CE SERIES

Chemical Reactors Teaching Equipment – CEXC

COMPUTER CONTROLLED AS STANDARD
5 REACTORS AVAILABLE
TUBULAR, TRANSPARENT BATCH, CSTR, PLUG FLOW, LAMINAR FLOW
OPEN ENDED FOR PROJECT WORK

The Armfield CEXC family is a range of chemical reactors specifically developed for the teaching and demonstration of chemical reactor capabilities to chemical engineering students. Real chemical reactions take place within the reactors. Armfield has developed a number of representative reactions which are easy and safe for students to use in the laboratory environment.

CEXC service unit shown fitted with CEB-MkII transparent batch reactor (laptop not supplied)

Unique features

- Computer control and data logging as standard
- Compact benchtop equipment
- Real-time reaction monitoring instrumentations eliminating the inconvenience and inaccuracy of multiple iterations
- Safe and student friendly
- Transparent reactors enabling the student to see what is happening
- Colour tracer experiments possible for some reactor types
- Cost effective. Up to five reactors share the same service unit
- Five different reactor types available:
  - Continuous stirred tank reactor - CEM-MKII
  - Tubular reactor - CET-MKII
  - Batch reactor - CEB-MKII
  - Laminar flow reactor - CEY
  - Plug flow reactor - CEZ

UK office - email: sales@armfield.co.uk tel: +44 (0) 1425 478781 (for ROW)
USA office - email: info@armfield.inc tel: +1 (609) 208-2800 (USA only)

Issue: 3
URL: http://www.armfield.co.uk/cexc
Applications ChE IP

CEXC Chemical reactors teaching unit

The CEXC Chemical reactors teaching unit provides the services required to run the various reactor types. It includes; a hot water re-circulator used to control the temperature of the reactions, glass feed vessels for the reactants, two peristaltic pumps to pump the reagents to the reactors, computer software for data logging, sensors and instrumentation.

The CEXC is fully computer controlled, supplied with software to allow the user to; vary the feed pump speeds and flow rates, vary the heater power in the hot water, implement a PID control loop ensuring stable temperatures, switch on and off the hot water pump and to control the speed of the stirrers used on some of the reactors.

Instrumentation for temperature and conductivity measurements is also supplied and these values are displayed on the computer screen. Two 'K' type thermocouples are included; one for the hot water and one for the reactor contents.

Note: An input for a third user-supplied sensor is also provided for project work.

Full educational software is provided with the CEXC for all the Armfield chemical reactors.

Separate programs are provided for each reactor. Typical facilities are:

- All the temperatures and flow rates are displayed on a diagrammatic representation of the equipment
- The feed pump speeds are between 0 and 100%. The predicted flow rate for these speeds can be displayed and used for subsequent calculations. These values can be user calibrated for greater accuracy
- The stirrer speeds can be controlled in a similar manner
- The hot water temperature is set by entering a required temperature set point into a PID control function
- Data from the sensors is logged into a spreadsheet format
- Sophisticated graph plotting facilities are provided. Comparisons between data taken on different runs can be displayed
- Processing of measured values to obtain calculated values
- The data samples (measured and calculated) can be saved or exported directly in Microsoft Excel format
- Data from the sensors can be displayed independently from the data logging. This can be in bar graph format or a recent history graphical display

Presentation screens are available giving an overview of the software, the equipment, the procedure and the associated theory. This is backed up by a detailed 'Help' facility giving in-depth guidance and background information

Ordering specification

- A self-contained benchtop service unit designed to provide services for up to five different chemical reactors:
  - Continuous Stirred Tank Reactor – CEM-MKII
  - Tubular Reactor – CET-MKII
  - Transparent Batch Reactor – CEB-MKII
  - Laminar Flow Reactor – CEY
  - Plug Flow Reactor – CEZ
- Fully computer controlled and supplied with educational software specific to each reactor type. Simple interfacing to the (user supplied) computer by a USB interface
- Two peristaltic feed pumps with individually variable flow rates 0-140 ml/min
- Provides PID temperature-controlled hot water in order to maintain reactor temperature
- Complete with two thermocouples, an input for a third (user) thermocouple and a dual-range conductivity sensor
- A comprehensive instruction manual is included which details installation and operating procedures

A dual-range conductivity sensor allows for a wide range of operation. Armfield has developed an algorithm for the saponification reaction (ethyl acetate and sodium hydroxide) linking the degree of conversion of the reactants to the electrical conductivity, thus allowing the progress of the reaction to be monitored using the software.

The service unit includes a mounting position for the reactor being used. It is possible to change reactors quickly and easily without the use of tools. All fittings on the CEXC and the reactors are of the quick-release type. The CEM-MkII, CET-MkII and CEB-MkIII reactors are completely contained on the CEXC base unit. The CEY and CEZ also include floor standing columns for positioning next to the CEXC base unit.

The CEXC provides a locating position for two standard 2.5 litre chemical storage bottles for the reagents within the plinth. This provides safety in use. The bottles can be quickly capped and removed as necessary for safe handling. Two 2.5 litre bottles are also provided with the equipment. Alternatively, for longer experiments, larger feed vessels could be located either on the floor or on the bench next to the equipment.

The CEXC requires a computer (not supplied by Armfield), running Windows 7 or above, with a spare USB port.

Optional accessory - CW-17 Chilled water circulating unit

The CW-17 is a thermostatically controlled chilled water circulating unit which can be used for providing water at below ambient temperature. It is essential for use with the CEZ reactor and for the CEB-MkIII isothermal demonstration and can be used with the other reactors. The temperature of the water is controlled by an adjustable thermostat mounted on the CW-17. Alternatively, it can be used as an ice bank chiller to supply water slightly above freezing point.

Essential accessories

CEXC	CEM-MkII	CET-MkII	CEB-MkIII	CEY	CEZ
At least one reactor accessory	CEXC	CEXC	CEXC	CEXC	CEXC
Windows PC with 2 spare USB ports			CW-17 (for isothermal operation)		CW-17

Requirements

Scale

Electrical supply: Single phase *(See ordering codes below)*

PC (see essential accessories)

At least 1 reactor - CEM-MKII, CET-MKII, CEB-MKII, CEY, CEZ

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and crated shipping specifications	
Volume	0.4m^3
Gross weight	40Kg

Ordering codes

CEXC-A:	220-240V / 1ph / 50Hz, 10 amp
CEXC-B:	120V / 1ph / 60Hz, 10 amp
CEXC-G:	220-240V / 1ph / 60Hz, 10 amp
CW-17-A:	220-240V / 1ph / 50Hz, 13 amp
CW-17-G:*	220-240V / 1ph / 60Hz, 13 amp

*CW-17-G version has optional 3kVA transformer available to accommodate 120V / 1ph / 60Hz supply. If you require this option please specify at time of order.

CEM-MKII Continuous stirred tank reactor (CSTR)

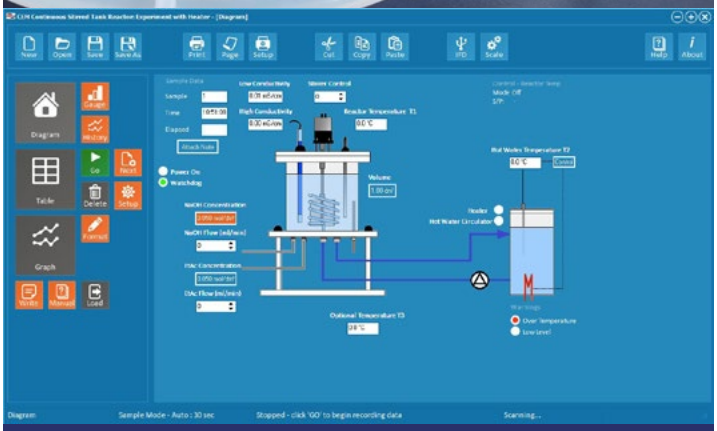
The CEM-MKII Continuous stirred tank reactor is probably the most common type of reactor found in industry. The CEM-MkII is a small-scale demonstration version for educational use. It is extremely flexible in use and can be used for both continuous and batch reactions.

The volume of the reactor is adjustable to between 0.4 and 1.5 litres using an adjustable standpipe allowing different hold-up volumes and residence times to be investigated. The temperature probe and conductivity probe (supplied with the CEXC) can be positioned in the reactor vessel.

A stainless steel coil is used for temperature control of the reactor from the hot water supply on the CEXC (or cold water from such as the CW-17 Chilled Water Circulating Unit).

A variable-speed mixer/agitator is included (controlled by the CEXC) together with baffles to improve the mixing.

The CEM-MkII uses the saponification reaction and uses conductivity to measure the progress of the reaction. It also uses a step input change experiment to obtain the residence time distribution.



CEM-MKII Software screen capture

Experimental content

- To find the reaction rate constant in a Continuous Stirred Tank Reactor
- Effect of varying the temperature on reaction rate
- Effect of varying the reactor volume
- Effect of varying the mixing speed
- Effect of varying the feed rate
- Effect of varying the flow rate on conversion
- Determination of the Residence Time using tracer techniques
- To determine the effect of inadequate mixing on the reaction rate
- Evaluation of empirical rate expressions from experimental data

In use the CEM-MkII is wholly contained on the CEXC. When removed from the CEXC, storage dimensions are 350mm high, 250mm wide, 300mm deep.

Ordering specification

- A small-scale continuous stirred tank reactor for use with the CEXC
- Adjustable volume of 0.4-1.5l
- The vessel is equipped with a variable-speed square blade turbine agitator
- The vessel is constructed from borosilicate glass and PVC with stainless steel heat transfer coil and removable reactor baffle
- Fitting points for temperature and conductivity sensors (supplied with CEXC)

Requirements	Scale
CEXC	

Requires CEXC Base unit to operate

Consumables:

- 50ml Ethyl Acetate
- 20g NaOH Sodium Hydroxide
- 100g Potassium Chloride

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and created shipping specifications	
Volume	0.4m^3
Gross weight	40Kg

Ordering codes

CEM-MKII

CET-MKII Tubular reactor

The CET-MKII Tubular reactor is in the form of a tube wrapped in a spiral around an acrylic former which is enclosed in a transparent tank. Water at a controlled temperature (from the CEXC) is circulated within the tank, this maintains the reactants at constant temperatures.

The reagents are piped separately to the reactor through quick-release fittings mounted on the lid, they are preheated in stainless steel coils in the water tank before being mixed and fed into the reactor coil.

Mounting positions are provided for the CEXC water temperature sensor (in the water tank) and the conductivity probe (at the reactor output).

CET-MkII uses the saponification reaction and conductivity to measure the progress of the reaction.

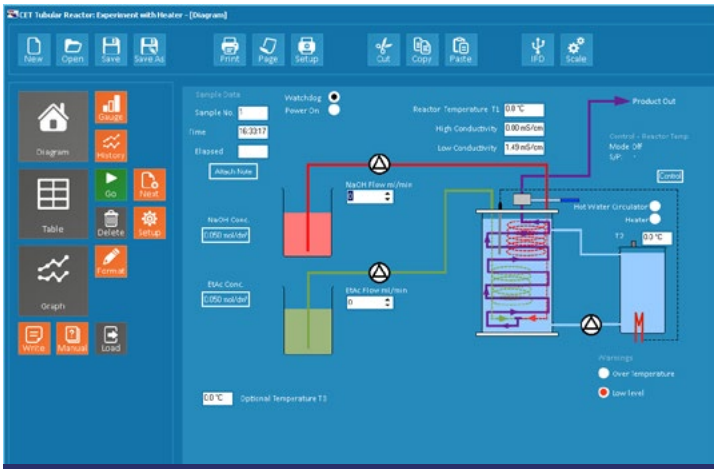
Experimental content

- Determination of reaction rate constant using a tubular reactor
- Effect of varying the temperature on reaction rate
- Effect of varying the reactant concentration on reaction rate
- Effect of varying the feed rate
- Investigation of the effect of throughput on conversion
- Demonstration of the temperature dependence of the reaction and the rate constant
- Determination of the residence time distribution
- Study of the effect of flow rate on conversion
- To determine the kinetic constant of a reaction using an indicator for visually monitoring

When in use the CET-MkII is wholly contained on the CEXC.
When removed from the CEXC, storage dimensions are 500mm high, 250mm wide and 300mm deep.

Ordering specification

- A small-scale tubular reactor for use with the CEXC capable of demonstrating large-scale behaviour
- The 20m long reactor coil is mounted in a clear acrylic vessel through which heating or cooling medium is circulated. Volume of reactor coil is 0.4l
- Two heat exchanger coils bring the reactants up to the reaction temperature separately before they are mixed to start the reaction
- Fitting points for temperature and conductivity sensors (supplied with the CEXC)



CET-MKII Software screen capture

Requirements	Scale
CEXC	

Requires CEXC Base unit to operate

Consumables:

- 50ml Ethyl Acetate
- 20g NaOH Sodium Hydroxide
- 100g Potassium Chloride

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and crated shipping specifications	
Volume	0.1m^3
Gross weight	10Kg

Ordering codes

CET-MKII

CEB-MKIII Transparent batch reactor

The CEB-MkIII Transparent batch reactor is a double-skinned glass vessel with a one-litre internal working volume, fitted with a variable-speed agitator.

Hot water from the CEXC or cold water from the CW17 can be circulated through the jacket for temperature control purposes maintaining the reactor contents at constant temperature.

Glands in the clear acrylic lid allow the CEXC conductivity and temperature probes to be fitted to facilitate monitoring of the reactions in progress such as the important saponification reaction.
Isothermal and adiabatic operation reactions may be demonstrated. (Note, the isothermal reaction requires the Armfield CW17 accessory if experiments at low temperature are to be studied or if the ambient temperature is high).

For adiabatic operation, the use of dyes enables the chemical reaction rates to be monitored visually by the change in colour at different degrees of conversion.

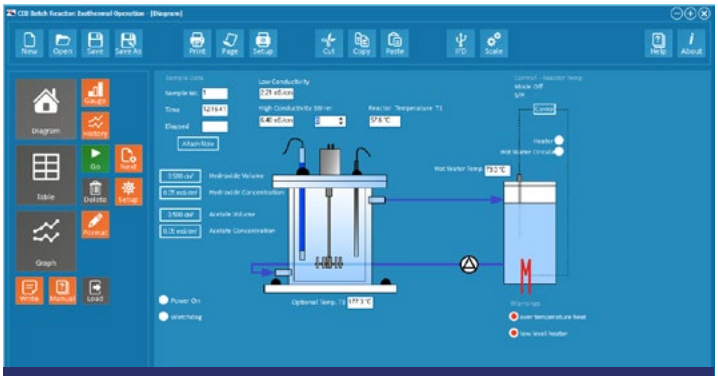
Experimental content

- Isothermal Operation -To Determine the reaction rate constant in a stirred batch reactor.
- Adiabatic Operation - To determine the rate equation for the hydrolysis of acetic anhydride to acetic acid in an adiabatic reactor.
- Investigation of the effect of reactant concentration on the reaction rate
- Investigation of the effect of temperature on conversion
- Visual monitoring of the chemical reactions
- Study of the temperature variation of an exothermic reaction on an adiabatic operation

Note: CEB-MkIII is designed for use with the CEXC service unit. CEB-MkIII can be used with the CEX service unit, but an additional 5TS5 temperature sensor will be required for complete functionality.

Ordering specification

- A small-scale batch reactor for use with the chemical reactors service unit designed to demonstrate both adiabatic and isothermal operation CW-17 accessory is recommended for isothermal operation).
- 1l working volume
- The vessel includes a jacket through which hot water from the CEXC or chilled water from the CW-17 is passed. A variable-speed agitator aids heat transfer through the vessel
- The vessel is made of glass to give full visibility of the contents and enables the use of colour tracers to illustrate the reaction process
- Fitting points for temperature and conductivity sensors (supplied with the CEXC)



CET-MKII Software screen capture

Requirements	Scale
CEXC	

Requires CEXC Base unit to operate

Consumables:

- 20g NaOH Sodium Hydroxide
- 50ml Ethyl Acetate
- 10mg Crystal Violet
- 100ml Acetic Anhydride
- 150ml Acetic Acid
- 25ml Sulphuric Acid

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and crated shipping specifications	
Volume	0.1m^3
Gross weight	15Kg

Ordering codes

CEB-MKIII

CEY Laminar flow reactor

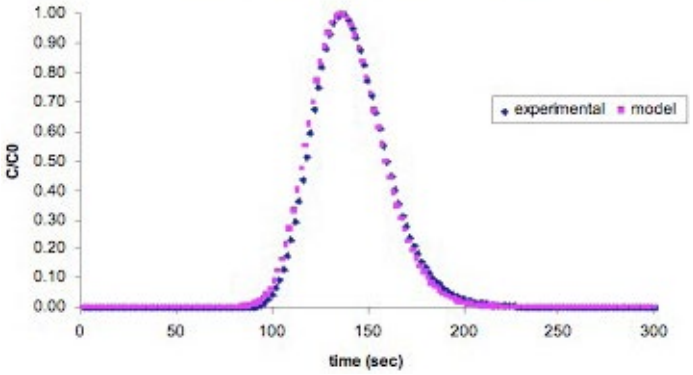
The CEY Laminar flow reactor is a tubular reactor made of clear acrylic, mounted on a floor standing steel frame with two diffusers packed with glass beads located at the ends. A static premixer at the bottom of the column provides premixing of the reagents entering the reactor to improve the flow distribution.

It includes two reagent vessels fitted with heat exchangers, mounted on the CEXC plinth. The heat exchangers are used to cool down the reagents before performing the experiment. A cold water jacket keeps the reactor contents at constant temperature in order to maintain the laminar characteristic. A thermostatically controlled supply of chilled water is required for this such as the CW17.

A clear acrylic sensor block is mounted on the frame for the CEXC conductivity and temperature sensors. The reagents are fed to the reactor by the CEXC peristaltic pumps using PTFE tubing. Pulsation dampers are used to ensure a smooth flow.

Tracer experiments and conversion experiments may be demonstrated and followed visually. Conductivity data logging allows the student to apply the flow pattern characterisation theory and compare it with the experimental results.

Normalised concentration of KCL at the exit of the reactor



Experimental content

- Determination of the residence time distribution of a Plug Flow reactor
- Study of the reactor response to different perturbations:
- step and pulse change
- Effect of flow rate and feed concentration on the determination of flow pattern
- Demonstration of the flow pattern in the reactor and comparison with the theoretical model
- Determination of the steady-state conversion of a second order reaction
- Effect of flow rate and feed concentration on the steady-state conversion
- Visual demonstration of the reactor response with tracer techniques
- Visual monitoring of the steady-state conversion for a chemical reaction

Ordering specification

- A small scale laminar flow reactor (400ml working volume) designed to demonstrate both flow pattern characterisation and steady-state conversion in a tubular reactor
- The reactor column is 1300mm long including diffusers packed with glass beads
- A static premixer is fitted at the base of the column
- Reactor column is jacketed with easy connections for recirculating cooling system
- A feed assembly is supplied with the reactor which consists of two pulsation dampers mounted on a base plate, special lids for Service Unit reagent vessels and PTFE interconnecting pipe
- Stainless steel coils are mounted on the reagent vessel lids to cool their contents. Quick-release connectors allow easy supply of cold transfer medium to the coil and reagents
- The unit is mounted on a painted frame and includes a sensor block for conductivity and temperature sensors
- Can perform flow visualisation where the progress of the reaction can be monitored visually using colour
- Can also perform true reactions where the progress of the reaction is recorded using the CEXC conductivity sensor and compared with the theory

Requirements

CEXC

Scale

Requires CEXC Base unit to operate

Consumables:

- 100g Potassium Chloride
- 20mg Indigo Carmine
- 20g NaOH Sodium Hydroxide
- 50ml Ethyl Acetate

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and crated shipping specifications	
Volume	0.5m^3
Gross weight	22Kg

Ordering codes

CEY

CEZ Plug flow reactor

The CEZ Plug flow reactor demonstrates step and pulse changes for plug flow characterisation and steady-state conversion for a second order reaction. It is a tubular packed column reactor made of clear acrylic and mounted on a steel frame. A static premixer at the bottom of the column provides premixing of the reagents entering the reactor to improve the flow distribution.

A clear acrylic sensor block is mounted on the floor standing frame and houses the CEXC conductivity and temperature sensors.
The reagents are fed to the reactor by the CEXC feed pumps using PTFE tubing. A six-port injection valve fitted to the CEXC is used to provide the step or pulse input changes of the reagents.

Tracer experiments and conversion experiments may be demonstrated and followed visually. Conductivity data logging allows the student to apply the flow pattern characterisation theory and compare it with the experimental results.

Experimental content

- Determination of residence time distribution of a Laminar flow reactor
- Flow pattern characterisation - Step change
- Flow pattern characterisation - Pulse change
- Study of the reactor response to inlet perturbations: step change
- Effect of flow rate and feed concentration on the determination of flow pattern
- Effect of temperature on the laminar flow characterisation
- Demonstration of the flow pattern in the reactor and comparison with the theoretical model
- Determination of the steady-state conversion of a second order reaction
- Effect of flow rate and feed concentration on the steady-state conversion
- Visual monitoring of the steady state

Ordering Specification

- A small-scale plug flow reactor for use with the CEXC designed to demonstrate both flow pattern characterisation and steady-state conversion in a packed tubular reactor with axial dispersion
- The reactor column is 1044mm long with a 1l working volume. It is packed with 3mm diameter glass beads
- A feed assembly is supplied with the reactor which consists of a six-port injection valve mounted on a base plate and a feed vessel assembly with heat exchangers for cooling for use with the CEXC and the CW-17
- The reactor assembly is mounted on a painted frame and includes a sensor block for the conductivity and temperature sensors from the CEXC
- Can perform flow visualization where the progress of the reaction can be monitored visually using colour
- Can also perform true reactions where the progress of the reaction is recorded using the CEXC conductivity sensor and compared with the theory

Requirements

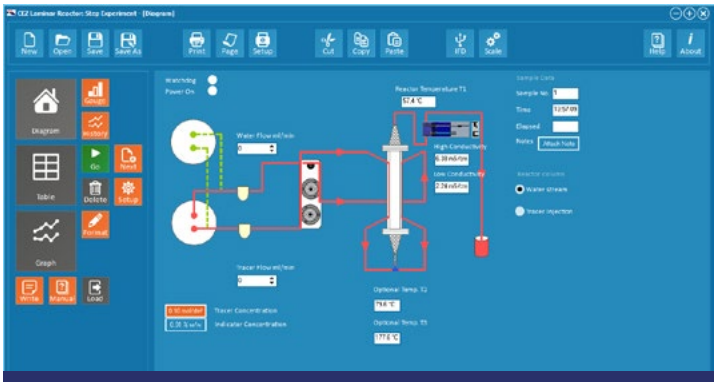
CEXC

Requires CEXC Base Unit to operate

Consumables:

- 500ml of 2M Hydrochloric acid
- 10mg Crystal Violet
- 50ml Ethyl Acetate
- 20g NaOH Sodium Hydroxide
- 20mg Indigo Carmine

Scale



CEZ Software screen capture

Overall dimensions

Length	1.00m
Width	0.50m
Height	0.50m
Packed and crated shipping specifications	
Volume	0.5m^3
Gross weight	22Kg

Ordering codes

CEZ

armfield

www.armfield.co.uk

armfield
Part of Judges Scientific PLC

Social Media search Armfield Ltd

YouTube

Armfield Agents

Armfield products are distributed throughout the world. It is our policy in most countries to deal direct or through proven and accredited sales agents, who after suitable approval, may become exclusive representatives.

In exchange for this exclusivity they are required to offer a comprehensive service including the highest degree of after sales support.

Customer Demonstration

To arrange a demonstration please contact your local Armfield representative. Details can be found on our website here: **www.armfield.co.uk**, or contact Armfield HQ directly using the information below.

Your local Armfield Agent:

armfield worldwide

GLOBAL REPRESENTATION

To locate a contact in your area visit:

www.discoverarmfield.com/contact

U.S. Head Office:

Armfield Inc.
9 Trenton Lakewood Road
Clarksburg NJ 08510
USA

Tel/Fax: +1 (609) 208-2800
E-mail: info@armfieldinc.com
Support: armfieldassist.com

Head Office:

Armfield Limited
10 Headlands Business Park
Ringwood, Hampshire
BH24 3PB England

Telephone: +44 (0)1425 478781
E-mail: sales@armfield.co.uk
Support: armfieldassist.com

An ISO 9001 Company

CE

Products CE certified

Innovative engineering teaching and research equipment

armfield®
Part of Judges Scientific PLC