



armfield

CHEMICAL REACTORS TEACHING EQUIPMENT

CEX series
issue 5



CEX service unit shown with the CEM MkII reactor installed and connected to a computer through an IFD6 interface device.

The Armfield range of small scale chemical reactors comprises four units which represent the most common types of chemical reactor found in industry.

Three of the reactors may be individually mounted on a common bench top service unit (CEX) which provide all the services for self contained operation. These are Continuous Stirred Tank Reactors (CSTR), Tubular Reactor (Plug Flow), Batch Reactor.

The fourth reactor - stirred tank reactor in series - is mounted on a dedicated unit.

The reactors use the saponification reaction between ethyl acetate and sodium hydroxide. This provides a well understood and safe reaction for the students to investigate the different reactor types.

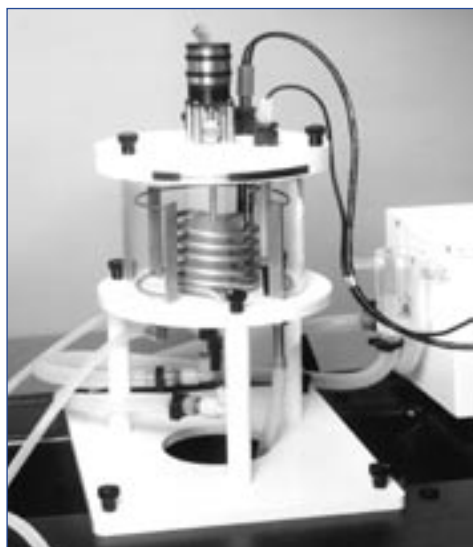
Armfield have developed a set of algorithms which link the degree of conversions of the reactants to the electrical conductivity of the product. In this way the progress of the reaction can be monitored in real time, without the inconvenience and inaccuracy of titration methods.

FEATURES

- *Small bench top equipment*
- *Real time reaction monitoring*
- *Data logging facility available*
- *Cost effective - 3 reactors share same service unit*
- *Safe and student friendly*
- *Four different types of reactor*

Basic Process Principles

CE



CEM MkII Continuous Stirred Tank Reactor

TECHNICAL DESCRIPTION

The series of three reactors is designed to fit interchangeably onto the common Chemical Reactors Service Unit (CEX). Each reactor is mounted on a PVC base which attaches to the service unit by means of thumbnuts.

The appropriate services such as reagent feed pumps, hot water circulator and instrumentation for conductivity and temperature measurement are connected to the reactor.

For temperature control, the CEM MkII and CEB MkII reactors employ submerged coils through which the heater water is circulated, the CET MkII reactor coil is itself submerged in the temperature controlled water within the reactor vessel.

CEM MkII and CEB MkII reactors each incorporate a stirrer driven by a lid-mounted electric motor to provide efficient mixing.



CET MkII Tubular Reactor

CEX CHEMICAL REACTORS SERVICE UNIT

This comprises feed tanks, feed pumps with variable speed drive, stirrer with variable speed drive, hot water circulator, automatic temperature controller and conductivity sensor with display and computer output.

The supporting base is of robust vacuum formed high impact plastic, designed for bench mounting.

ORDERING SPECIFICATON

- A self contained bench top service unit designed to accommodate three different chemical reactors:
 - Continuous Stirred Tank Reactor (CSTR)
 - Tubular Reactor
 - Batch Reactor
- The service unit provides PID temperature controlled hot water in order to maintain reactor temperature.
- It is supplied with a conductivity sensor and display.
- A comprehensive instruction manual is included which details installation and operating procedures.

SERVICES REQUIRED

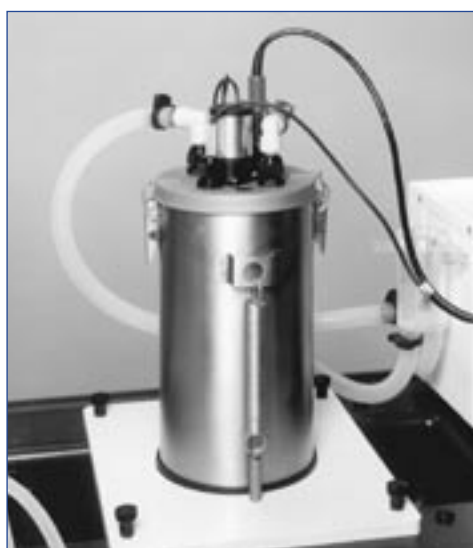
CEX-A 220/240v/1ph/50Hz @ 10amps
 CEX-B 120v/1ph/60Hz @ 20 amps

OVERALL DIMENSIONS

Height: 550mm
 Width: 1.0m
 Depth: 500mm

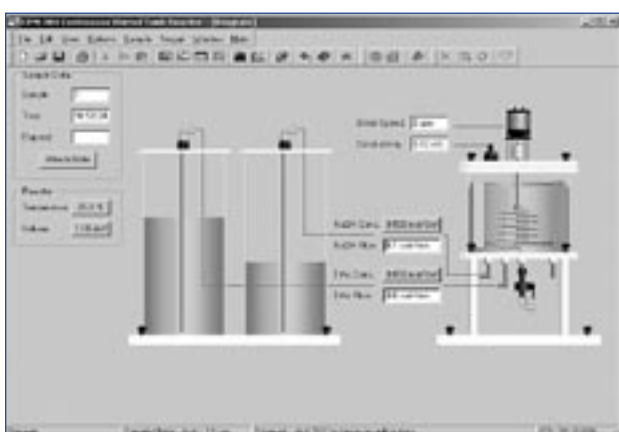
SHIPPING SPECIFICATION

Volume: 0.40m³
 Gross weight: 40kg



CEB MkII Batch Reactor

CEM MkII CONTINUOUS STIRRED TANK REACTOR



CEM - Mimic diagram

DEMONSTRATION CAPABILITIES

- ▶ variation of conversion with residence time
- ▶ determination of reaction rate constant
- ▶ residence time distribution
- ▶ evaluation of empirical rate expressions from experimental data
- ▶ effect of temperature on reaction rate
- ▶ effect of efficiency of mixing

TECHNICAL DESCRIPTION

The reactor volume is adjustable with a maximum of 2 litres and a minimum of 1 litres. The reactor is equipped with a variable speed turbine agitator and baffle arrangement to ensure thorough mixing. A submerged stainless steel coil is used for operating the reactor at different temperatures. Quick release connectors allow easy supply of heat transfer medium to the coil and reagent from the feed pumps of the service unit. Glands in the lid allow fitting of the conductivity and temperature probes of the service unit. Operation at temperatures below ambient is possible.

ORDERING SPECIFICATION

- A small scale continuous stirred tank reactor with an adjustable volume of 0.4 - 1.5 litres.
- The vessel is equipped with a variable speed square blade turbine agitator with a speed range 0-230rpm.
- The vessel is constructed from borosilicate glass and PVC with stainless steel heat transfer coil and removable baffle.
- Glands are mounted in the lid for fitting of appropriate sensors.
- The vessel is mounted on a PVC baseplate which fits directly onto the service unit.
- Demonstration capabilities:
 - Determination of reaction rate constant
 - Variation of conversion with residence time
 - Evaluation of empirical rate expressions from experimental data
 - Effect of temperature and mixing efficiency on reaction kinetics

ESSENTIAL ARMFIELD ACCESSORIES

CEX Chemical Reactor Service Unit

OPTIONAL ARMFIELD ACCESSORY

CEX-304IFD Data Logging Accessory

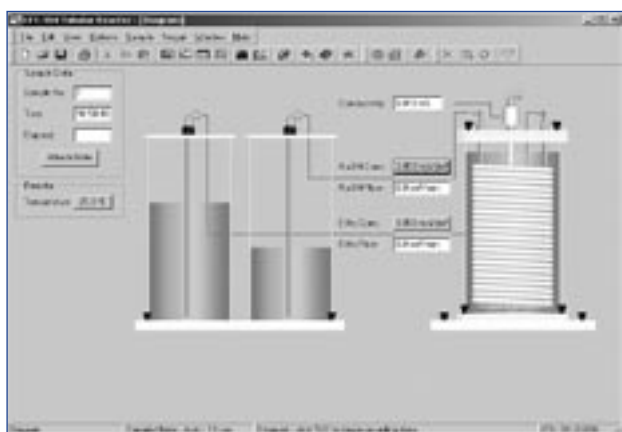
OVERALL DIMENSIONS

Height: 500mm
Width: 250mm
Depth: 300mm

SHIPPING SPECIFICATION

Volume: 0.1m³
Gross weight: 10kg

CET MKII TUBULAR REACTOR



CET - Mimic diagram

DEMONSTRATION CAPABILITIES

- determination of reaction rate constant
- investigation of the effect of throughput on conversion
- demonstration of the temperature dependence of the reaction and the rate constant

TECHNICAL DESCRIPTION

The Armfield Tubular Reactor or 'plug flow' 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 is circulated within the tank, this maintains the reactants at constant temperatures. Reagents are separately piped to the reactor through quick release fittings mounted on the lid. Reagents are pre-heated in stainless steel coils before being mixed and loaded into the reactor coil.

ORDERING SPECIFICATION

- A small scale tubular reactor (volume is 0.4 litres) capable of demonstrating large scale behaviour.
- The reactor coil is mounted in a clear acrylic vessel through which heating or cooling medium is circulated. Length of reactor coil is 20m.
- Two pre-heat coils bring the reactants up to the reaction temperature separately before they are mixed in a Y piece after which the reaction begins.
- Performance is monitored by a conductivity sensor mounted in a flow cell at the end of the reactor coil.
- Quick release fittings are used for process and service connections to enable quick mounting and removal from the service unit.
- Demonstration capabilities:
 - Determination of the rate constant

ESSENTIAL ARMFIELD ACCESSORIES

CEX Chemical Reactor Service Unit

OPTIONAL ARMFIELD ACCESSORY

CEX-304IFD data logging accessory

OVERALL DIMENSIONS

Height: 500mm
Width: 250mm
Depth: 300mm

SHIPPING SPECIFICATION

Volume: 0.2m³
Gross weight: 15kg

CEB MkII BATCH REACTOR



CEB - Mimic diagram

DEMONSTRATION CAPABILITIES

- to determine the effect of reactant concentration on the reaction rate
- to find the reaction rate constant of an isothermal stirred batch reactor

TECHNICAL DESCRIPTION

The Armfield Batch Reactor is a vacuum insulated flask in a stainless steel casing which is mounted onto a PVC base. The baseplate is designed to be fitted to the CEX Reactor Service Unit. The lid of the reactor houses an electric motor driven propellor agitator which can be controlled at various speeds from the service unit. A stainless steel heat transfer coil is also supported in the lid to allow heating or cooling of the reactor contents. Glands in the lid allow conductivity and temperature probes to be fitted to facilitate monitoring of the reactions in progress. Isothermal and adiabatic reactions may be demonstrated.

NOTE: Isothermal reactions require the Armfield CW-16 Chilled water circulating unit.

ORDERING SPECIFICATION

- A small scale batch reactor (1 litre working volume) designed to demonstrate both adiabatic and isothermal operation (isothermal operation requires an additional chiller unit).
- The unit is vacuum insulated and equipped with a variable speed agitator, heat transfer coil, temperature and conductivity sensors.
- The unit has a stainless steel casing and is mounted on a PVC baseplate which itself fits onto the service unit.
- Demonstration capabilities:
 - Effect of temperature on reaction kinetics
 - Determination of the rate equation and activation energy through mass and energy balances

ESSENTIAL ARMFIELD ACCESSORIES

CEX Chemical Reactor Service Unit
CW-16 Chilled Water Circulating Unit

OPTIONAL ARMFIELD ACCESSORY

CEX-304IFD data logging accessory

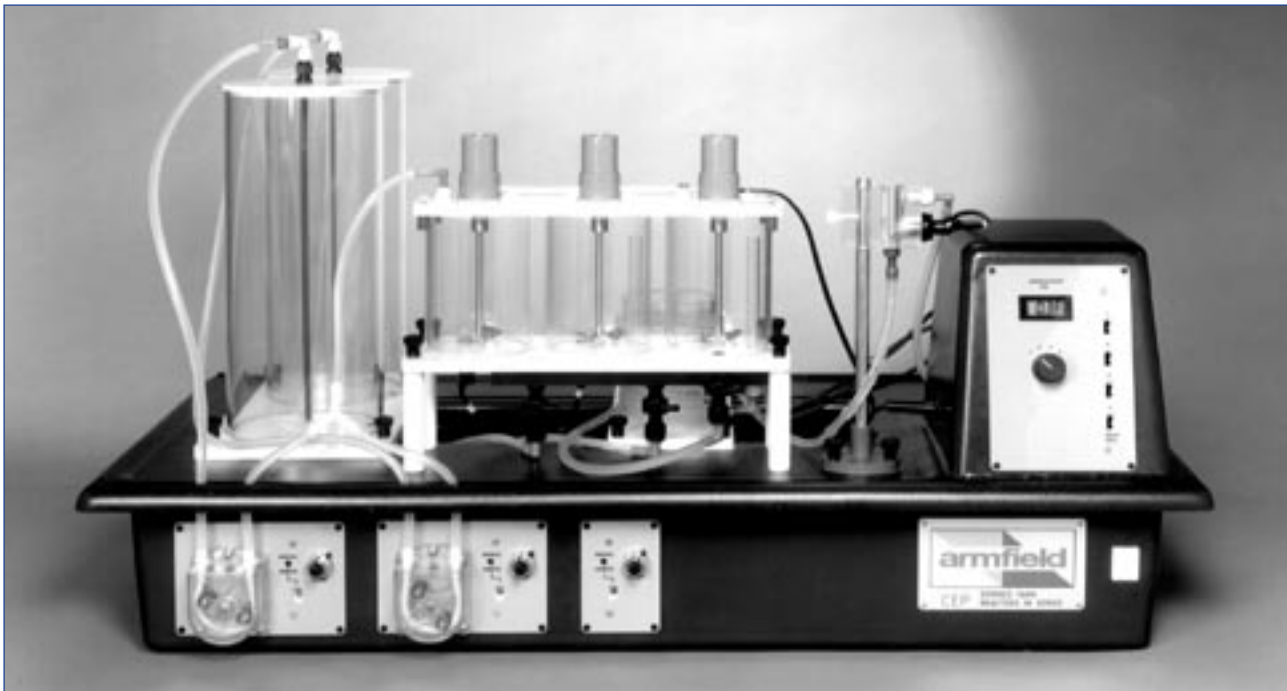
OVERALL DIMENSIONS

Height: 350mm
Width: 250mm
Depth: 350mm

SHIPPING SPECIFICATION

Volume: 0.1m³
Gross weight: 10kg

CEP MkII STIRRED TANK REACTORS IN SERIES



CEP - Mimic diagram

DEMONSTRATION CAPABILITIES

- investigation of dynamic behaviour of stirred tank reactors in series
- effect of step input change
- response to an impulse change
- influence of flow rate
- investigation of time constant using 'dead time' coil
- investigation of chemical reaction in a three tank system

TECHNICAL DESCRIPTION

The Armfield Stirred Tank Reactors in Series unit is designed to follow the dynamics of the perfectly mixed multi-stage process. Dynamic behaviour can be studied as can multi-stage chemical reaction. Bench mounted and self-contained, the unit requires only to be connected to a single phase electrical supply for operation.

There are three reactor vessels connected in series, each containing a propellor agitator driven by a variable speed electric motor.

Two reagent vessels and two variable speed feed pumps feed reagents into the first reactor in line.

For certain experiments the feed can be connected to the third reactor and a dead-time coil, also positioned on the vacuum formed plinth.

Each reactor and the exit port of the dead-time coil are fitted with conductivity probes for monitoring the process.

Conductivity is displayed on a digital meter on the console through a selector switch and all four probes can be connected to the optional Armfield data logging accessory CEX-304IFD.

ORDERING SPECIFICATION

- A self-contained bench mounted small scale unit fitted with three continuous stirred reactors in series which are fed from two 5 litre tanks. Each reactor is fitted with a conductivity probe.
- There are two independent, variable speed feed pumps.
- A dead-time residence coil can also be attached to the exit of the last reactor in the series.
- Demonstration capabilities:
 - Investigation of dynamic behaviour of stirred tank reactors in series
 - Influence of flow rate and step input change
 - Investigation of chemical reaction in a three tank system
 - Investigation of time constant using a dead-time coil

OPTIONAL ARMFIELD ACCESSORY

CEX-304IFD data logging accessory

SERVICES REQUIRED

Single phase electrical supply

CEP-A: 220/240v/1ph/50Hz @ 5 amps

CEP-B: 120v/1ph/60Hz @ 10amps

OVERALL DIMENSIONS

Height: 550mm

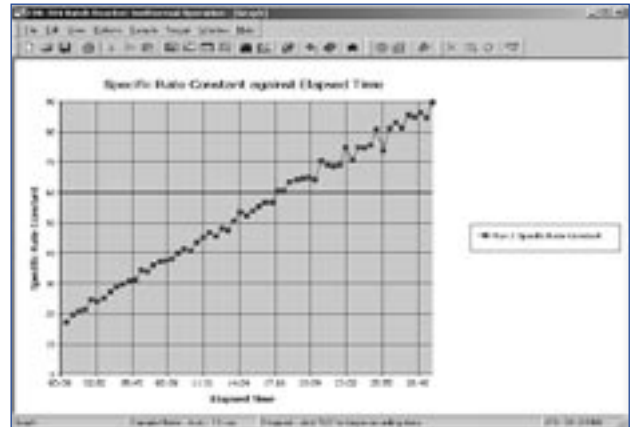
Width: 1.0m

Depth: 500mm

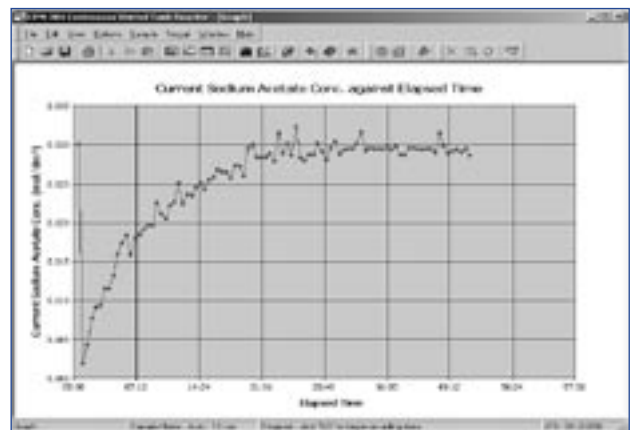
SHIPPING SPECIFICATION

Volume: 0.8m³

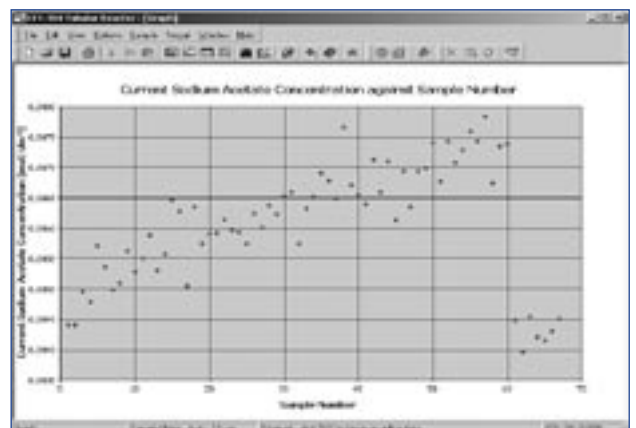
Gross weight: 50kg



CEB - Graphical representation of data from a typical experiment



CEM - Graphical representation of data from a typical experiment



CET - Graphical representation of data from a typical experiment

CEX-304IFD Data Logging Accessory (Including Educational Software)



The IFD6 Interface device

SOFTWARE CAPABILITIES

The software is designed to simplify the tasks of both the students and faculty, by eliminating repetitive tasks, providing instruction on the investigation and the theory, and providing a record of the results. It allows the student to complete the investigation and process the results in a standard laboratory session, giving the time to repeat any necessary measurements and analysis.

Software features include:

- Presentation screens outlining the investigations, the theory and the equipment
- Detailed help texts describing how to use the software, set up the equipment, perform the investigation and the associated theory
- Real time schematic representations of the equipment and sensor measurements
- Data logging, with full control over sample rates
- Fully flexible graph plotting
- Student questions

TECHNICAL DESCRIPTION

The system uses the Armfield IFD6 Interface Device which digitises the analogue inputs and transfers the data to the computer. This allows the temperature or conductivity measurements, together with an indication of the pump rates set on the chemical reactors service units to be logged on a PC. The package comprises the hardware and appropriate software for the reactors.

The interface to the PC is via USB, requiring no additional hardware in the PC. Therefore any PC including laptop and notebook versions may be used.

The software is provided on CD-ROM.

ESSENTIAL ADDITIONAL EQUIPMENT

(not supplied by Armfield)

The user must have access to a Pentium computer with a CD-ROM drive, running either Windows 98, 2000, ME or XP.

ORDERING SPECIFICATION

CEX-304IFD data logging accessory and educational software for Continuous Stirred Tank Reactor, Tubular Reactor, Batch Reactor and Stirred Tank Reactors in Series: comprises interface device + software + leads.

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