



Common items for the Chemical Reactors

① QUS. Service Unit:

This unit is common for the Chemical Reactors, and can work with one or several reactors.

Accommodation and exchange system of the reactors, quick and easy to handle.

It supplies all the services for the operation of each reactor.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

2 Peristaltic dosing pumps with variable speed. Flow rate up to 3 l./h. (Unit standard disposition). With another disposition, they could reach a flow rate up to 10 l./h.

Thermostatic bath of 9 l. capacity. Temperature PID Control of hot water in order to maintain the reactor temperature.

This service unit provides PID temperature controlled hot water in order to maintain reactor temperature.

Pump of 3 l./min., with variable flow, to impel the thermostatisation water from the bath to the reactor. Flow meter.

2 Tanks for the reagents, of 1 liter capacity each one, made in Pyrex glass.

The control of the reaction is carried out by a conductivity cell.

Three "J" type temperature sensors, one to know the thermostatic bath temperature in a continuous way and two sensors to know the water temperature at the thermostatic bath water inlet and outlet.

All elements of this unit are chemically resistant.



QUS

② Electronic Console:

Metallic box.

Temperature sensors connectors.

Digital display for temperature sensors.

Selector for temperature sensors.

Pumps controller.

Stirrer controller.

Heating resistance controller.



Electronic Console

③ Chemical Reactors

③.1 QRCA. Continuous Stirred Tank Reactor:

Small scale Continuous Stirred Tank Reactor, designed to demonstrate the behavior of a reactor used for homogeneous reactions liquid-liquid.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

Reactor body made in borosilicate glass, with a maximum capacity of 2 liters, specially designed to work in continuous. It also allows batch operation.

Adjustable volume from 0.4 to 1.5 l.

Stainless steel heat transfer coil and a baffle (removable).

Variable speed stirrer. Stirrer range: 0-220 rpm.

Reactor lip with connectors for the appropriate sensors.

Temperature sensor "J" type to control the temperature into the reactor.

Conductivity cell to control the reaction.

Easy and quick assembly on the Service Unit.

All elements of this unit are chemically resistant.

This unit is supplied with the following manuals: Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRCA

③ **Chemical Reactors** (continuation)③.2 **QRT. Tubular Flow Reactor:**

Reactor composed by a continuous tube where the reagents are introduced through the coil end and the products are obtained through the inverse end. Into it, a continuous reagents mix is produced, so the composition will be different at each point.

This type of reactors are industrially used for homogeneous reactions liquid-liquid, generally in isothermal conditions.

With this small scale reactor, the behavior of this type of reactors used at industrial level can be observed.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

Tubular flow reactor of volume 0.4 l. Coil shaped. Placed into an acrylic vessel through which the cooling or heating medium is circulated. Coil length: 20 m.

Electric pre-heater of 12 loops and loop diameter of 70 mm approx., for the two reagents feed lines. It is before the mix and currents inlet to the reactor.

Temperature controlled by water jacketed. Temperature control by a temperature sensor "J" type.

Two temperature sensors "J" type to know the reagents outlet temperature from the pre-heater.

Conductivity cell to control the reaction.

Reactor lip with connectors for the appropriate sensors.

Easy and quick assembly on the Service Unit.

All elements of this unit are chemically resistant.

This unit is supplied with the following manuals:

Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRT

③.3 **QRD. Batch Reactor:**

Small scale Bath Reactor, designed for the kinetic study of homogeneous reactions liquid-liquid, both in adiabatic conditions and in isothermal conditions.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

The reactor body is an isolated vessel with a stainless steel external casing. The working volume is 1 liter.

Heat transfer coil made in stainless steel and reactor baffle, of 4.5 loops of 76 mm of diameter and 1250 mm length. The tube internal diameter is of 6 mm and the external one is of 8 mm.

Variable speed stirrer. Stirrer range: 0-220 rpm.

Temperature sensor "J" type to control the temperature into the reactor.

Conductivity cell to control the reaction.

Reactor lip with connectors for the appropriate sensors.

Easy and quick assembly on the Service Unit.

All elements of this unit are chemically resistant.

This unit is supplied with the following manuals:

Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRD

③ **Chemical Reactors** (continuation)

③.4 **QRS. Stirred Tank Reactors in Series:**

The stirred tank reactors in series are used to increase the reagents conversion referred to an only reactor and so obtain product with higher purity.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

3 Continuous stirred tank reactors connected in series.

Reactors body made in borosilicate glass.

Each reactor is fitted with a conductivity cell.

Each one has a stirrer with variable speed.

The two reagent vessels and the two variable speed dosing pumps (at the QUSC Service Unit) feed reagents into the first reactor in line.

A dead-time residence coil can also be attached to the exit of the last reactor in the series.

For some experiments, the feed can be connected to the third reactor and a dead-time coil.

Temperature sensors.

Easy and quick assembly on the Service Unit.

All elements of this unit are chemically resistant.

This unit is supplied with the following manuals:

Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRS

③.5 **QRL. Laminar Flow Reactor:**

Small scale Laminar Flow Reactor, designed to demonstrate the flow pattern characterisation and the steady state conversion in a tubular reactor.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

Working volume: 400 ml.

The reactor column is 1300 mm long approx. including 2 diffusers packed with glass balls.

At the bottom of the column a premixer provides a complete mixing of the reagents entering the reactor and improves the flow distribution.

The reactor refrigeration jacket keeps its contents at constant temperature to keep the laminar flow conditions.

The reagents are fed to the reactor by the peristaltic dosing pumps of the Service Unit.

Temperature sensors.

Conductivity cell to control the reaction.

Easy and quick connection with the Service Unit.

All elements of this unit are chemically resistant.

This unit is supplied with the following manuals:

Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRL

③ **Chemical Reactors** (continuation)③.6 **QRP. Plug Flow Reactor:**

Small scale Plug Flow Reactor, designed to demonstrate the flow pattern characterisation and the steady state conversion in a tubular reactor with axial dispersion.

Working volume: 1 litre.

Anodized aluminium structure and panels in painted steel (epoxy paint).

Main metallic elements in stainless steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

The reactor column is 1100 mm long approx., packed with 3 mm diameter glass balls.

At the bottom of the column a premixer provides a complete mixing of the reagents entering the reactor and improves the flow distribution.

The reagents are fed to the reactor by the 2 peristaltic dosing pumps of the Service Unit.

The unit uses a 6 ports injection valve which injects the reagent dose on the carrier at the reactor tube inlet.

Temperature sensors.

Conductivity cell to control the reaction.

Easy and quick connection with the Service Unit.

All elements of this unit are chemically resistant.

This unit is **supplied with the following manuals:** Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.



QRP

④ **Cables and Accessories**, for normal operation.⑤ **Manuals:**

This trainer is **supplied with the following Manuals for each Chemical Reactor:** Required service, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.

Some Practical Possibilities of the Trainer:

Practices to be done with the Continuous Stirred Tank Reactor (QRCA):

- 1.- Determination of the ionic conductivities.
- 2.- Batch operation. Obtaining of the reaction order respect to ethyl-Acetate. Initial velocity method.
- 3.- Batch operation. Obtaining of the reaction order respect to sodium hydroxide. Initial velocity method.
- 4.- Batch operation. Velocity Constant Computation. Constant sodium hydroxide initial concentration.
- 5.- Batch operation. Velocity Constant Computation. Constant ethyl-acetate initial concentration.
- 6.- Velocity equation formulation.
- 7.- Batch operation. Variation of the kinetic constant with temperature. Arrhenius Equation.
- 8.- Batch operation. Theoretical and experimental conversion comparative. Deviation from ideality.
- 9.- Batch operation. Mixture effects.
- 10.- Continuous operation.
- 11.- Continuous operation. Mixture effects.
- 12.- Measurement conductivity system: conductimeter.
- 13.- Variation of conversion with residence time.
- 14.- Residence time distribution.
- 15.- Determination of reaction rate constant.

Practices to be done with the Tubular Flow Reactor (QRT):

- 16.- Analysis of reagents and products.
- 17.- Ionic conductivities determination.
- 18.- Theoretical conversion of the tubular reactor.
- 19.- Experimental determination of the conversion of the tubular reactor.
- 20.- Dependence in the residence time.
- 21.- Determination of the reaction order.
- 22.- Dependence of the speed constant and the conversion with the temperature.
- 23.- Measurement conductivity system: conductimeter.
- 24.- Complete emptying of the unit.
- 25.- Determination of reaction rate constant.

Practices to be done with the Batch Reactor (QRD):

- 26.- Determination of the ionic conductivities.
- 27.- Batch work. Calculation of the order of the reaction referred to the ethyl-acetate. Initial velocity method.
- 28.- Batch operation. Determination of the order of the reaction referred to the sodium hydroxide. Initial velocity method.
- 29.- Batch operation. Determination of the speed constant, the initial concentration of the sodium hydroxide is constant.
- 30.- Batch operation. Determination of the speed constant, the initial concentration of the ethyl acetate is constant.
- 31.- Formulation of the speed equation.
- 32.- Batch operation. Variation of the kinetic constant when the temperature is not constant: Arrhenius equation.
- 33.- Batch operation. Comparison of the theoretical and the experimental conversion: Deviation from the ideality.
- 34.- Calculation of the heat transference coefficient of the coil.
- 35.- Calculation of the hydrolysis reaction enthalpy.
- 36.- Batch operation. Mixture effects.
- 37.- Measurement conductivity system: conductimeter.

Practices to be done with Stirred Tank Reactors in Series (QRS):

- 38.- Investigation of dynamic behaviour of stirred tank reactors in series.
- 39.- Determination of the ionic conductivities.
- 40.- Influence of flow rate.
- 41.- Work with just one reactor in continuous.
- 42.- Work with just one reactor in continuous with mixture effects.
- 43.- Work with 3 reactors in continuous.
- 44.- Effect of step input change.
- 45.- Response to an impulse change.
- 46.- Investigation of time constant using dead time coil.

Practices to be done with Laminar Flow Reactor (QRL):

- 47.- Determination of the residence time distribution of the reactor.
- 48.- Effect of flow rate and feed concentration on the determination of flow pattern.
- 49.- Steady state conversion for a reaction with laminar flow.
- 50.- Effect of flow rate and feed concentration on the steady state conversion.
- 51.- Demonstration of the flow pattern in the reactor and comparison with the theoretical model.
- 52.- Effect of the temperature on the laminar flow characterisation.
- 53.- Determination of the steady state conversion of a second order reaction.
- 54.- Flow pattern characterisation in a laminar flow reactor.
- 55.- Measurement conductivity system: conductimeter.

Practices to be done with Plug Flow Reactor (QRP):

- 56.- Determination of the residence time distribution of the reactor.
- 57.- Effect of flow rate and feed concentration on the determination of flow pattern.
- 58.- Study of the reactor response to different perturbations: step and pulse change.
- 59.- Effect of flow rate and feed concentration on the steady state conversion.
- 60.- Demonstration of the flow pattern in the reactor and comparison with the theoretical model.
- 61.- Determination of the steady state conversion of a second order reaction.
- 62.- Understanding the principles of tracer techniques in flow pattern characterisation.
- 63.- Measurement conductivity system: conductimeter.

ORDER INFORMATION

Items always supplied as minimum configuration

- ① QUS. **Service Unit.** (Common for the Chemical Reactors and can work with one or several reactors).
- ② **Electronic Console.** (Common for the Chemical Reactors and can work with one or several reactors).
- ③ **Available Chemical Reactors:**
- ③① QRCA. **Continuous Stirred Tank Reactor**, and/or
 - ③② QRT. **Tubular Flow Reactor**, and/or
 - ③③ QRD. **Batch Reactor**, and/or
 - ③④ QRS. **Stirred Tank Reactors in Series**, and/or
 - ③⑤ QRL. **Laminar Flow Reactor**, and/or
 - ③⑥ QRP. **Plug Flow Reactor.**
- ④ **Cables and Accessories**, for normal operation.
- ⑤ **Manuals:** This trainer is **supplied with the following Manuals for each Chemical Reactor:** Required service, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.

REQUIRED SERVICES

- Electrical supply: single-phase, 220V/50Hz or 110V/60 Hz.
- Water supply and drainage.

RECOMMENDED ACCESSORIES

- Chemical reagents: ethyl acetate, sodium acetate and sodium hydroxide.
- Laboratory materials as: burettes, test tubes, glasses, balance and a 1 litre glass flask.

DIMENSIONS & WEIGHTS

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|---------------------|--|
| QUS Unit: | - Dimensions: 800 x 800 x 1000 mm. approx.
- Weight: 50 Kg. approx. |
| QRCA Unit: | - Dimensions: 330 x 330 x 500 mm. approx.
- Weight: 10 Kg. approx. |
| QRT Unit: | - Dimensions: 330 x 350 x 500 mm. approx.
- Weight: 15 Kg. approx. |
| QRD Unit: | - Dimensions: 330 x 330 x 500 mm. approx.
- Weight: 10 Kg. approx. |
| QRS Unit: | - Dimensions: 950 x 450 x 500 mm. approx.
- Weight: 35 Kg. approx. |
| QRL Unit: | - Dimensions: 330 x 330 x 1490 mm. approx.
- Weight: 25 Kg. approx. |
| QRP Unit: | - Dimensions: 330 x 330 x 1350 mm. approx.
- Weight: 25 Kg. approx. |
| Electronic Console: | - Dimensions: 490 x 330 x 310 mm. approx.
- Weight: 10 Kg. approx. |

AVAILABLE VERSIONS

Offered in this catalogue:

- QR. **Chemical Reactors Trainer.**

Offered in other catalogues:

- QRC. **Computer Controlled Chemical Reactors Trainer.**
- QRQC. **Computer Controlled Chemical Reactors Training System.**

* Specifications subject to change without previous notice, due to the convenience of improvements of the product.



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Issue: ED01/11
Date: May/2011

REPRESENTATIVE: