Fermentation and Bioprocess System

Cleaver SCIENTIFIC

Benchtop
0.5 to 20 L

Pilot Scale
30L & 50L

Production Scale
>100L

FS-05   FS-06   FS-07

Topics

▶ Benchtop fermentation system

- Controller
- Vessel Types
- Optional Devices & Accessories
- Fermenter Interface & Features
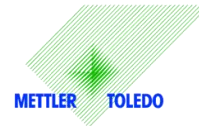
The 4th Generation Controllers

FS-05   **FS-06**   **FS-07**

FS-05 Parallel Fermentation System

➢ 10.4" Touch Screen

➢ Compatible Vessel Volume: 0.5L, 1L, 3L, 5L, 10L, 15L, 20L

➢ Connect up to two vessels and compatible with all types of vessels

➢ Standard METTLER TOLEDO pH & DO sensors

➢ Eight built-in peristaltic pumps

➢ Optional devices available & 4 external peristaltic pumps

#VERSATILE
#FLEXIBLE

FS-06 One Fermentation System

➢ 8" Touch Screen

➢ Compatible Vessel Volume: 0.5L, 1L, 3L, 5L, 10L

➢ Three peristaltic pumps

➢ Standard METTLER TOLEDO pH & DO sensors

➢ Only 1 external peristaltic pump

#COMPACT
#SPACESAVING
#PERSONALUSE

FS-07 Evo Fermentation System

➢ 10.4" Touch Screen

➢ Compatible Vessel Volume: 0.5L, 1L, 3L, 5L, 10L, 15L, 20L

➢ Compatible with all types of vessels

➢ Standard METTLER TOLEDO pH & DO sensors (Dissolved Oxygen)

➢ Four built-in peristaltic pumps

➢ Optional device available & 2 external peristaltic pumps

#COMPATIBILITY

FS-06-EPM
▶ Expansion Module for FS-06

➢ Flexible and expandable

➢ Additional Software Feature: 2-stage DO cascade, pH & DO Stat

➢ Optional Device Available: 2 external peristaltic pump
  Oxygen Enrichment Module
  Gas Mixing Station
  Photosynthesis Lighting Module
  ORP Probe

▶ Controller Selection Guide

Model	FS-05	FS-06	FS-06-EPM	FS-07
I want to add additional pumps to the controller	✓	✓	✓	✓
I want to work with small pilot-scale, 15L or 20L	✓			✓
I have limited lab space		✓	✓	
I want to do a parallel study	✓			

Specifications

| Model	FS-05	FS-06	FS-06 + FS-06EPM*	FS-07
Heating System	Duo heating			
Working Volume Range	500ml - 20L	500ml - 10L	500ml - 10L	500ml - 20L
Autoclavable Glass Vessels	Yes			
Interchangeable Vessels	Compatible with all types of vessels, except for 5L solid state which is only for FS-05 and FS-07 controller			
Number Of Vessels Controlled Per Controller	2	1	1	1
Number Of Vessels Controlled Via Remote Software	Max 32	Max 16	Max 16	Max 16
Touchscreen Controller	10.4"	8"	8"	10.4"
Number Of Peristaltic Pumps	8	3	3	4
Gas Mixing Options	Available	No	Available, *	Available
Oxygen Enrichment	Available	No	Available, *	Available
Mass Flow Controller	Available	No	No	Available
Off Gas Analyzer	Available	No	No	Available
ORP Probe	Available	No	Available, *	Available
Lighting Module	Available	No	Available, *	Available
External Pump	4 max.	1 max.	2 max.	2 max.
Solid State	Available	No	No	Available

* Optional expansion module (FS-06-EPM) needed.

Features

- Five interchangeable types of glass vessel
- Submerged and solid state integration
- Intuitive user interface
- 15-step sequence program
- Multilanguage user interface
- EZScript for advanced process control
- Smart communication technology

Features

Five Interchangeable types of glass vessels
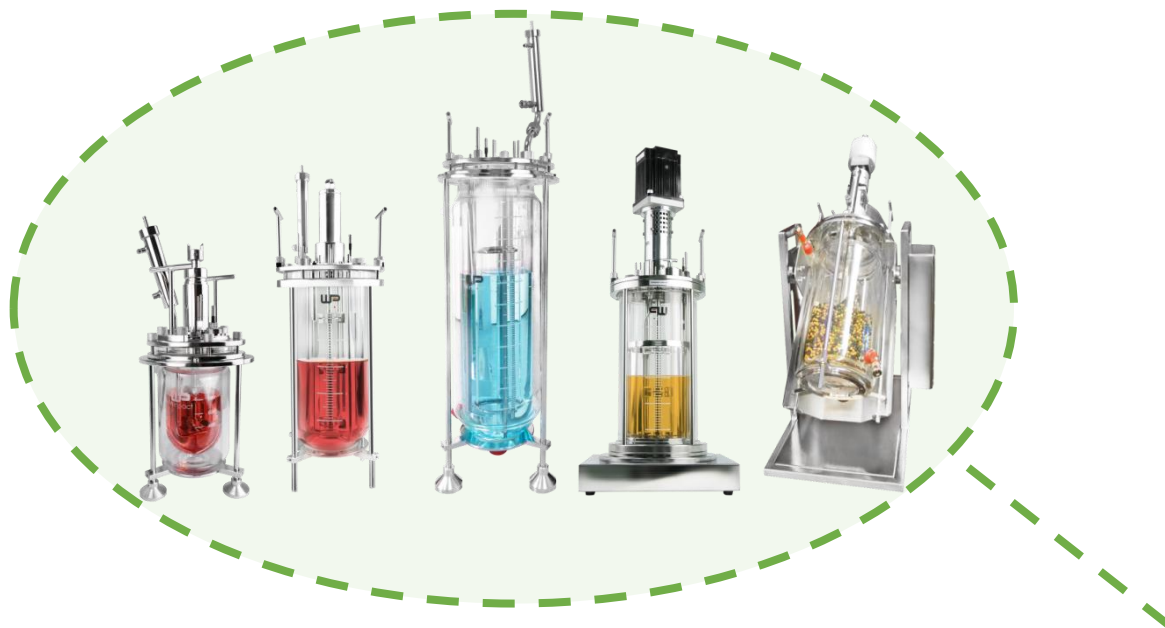
*Compatible with all types of vessel, except 5L
solid state (only usable with FS-05 and FS-07)

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➢ **Submerged and solid state integration**

Submerged Culture   **Solid State**   **Submerged Culture**

*Compatible with all types of vessel, except 5L solid state (only usable with FS-05 and FS-07)
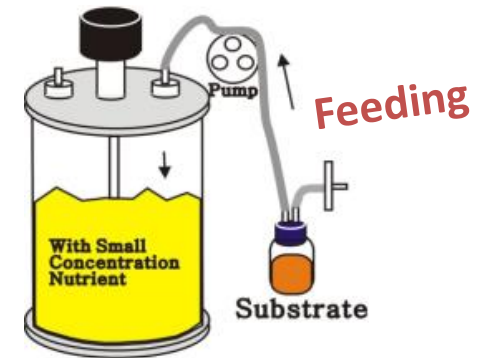
➢ Variable-speed Peristaltic Pumps

➢ Dual direction
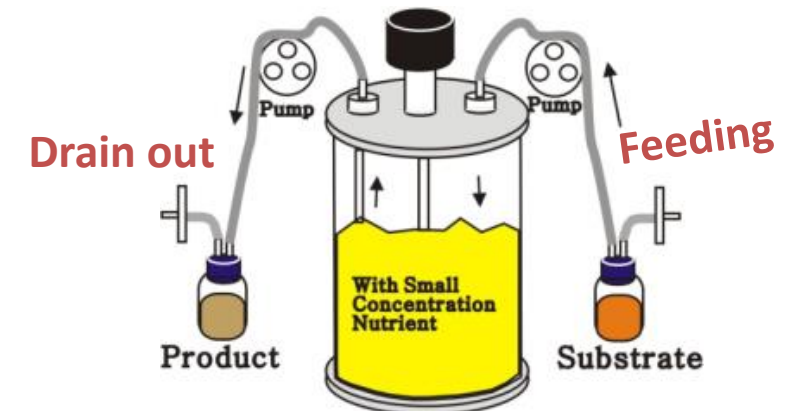➢ Variable speed: 1-65 rpm
➢ Manual or 15-step sequence control

Fed-batch fermentation

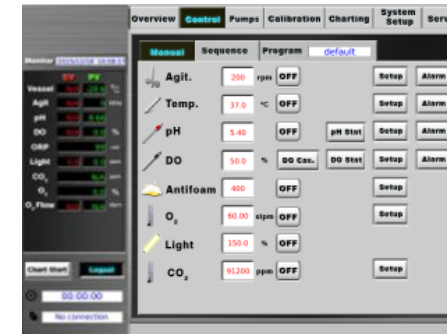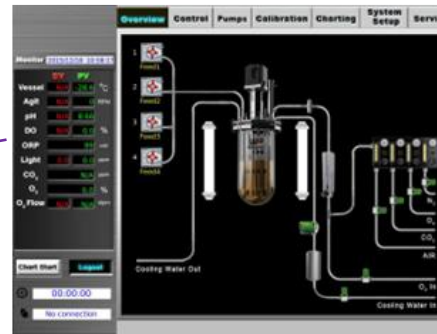Feeding

With Small Concentration Nutrient

Substrate

Continuous culture

Drain out

Feeding

With Small Concentration Nutrient

Product

Substrate

▶ Features

➤ Intuitive user interface
➤ Multilanguage user interface

▶ Features

➤ 15-step sequence program

➤ Choose either **Manual** or **15-step sequence control**
for Agitation, Temperature, O_2, Feeding, etc.

Agit Program

RPM	1	2	3	4	5	6	7	8
RPM	100	150	200	300	100	0	300	600
MIN.	60	50	80	0	120	0	50	30
Now	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|

	9	10	11	12	13	14	15
RPM	800	500	500	300	200	150	300
MIN.	200	60	60	120	60	10	300
Now	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|

Prev. Step	Next Step	Close

Feed1 Program

	1	2	3	4	5	6	7	8
RPM:	20	45	60	30	65	45	40	0
ON:	60	2	5	5	10	15	8	0
OFF:	60	0	2	2	5	6	6	0
Cycle:	360	30	5	0	100	85	16	0
Now	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|

	9	10	11	12	13	14	15
RPM:	0	0	0	0	0	0	0
ON:	0	0	0	0	0	0	0
OFF:	0	0	0	0	0	0	0
Cycle:	0	0	0	0	0	0	0
Now	⇒|	⇒|	⇒|	⇒|	⇒|	⇒|

ON/OFF unit: second   second   minute

Prev. Step	Next Step	Close

▶ Features

➤ EZScript for advanced process control

- ➤ Write your own program using a computer language called BASIC
- ➤ Almost everything can be controlled

Overview	Control	Pumps	Calibration	Charting	System Setup	Service

| Scripts	Console
Print "your batch details"	Your batch details
Agit_SV (300)	Set Agitation 300rpm
Temp_SV(27.8)	Set Temp 27.8C
PH_SV(5.91)	Set pH 5.91
DO_SV(40)	Set DO 40%
If(	If DO is lower than 40%
DO_PV (<40)	Increase agitation speed
MANU_DO_CASCADE agit	From 100rpm
Agit_DOCA_min (100)	To 500rpm
Agit_DOCA_max (500)	With 10rpm increment
Agit_DOCA_step (10)	Check if DO is 40%
Check DO_PV (= 40)	

▶ Features

➤ Smart communication technology
Control up to 16 systems via remote monitoring
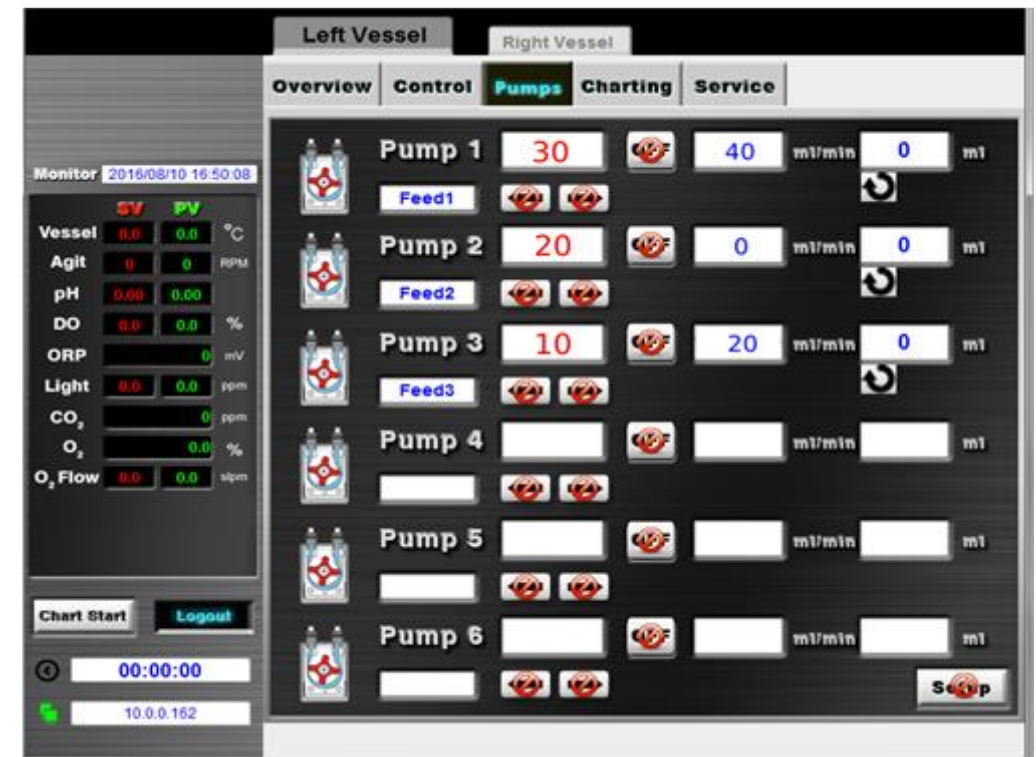
► Features

➢ **Smart communication technology**

1 PC
16 Controllers
32 Vessels
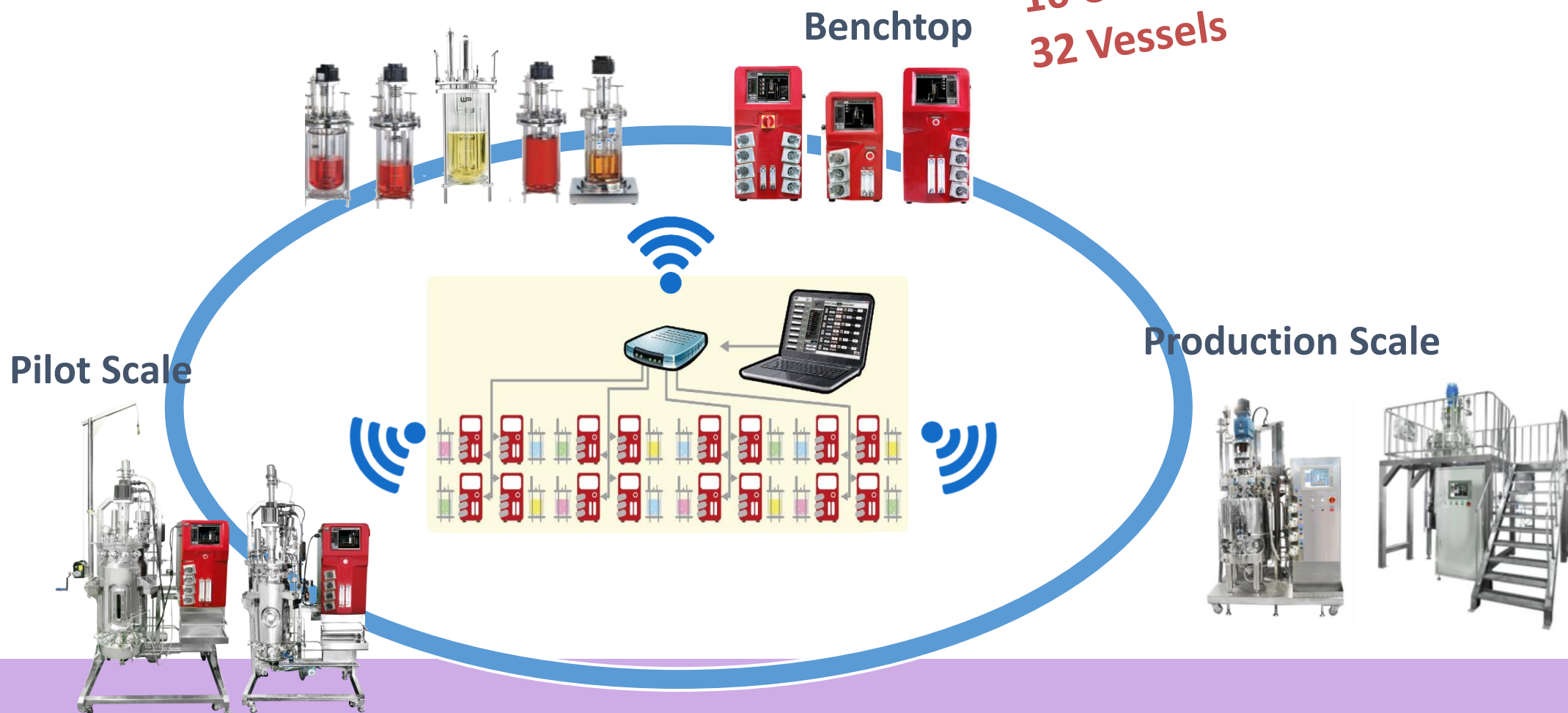
Benchtop

Pilot Scale

Production Scale

Topics

▶ Benchtop fermentation system

- Controller
- Vessel Types
- Optional Devices & Accessories
- Fermenter Interface & Features

Vessel Types

Type A

Jacketed vessel

Type B

Single wall

Type B Blanket

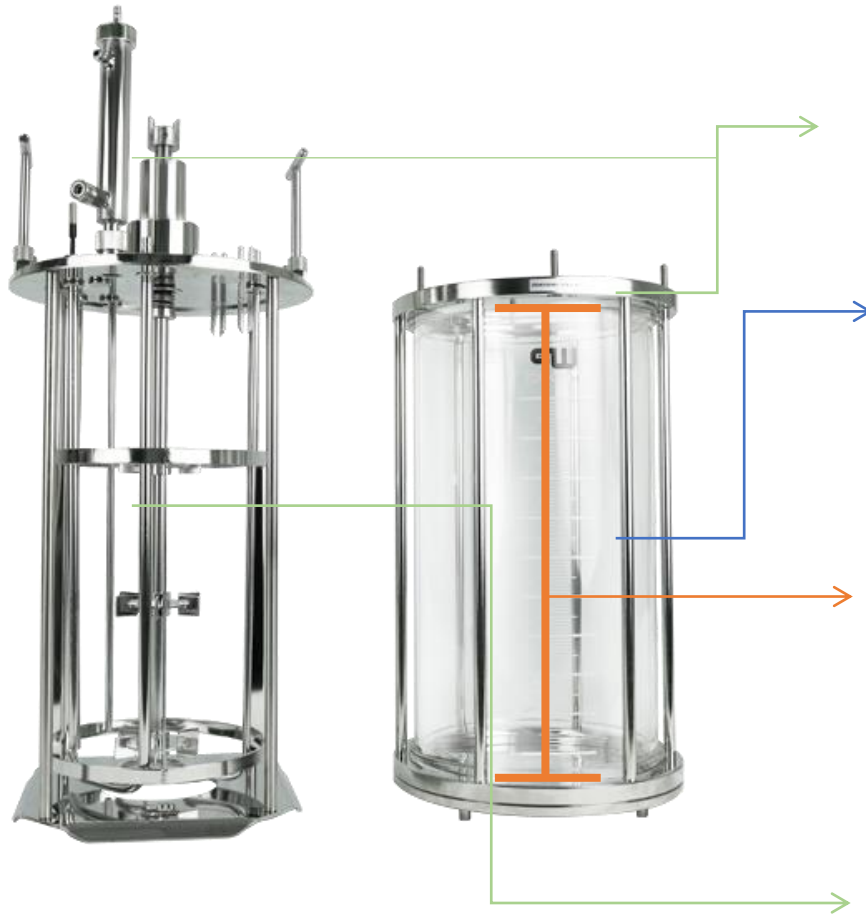B+ blanket. Single wall with blanket

Type C

Air lifter

Type D

Single wall with heating base

Solid state

Solid state

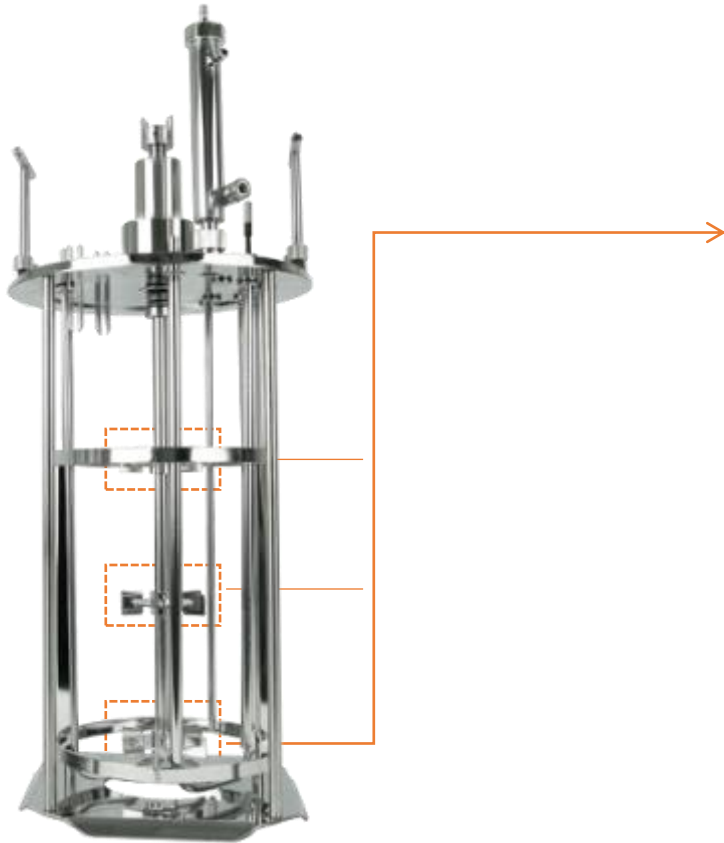# ▶ Typical Stirring Tank Design

Medium-free: Sanitary SUS 316

**Premium German-made
Borosilicate Glass**

**2:1 or 3:1 (air lifting) H/D Ratio
ideal for
mixing & homogeneity**

**In contact with medium:
Sanitary SUS 316**

Typical Stirring Tank Design

Impeller: Mixing & Breaking up bubbles
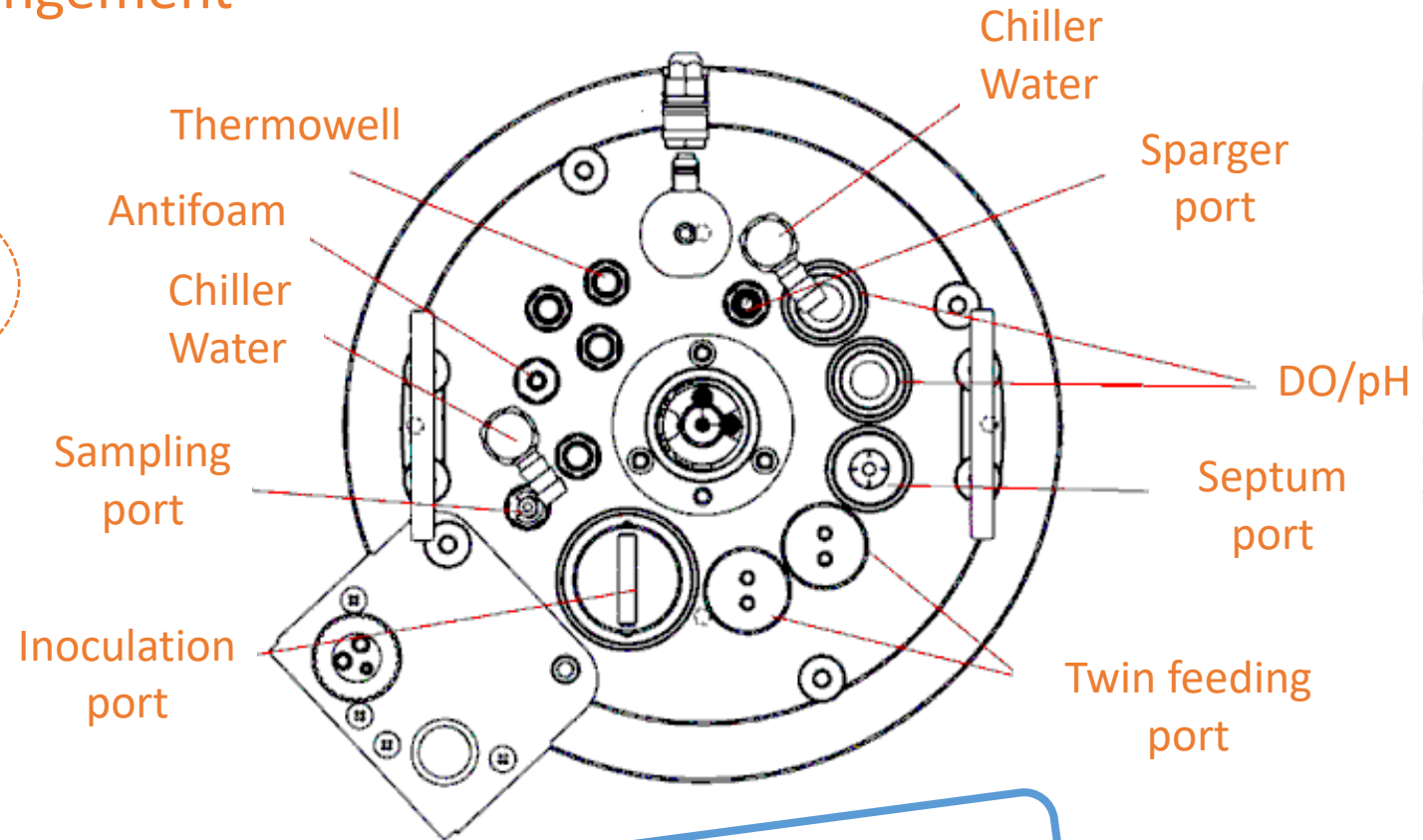
Rushton
Standard

Pitched Blade
Shear-force
sensitive cells

?

Customized
impellers
available

Typical Stirring Tank Design

Headplate arrangement

Thermowell

Antifoam

Chiller Water

Sampling port

Inoculation port

Chiller Water

Sparger port

DO/pH

Septum port

Twin feeding port

Customization upon request

FS-V-A Type Vessel-Thermostat Double Jacketed

Key features:

➢ Uniform temperature control

➢ Suitable for temperature and shear-force sensitive cells such as **mammalian** and **insect cell cultures** (with pitched blade impellers)
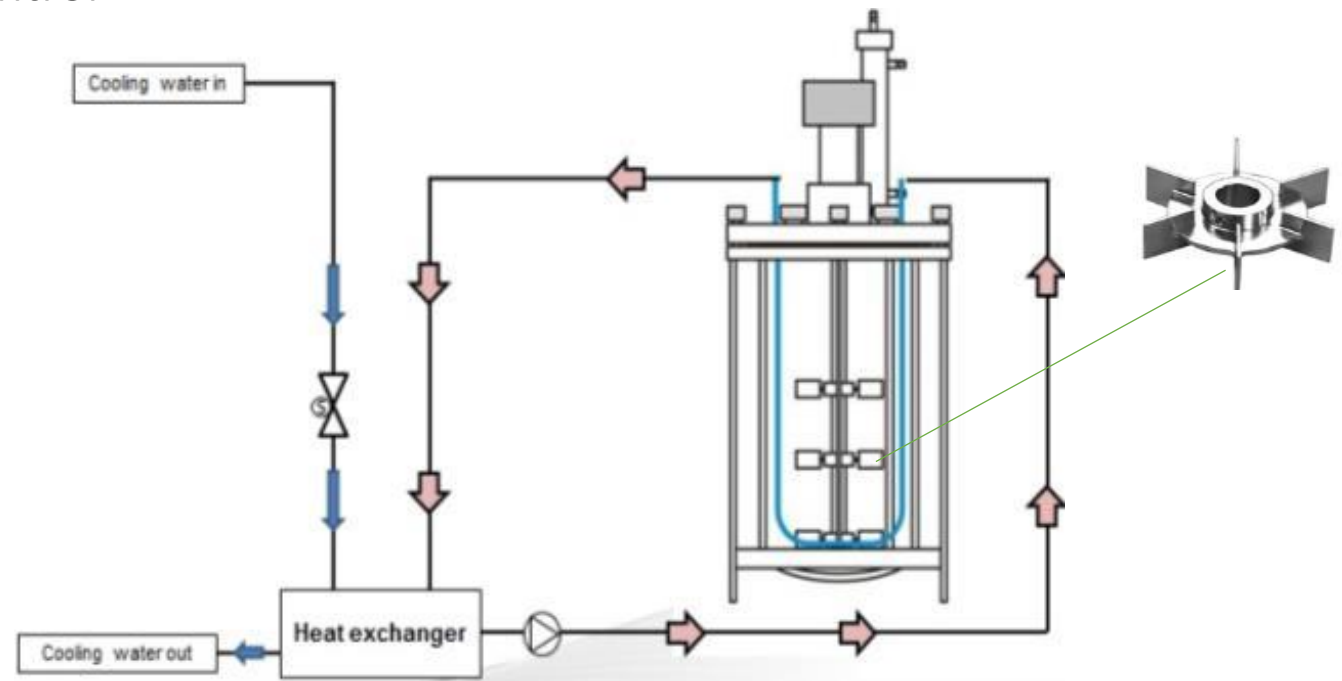

FS-V-AS5L   **FS-V-A01L**

FS-V-B Type Vessels – Thermostat Single Wall Dish Bottom

Key features:

➢ Stainless steel cooling coil for temp. control

➢ No dead volume with dish bottom

➢ Suitable for **microbes**

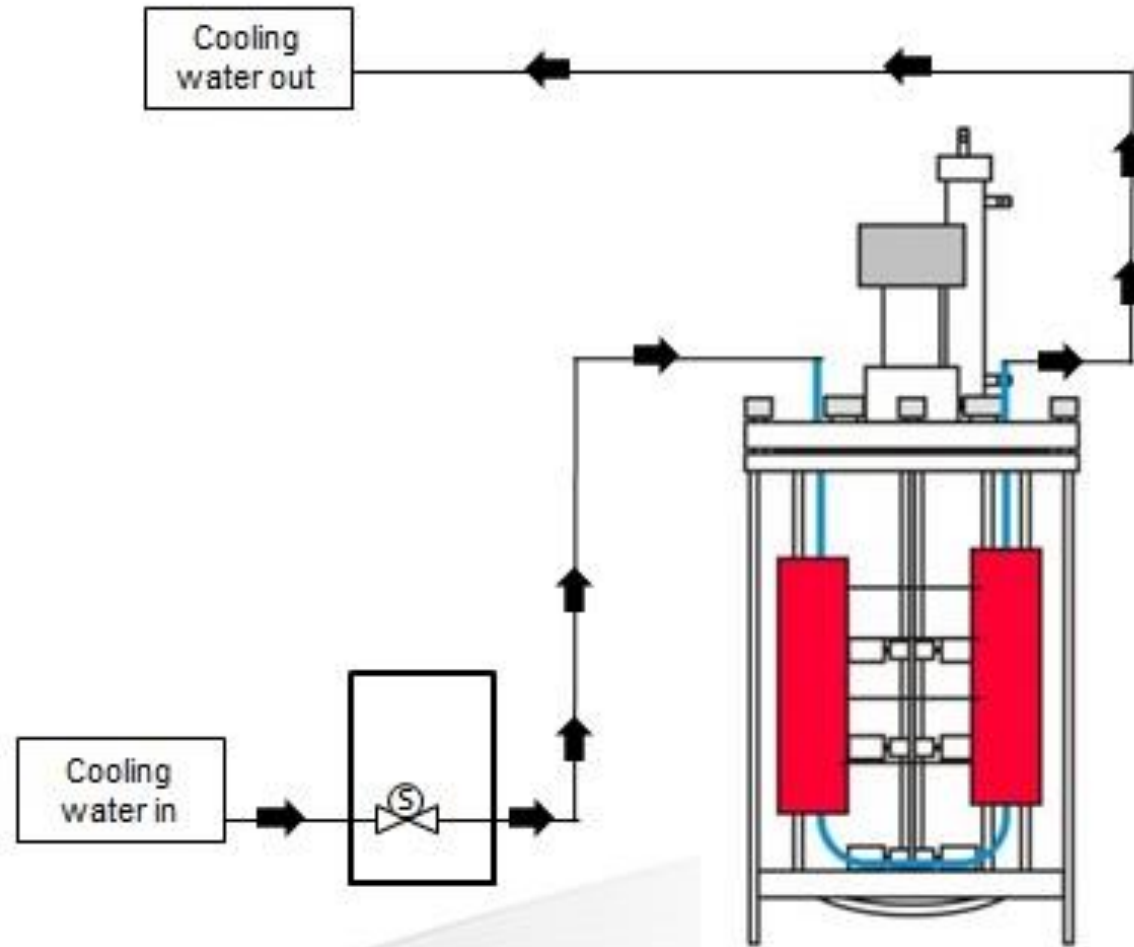# FS-V-B Type Vessels – Dry Heating Single Wall w/ Heating Blanket

▶ Key features:

➢ Heat evenly and quickly

➢ Ideal for photosensitive and photo-inhibition cultures, such as **microalgae** and **nitrifying bacteria**

➢ Suitable for cultures which can withstand quick temp. change

FS-V-B05L

FS-V-B Type Vessels – Dry Heating Single Wall w/ Heating Blanket

FS-V-B05L

▶ **FS-V-C Type Vessels –Air Lifter**
   Thermostat & no temperature control

▶ **Key features:**

➤ No impeller design: micro-sparger and adjustable draft tube to facilitate water circulation

➤ Single or Double -Walled 3:1 glass vessel

➤ Suitable for shear-sensitive cells and photosynthesis reaction: **plant cell, microalgae, cyano-bacteria**
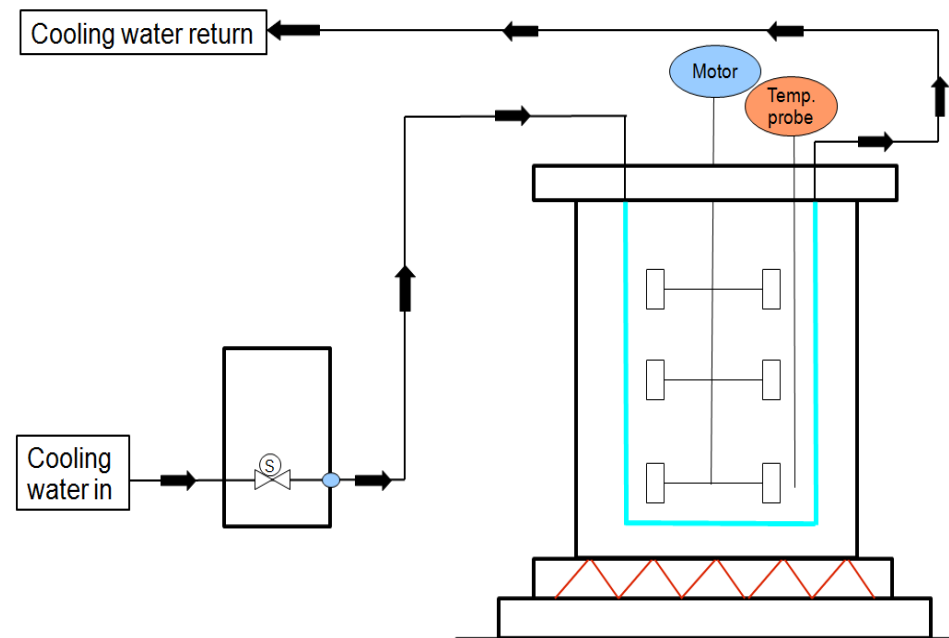

FS-V-C053   FS-V-C054

Lighting Module (FS-O-PB-2)

FS-V-D Type Vessels – Dry Heating Single Wall w/ Heating Base

Key features:

➢ Rapid temperature change with heating base

➢ Temperature control up to 90 ℃

➢ Designed for dominated strains of microbes

FS-V-D05L

▶ FS-V-SA05 Type Vessel-Thermostat Double Jacketed

▶ Key features:

➢ Special for low water level culture conditions

➢ Broken type, Anchor type and Spiral type impellers available.

➢ Solid state vessel performs 0-90 degrees rotation and 120 degrees for harvest.

➢ Ideal for **filamentous fungi**

Fruit body

Cleaver
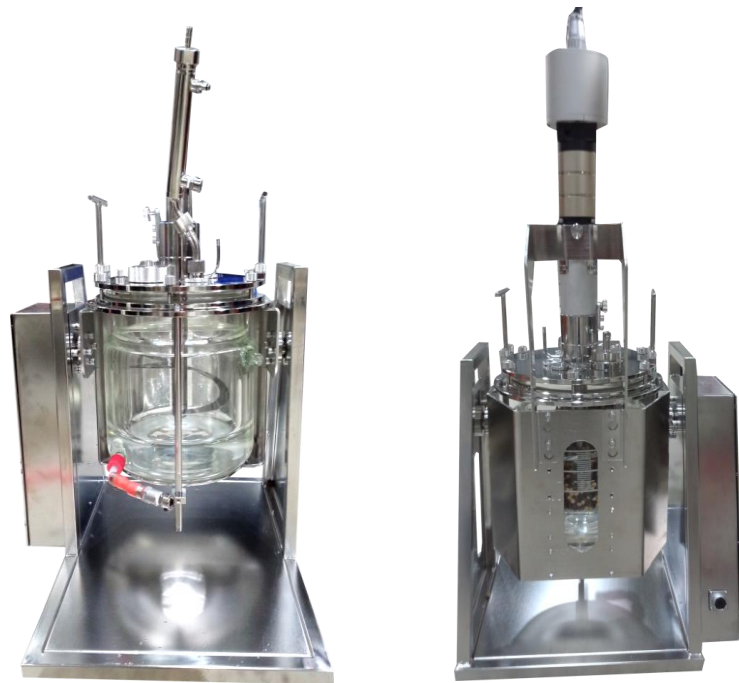SCIENTIFIC

Broken   **Anchor**   **Spiral**

5L solid state

Customization for Solid State Cultures

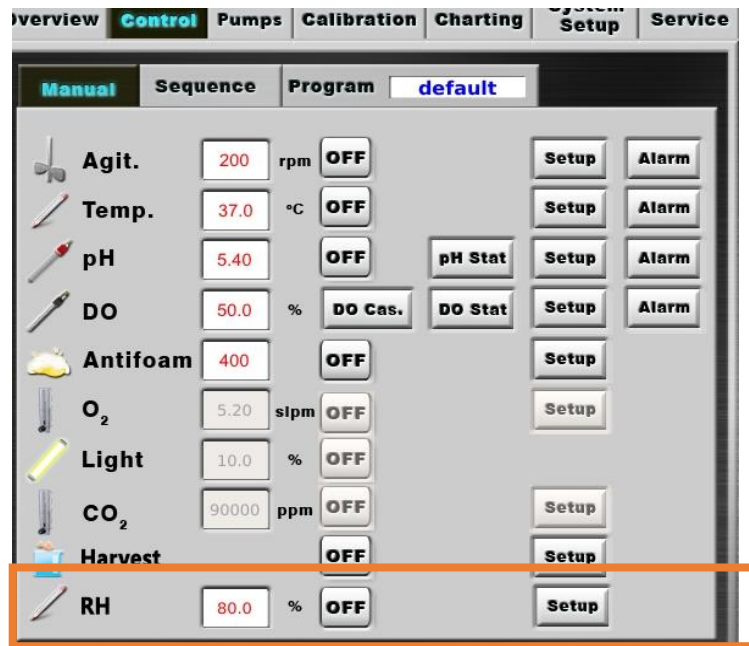## 3L Solid State Vessel

Front view

Rear view

#CUSTOMIZATION

Four kinds of impellers available!

Customization for Solid State Cultures

➢ Humidifier for Solid State Cultures

#CUSTOMIZATION

Control the humidity to get fruit body

Relative Humidity

▶ Specifications

		Double Jacketed Dish Bottom Vessel (FS-V-A series)				
	Vessel Type	Double Jacketed Dish Bottom Vessel (FS-V-A series)				
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings				
	Working Volume **	500ml	1L	3L	5L	10L
	Total Volume Δ	1L	1.5L	3.8L	6.8L	12.5L

		Single Wall Dish Bottom Vessel (FS-V-B series)			
	Vessel Type	Single Wall Dish Bottom Vessel (FS-V-B series)			
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings			
	Working Volume **	1L	3L	5L	10L
	Total Volume Δ	1.5L	3.8L	6.8L	12.5L

		Air Lifter Vessel (FS-V-C series)	
	Vessel Type	Air Lifter Vessel (FS-V-C series)	
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings	
	Working Volume **	5L single wall	5L double jacketed
	Total Volume Δ	7L	

		Single Wall Dish Bottom Vessel With Heating Blanket (FS-V-B series)					
	Vessel Type	Single Wall Dish Bottom Vessel With Heating Blanket (FS-V-B series)					
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings					
	Working Volume **	1L	3L	5L	10L	15L	20L
	Total Volume Δ	1.5L	3.8L	6.8L	12.5L	18.7L	23.7L

		Single Wall Plain Bottom Vessel With Heating Base Unit (FS-V-D series)		
	Vessel Type	Single Wall Plain Bottom Vessel With Heating Base Unit (FS-V-D series)		
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings		
	Working Volume **	3L	5L	10L
	Total Volume Δ	3.7L	6.7L	13.1L

		Solid State (FS-V-SA05P)
	Vessel Type	Solid State (FS-V-SA05P)
	Material	Borosilicate glass / 316L stainless steel for headplate and all fittings
	Working Volume **	5L
	Total Volume Δ	6.8L

** Suggested Max.   Δ Total volumes are approximate and may vary slightly.

▶ Vessel Applications

Vessel Application

Application \ Vessel	FS-V-A series Double Jacketed Dish Bottom Vessel	FS-V-B series Single Wall Dish Bottom Vessel	FS-V-C series Air Lifter Vessel	FS-V-B series Single Wall Dish Bottom Vessel with Heating Blanket	FS-V-D series Single Wall Plain Bottom Vessel with Heating Base Unit	FS-V-SA05P Solid State
Mammalian Cell Culture	●●	●○	○○	●○	○○	○○
Aerobic Microorganism Culture (Note 1)	●●	●●	●●	●●	●●	○○
Micro-aerobic Microorganism Culture (Note 2)	●●	●●	○○	●●	●●	○○
Anaerobic Microorganism Culture (Note 3)	●○	●●	○○	●●	●●	○○
Fragile Cell Culture (Note 4)	●●	●○	●●	●○	○○	○○
Photosynthesis Cell Culture (Note 5)	●○	●●	●●	○○	●○	○○
Plant Cell Culture	●○	●○	●●	○○	○○	○○
Insect Cell Culture	●●	●○	○○	●○	○○	○○
Solid State / Semi-solid State	○○	○○	○○	○○	○○	●●

●● Excellent   ●○ Good   ○○ Not recommended

Note:
1. Some bacteria; yeast; fungi
2. Facultative culture (For example, some Lactobacillus; ethanol production)
3. Same as Note 2
4. This vessel is excellent for fragile cells that are easily sheared by any type of mechanical impeller
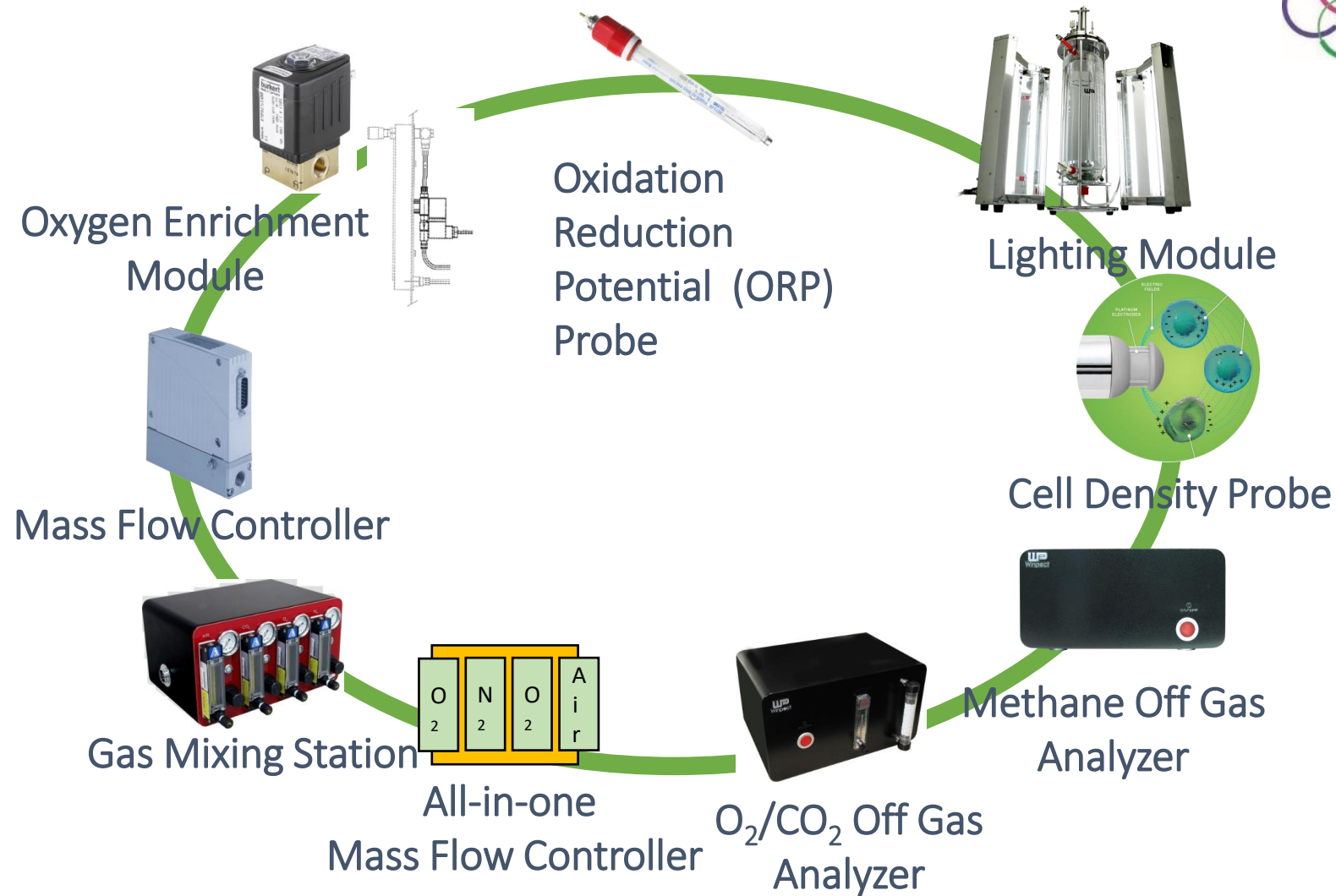5. Plant; algae; cyanobacteria (blue-green algae)

Topics

▶ Benchtop fermentation system
- Controller
- Vessel Types
- **Optional Devices & Accessories**
- Fermenter Interface & Features

Optional Devices

Oxygen Enrichment Module

Oxidation Reduction Potential (ORP) Probe

Lighting Module

Mass Flow Controller

Cell Density Probe

Gas Mixing Station

All-in-one Mass Flow Controller

O_2/CO_2 Off Gas Analyzer

Methane Off Gas Analyzer

▶ **Optional Devices**

To enhance fermentation control experience

➢ Oxygen Enrichment Module (FS-O-OE)
  ➢ Supply O_2 to Maintain aerobic environment
  ➢ Flow rate duration via solenoid valve
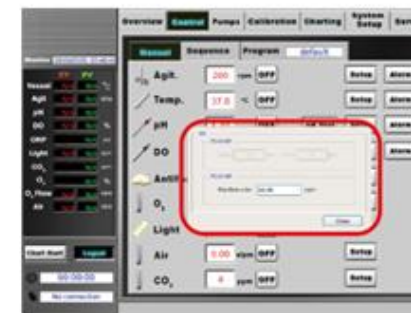 ➢ Manually flow rate adjustment via flow meter
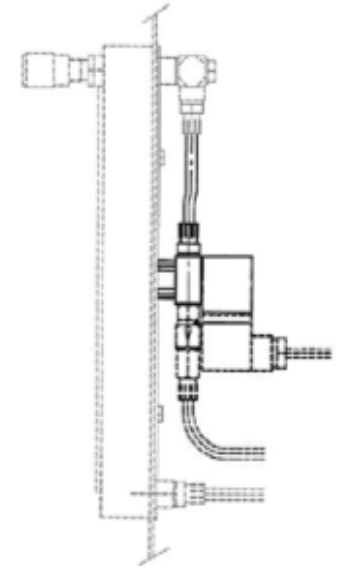
▶ Optional Devices

To enhance fermentation control experience

➢ Oxygen Enrichment Module with Mass Flow Control (FS-O-MF)
  - ➢ Supply O_2 to Maintain aerobic environment
  - ➢ More precise and accurate control
  - ➢ Automatic control for gas flow

▶ Optional Devices

To enhance fermentation control experience

➢ Gas Mixing Station (FS-O-GM)
  - ➢ Supply air, O_2, N_2 and CO_2 independently
  - ➢ O_2 to increase DO level
  - ➢ N_2 to create anaerobic environment
  - ➢ CO_2 as alternative for pH control or provide carbonate for cell culture

▶ Optional Devices

To enhance fermentation control experience

- ➢ CO_2/O_2 Off-Gas Analyzer (FS-O-
  - ➢ Measure the amount of CO_2/O_2 off- gas
  - ➢ Monitor metabolic activities that exhale CO_2/O_2
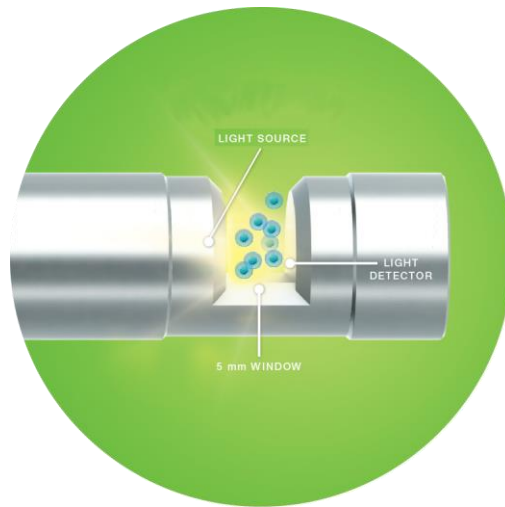
**Methane Off-Gas Analyzer
(*Customized)**

▶ Optional Devices
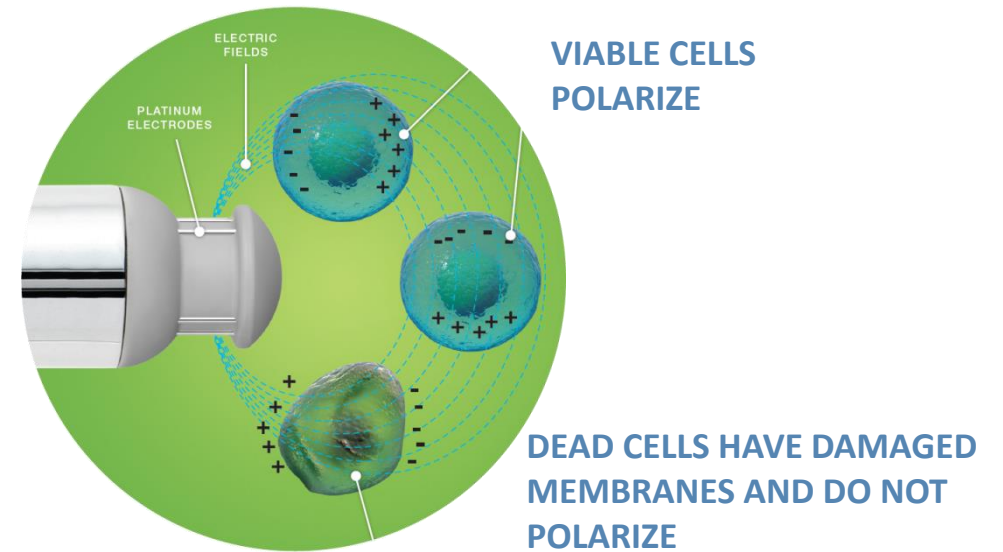## To enhance fermentation control experience 💬

➢ Online Cell Density Devices
  ➢ Measure the amount Monitor cell growth rate without sampling
  ➢ Reduce the risk of contamination form sampling 💬
  ➢ Integration with fermentation system

Total Cell Density / Turbidity

Measurement at NIR

VIABLE CELLS POLARIZE

DEAD CELLS HAVE DAMAGED MEMBRANES AND DO NOT POLARIZE

Viable Cell Density

Permitivity

Optional Devices
To enhance fermentation control experience

- External Pump
  - Digital control by microprocessor controller, more precise
  - Easy load pump head
  - Expand with the 2nd pump head with MU-D01/02

MU-D01/ MU-D02

MU-D03

Expand your feeding pumps!

▶ Optional Devices
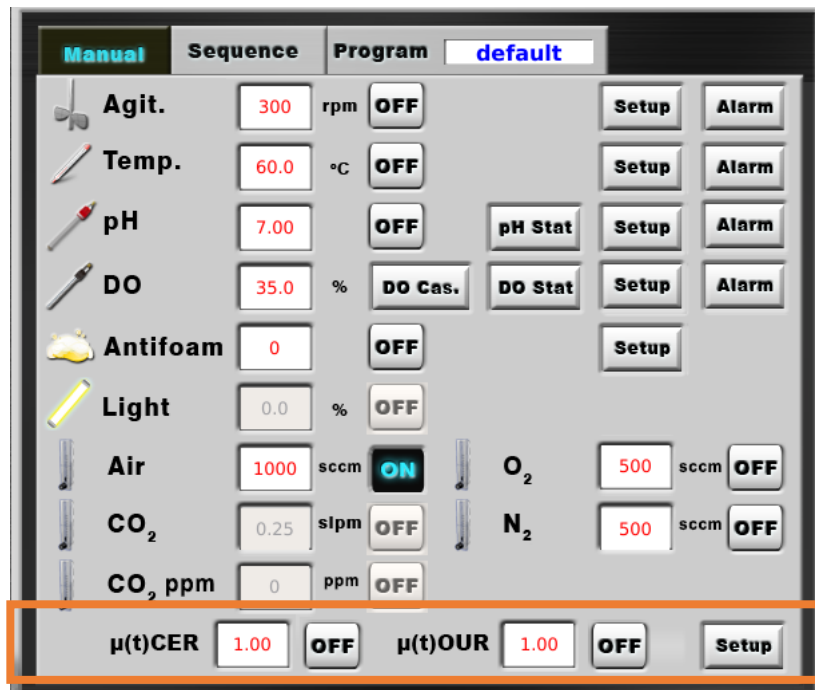**To enhance fermentation control experience**

➢ Photo-bioreactor Lighting Module (FS-O-PB)
- ➢ Artificial light for photosynthesis
- ➢ Adjustable light intensity
- ➢ Fluorescent light source

Application of Off-Gas Analyzer & Software Customization

➢ Get the information about cell metabolism via **CER** and **OUR**

✧ **Monitor culture status to improve production process and yields**

CER (Carbon Dioxide Evolution Rate) - the rate that CO_2 is being consumed

OUR (Oxygen Uptake Rate) - the rate that is O_2 being produced
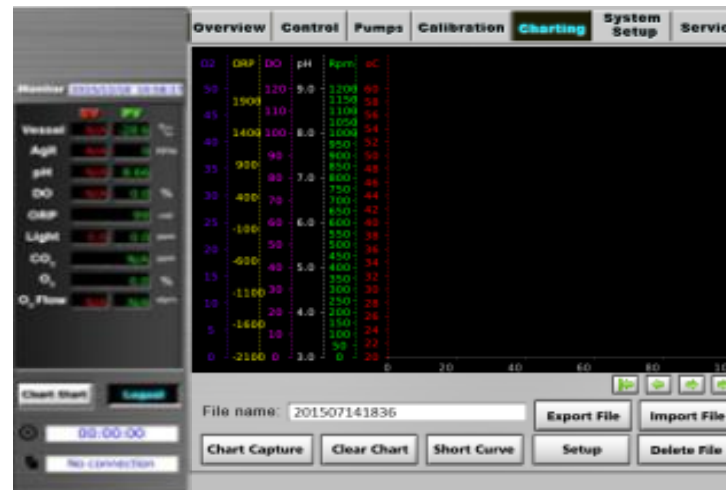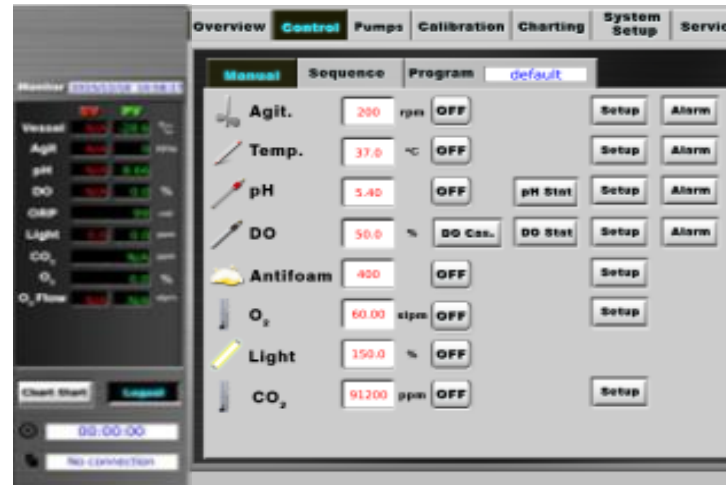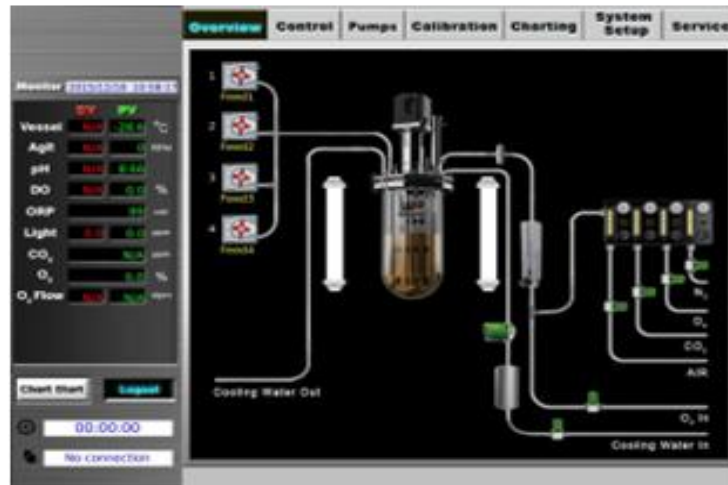
Topics

▶ Benchtop fermentation system

- Introduction
- Vessel Types
- Optional Devices
- Fermenter Interface & Features

Fermenter Interface & Features ➤ **Intuitive user interface**

Fermenter Interface & Features

Charting

Optional Accessories

Motor Shaft Protection Cap

Fermentation Bottle Holder

Sampling Device

Stainless Steel Supporting foot

Composite Vessel Handles

Vessel Stand

Headplate Stand

Many Thanks!

Questions?