Effective/Stress Path Triaxial Tests

The AUTOTRIAX Automatic Triaxial System not only can perform Effective Stress triaxial tests with all the above advantages but is the unique and indispensable apparatus to perform the Stress Path triaxial test. Infact this test is performed to allow the engineering to replicate the changes in stress conditions soil sample subjected to compression and extension both in loading and unloading status. If few words, that soil, due for example to excavation, or construction or natural events, can produce the changes of magnitude of the principal stresses (major and minor). This test can only be accurately and reliably performed with a servocontrolled closed loop system.

Permeability Tests in Triaxial Cell

The permeability test can be automatically performed with the AUTOTRIAX system using the appropriate accessories. For more information see page 110.

Unsaturated Soil Testing

The unsaturated soil testing can be automatically performed with the AUTOTRIAX system using the appropriate accessories. For more information see page 110.
**AUTOTRIAX**

**AUTOTRIAX SYSTEM DESCRIPTION**

The system consists essentially of the following components:

**Triaxial compression frame**
A suitable machine is our model 28-WF4005 or 28-WF4010, 50 or 100 kN cap.

**Triaxial Cell with vacuum top cap**
A suitable models are our Tri-Cell Plus 28-WF4070/P to 28-WF4150/P equipped with vacuum top cap.

**Control Unit**
The RTC, Real time control box, 29-WF4530 with 29-WF4537 expansions modules, are the brain of the AUTOTRIAX. Provide the automatic control and drive of up to three triaxial systems.

**Data acquisition unit**
The ATD, Automatic Triaxial Datalog, 29-WF4616 and 29-WF4616/UP1 Expansion, provides the automatic data acquisition and broadcasts all transducers measurements on the high speed comnunications network to the RTC Real Time Control box.

**Test Softwares**
These softwares are the interface between the operator and the AUTOTRIAX System to manage automatically all test stages.

Various Software packages are available depending on the test to be performed: 29-WF4616/S1 to 29-4616/S6.

See page 109-110

**Pressure Systems**
Two models available depending on the maximum pressure to be applied:
- **Hydromatic** servo-controlled hydraulic actuator 29-WF4502 for pressures up to 3500 kPa
- **Servoflow** electro-pneumatic servo-valve 29-WF4511 and 29-WF4512 expansion, for pressures up to 1000 kPa

The Close/Open Microeletrovalves 29-WF4515 are accessories for the pressurelines.

All the above components are fully described in the following pages.

---

**Flow diagram of the AUTOTRIAX system**
RTC Real Time Control box

RTC AUTOMATIC TRIAXIAL TEST CONTROLLERS

Description

The base RTC (Real Time Control) system is made up of a chassis fitted with one module. This will control one fully automated triaxial test system. The RTC chassis can be fully expanded by installing two additional modules to allow control of three fully automated triaxial test systems. One RTC module can control:
- two pressure lines up to 3500 kPa
- two ON/OFF valves for drainage lines
- the speed of the Triaxial load frame
- the flow direction of the automatic volume change

The base RTC system comes with RTC software which manages the transducers calibration and the setup of up to three systems. The calibration data can be exported to the supplied calibration spreadsheet template to print calibration certificates.

The RTC module, ATD data logger and computer running the software modules are all connected together by a high speed communications and control network which allows simultaneous communication between the RTC modules, ATD data logger and computer. When the RTC module receives a command from the test software, (e.g. a pressure increase, closing the pressure line to the triaxial cell, changing the triaxial load frame speed or changing the automatic volume change device flow direction), the commands are then applied to the triaxial system by a closed loop control system using feedback from the ATD data logger. The RTC module then runs independently of the test software maintaining all the current parameters until new commands are sent from the test software.

NOTE

Upgrading existing standard triaxial systems:
The advantage of the RTC system is that existing manual triaxial compression frames can be used as part of a semi-automated system. When you require the full automation you will need to upgrade to a Tritech triaxial load frame 29-WF4005 and/or vacuum cap assembly.

Specifications

Hardware:
Closed loop control system firmware with:
2 x pressure control outputs
2 x open and close valve control outputs
2 x automatic volume change device flow control outputs
1x RS-232 port for triaxial load frame
1 x network Ethernet port

Dimensions: 320x270x140mm (lxdxh)

Weight: 3 kg approx.

Software:
RTC module management software
• System setups
• Channel management
• Transducer calibration
  - From 2 to 10 calibration points
  - Linear or polynomial best fit equations
  - Export calibration data to a spreadsheet template for printing certificates

NOTE

MS excel is required to run the supplied calibration certificate spreadsheet templates

29-WF4531 RTC expansion module for two pressure outputs

This module added to the base system 29-WF4530 or to the 29-WF4537 controls two more pressure outputs and the relevant accessories to measure the volume change.
The base system RTC can accept up to three 29-WF4531 modules to be used for permeability or unsaturated tests.

Specifications

Same as module 29-WF4530 previously described except for the RS232 and Ethernet ports which are not available

29-WF4537 RTC extension module

This module added to the base system controls another fully automated triaxial test system. A maximum of two RTC expansion modules can be installed for a triaxial system control.

Specifications

Same as model 29-WF4530

NOTE

29-WF4537 RTC modules must be factory installed

NOTE

Insertion of 29-WF4531 and 29-WF4537 in a 29-WF4530 RTC base system

NOTE

MS excel is required to run the supplied calibration certificate spreadsheet templates

29-WF4537 RTC modules must be factory installed

* The P.C. shall be provided by the user
**SERVOFLOW**

**PNEUMATIC PRESSURE CONTROLLER**

FOR PRESSURES UP TO 1000 kPa

**Description**

The SERVOFLOW pneumatic pressure controller consists of an electro-pneumatic control valve that reduces the supply air pressure to a regulated output air pressure which is directly proportional to an electrical input signal received from the RTC module. Each SERVOFLOW has an integral safety valve and is supplied complete with pressure transducer and de-airing block.

**29-WF4511 SERVOFLOW Base system**

Chassis fitted with one SERVOFLOW which allows control of one pressure line. The chassis can be fully expanded by installing an additional SERVOFLOW to allow control of two pressure lines.

**Specifications**

Supply pressure: up to 1000 kPa  
Output pressure: up to 1000 kPa  
Air consumption: 0.1 cu.m/hr  
Electrical connection: 25 pin D type

Dimensions: 255x210x140 (lxdxh)  
Weight: 2 kg

**HYDROMATIC**

**HYDRAULIC PRESSURE CONTROLLER**

FOR PRESSURES UP TO 3500 kPa

**Description**

The HYDROMATIC pressure controller consists of a hydraulic piston driven by a ball screw and gear box mounted on a ball slide. The system is driven via a stepper motor controlled by the RTC module closed loop control system. The apparatus has a clear Perspex cover allowing moving parts to be viewed.

**29-WF4502 HYDROMATIC**

Servo controlled hydraulic actuator with pressure adjustable to 3500 kPa

**Specifications**

Supplied pressure: none required  
Output pressure: up to 3500 kPa  
Pressure accuracy: +/-0.1% of full scale  
Electrical connection: 25 pin D type  
Power supply: 110-240V, 50/60 Hz, 1ph

Dimensions: 60x138x163 mm (lxdxh)  
Weight: 5 kg

**29-WF4515 Two way open and close valve**

**Specifications**

Power supply: 24Vdc from the RTC module  
Solenoid operating speed: <10ms

**Weight:** 0.2 kg

**NOTE**

The 29-WF4512 SERVOFLOW expansion must be factory installed

---

**PRESSURE LINE OPEN AND CLOSE VALVE**

**Description**

This two way solenoid valve is positioned on the triaxial cell to open and close the pressure line to the cell. This is powered and controlled by the RTC module.

**29-WF4412 Automatic volume change transducer with automatic flow inversion for remote control**

**Specifications**

Capacity: 100 cc  
Accuracy: 0.1 cc  
Max operating pressure: 2000 kPa  
Power supply: 24Vdc from RTC module  
Solenoid operating speed: <10 ms

Dimensions: 260x280x400 mm (lxdxh)  
Weight: 9 kg

---

**Automatic Triaxial System.**

Pressure systems/Volume change transducer

Testing equipment for the construction industry
Introduction

The ATD (Automatic Triaxial Datalog) comes in two versions of 16 or 32 channels. It provides automatic data acquisition for the automatic triaxial system. The ATD broadcasts all transducer values on the high speed communications network to the RTC modules and computer running the testing software modules for the automatic test control, data logging and processing. The offset and gain values during the transducer calibration are adjustable for each channel and saved in firmware. It is compatible with all transducers required for effective stress and stress path triaxial testing such as pressure, displacement, load and volume change.

ATD 16 channel data acquisition for automatic triaxial system

ATD module to expanded 29-WF4616 from 16 to 32 acquisition channels for automatic triaxial systems. It shall be factory installed.

General specification

Hardware

Number of channels: 16 (29-WF4616) or 32 (29-WF4616+29-WF4616/UP1)

Sensors outputs:
- $V_{in}$ adjustable up to 10 V DC (common to all channels)
- compatible with 3 and 4 wires sensors single and double ended

Sensors inputs:
- from -10V to +10V including the following sensors:
  - any amplified sensor with DC output;
  - potentiometric transducers;
  - wheatstone bridge transducers with mV/V DC output (load cells, pressure transducers, linear transducers, and equivalent)
  - sensors impedance from 100 Ohm to 10 kOhm

Real resolution: ± 32 000 divisions

Sampling rate: adjustable up to 10 samples/sec per channel

Data storage capacity: 8 Mbytes

Communication ports: RS232 and USB for data download to PC with software included

Power supply: 110-230V; 50-60Hz; 1ph.

On-board firmware

Suitable for remote management of the logger with AUTOGEOLAB software modules (see separate description on page 53).

Minimum PC Specifications:
- Processor speed 500 MHz minimum
- Hard disk 200 MByte minimum
- RAM 512 Mbyte
- CD – ROM
- 1 serial port RS232 or USB with adapter USB-RS232 or Ethernet card with adapter Ethernet-RS232
- Windows® 2000 Professional or XP
- Monitor minimum resolution 800x600 pixel
- MS Excel® suggested
- A4 printer

Dimensions: 320x270x140mm (lxdxh)

Weight: 2.5 kg approx.

NOTE

The 29-WF4616/UP1 16 channel expansion module must be factory installed.

Interface and interconnection accessories

29-WF4640 LAN-RS232 converter to connect the ATD to the high speed communications and control network. 230 V; 50 Hz; 1 ph.

29-WF4645/COMP Communication package including Personal Computer (minimum: 2.4GHz, 1GB RAM, HD 250GB, DVD-RW, Office, LCD 17” Monitor and 8 port LAN HUB converter for AUTOTRIAX network connection.

* LAN = Local Area Network
**Introduction**

These software modules are used in conjunction with the RTC chassis, RTC modules and ATD all connected using the high speed communications and control network. They allow the full automation of triaxial tests including effective stress and stress path testing using different testing standards such as BS1377, ASTM and EN. From the start to the end of the triaxial test the software modules have total control of the triaxial frame, the adjustment of pressure to the triaxial cell, the opening and closing of pressure lines to the triaxial cell, and the measurement of continuous volume change to perform automatically the different stages required.

The software modules have an export function to automatically transfer test data into a spreadsheet template. The software modules come with a standard processing spreadsheet template which can be fully customised.

The following software testing modules are available:

- **29-WF4616/S1**
  **Effective Stress software to BS 1377:8**
  Automatically performs the test depending on reference standard: BS 1377:8
  - Saturation with full automatic control
  - Isotropic consolidation stage with volume change measurement
  - Consolidated undrained triaxial compression with measurement of pore pressure
  - Consolidated drained triaxial compression with measurement of volume change
  - Non standard shearing of the specimen in extension (undrained or drained)
  - Export test data to a spreadsheet template for processing and plotting

- **29-WF4616/S2**
  **Stress Path software**
  Automatically performs the different stages of a stress path triaxial test.
  - Saturation stage automatic or manual
  - Consolidation stage:
    - Isotropic
    - Anisotropic
    - \( k_0 \) with axial or radial stress control
    - \( k_0 \) control can use either radial belt measured sample volume change methods
  - User defined target stress parameters (\( p \), \( q \), \( s \) and \( t \))
  - Monotonic shear stage in compression or extension
  - Export test data to a spreadsheet template for processing and plotting

- **29-WF4616/S4**
  **Effective Stress software to ASTM D4764**
  Automatically performs the test depending on reference standard: ASTM D4764
  - Saturation with full automatic control
  - Isotropic consolidation stage with volume change measurement
  - Consolidated undrained triaxial compression with measurement of pore pressure
  - Consolidated drained triaxial compression with measurement of volume change
  - Non standard shearing of the specimen in extension (undrained or drained)
  - Export test data to a spreadsheet template for processing and plotting
  - Multi stage test
29-WF4616/S5
Unsaturated soil triaxial test software
Automatically performs the test stages using the axis translation method:
- Simultaneous and independent control of air pressure, pore water pressure and axial stress
- Performance of various test stages: saturation, consolidation and shear
- Test data recording of each stage

29-WF4616/S6
Permeability triaxial test software to BS 1377:6
Automatically performs permeability test in triaxial cell conforming BS 1377:6, part 6.3:
- Automatic control of saturation stage
- Isotropic consolidation stage with pore pressure and volume change measurements
- Automatic procedure to generate hydraulic gradient through the sample and constant head water flow
- Export test data to a spreadsheet template for processing and plotting.
Automatic Triaxial Testing

Automatic triaxial system/Automatic data acquisition and processing

Stress path software screen

Transducer calibration

Effective stress set up
Automatic Triaxial Testing

Automatic Triaxial Testing. Typical configurations

The following tables represent a practical guide for typical configurations limited to the parts required for the automation.

**TABLE A - PNEUMATIC SYSTEM WITH CELL PRESSURE UP TO 1000 kPa AND BACK PRESSURE UP TO 1000 kPa**

<table>
<thead>
<tr>
<th>Codice</th>
<th>Descrizione</th>
<th>Effective Stress Number of systems</th>
<th>Stress path Number of systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>29-WF4530</td>
<td>RTC chassis and RTC module</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4531</td>
<td>RTC expansion module</td>
<td>- - -</td>
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<tr>
<td>29-WF4537</td>
<td>RTC module</td>
<td>- 1 2</td>
<td>- 1 2</td>
</tr>
<tr>
<td>29-WF4511</td>
<td>SERVOFLOW base system</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>29-WF4512</td>
<td>SERVOFLOW expansion</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>28-WF4320</td>
<td>Air/Water Bladder</td>
<td>2 4 6</td>
<td>2 4 6</td>
</tr>
<tr>
<td>28-WF4005</td>
<td>Tritech 50</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>29-WF4515</td>
<td>Two way Open and Close valve</td>
<td>2 4 6</td>
<td>2 4 6</td>
</tr>
<tr>
<td>29-WF4412(*)</td>
<td>Automatic volume change</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>29-WF4616</td>
<td>ATO 16 channels</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4616/UP1</td>
<td>16 channels expansion module</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>29-WF4645/COMPL</td>
<td>LAN – HUB</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
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<td>29-WF4640</td>
<td>LAN - RS232 1 converter</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4616/S1</td>
<td>Effective stress software module</td>
<td>1 1 1</td>
<td>- - -</td>
</tr>
<tr>
<td>29-WF4616/S2</td>
<td>Stress path software module</td>
<td>- - -</td>
<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4616/S4</td>
<td>Effective stress software for Automatic Triaxial ASTM</td>
<td>1 1 1</td>
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</tr>
<tr>
<td>29-WF4616/S5</td>
<td>Unsaturating test software</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>29-WF4616/S6</td>
<td>Permeability test software BS</td>
<td>- - -</td>
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</tr>
</tbody>
</table>

(*) In the cell pressure and back pressure lines, where the volume change apparatus 29-WF4412 is connected, the pressure has to be limited to up to 2000 kPa.

**TABLE B - HYDRAULIC SYSTEM WITH CELL PRESSURE UP TO 3000 KPA AND BACK PRESSURE UP TO 3000 KPA**

<table>
<thead>
<tr>
<th>Codice</th>
<th>Descrizione</th>
<th>Effective Stress Number of systems</th>
<th>Stress path Number of systems</th>
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</thead>
<tbody>
<tr>
<td>29-WF4530</td>
<td>RTC chassis and RTC module</td>
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<td>29-WF4531</td>
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<td>29-WF4537</td>
<td>RTC module</td>
<td>- 2 3</td>
<td>- 2 3</td>
</tr>
<tr>
<td>29-WF4502</td>
<td>HYDROMATIC pressure system</td>
<td>2 4 6</td>
<td>2 4 6</td>
</tr>
<tr>
<td>29-WF4511</td>
<td>SERVOFLOW base system</td>
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<td>- - -</td>
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<td>28-WF4005</td>
<td>Tritech 50</td>
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<td>1 2 3</td>
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<tr>
<td>29-WF4515</td>
<td>Two way Open and Close valve</td>
<td>2 4 6</td>
<td>2 4 6</td>
</tr>
<tr>
<td>29-WF4412(*)</td>
<td>Automatic volume change</td>
<td>1 2 3</td>
<td>1 2 3</td>
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<td>ATO 16 channels</td>
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<td>29-WF4616/UP1</td>
<td>16 channels expansion module</td>
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<td>- - -</td>
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<tr>
<td>29-WF4645/COMPL</td>
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<td>1 1 1</td>
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<td>LAN - RS232 1 converter</td>
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<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4616/S1</td>
<td>Effective stress software module</td>
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</tr>
<tr>
<td>29-WF4616/S2</td>
<td>Stress path software module</td>
<td>- - -</td>
<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4616/S4</td>
<td>Effective stress software for Automatic Triaxial ASTM</td>
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<td>29-WF4616/S5</td>
<td>Unsaturating test software</td>
<td>- - -</td>
<td>- - -</td>
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<tr>
<td>29-WF4616/S6</td>
<td>Permeability test software BS</td>
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</table>

**TABLE C - HYDRAULIC/PNEUMATIC SYSTEM WITH CELL PRESSURE UP TO 3000 KPA AND BACK PRESSURE UP TO 1000 KPA**

<table>
<thead>
<tr>
<th>Codice</th>
<th>Descrizione</th>
<th>Effective Stress Number of systems</th>
<th>Stress path Number of systems</th>
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</thead>
<tbody>
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<td>29-WF4530</td>
<td>RTC chassis and RTC module</td>
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<td>1 1 1</td>
</tr>
<tr>
<td>29-WF4531</td>
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<td>- - -</td>
</tr>
<tr>
<td>29-WF4537</td>
<td>RTC module</td>
<td>- 1 2</td>
<td>- 1 2</td>
</tr>
<tr>
<td>29-WF4502</td>
<td>HYDROMATIC pressure system</td>
<td>1 2 3</td>
<td>1 2 3</td>
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<tr>
<td>29-WF4511</td>
<td>SERVOFLOW base system</td>
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<td>29-WF4412(*)</td>
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<td>1 2 3</td>
<td>1 2 3</td>
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<td>1 1 1</td>
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<tr>
<td>29-WF4616/UP1</td>
<td>16 channels expansion module</td>
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<td>Permeability test software BS</td>
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</tbody>
</table>

(*) In the cell pressure and back pressure lines, where the volume change apparatus 29-WF4412 is connected, the pressure has to be limited to up to 2000 kPa.

(**) The unsaturated triaxial testing can be performed with 1000 kPa maximum air pressure.
Automatic Triaxial Testing

SOIL MECHANICS

Three possible Automatic Triaxial configuration for effective stress test

<table>
<thead>
<tr>
<th>Permeability</th>
<th>Unsaturated</th>
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<tr>
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Testing equipment for the construction industry