INSTRUCTION MANUAL

CEM MkII

CONTINUOUS STIRRED TANK REACTOR

CEM MkII

ISSUE 14

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⚠ IMPORTANT SAFETY INFORMATION

All practical work areas and laboratories should be covered by local regulations which must be followed at all times. If required, Armfield can supply a typical set of laboratory safety rules.

Your CEM Continuous Stirred Tank Reactor has been designed to be safe in use when installed, operated and maintained in accordance with the instructions in this manual. As with any piece of sophisticated equipment, dangers may exist if the equipment is misused, mishandled or badly maintained.

⚠ Water-Borne Hazards

The equipment described in this instruction manual involves the use of water which under certain conditions can create a health hazard due to infection by harmful micro-organisms.

For example, the microscopic bacterium called Legionella pneumophila will feed on any scale, rust, algae or sludge in water and will breed rapidly if the temperature of water is between 20 and 45°C. Any water containing this bacterium which is sprayed or splashed creating air-borne droplets can produce a form of pneumonia called Legionnaires Disease which is potentially fatal.

Legionella is not the only harmful micro-organism which can infect water, but it serves as a useful example of the need for cleanliness. Under the COSHH regulations, the following precautions must be observed:

Any water contained within the product must not be allowed to stagnate, ie. the water must be changed regularly.

Any rust, sludge, scale or algae on which micro-organisms can feed must be removed regularly, i.e. the equipment must be cleaned regularly.

Where practicable the water should be maintained at a temperature below 20°C or above 45°C. If this is not practicable then the water should be disinfected if it is safe and appropriate to do so. Note that other hazards may exist in the handling of biocides used to disinfect the water.

A scheme should be prepared for preventing or controlling the risk incorporating all of the actions listed above.

Further details on preventing infection are contained in the publication "The Control of Legionellosis including Legionnaires Disease" - Health and Safety Series booklet HS (G) 70.

⚠ ELECTRICAL SAFETY

The equipment described in this Instruction Manual operates from a mains voltage electrical supply. It must be connected to a supply of the same frequency and voltage as marked on the equipment or the mains lead. If in doubt, consult a qualified electrician or contact Armfield. The equipment must not be operated with any of the panels removed.

To give increased operator protection, the unit incorporates a Residual Current Device (RCD), alternatively called an Earth Leakage Circuit Breaker, as an integral part of this equipment. If through misuse or accident the equipment becomes electrically dangerous, the RCD will switch off the electrical supply and reduce the severity of any electric shock received by an operator to a level which, under normal circumstances, will not cause injury to that person.

At least once each month, check that the RCD is operating correctly by pressing the TEST button. The circuit breaker **MUST** trip when the button is pressed. Failure to trip means that the operator is not protected and the equipment must be checked and repaired by a competent electrician before it is used.

HOT SURFACES AND LIQUIDS

The unit incorporates a pumped electric water heater, and is capable of producing temperatures that could cause skin burns.

Before disconnecting any of the pipes or tubing:

- Stop all the pumps.
- Leave time for the water to cool
- Check that the temperature is at a safe level

Do not touch any surfaces close to 'Hot Surfaces' warning labels, or any of the interconnecting tubing, whilst the equipment is in use.

CHEMICAL SAFETY

Details of the chemicals intended for use with this equipment are given in the Product Manuals for the different reactor options available with this equipment. Chemicals purchased by the user are normally supplied with a COSHH data sheet which provides information on safe handling, health and safety and other issues. It is important that these guidelines are adhered to.

Note:

- It is the user's responsibility to handle chemicals safely
- Prepare chemicals and operate the equipment in well ventilated areas
- Only use chemicals specified in the equipment manuals and in the concentrations recommended

ARMFIELD LIMITED

OPERATING INSTRUCTIONS AND EXPERIMENTS

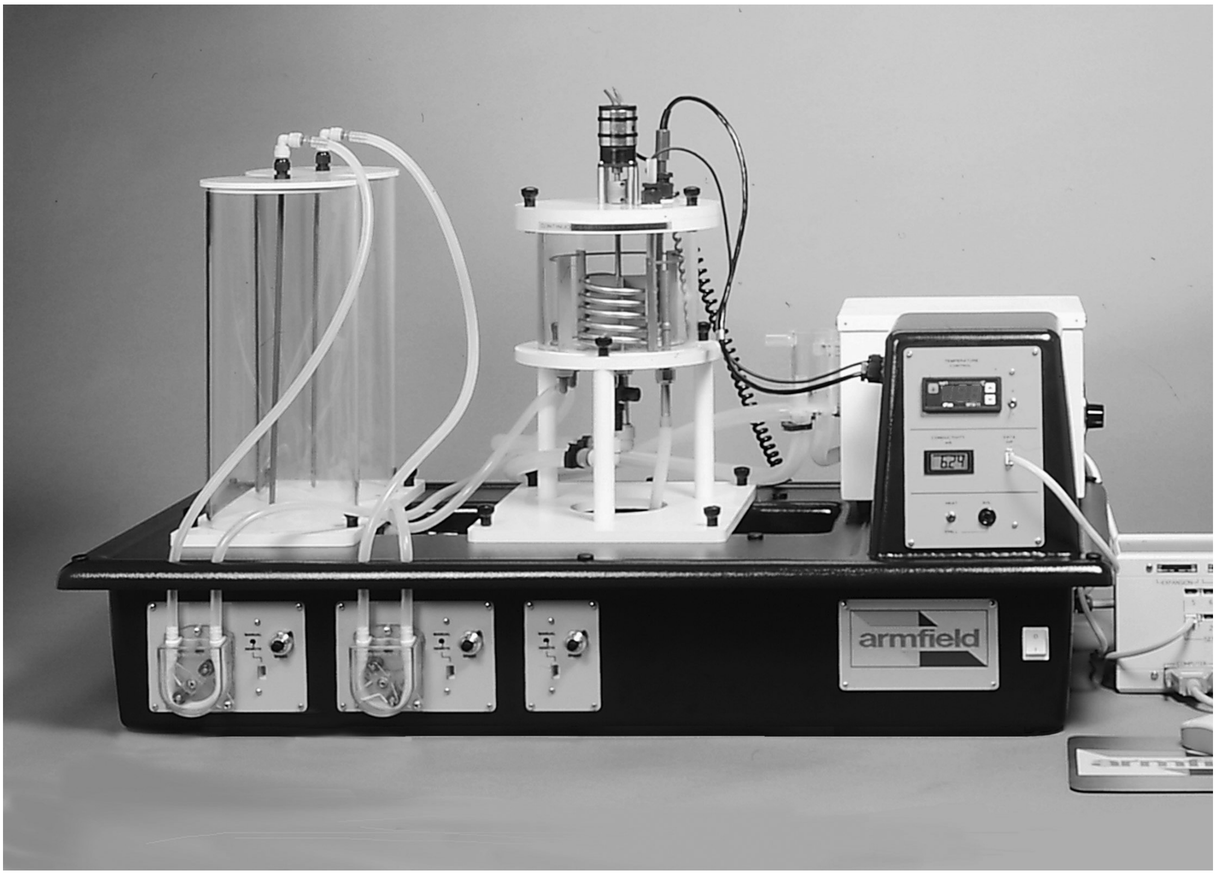
CEM CONTINUOUS STIRRED TANK REACTOR

1. INTRODUCTION

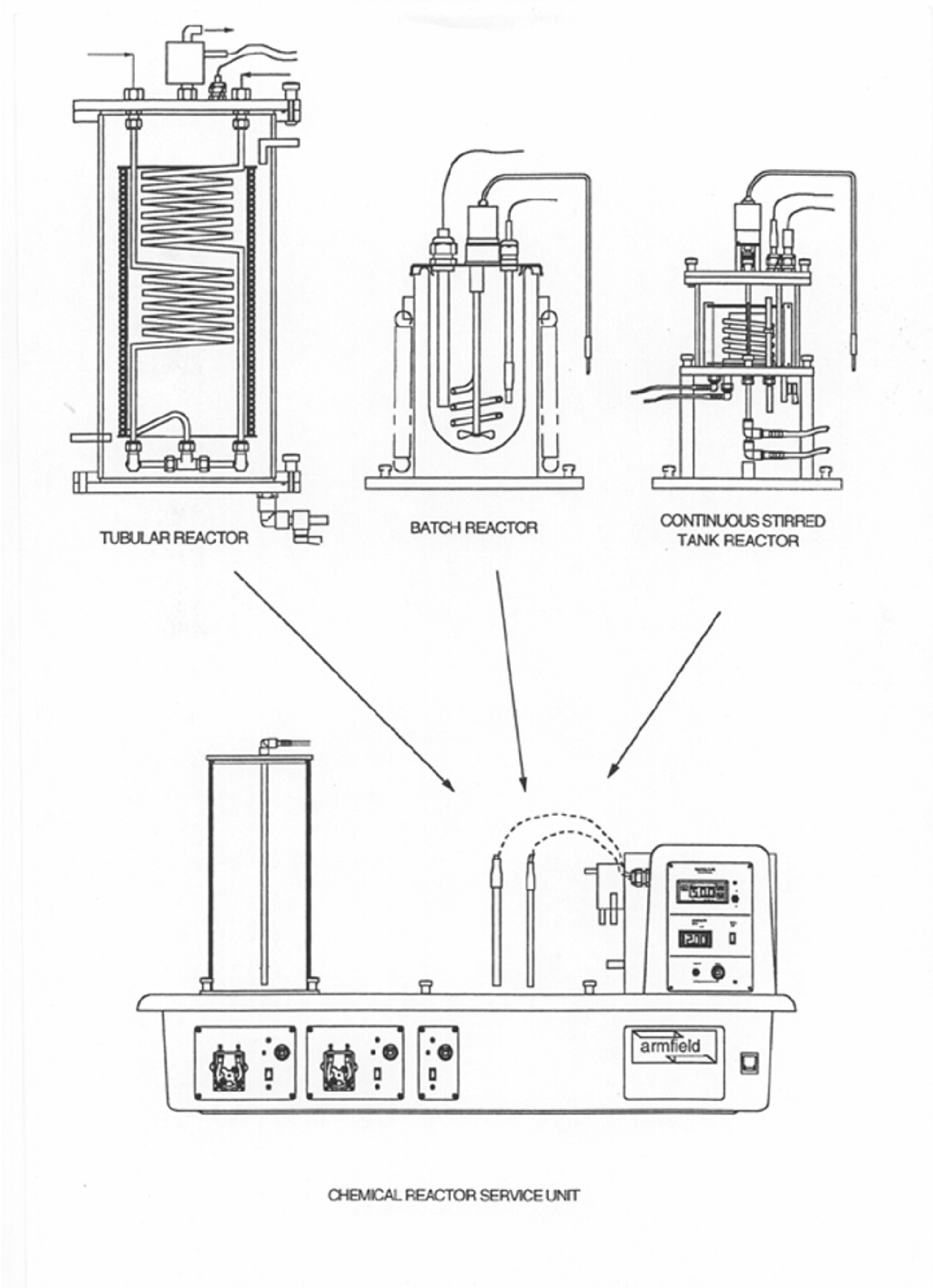
The continuous stirred tank reactor in the form of either a single tank or (more often) tanks in series, is used widely and is particularly suitable for liquid phase reactions. It is particularly used in the organic chemicals industry. Advantages include consistent product quality, straightforward automatic control and low manpower requirements.

The Armfield CEM MkII Tubular Flow Reactor is specially designed to allow detailed study of this important process. It is one of three reactor types which are interchangeable on the Reactor Service Unit (CEX MkII), the others being CET MkII - Tubular Reactor and CEB MkII - Batch Reactor.

Reactions are monitored by conductivity probe as the conductivity of the solution changes with conversion of the reactants to product. This means that the inaccurate and inconvenient process of titration, which was formally used to monitor the reaction progress, is no longer necessary.



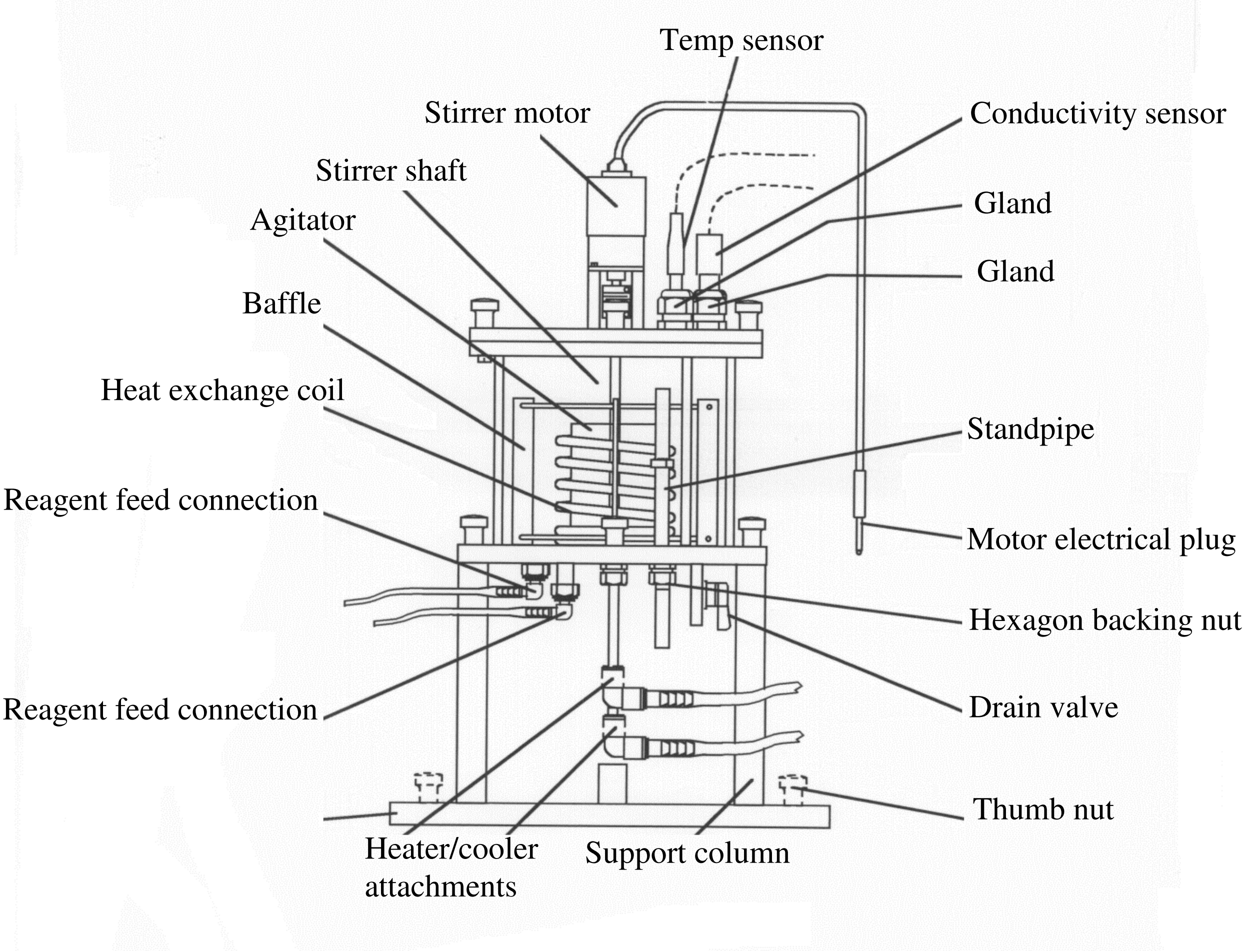
CEX fitted with CEM MkII continuous stirred tank reactor


TUBULAR REACTOR
BATCH REACTOR
CONTINUOUS STIRRED
TANK REACTOR
armfield
CHEMICAL REACTOR SERVICE UNIT

2. EQUIPMENT DESCRIPTION

2.1 The Reactor Vessel

The reactor vessel is set on a baseplate which is designed to be located on the four studs of the CEX service unit and then secured by thumbnuts. The reactor is supported by three pillars; position the reactor on the CEX service unit such that a single pillar is to the front.



A stainless steel coil inside the reactor provides the heat transfer surface for either heating or coiling the chemical reactants. The coil is connected either to the hot water circulator or the CW-16 chiller. The coil inlet is at the front of the reactor and the coil return is at the rear of the reactor.

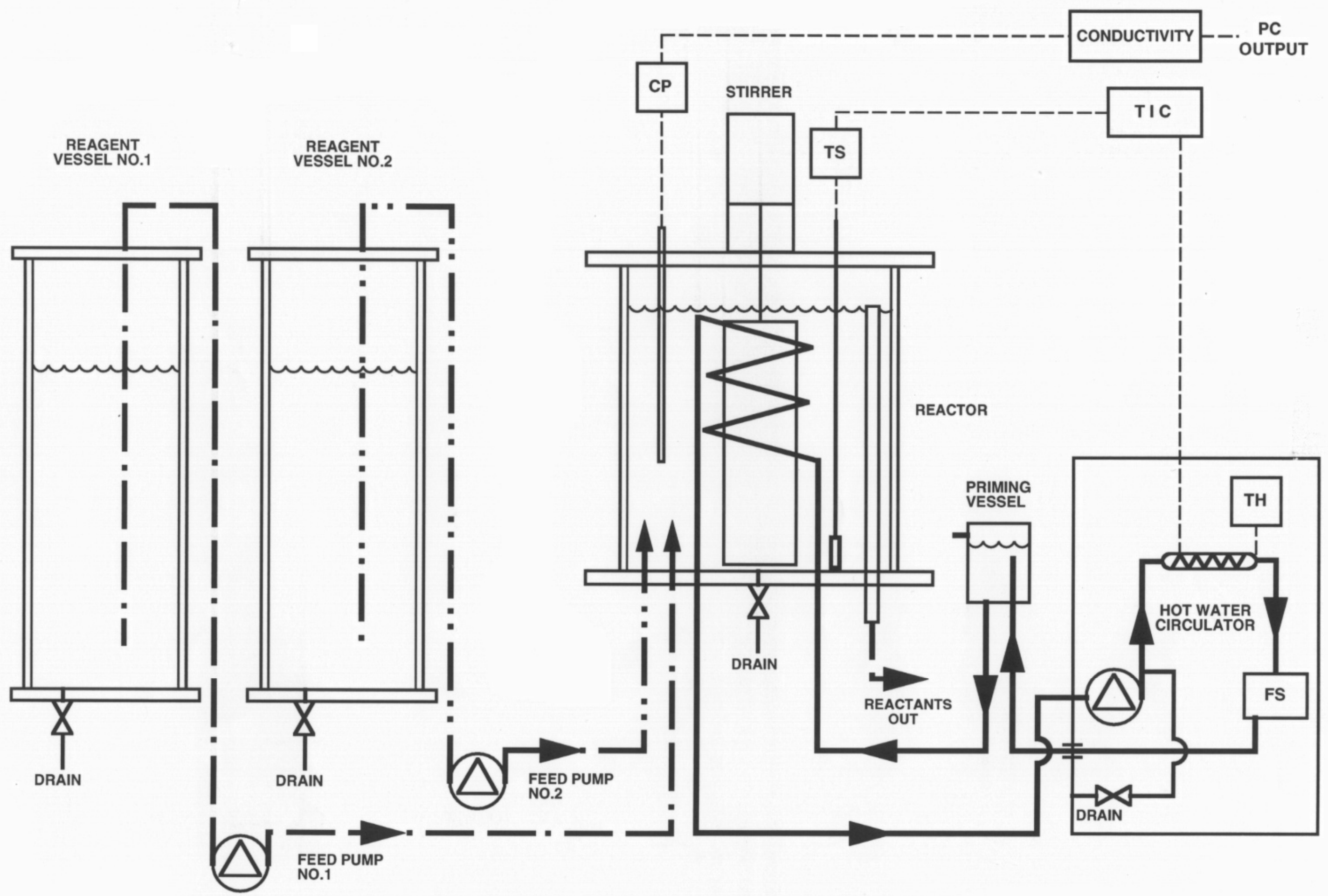
A turbine agitator works in conjunction with a baffle arrangement to provide efficient mixing and heat transfer. The agitator is driven by an electric motor mounted on the lid of the reactor. The motor is driven by a variable speed unit mounted in the front of the service unit. The socket for the motor electrical plug is sited at the rear of the service unit.

Glands in the reactor lid house the conductivity and temperature sensors provided with the service unit. The larger of the two glands is for the conductivity probe. The glands are unscrewed by hand, the probes inserted completely into the reactor until they rest on the reactor base and then the glands re-tightened by hand. Sockets in the side of the console on the service unit are provided to connect each probe. These are of different size so that the probes cannot be wrongly connected.

2.2 Flow of materials

Chemical reagents are pumped from the two feed tanks into the reactor separately through connectors in the base of the reactor. The two feed pumps of the service unit are connected to these. As reagents are pumped into the reactor, the level increases until it finally overflows the stand pipe and flows to drain. The stand pipe may be adjusted in height by loosening the hexagonal backing nut. A mark is etched onto the stand pipe. For maximum operating volume of the reactor, this mark should be aligned with the backing nut. A stop prevents the stand pipe from being completely removed, and this also defines the minimum working volume which is half the maximum volume.

When the reactor is not being used, it can be drained using the valve sited on the underside of the reactor.



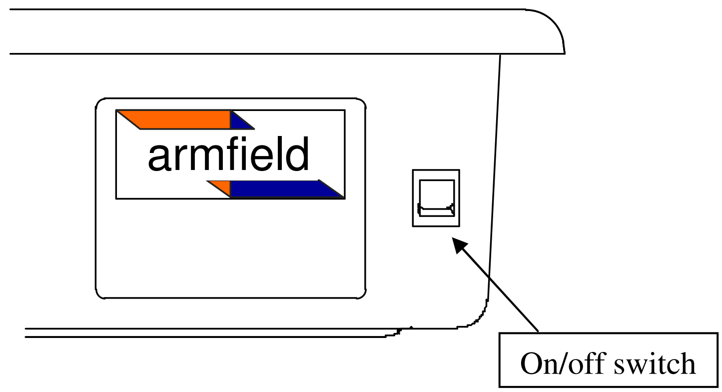
CEM MKII CONTINUOUS STIRRED TANK REACTOR

3. OPERATION

The apparatus must be set up in accordance with the installation sheet supplied (see Appendix A for details). Additionally, ensure that you have read the safety information at the beginning of this manual.

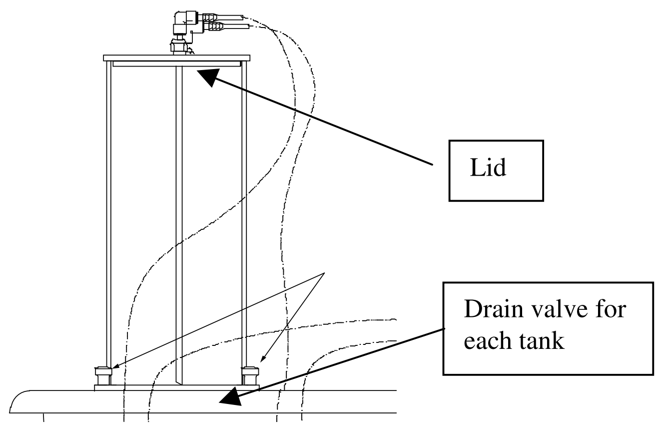
3.1 Switching on the unit

The unit is switched on using the switch on the front of the unit. The circuit breakers and RCD device located at the rear of the unit should be turned on beforehand. Both the temperature controller and conductivity display should illuminate.



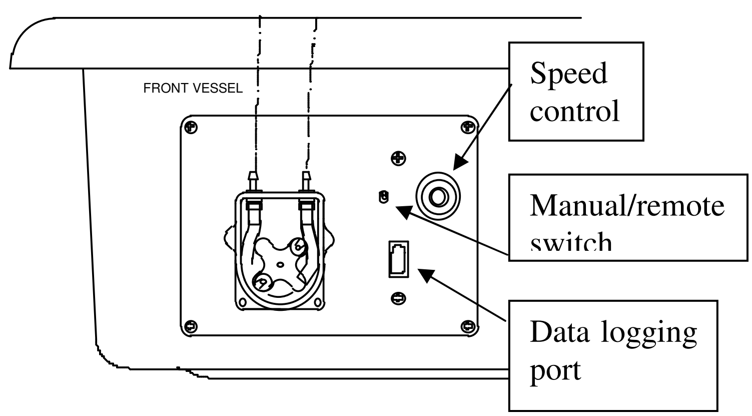
3.2 Filling the feed tanks

Lift the feed tank lids and pour solutions in from above. A drain tap is located at the base of each vessel in order to drain residual liquid.



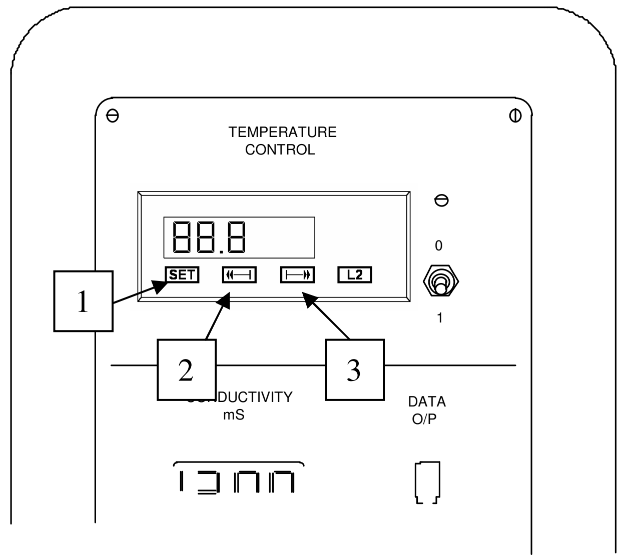
3.3 Controlling the feed pumps

For normal use the feed pump is set to MANUAL and controlled using the rotary switch next to the pump head. Turning the dial clockwise increases pump speed. The pump can be switched off by reducing the pump speed to zero or by changing the switch to the REMOTE position.



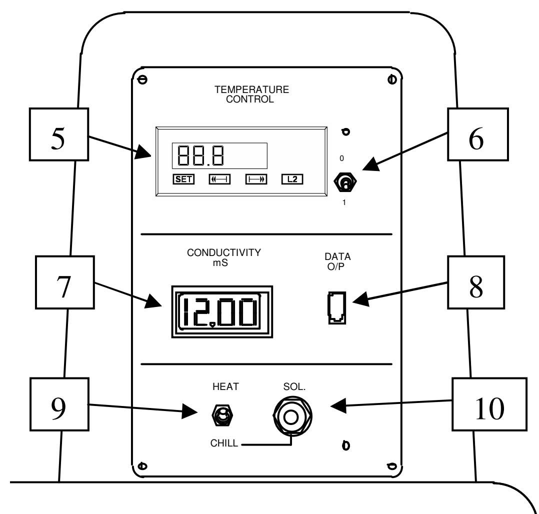
3.4 Operation of temperature controller

Temperature is displayed in °C. The set-point temperature is shown by pressing button **1** and the value adjusted up and down using buttons **2** and **3** respectively. The display will revert to the process temperature after a short period.



3.5 Operating the console

When the CEX is used with the hot water circulator then switch **9** should be positioned to heat. It is used in the chill position when CEX is used in conjunction with the CW16 chiller. Also control for the CW16 chiller solenoid valve should be plugged into socket **10**. Temperature in the reactor is displayed on the controller (**5**). The hot water circulator is turned on using switch **6**. Conductivity is displayed on the meter (**7**) and can be remotely logged from socket **8**.
Note: when using the chiller the temperature controller parameters should be changed in accordance with the Routine Maintenance section.



3.6 Calibrating the feed pumps

Both peristaltic pumps require calibration so that exact flow rates are known. Calibration should be carried out for both pumps since there may be small differences between them.

Fill both reagent vessels. Set the feed pump to 2.0 and determine the flow rate by measuring the volume collected for a defined period. Repeat the procedure for 4.0, 6.0, 8.0 and 10.0 and plot flowrate versus pump speed.

3.7 Operating the CEM MkII

Temperature in the reactor is controlled by circulating heating or cooling liquid through the internal coil.

The volumetric ratio in which the reactants are mixed is defined by the relative flow rates of the two pumps. If the pumps are operated at the same flow rate then the reactants are mixed in equal volumes.

The degree of mixing may be adjusted using the agitator speed control on the front of the service unit.

The extent of conversion of the reactants is determined from the conductivity, which is measured by the conductivity probe.

4. SPECIFICATIONS

4.1 Reactor dimensions:

Vessel diameter:	0.153m
Maximum vessel depth:	0.108m
Maximum volume:	2.0L
Minimum vessel depth:	0.054m
Minimum operating vol:	1.0L

5. EXPERIMENTAL PROCEDURES

The Armfield continuous stirred tank reactor is designed to demonstrate the mechanism of a chemical reaction in this type of reactor as well as the effects of varying the process conditions such as reaction temperature, reactor volume, stirring rate, feed rate etc.

The reactor volume can be varied by adjusting the height of the internal standpipe. The actual volume must be checked by filling the reactor with water to the overflow then draining the reactor contents into a measuring cylinder.

Calibration of the feed pumps is achieved by pumping water from the reagent tanks to a measuring cylinder over a timed period for a range of pump speeds. A calibration graph for each pump of % speed vs. flowrate (ml/min) can then be drawn.

The conductivity of the reacting solution in the reactor changes with the degree of conversion and this provides a convenient method for monitoring the progress of the reaction either manually or by computer.

The reaction chosen is the saponification of ethyl acetate by sodium hydroxide as it can be carried out under safe conditions of temperature and pressure and is well documented.

The experiments involve the collection and storage of conductivity data. The data output port in the console must be connected to the Armfield IFD data logger and the computer as detailed in the instruction leaflet supplied with the interface. This will enable data logging of the conductivity at selected time intervals over a selected period of time.

If a computer is not available then the conductivity can be recorded manually at half minute intervals by reading the value directly from the conductivity meter in the console.

Although it may be possible to carry out demonstrations using other chemicals, it is not advisable as the materials of construction of the reactor may not be compatible.

Before carrying out reactions involving any other reagents please refer to Armfield Ltd. for advice.

5.1 DILUTION OF ETHYL ACETATE

Armfield recommends the use of a 0.1M solution of Ethyl Acetate in the CEM MkII reactor. This should be made by diluting concentrated Ethyl Acetate as follows:

$$\text{Volume of concentrate} = \frac{\text{Mol Wt}}{10} \times \frac{1}{\text{Density}} = \frac{88.11}{10 \times 0.90} = 9.79 \text{ ml per litre of solution}$$

Therefore add 9.79 ml of concentrated Ethyl Acetate to 900 ml of deionised or distilled water.

Shake the mixture vigorously until the two liquids have mixed. Add further water to make up the final volume to 1000 ml.

Note: The practice of making a strong solution (e.g. 1M) then further diluting this to the required concentration (e.g. 0.1M) cannot be applied when using Ethyl Acetate. The required dilution should be made directly as stated above.

5.2 DILUTION OF SODIUM HYDROXIDE

Armfield recommends the use of a 0.1M solution of Sodium Hydroxide in the CEM MkII reactor. This may be made by adding 4.0g of NaOH to 960ml of deionised water then making up the solution to 1000ml.

5.3 OPERATION AS A BATCH REACTOR

If the unit is operated as a batch reactor (no continuous feed to the reactor) then temperature control of the vessel contents will not be possible using the standard arrangement.

If it is required to operate in batch mode with the temperature elevated above ambient then the temperature sensor should be removed from the gland in the top of the reactor and placed in the vessel on the side of the hot water circulator. The temperature controller will then regulate the temperature of the water flowing through the heating coil, preventing overshoot and maintaining the vessel contents at a steady value. The actual temperature of the vessel contents can be monitored using a spirit filled glass thermometer (not supplied) through the vacant gland in the lid. Any small offset in the actual temperature of the reactor contents can be compensated by changing the set point on the controller by a corresponding amount.

As the standard reaction is exothermic the heat generated by the reaction will result in a rise in temperature of the vessel contents that is unavoidable. If it is required to maintain the reaction at a more precise temperature then it will be necessary to perform the trial at a temperature below the ambient temperature using the optional chilled water circulator CW-16 (not supplied) connected to the coil in the reactor vessel.

5.4 EXPERIMENT A

To find the reaction rate constant in a Continuous Stirred Tank Reactor

THEORY

The reaction:-

$$NaOH + H_3COOC_2H_5 \rightarrow CH_3COONa + C_2H_5OH$$

Sodium Hydroxide + Ethyl Acetate → Sodium Acetate + Ethyl Alcohol

can be considered equi-molar and first order with respect to both sodium hydroxide and ethyl acetate, i.e. second order overall, within the limits of concentration (0 - 0.1M) and temperature (20 - 40°C) studied.

The reaction carried out in a Continuous Stirred Tank Reactor or Tubular Reactor eventually reaches steady state when a certain amount of conversion of the starting reagents has taken place.

The steady state conditions will vary depending on concentration of reagents, flowrate, volume of reactor and temperature of reaction.

METHOD

Make up 5.0 litre batches of 0.1M sodium hydroxide and 0.1M ethyl acetate.

IMPORTANT: It is essential when handling these chemicals to wear protective clothing, gloves and safety spectacles.

Remove the lids of the reagent vessels and carefully fill with the reagents to a level approximately 50mm from the top. Refit the lids.

Adjust the set point of the temperature controller to 30°C.

Collection of conductivity data will be until a steady state condition is reached in the reactor and this takes approximately 30 minutes. It is advisable to set the data collection period to, say, 45 minutes.

Using the calibration graph for each of the feed pumps, set the pump speed control to give 40 ml/min flowrate.

Set the agitator speed controller to 7.0.

Switch on both feed pumps and the agitator motor, and instigate the data logger program (or begin taking readings if no computer is being used). After a few minutes the temperature sensor tip will be covered (about 25mm of liquid in reactor) – switch on the hot water circulator.

It has been determined that the degree of conversion of the reagents affects the conductivity of the reactor contents so that recording the conductivity with respect to time using the Armfield data logger can be used to calculate the amount of conversion.

INTERPRETATION OF RESULTS.

Having recorded the conductivity of the contents of the reactor over the period of the reaction, the conductivity measurements must now be translated into degree of conversion of the constituents.

Both sodium hydroxide and sodium acetate contribute conductance to the reaction solution whilst ethyl acetate and ethyl alcohol do not. The conductivity of a sodium hydroxide solution at a given concentration and temperature, however, is not the same as that of a sodium acetate solution at the same molarity and temperature and a relationship has been established allowing conversion to be inferred from conductivity.

The calculations are best carried out using a spreadsheet such as EXCEL so that the results can be displayed in tabular and graphical form.

On conclusion of the experiment using the Armfield data logger, a set of readings of conductivity with time will be stored in the computer.

At this point, this data can be transferred onto the spreadsheet.

Start the spreadsheet program.

Now enter the following known constants from the experiment using the Nomenclature list on page 23. Ensure use of correct units.

F_a =
F_b =
a_μ =
b_μ =
c_μ =
T =
V =

Using the spreadsheet, calculate the values of a_o, b_o, c_∞, a_∞, $\Lambda_{c\infty}$, Λ_{ao}, $\Lambda_{a\infty}$, Λ_o and Λ_∞. from the following formulae:-

$$a_0 = \frac{F_a}{F_a + F_b} \cdot a_\mu$$

$$b_0 = \frac{F_b}{F_a + F_b} \cdot b_\mu$$

c_∞	=	b_o	for $b_o < a_o$
c_∞	=	a_o	for $b_o \geq a_o$
$\Lambda_{c\infty}$	=	$0.070[1+ 0.0284(T-294)]\ c_\infty$	for $T \geq 294$

Λ_{ao}	=	$0.195[1+ 0.0184(T-294)]\ a_o$	for $T \geq 294$
Λ_o	=	Λ_{ao}	assumes $c_o = 0$
a_∞	=	0	for $a_o < b_o$
a_∞	=	$(a_o - b_o)$	for $a_o \geq b_o$
$\Lambda_{a\infty}$	=	$0.195[1+ 0.0184(T-294)]\ a_\infty$	if $a_\infty \neq 0$
Λ_∞	=	$\Lambda_{c\infty} + \Lambda_{a\infty}$	

For the values of each of the above, the spreadsheet can be used to calculate values of sodium hydroxide concentration (a_1) and sodium acetate concentration (c_1) and the degree of conversion (X_a) and (X_c) for each of the samples of conductivity taken over the period of the experiment.

These can be calculated and listed in columns (use spreadsheet COPY facility) alongside the readings of conductivity using the following equations:-

$$a_1 = (a_\infty - a_0)\left[\frac{\Lambda_0 - \Lambda_1}{\Lambda_0 - \Lambda_\infty}\right] + a_0$$

$$c_1 = c_\infty\left[\frac{\Lambda_0 - \Lambda_1}{\Lambda_0 - \Lambda_\infty}\right] \quad , \qquad \text{for } c_0 = 0$$

$$X_a = \frac{a_0 - a_1}{a_0}$$

$$X_c = \frac{c_1}{c_\infty} \quad , \qquad \text{for } c_0 = 0$$

To calculate the specific rate constant, *k*:-

The overall mass balance at steady-state condition may be written as:-

Input – Output ± Reaction = 0

i.e. for a reactant a in a reactor of volume V

$$\frac{d(Va_1)}{dt} = F \cdot a_0 - F \cdot a_1 - V \cdot k \cdot a_1^2$$

For the continuous reactor operating at steady state the volume may be assumed constant and

$$k = \frac{F}{V} \cdot \frac{a_0 - a_1}{a_1^2} = \frac{(F_a + F_b)}{V} \cdot \frac{(a_0 - a_1)}{a_1^2} \quad \text{mol/dm}^3\ \text{sec}$$

The steady state concentration of NaOH in the reactor (a_1) may be used to calculate the specific rate constant (k).

Comment upon the results obtained.

Notes:

1. It is recommended that this experiment should be repeated at various other temperatures to investigate the relationship between the specific rate constant (k) and the temperature of reaction.

2. It is further recommended that the experiment be repeated using dissimilar flow rates for the caustic soda and ethyl acetate solutions to investigate the effect that this will have upon the saponification process.

5.5 EXPERIMENT B

To determine the effect of inadequate mixing on the reaction rate

THEORY

The rate of reaction is measured by the amount of reactants converted to products in a unit of time. In order for reaction to occur, particles must come into contact and this contact must result in interaction. The rate of reaction depends on the collision frequency and collision efficiency of particles of the reacting substances. These factors are optimised by thorough mixing of the reactants using stirrers and baffles within the reactor. Inefficient mixing will result in reduced reaction rates.

Considering the reaction between sodium hydroxide and ethyl acetate, if the initial concentrations are equal (both a_0) and the conversion (X_a) then the concentrations are as follows:

NaOH	+	$CH_3COOC_2H_5$	→	C_2H_5OH	+	CH_3COONa
$(a_0 - X_a)$		$(a_0 - X_a)$		(X_a)		(X_a)

METHOD

Repeat Experiment A after removing the baffles from the reactor. This is achieved by removing the conductivity and temperature probes then removing the lid of the reactor. The baffle arrangement simply lifts out.

Repeat the experiment with baffles removed and no stirring action.

Three sets of data will be obtained:

a. Stirred reactor with baffle (see Experiment A)
b. Stirred reactor, no baffle
c. Un-stirred reactor, no baffle

Graphs of the reaction conversion with time can be plotted using the data logger (or using the manual readings obtained if not using the logger).

Comment on the results obtained. How did removal of the baffle affect the reaction rate? What effect does stirring have on the reaction rate?

5.6 EXPERIMENT C

Dynamic behaviour of continuous stirred tank reactors

THEORY

Effect of a step input change, calculation of the average residence time.

If C = concentration in tank at time t after input step change
C_0 = concentration of the input

Then $$C = C_0\left(1 - e^{-\frac{t}{t_c}}\right)$$ where t_c = time constant

and $$\frac{dC}{dt} = \frac{C_0 \cdot e^{\frac{t}{t_c}}}{t_c}$$

$$= \frac{C_0}{t_c} \quad \text{at } t = 0$$

Hence t_c may be found graphically.

METHOD

Make up 5.0 litres of a solution of 0.1M sodium hydroxide and fill one of the feed vessels to approximately 50.0mm from the top of the vessel. Fill the other feed vessel with demineralised water.

Start the reactor stirrer and set to a speed of '7.0' on the speed adjust dial. The experiment can be carried out at room temperature initially. If other reactor temperatures are required this is achieved using the hot water circulator and the temperature controller in the console as detailed in previous experiments.

Start the sodium hydroxide feed pump and set the speed control to maximum in order to fill the reactor to the overflow as quickly as possible. When the reactor is full, slow the feed pump to give a flow rate of 20.0 ml/min.

At this point start taking readings of conductivity at regular intervals manually or, if using the Armfield data logger, initiate the program.

Start the water feed pump and set to 50.0 ml/min.

The conductivity of the reactor contents will begin to reduce and, after a period of approximately 1 hour, will approach the conductivity of the feed solution.

The final concentration in the reactor will be:-

$$c_\infty = \frac{20}{70} \cdot 0.05 = 0.014\text{M}$$

Calculate $\ln\frac{c_\infty - c_1}{c_\infty - c_0}$ where c_1 is the concentration at time t, and c_0 is the concentration of NaAc at the start, for readings of t throughout the experiment. Plot this value against t and calculate the slope (straight line graph passing through the origin). The slope is the average residence time t_R which should be equal to $\frac{V}{F}$ where V is the reactor volume and F is the total flow rate into the reactor.

5.7 Nomenclature

a_μ	sodium hydroxide conc. in feed vessel	(mol/dm^3)
a_o	sodium hydroxide conc. in mixed feed	(mol/dm^3)
a_1	sodium hydroxide conc. in reactor at time t	(mol/dm^3)
a_∞	sodium hydroxide conc. in reactor after ∞ time	(mol/dm^3)
b	ethyl acetate conc.	(mol/dm^3)
(same subscripts as above for a)		
c	sodium acetate conc.	(mol/dm^3)
(same subscripts as above for a)		
F	total volume feed rate	(dm^3/s)
F_a	volumetric feed rate of sodium hydroxide	(dm^3/s)
F_b	volumetric feed rate of ethyl acetate	(dm^3/s)
k	specific rate constant	
r	reaction rate	
t_R	residence time	(s)
t	elapsed time	(s)
T	reactor temperature	(K)
V	volume of reactor	(dm^3)
X_a	conversion of sodium hydroxide = $\frac{a_0 - a_1}{a_0}$	
X_c	conversion to sodium acetate = $\frac{c_1 - c_0}{c_\infty}$	
Λ	conductivity	(Siemens/cm)
Λ_o	initial conductivity	
Λ_1	conductivity at time t	
Λ_∞	conductivity after ∞ time	
Λ_a	sodium hydroxide conductivity	
Λ_c	sodium acetate conductivity	
C	concentration in tank at time *t* after input step change	
C_0	concentration of the input	
t_c	time constant	

ROUTINE MAINTENANCE

To preserve the life and efficient operation of the equipment it is important that the equipment is properly maintained. Regular maintenance of the equipment is the responsibility of the end user and must be performed by qualified personnel who understand the operation of the equipment.

5.8 General

The equipment should be disconnected from the electrical supply when not in use. After use the feed tanks, reactor vessel, sump tray and pipework should be washed through with water to remove chemical residues and then drained.

5.9 RCD test

Test the RCD by pressing the TEST button at least once a month. If the RCD button does not trip when the Test button is pressed then the equipment must not be used and should be checked by a competent electrician.

5.10 Calibration of the conductivity sensor

The conductivity conditioning circuit (which provides the reading from the conductivity probe supplied with the CEX service unit) is located on a printed circuit board inside the electrical console. This circuit is calibrated before despatch and should not require re-calibration. However, should re-calibration become necessary the appropriate calibration potentiometers can be located using the diagram given in the CEX manual (Routine Maintenance).

Ensure the equipment has been connected to the electrical supply and switched on for at least 20 minutes. To access the PCB remove the front panel from the electrical console by removing the four fixing screws. It is not necessary to detach the PCB from the front panel.

Disconnect the conductivity probe from the socket at the left-hand side of the electrical console. Connect an AC Voltmeter (Range AC mV) to pins 1 and 2 of the vacant socket and adjust potentiometer VR2 on the PCB to give a reading of 50 mV (RMS) on the Voltmeter (probe excitation voltage).

Disconnect the Voltmeter then reconnect the probe to the appropriate socket having removed the probe from the appropriate reactor fitted to the CEX.

Fill a small beaker with a Conductivity Standard (e.g. 0.1M KCI giving a conductivity of 12.88 mS at 25°C) and measure the temperature of the Standard using a suitable thermometer. From the table supplied with the Standard determine the actual conductivity of the solution at the measured temperature.

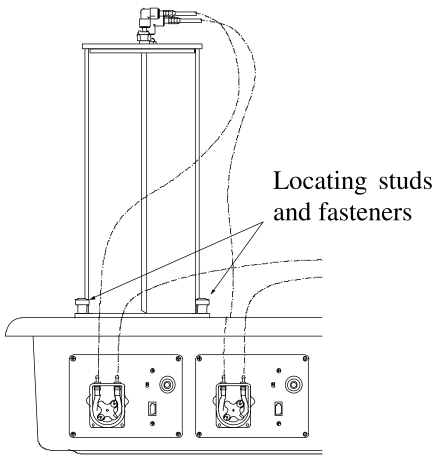
Immerse the probe into the Conductivity Standard in the beaker then adjust potentiometer VR1C to give a reading on the display to match the conductivity of the Standard solution.

When the conditioning circuit has been re-calibrated replace the front panel of the electrical console and re-install the probe in the appropriate reactor on the CEX service unit.

6. APPENDIX: CEM/CEX INSTALLATION GUIDE

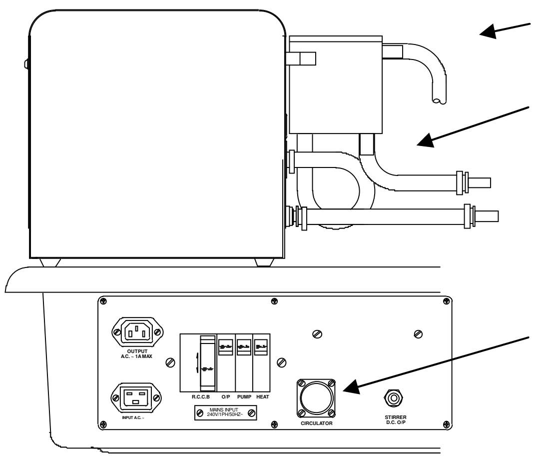
1 MOUNTING THE FEED VESSEL ASSEMBLY

Fit the reagent vessel assembly to the CEX using the 4 locating studs and black hand nuts



Connect the tubing on the left hand side of each of the two feed pumps to the standpipe located in each of the reagent vessels. (Left feed pump to front vessel, right feed pump to rear vessel)

2 MOUNTING THE HOT WATER CIRCULATOR (HWC)

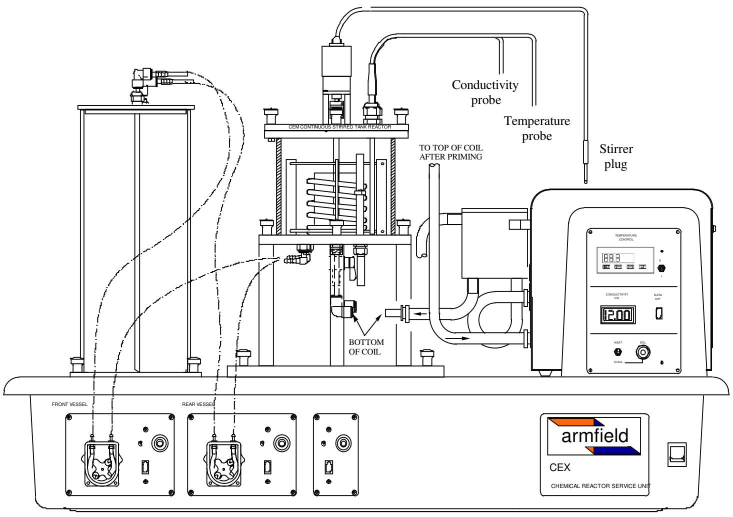


Rear view of CEX showing positioning of HWC

Hoses on the HWC should be orientated as shown in the diagram

The lead from the HWC plugs into the socket indicated. Carefully line up the pins in the plug with the socket. Once connected rotate the locking collar on the plug until it clicks into position

3 MOUNTING THE CEM MKII ONTO THE CEX



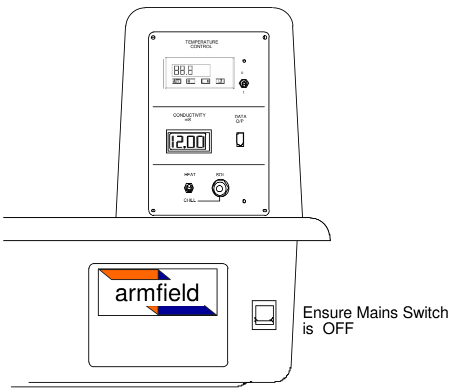
- Fit the CEM MkII assembly to the CEX using the 4 locating studs and black thumbnuts. The reactor is supported by 3 pillars, position the reactor on the CEX so that a single pillar support is foremost
- Connect the remaining two pipes from the feed pumps to the connectors on the base of the reactor as shown.
- Connect the conductivity probe and temperature sensor plugs to the sockets on the left hand edge of the control console. Connect the stirrer plug to the socket located on the rear of the CEX.
- Fit the conductivity and temperature sensors to the CEM. Each probe fits in a gland. The gland nut should be loosened to fit the probes and then tightened to secure them. Probes should reach the bottom of the reactor

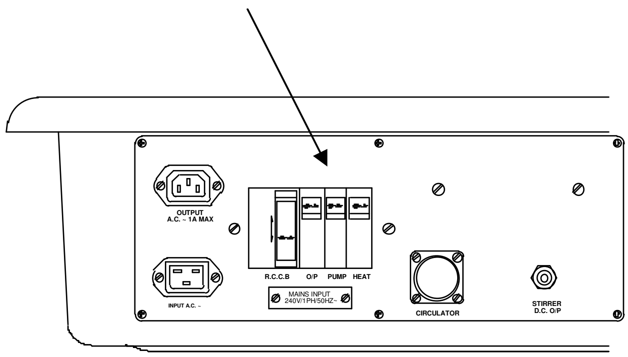
4 CONNECTION TO ELECTRICITY SUPPLY

Check that the voltage specified on the equipment matches the supply voltage. **NOTE**: this unit **MUST** be earthed.

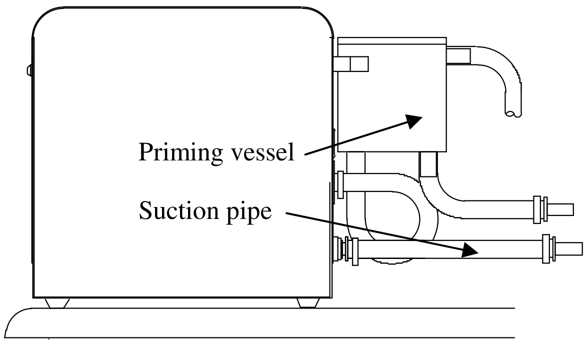
Brown	- Live (hot)
Blue	- Neutral (hot)
Green/yellow	- Earth (ground)

Ensure that circuit breakers and RCCD are ON (up)



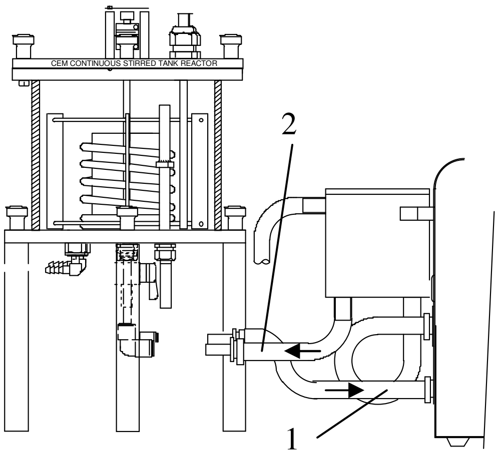


5 PRIMING THE HOT WATER CIRCULATOR



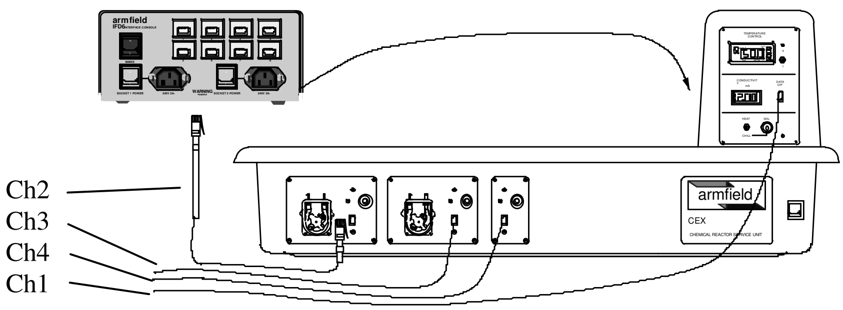
- Connect suction pipe of the HWC to a cold water supply (preferably deionised).
- Switch on the mains switch on the front of the CEX.
- Adjust the temperature controller set-point to a temperature below ambient (see Operation instructions overleaf).
- Then switch on the pump switch at the side of the temperature controller.

6 CONNECTING THE HWC TO CEM MKII



- Connect suction pipe of the HWC (**1**) to the connection for the top of the coil (rear).
- Connect the supply pipe of the HWC (**2**) to the connection for the bottom of the coil (front).
- Turn on the mains switch and then the pump switch and refill the HWC expansion tank as required.

7 CONNECTING TO THE DATA LOGGER (OPTION)



- The IFD is powered by from the mains outlet on the rear of the CEX.
- Connect channels as shown.