-D0556/B	Distance pad	-	1
45-D0556/1[(1)]	Spare rubber sleeve	-	5
45-D0557/A	Rock sample extruder	-	1
45-D0577/4[(1)]	Extruder adapter set for NX samples	-	1
45-D0556/H	Holding device for Hoek cell	-	1
Uniaxial components			
45-D9035	Compression device for samples up to 55mm diameter x 110 mm height	1	-
Strain measurement (Select suitable strain gauges from the models listed below)			
82-P0398	Electrical compensationdevice	1	1
82-P0399/B	Strain gauge application kit	1	1
82-P0399/1	Connecting terminals, 50 pairs	1	1
82-P0390	10 mm strain gauge, 10 pieces	1	1
82-P0391	20 mm strain gauge, 10 pieces	1	1
82-P0392	30 mm strain gauge, 10 pieces	1	1
82-P0393	60 mm strain gauge, 10 pieces	1	1
82-P0070/3	Excel template for uniaxial tests, with stress-strain analysis, elastic modulus and Poisson's ratio processing	1	1
82-P0070/4	Excel template for triaxial tests, with stress-strain analysis and failure envelope processing	-	1

(1) Other models are available. See Hoek cells and Rock sample extruder on page 184,185

Rock permeability

This test is performed to measure the water flow through a rock specimen contained in a Hoek cell and subjected to a high confining pressure. The hydraulic gradient within the rock sample is supplied by a constant pressure apparatus and the water permeating the sample is collected in a burette. A couple of end caps are also necessary to fit the Hoek cell.

Constant pressure apparatus

This apparatus, originally designed for soil mechanics test applications, provides an infinitely variable constant pressure and can be used, in conjunction with the Hoek cells and permeability end caps, to test the permeability of rock at high confining pressures in the laboratory. The apparatus comprises: a motorized hydraulic pump, honed piston/spring assembly, precision test gauge 0-3500 kPa range, cylindrical oil/water interchange vessel, valves, and 2 kg of high viscosity oil.

Alternatively, lateral pressure can be applied with the 45-D0558 Low friction pressure maintainer or with the 45-C7022/RCK Sercomp 7 Rock Servo-hydraulic control console which is part of the Automatic Triaxial test system (see page 187)

A typical configuration for a rock permeability test set is shown in the table.

Specifications

Pressure range: 0 to 3500 kPa
Overall dimensions: 310 x 300 x 390 mm
Weight: 16 kg (approx.)

Ordering information

28-WF4312

Oil and water constant pressure apparatus for pressures up to 3500 kPa.
230 V, 50-60 Hz, 1 ph.

28-WF4314
As above but 110 V, 60 Hz, 1 ph.

Accessories

(Hoek cell accessories for permeability testing see page 184)

Permeability end caps

45-D0553/3

Permeability end cap, AX size, 30.10 mm diameter x 60 mm height.

45-D0554/3

Permeability end cap, 1.5 in. size, 38.10 mm diameter x 75 mm height.

45-D0555/3

Permeability end cap, BX size, 42.04 mm diameter x 85 mm height.

45-D0556/3

Permeability end cap, NX size, 54.74 mm diameter x 100 mm height.

Connecting hose

28-WF4191

Connecting hose for the Hoek cell.

Typical configuration of a semi-automatic system for permeability tests on rock specimens

Code	Description	Q.ty
28-WF4312	Oil and water constant pressure apparatus	1
28-WF0490	Nylon tubing, 6 mm ODx 4 mm ID, 20 m coil	1
45-D0556(1)	Hoek cell NX size, 54.74 mm diameter x 100 mm height	1
45-D0556/3(1)	Permeability end caps for NX Hoek cell, set of two.	1
28-WF4191	Connecting hose for the Hoek cell	1
86-D1160	Graduated glass burette, 25 ml capacity, 0,1 ml divisions	1
86-D1445	Support base, 200 x 130 mm, complete with rod, 10 mm diameter x 500 mm length	1
86-D1451	Double sleeve metal/glass	1
45-D0558	Low-friction pressure maintainer	1
45-C7022/RCK	Sercomp Rock control console(2)	1

(1) Other models are available. See Hoek cells on page 184
(2) An alternative to the manual model 45-D0558. See Sercomp 7 Rock on page 187

28-WF4312 with Hoek cell, Permeability end caps, burette, support base and metal/glass sleeve

Manual lateral pressure system

45-D0558

Low fiction manual pressure maintainer for lateral pressure in the Hoek triaxial cells, including pump and precision pressure gauge.

- Max. working pressure: 70 MPa
- Weight approx.: 15 kg

Splitting tensile test device

Standards

ASTM D3967

This apparatus, originally developed for testing cement specimens in compression, can be used for splitting tensile tests on rock disks with dimensions from dia. 54 mm to 64 mm.

It can be used as an accessory with a suitable universal tester such as one of the UNIFRAME universal testers.

See page 388

- Platens diameter 75 mm
- Hardness platens: 60 HRC
- Vertical daylight: 65 mm
- Total height: 234 mm
- Weight: 13 kg (approx.)

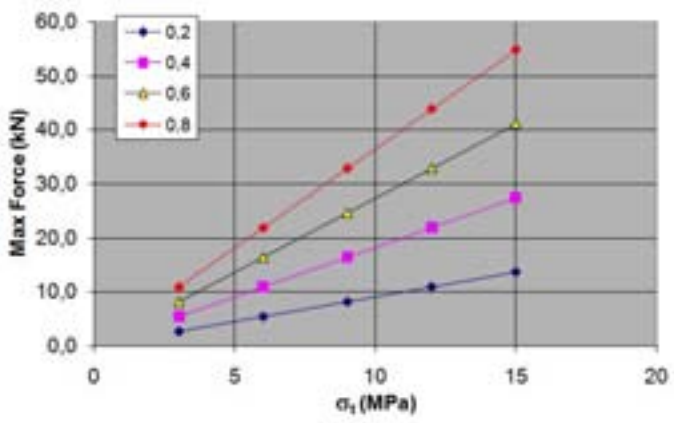
45-D9032/H

Compression device for indirect tensile test on rock specimens. Supplied with distance piece for specimen dia. 54 mm to 64 mm.

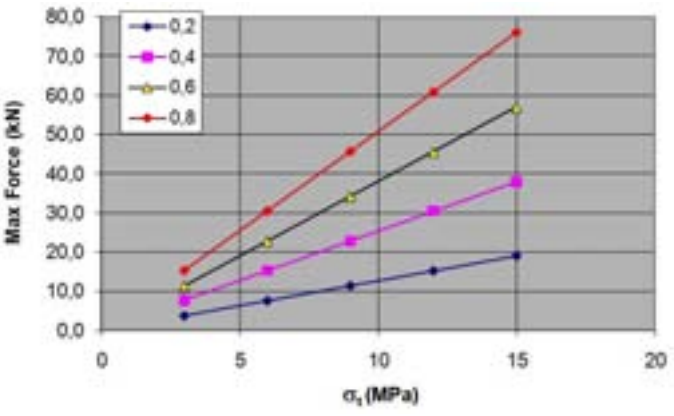
45-D9032/H

The typical failure loads of rock disks dia. 54 mm and 63.5 mm are plotted below in relation to the corresponding indirect tensile strength:

Rock core dia. 54 mm



Rock core dia. 63,5 mm



σ_t = Range of splitting tensile strength of rock samples (from ASTM D3967)

Slake durability index apparatus

Standards

ASTM D4644

The slake durability test has been developed to assess the deterioration of rocks over a period of time when subjected to water immersion. The test apparatus consists of a motorized drive unit which is mounted on a baseplate and can rotate two drums at a speed of 20 rpm. The tank assemblies are filled with water to a level 20 mm below the drum axis. The test drums are manufactured from 2 mm mesh, and measure 140 mm diameter x 100 mm ong. Two drums are already included, while two additional ones can be ordered separately - see Accessories.

- Overall dimensions:
  1400 x 400 x 380 mm (w x d x h)
- Weight: 30 kg (approx.)

45-D0546/A

Slake durability apparatus. 230 V, 50 Hz, 1 ph.

45-D0546/AY
As above but 220 V, 60 Hz, 1 ph.

45-D0546/AZ
As above but 110 V, 60 Hz, 1 ph.

Accessories

45-D0546/2

Mesh drum, complete with tank, base and coupling.