



Bio Reactor Systems



# XPLORER



## The bench mark for R+D Bio-reactors

- ... Single and parallel fully automated, modular systems
- ... Aerobic, anaerobic plus microbial, cell cultures and bio-fuels
- ... Range of interchangeable size vessels

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# Introduction to Xplorer

## **Application Focused**

... Specific packs for typical anaerobic, microbial, cell culture and bio-fuel applications

... Several options available to extend each pack

... Custom designs available for highly specific or demanding projects.

## **Basic Features**

- Fully computer controlled
- Batch, fed-batch and continuous modes with multiple pumps
- pH and DO monitoring
- pH control when needed (uni or bi-directional)
- Optical density (turbidity) option for on-line progress tracking
- Stirrer speed (monitoring/control)
- Gas additions: air or up to 4-gas mixture, possibly pH control with CO<sub>2</sub>.
- All probes suitable for sterilization in an autoclave

# System Selection

## **In General...**

... Start with application to determine the control and data logging features needed.

... Pick the working vessel volume. Several different reactor vessels can be used interchangeably – sometimes need extra set of probes.

... Decide on single or multiple (parallel) vessel operating platform. The extra vessels will be run from a common controller.

## **Single Reactor**

One set of sensors (probes) with necessary gas and liquid dosing features integrated into one dedicated computer (could be touch screen). The minimum working volume of the reactor can be 30ml, 100ml, 170ml and higher up to 10L.

## **Parallel Reactors**

Multiple reactors can be used in parallel, separately controlled and monitored. In principle any number can be selected but 4, 6 or 8 is common. The multiple reactors can be of different size and can be operated at different conditions.

## **Choice of Reactor Vessels**

### **Xplorer Mini**

Three vessel sizes working volume:  
30-100ml, 100-350ml, 170-500ml



### **Xplorer Bench**

Vessel volumes available:  
0.5L, 1L, 2L, 5L and 10L



## **Different size reactor: Interchangeability**

Remember, the same control and data logging system allows different vessel sizes to be used as you move from screening to development to pre-pilot:

- Same software interface
- Same probes (apart from power length)
- Result: Highly flexible and Interchangeable systems



## **Parallel bio-reactor Systems**

Any number of independent bio-reactors can be operated from the same control system. Each reactor will have its own set of probes, pumps, rotameters etc and therefore can operate at different conditions and be stopped and started at different times.

The vessels themselves can also be different sizes.



Different sizes,  
same design



## Stirring and temperature Control

### Standard Features

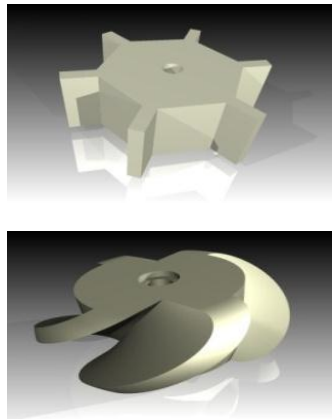
- Reactors placed on heated plate with magnetic stirring
- Fully computer controlled above room temperature and stirring up to 1200 rpm
- Heating across the reactor bases gives excellent temperature control above 25 °C for most bio-applications (better than 0.2 °C). See later for lower temperature operation.
- Stirring can be exactly the same as with overhead motors using suspended stirrer technique. Ideal for mini reactors; for larger (bench) reactors, overhead stirring is available. Mini reactors can also be supplied with overhead stirring.



## **Agitation: magnetic stirring**

**Ideally suited to small bio-reactors, proven performance;**

- No shaft seal or moving parts: no sterility issues
- Custom designed, scaled stirrers, excellent magnetic coupling.
- Range of stirrer designs (marine, rushton etc)
- Speed 200 to 1200 rpm



## **Agitation: Overhead stirring**

**Standard for larger reactors; optional for mini type;**

- Proven stirrer seal designs (mechanical and magnetic)
- Custom designed, scaled stirrers
- Range of stirrer designs.
- Single motor/controller design allows 50 to 1500 rpm



## **Temperature Control**

- Operating range typically ~ 25 °C to 60 °C (or higher)
- Totally separate temperature in each vessel (for parallel systems)
- Heating across reactor base, fast and accurate control
- Cooling: is possible on reactors with jackets that allow coolant water circulation. This is common on large reactors (above 1L) – control is still through the base heaters but coolant removes excess heat. Chilled fluid can also be circulated through jacket if temperature below ambient is needed. Computer controlled chillers can also be supplied.

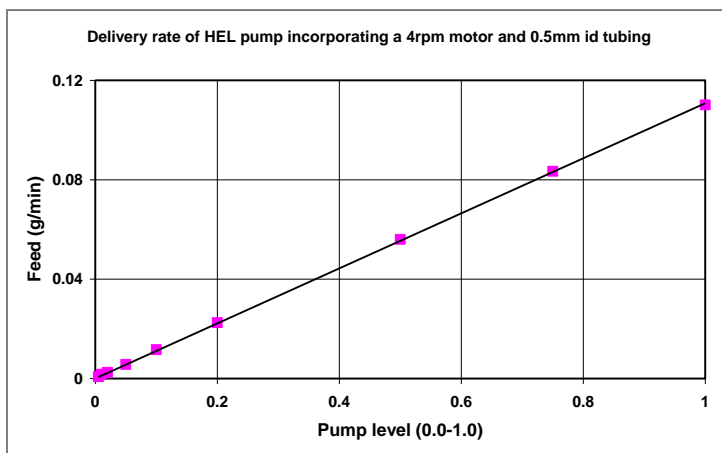
## pH Control

For conventional microbial systems, peristaltic pumps are used to add acid/base, providing control to better than 0.05 pH units using an adaptive control method. Single or bi-directional control may be selected. The software records (and displays) the total amount of acid or base consumed.

For cell cultures, pH is possible by gas (CO<sub>2</sub>) blending.

## Liquid Dosing

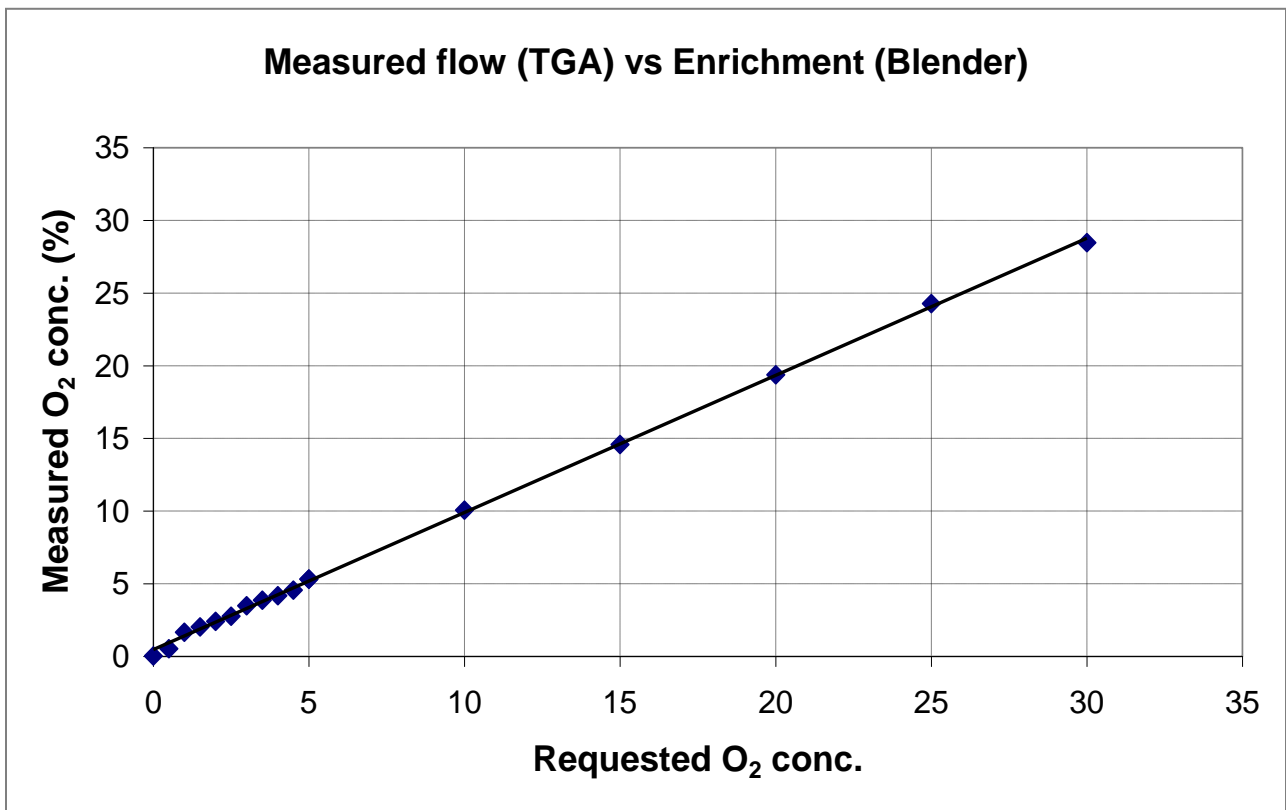
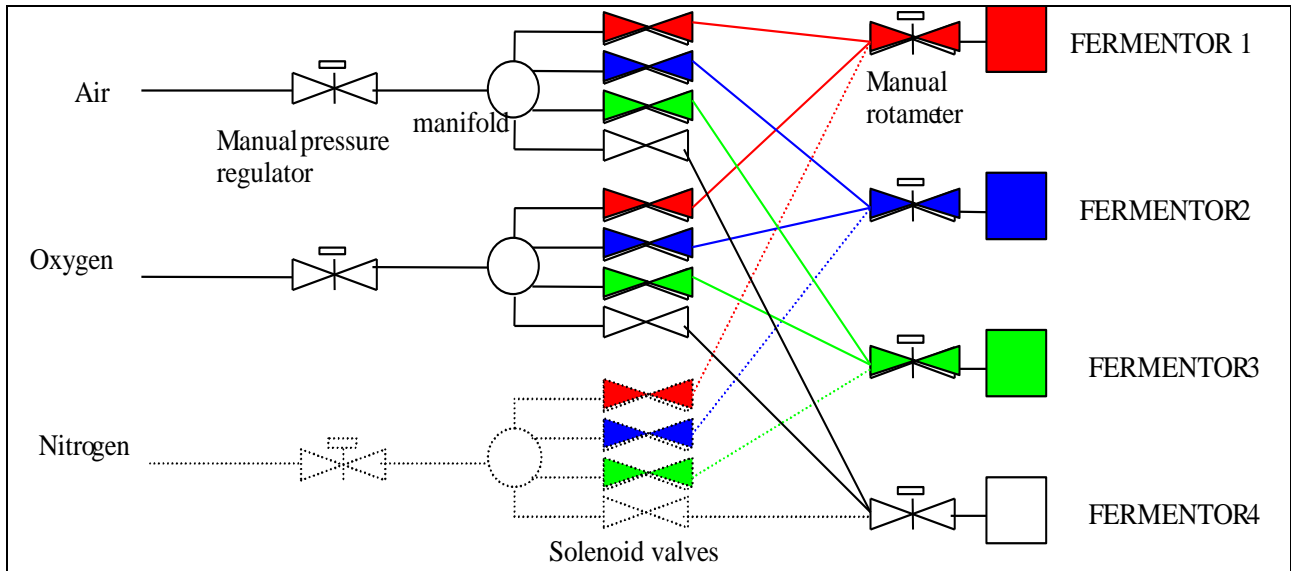
Highly linear pump drives are integrated into standard heads (choice of 6 different sizes) which enable exceptional pH and dosing control as well as a wide operating range. Though 2 pumps is standard for each reactor pack, up to 16 can actually be supported from a single controller. For multiple reactor configurations, this provides a very compact option.



## Gas Blending

Standard packs are supplied with a single manual rotameter (more can be added) but it is possible to include more sophisticated options. For microbial fermentations, automatic oxygen enrichment is possible if an air and oxygen (or enriched oxygen) source are supplied – the controller can be set to maintain a chosen dissolved oxygen (DO) value by altering the amount each gas. In the case of cell culture applications, 2,3 or 4 gases can be blended including CO<sub>2</sub> for pH control. Gases suited to bio-fuel applications can also be blended using the same method.

If necessary, the same hardware (ie valving system) can be used for either microbial or cell applications.



## Sterility

Long term sterility is important in all aspects of the design. All reactors are easy to disconnect and re-assemble assembly.

- 316ss lid with all screw fittings and self-sealing septa



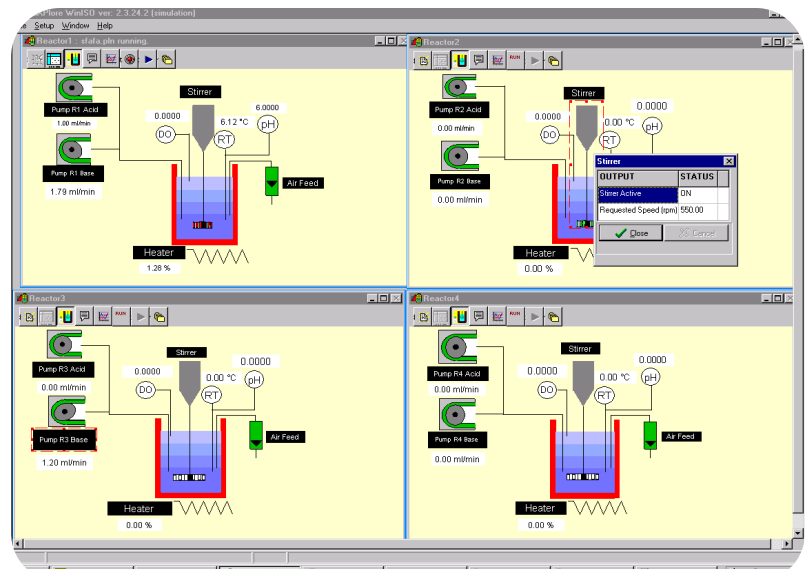
## Control System

### Three Levels of software

- Entry level system (ELS) with control from mimic, just one step at a time
- ELS interface but multi-steps, in parallel, terminating on time basis
- Full function interface with wide range of control and decision features.

### The main features include:

- Computer control of all important variables
- Each vessel totally independent
- Graphical view of all data
- Flexible recipe editor
- Remote "24/7" monitoring option
- Full record of all operations and data
- Highly expandable and configurable



## Customised Designs

One-off designs with any combination of features are available to increase productivity and/or for critical applications. The following are list of features that have been implemented in the past:

- Thermal activity monitoring (calorimetry)
- Off-gas analysis
- On-line optical density sensor
- Spectroscopic tracking of growth
- Novel control strategies to suit difficult applications
- One-off designs of any electronic, software or mechanical feature



## Conclusions

Explorer is a high-end bio-reactor system focusing especially on research scale applications which enables small scale research to pilot scale production, by simply using different vessel sizes : -

- **Scale up with ease** - At HEL we specialise in very small scale systems – there is a choice of 3 sizes below 500ml, each providing all the features available on traditional, larger reactors and therefore making scale-up easy.
- **Parallel operation as a standard feature**, with the widest choice of reactors, each fully controlled and monitored with total independence.
- **Design flexibility** enabling vessels of different sizes to be interchanged and operated with the same data logging and control platform.

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