

HyPerforma 5:1 500 L Single-Use Bioreactor

Introduction

The Thermo Scientific™ HyPerforma™ Single-Use Bioreactor (S.U.B.) provides state-of-the-art functionality, ease of use, and efficiency. The complete HyPerforma S.U.B. system consists of a bioreactor tank and HyPerforma S.U.B. BioProcess Container (BPC), which is available in 50, 100, 250, 500, 1,000, and 2,000 L sizes. The redesigned HyPerforma S.U.B. maintains traditional stirred-tank bioreactor design principles, including specific height-to-diameter ratios and optimized mixer location that delivers optimum cell viability, performance, and scalability from process development through production. Design is optimized for the 500 L bioreactor tank, which allows for mixing at a 5:1 turndown ratio. Advantages of the 5:1 system include:

- Streamlining bioprocesses by reducing seed vessel requirements and maximizing process vessel usage
- Seed vessels at 20% volume then feed up to full volume
- Reduce cell transfers and associated adaptation
- Reduce the number of single-use BPC usage

This data sheet provides information on the HyPerforma 5:1 500 L S.U.B. system, which includes the tank and standard S.U.B. BPC. The BPC utilizes dual-sparger design for cultures at nominal volume and a crossflow sparger strategically positioned just above the 20% liquid volume for seed cultures. Both sparge designs have been rigorously tested to provide high $k_L a$ values and optimal CO_2 stripping for improved pH control and decreased foaming.



The HyPerforma S.U.B. system consists of the following components:

- S.U.B. hardware unit available in turnkey format
- Complete mixing system with water jacket
- Drive shaft inserts into the S.U.B. BPC through the mixing drive motor and locks into the BPC agitator assembly

S.U.B. BPC (gamma-irradiated and ready to use)

- Agitator assembly is a single-use (polyethylene) impeller with a bearing/seal assembly linked to an external mixer drive
- Dual gas spargers available with crossflow and drilled-hole design
- Vent filter outlet for system exhaust
- Integrally sealed ports in the S.U.B. BPC allow for additional sensor probes and line sets
- Available in Thermo Scientific™ CX5-14 film and Aegis™ 5-14 Film options

System options (adaptable to your needs)

- Optional electrical box for remote agitation control
 - HyPerforma 5:1 S.U.B.s require a separate external temperature control unit
- Exhaust gas vent filter heaters
- Load cells
- Cable management tree
- Process control system
- See the ordering information for auxiliary components for S.U.B. control management. Choose an open architecture approach or a turnkey “ready-to-use” Thermo Scientific™ HyPerforma™ S.U.B. system

Additional options are listed in Tables 3–7.

Standard HyPerforma 5:1 S.U.B. hardware units

The 500 L standard 5:1 S.U.B. hardware units are available in the configurations below.

- 500 L jacketed S.U.B. with a 5:1 turndown ratio, AC motor, no E-box, and load cells without display
- 500 L jacketed S.U.B. with a 5:1 turndown ratio, AC motor, 240 VAC, E-box, and analog load cells

Table 1. 500 L standard 5:1 S.U.B. hardware unit with casters (leveling feet).

Description	Cat. No.
500 L jacketed S.U.B. with a 5:1 turndown ratio, AC motor, 120 VAC, no E-box, and analog load cells	SUB0500.8400
500 L jacketed S.U.B. with a 5:1 turndown ratio, AC motor, 240 VAC, E-box, and analog load cells	SUB0500.8401

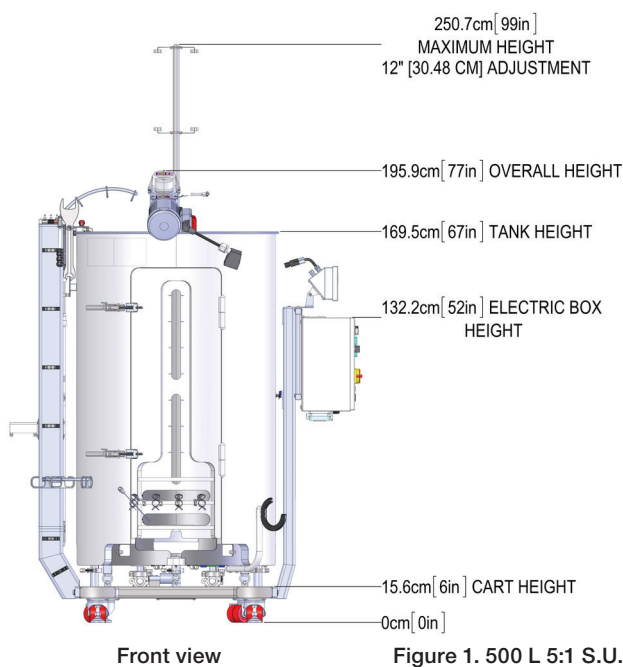
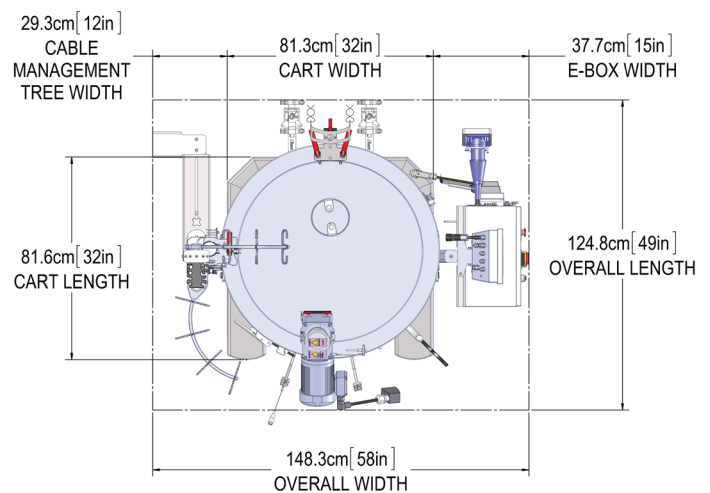


Figure 1. 500 L 5:1 S.U.B. hardware unit dimensions.



Design features

1. Exhaust vent filter holder (optional)
2. Mixing assembly with shield
3. Mixer motor
4. Bearing port receiver with clamp
5. Liquid sight windows
6. Electrical control panel (optional)
7. Probe hanger bracket
8. Probe access windows
9. Leveling casters
10. Load cells
11. Standard tool set: 3/8 in. x 150 in.-lb. square torque wrench, load cell, and motor cap lockout wrench
12. Cable management tree
13. Drive shaft (stored)
14. Stainless steel (grade 304) outer support container
15. Bleed valve
16. 3/8 in. dimpled jacket (side)
17. Cart assembly
18. Bottom cutouts/pins for BPC attachment/alignment
19. Quick-connect water inlet/outlet ports

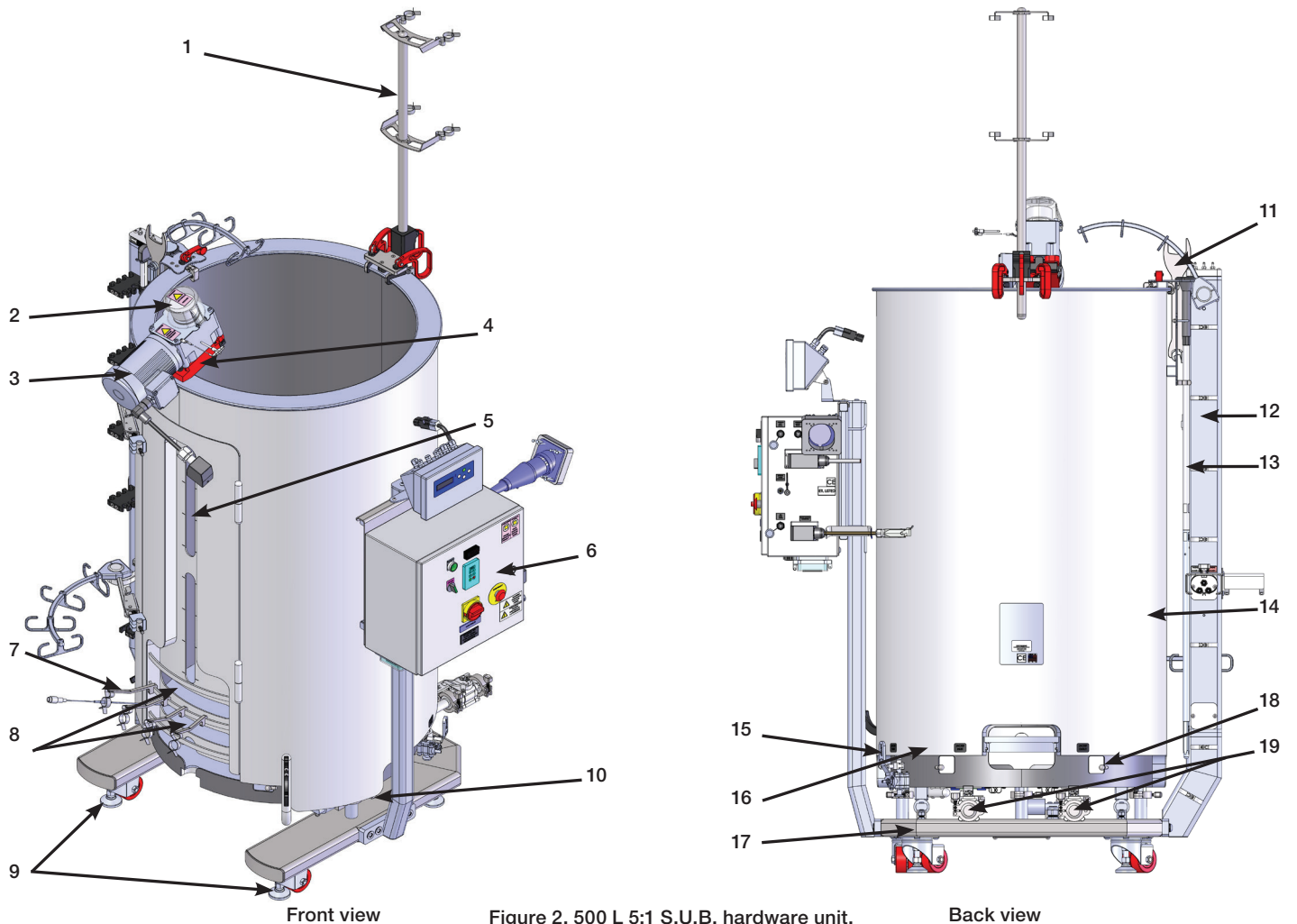


Figure 2. 500 L 5:1 S.U.B. hardware unit.

Table 2. 500 L Standard 5:1 S.U.B. system specifications.

	AC motor	DC motor	
Bioreactor geometry	Rated liquid working volume	500 L	
	Minimum liquid working volume	100 L	
	Total reactor volume (liquid and gas)	660 L	
	BPC chamber diameter	75.56 cm (29.75 in)	
	BPC chamber shoulder height	152.4 cm (60 in)	
	Liquid height at rated working volume	113.36 cm (44.63 in)	
	Fluid geometry at working volume (height:diameter ratio)	1.5:1	
	Overall reactor geometry (height:diameter ratio)	1.9:1	
Tank baffles	No		
General	Ceiling height required for drive shaft loading	282.19 cm (111.1 in)	
	Electrical power supply requirement (voltage, phase, current)	120/240 VAC, single, 20/10 A	Dependent on controller
	pH & dissolved oxygen (DO) probe, autoclavable type	12 mm diameter x 215-235 mm insertion length x 13.5 PG (pipe) thread	
Noise level	< 70 dB at 1.5 m		
Impeller	Impeller (quantity x blade count)	1 x 3	
	Impeller scaling (impeller diameter/tank diameter)	1/3	
	Impeller blade pitch (angle)	45°	
	Impeller diameter	25.1 cm (9.875 in)	
	Impeller, calculated power number (N)	2.1	
Agitation	Maximum mixing rate	30-150 rpm	
	Nominal agitation rating, power/volume ratio	20 W/m ³	
	Nominal agitation, 20% working volume	59 rpm	
	Nominal agitation, 50% working volume	80 rpm	
	Nominal agitation, 100% working volume	101 rpm	
	Nominal tip speed	137.2 cm/s (270 ft./min)	
	Counterclockwise mixing flow direction	Down-pumping	
	Agitation shaft resolved angle	16.5°	
	Agitation shaft centerline offset	5.08 cm (2 in.)	
	Overall drive shaft length	155.7 cm (61.3 in.)	
	Drive shaft diameter	1.91 cm (0.75 in.)	
	Drive shaft poly-sheath outside diameter	2.54 cm (1 in.)	
Impeller clearance from tank bottom	7.62 cm (3 in.)		

Table 2. 500 L Standard 5:1 S.U.B. specifications (continued).

		AC motor	DC motor
Motor	Agitation motor drive (type, voltage, phase), AC motor only	Induction, 208 VAC, 3 phase	–
	Agitation motor drive (type, voltage), DC motor only	–	Brushless, 48 VDC
	Motor power rating (AC motor)	372.8 W (0.5 hp)	–
	Motor power rating (DC motor)	–	400 W (0.268 hp)
	Motor torque rating	9.5 Nm (82 in.-lb.)	–
	Gear reduction	10:1	–
	Programmable Variable-frequency drive (VFD), remote panel interface, power fault auto restart	Standard	–
	Motor communication methods (for external controller)	0–10 V, 4–20 mA, Modbus	–
Temperature control	Jacket area: full/half volume	21.4/8.4 ft ²	
	Jacket volume	15.2 L	
	Jacket flow rate at 3.4 bar (50 psi)	136 L/min	
	Process connection	1.5 in. sanitary tri-clamp	
	Nominal heating/cooling load (W)	5,000 W	
	Approximate liquid heat-up time (5–37°C), 20% volume	1.1 hr	
	Approximate liquid heat-up time (5–37°C), 100% volume	2.2 hr	
	Resistance temperature detector (RTD) or thermocouple, 3.18 mm (1/8 in.) OD	RTD: Pt-100 (standard)	
Support container	Overall width	125.2 cm (49.3 in.) with E-Box	86.4 cm (34 in.)
	Overall length	124.4 cm (47.8 in.) with E-Box	116 cm (45.7 in.)
	Overall height	251.1 cm (98.9 in.)	
	Dry skid weight (mass)	354 kg (780 lb.)	
	Wet skid weight-rated working volume (mass)	853.8 kg (1882.3 lb.)	
Recommended operating parameters	Operating temperature range	Ambient to 40 ± 0.1°C (104 ± 0.2°F)	
	Motor speed	30–150 rpm	
	Volume range	100–500 L	
	Maximum bag pressure	0.03 bar (0.5 psi)	
	Continuous operating time	21 days mixing time at nominal volume only	

System options

Table 3 lists available S.U.B. system options for the 500 L size. The figures referenced below appear on pages 6 and 7.

- **Bioreactor probe assembly** (Figure 3)—required for each sterile electrochemical probe insertion. New CPC AseptiQuik™ connector is used on probe assembly SH30720.02 and mating probe belt on S.U.B. BPC for connection
- **Sparge line support** (Figure 4)—keeps gas lines in an upright position for optimal gas transfer
- **Heavy-duty tubing clamp** (Figure 5)—used for each probe port not in use, eliminating process fluid holdup
- **Autoclave tray for probe kits** (Figure 6)—aids in holding the probe assembly during the autoclave process
- Additional information on autoclave tray:
 - Fabricated from stainless steel
 - Plastic carry handle for easy transport right out of the autoclave
 - Positions probes on 15% incline for greater probe/membrane longevity
 - Will restrain probe bellows from collapsing during sterilization
 - Probe holder accommodates two probes
- **S.U.B. temperature sample port** (Figure 7)—provides in-situ temperature monitoring during culture process
- **Load cells** (Figure 8)—Mettler-Toledo™ Flexmount™ load cells allow for batch liquid-weight reading and three load cells; three load cells are mounted with summing box on the S.U.B. hardware unit

Table 3. 500 L S.U.B. system options.

Description	Cat. No.
Cable management tree	SV50992.03
Load cell with summation box, without display	SV50988.03
Autoclave tray	SV50177.01
Bioreactor probe assembly with CPC AseptiQuik connector (nonsterile for use in autoclave)	SH30720.02
Sparge line support	SV50177B.19
Heavy-duty tubing clamp (each)	SV20664.01
Heavy-duty tubing clamp (10 per pack)	SV20664.04
Sterile sampling manifold with luer lock (each)	SH30845.01
Sterile sampling manifold with luer lock (10 per pack)	SH30845.02
S.U.B. temperature/sample port	SV20750.01
PendoTECH pressure sensor	SH31134.01
Finesse pressure sensor	SH31134.02



Figure 3. Bioreactor probe assembly.



Figure 4. Sparge line support.



Figure 5. Heavy-duty tubing clamp.

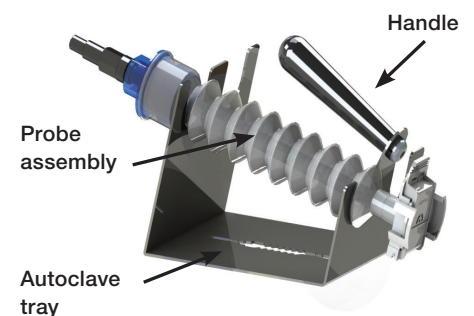


Figure 6. Autoclave tray for probe kits.



Figure 7. S.U.B. Temperature sample port.



Figure 8. Load cells.

- **Cable management tree** (Figure 9)—allows the end user to organize the S.U.B. BPC tubing lines for operator ease of use.
- **Sterile sampling manifolds**—available in 50 and 100 mL sizes for off-line sample retention.

Vent heaters

Vent heaters aid in reducing moisture buildup in exhaust filters from system off-gassing. Vent heaters are factory-preset at 50°C, allowing for condensation to return to the vessel. Recommended gassing strategies of the S.U.B. system are in the S.U.B. Validation Guide. Table 4 lists available vent heaters.



Figure 9. Cable management tree.

Table 4. Vent heater required for each exhaust filter on S.U.B. BPC.

Description	Cat. No.
120 VAC, 99.6 W, Meissner™ 10 in. series 46 vent filter heater, preset temperature bulb, IEC 320 C14	SV50191.33
240 VAC, 99.6 W, Meissner 10 in. series 46 vent filter heater, preset temperature bulb, IEC 320 C14	SV50191.34
120 VAC, 99.6 W, Meissner 10 in. series 46 vent filter heater, integrated, M12–4 pin connector*	SV50191.47
240 VAC, 99.6 W, Meissner 10 in. series 46 vent filter heater, integrated, M12–4 pin connector*	SV50191.48
120 VAC, 23.8 W, Pall™ Kleenpak™ KA3 series 46 vent filter heater, preset temperature bulb, IEC 320 C14	SV50191.31
240 VAC, 30.3 W, Pall Kleenpak KA3 series 46 vent filter heater, preset temperature bulb, IEC 320 C14	SV50191.32
120 VAC, 23.8 W, Pall Kleenpak KA3 series 46 vent filter heater, integrated, M12–4 pin connector*	SV50191.45
240 VAC, 30.3 W, Pall Kleenpak KA3 series 46 vent filter heater, integrated, M12–4 pin connector*	SV50191.46

* Require integration to a third party controller, which allows vent heater control through system HMI.

Harsh mount load cell display

Required for remote weight readout from a Mettler-Toledo™ summing box, various signal output options are provided for external control monitoring (Table 5). More information can be found in the Load Cell Data Sheet.



Figure 10. Harsh mount load cell display.

Spare parts

Table 6 lists the available spare parts of the 500 L S.U.B. systems. Spare parts are for standard reference only; configured S.U.B. tank drawings will be provided with a spare parts list specific to the S.U.B. tank ordered.

Table 5. Harsh mount load cell display options.

Description	Cat. No.
Mettler-Toledo™ IND331 display, with analog interface (STD), 120 VAC U.S. line cord/plug	SV50177.306
Mettler-Toledo IND331 display, with Allen-Bradley RIO interface, 120 VAC U.S. line cord/plug	SV50177.307
Mettler-Toledo IND331 display, with device net interface, 120 VAC U.S. line cord/plug	SV50177.308
Mettler-Toledo IND331 display, with ethernet/IP and Modbus TCP interface, 120 VAC U.S. line cord/plug	SV50177.309
Mettler-Toledo IND331 display, with Profibus interface, 120 VAC U.S. line cord/plug	SV50177.310

Table 6. Available spare parts.

Description	Cat. No.
DC motor	SV50237.22
AC motor	SV50237.18
Drive shaft	SV50959.12
RTD 304.8 cm (120 in) with Bulgin connector	SV50177.363
Probe holders	SV50177.23
Probe kit autoclave (SST with plastic carry handle)	SV50177.01
Adjustable filter bracket	SV50177.313

Table 7. 500 L Standard 5:1 S.U.B. BPC packaging.

Outer packaging	Supplied “flat-packed” Two polyethylene outer layers
Label	Description Product code Lot number Expiry date on outer packaging and shipping container
Sterilization	Irradiation (25–40 kGy) inside outer packaging
Shipping container	Durable cardboard carton
Documentation	Certificate of Analysis provided with each lot for delivery

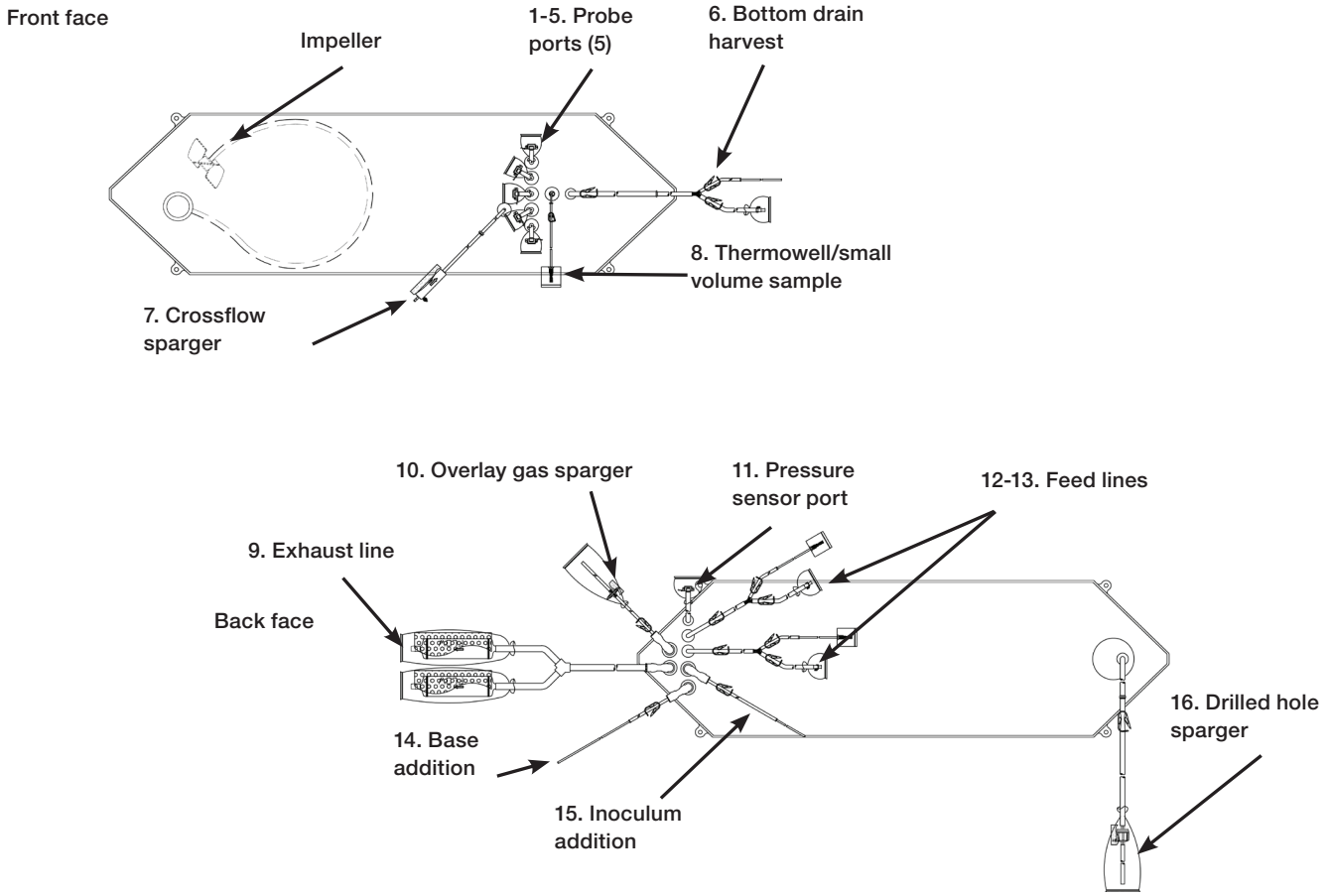


Figure 11. Standard 500 L 5:1 S.U.B. BPC.

500 L Standard 5:1 S.U.B. BPC systems

Table 8 shows the available standard 500 L S.U.B. BPC system options with drilled-hole, crossflow, and overlay spargers. Standard S.U.B. BPC packaging is shown in Table 7.

Table 8. 500 L Standard 5:1 S.U.B. BPCs.

Film	Cat. No.
CX5-14 film	SH31076.01
Aegis5-14 film	SH31077.01

* See standard drawing specifications below.

Table 9. 500 L Standard 5:1 S.U.B. BPC specifications.

	Description	Tubing set (inner diameter x outer diameter x length)	End treatment
1–5.	Probe ports (4)	12.7 mm (1/2 in.) tube ports	CPC AseptiQuik aseptic connectors
6.	Bottom drain harvest	12.7 mm (1/2 in.) ID x 19.1 mm (3/4 in.) OD C-Flex x 152 cm (60 in.) Reduced to 9.5 mm (3/8 in.) ID x 15.9 mm (5/8 in.) OD C-Flex x 30 cm (12 in.) Splits to 6.4mm (1/4 in.) ID x 11.1 mm (7/16 in.) OD C-Flex x 30 cm (12 in.) Reduced to 3.2 mm (1/8 in.) ID x 6.4 mm (1/4 in.) OD C-Flex x 30 cm (12 in.) and 9.5 mm (3/8 in.) ID x 15.9 mm (5/8 in.) OD C-Flex x 30 cm (12 in.)	Plugged 9.5 mm (3/8 in.) MPC insert
7.	Crossflow sparger	6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 8 cm (3 in.) Connected to check valve and 6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 183 cm (72 in.)	Meissner Steridyne™ 50 mm filter
8.	Thermowell/small volume sample	Thermowell adapter for 6.4 mm (1/4 in.) diameter 3.2 mm (1/8 in.) x 6.4 mm (1/4 in.) C-Flex tubing x 46 cm (18 in.)	SteriEnz pouch with injection site assembly
9.	Exhaust line	19.1 mm (3/4 in.) x 25.4 mm (1 in.) C-Flex tubing x 30 cm (12 in.) Splits to 19.1 mm (3/4 in.) x 25.4 mm (1 in.) x 15 cm (6 in.) and 19.1 mm (3/4 in.) x 25.4 mm (1 in.) C-Flex tubing x 15 cm (6 in.)	Meissner Ultra Cap 0.2 µm exhaust filters
10.	Overlay gas sparger	6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 15 cm (6 in.)	Hydrophobic vent filter with Emflon II, connected to 15 cm (6 in.) C-Flex tubing
11.	Pressure sensor port	12.7 mm (1/2 in.) x 19.1 mm (3/4 in.) C-Flex tubing x 8 cm (3 in.)	CPC AseptiQuik aseptic connector
12–13.	Feed lines	9.5 mm (3/8 in.) x 15.9 mm (5/8 in.) C-Flex tubing x 213 cm (84 in.) Splits to 6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 30 cm (12 in.) Reduced to 3.2 mm (1/8 in.) x 6.4 mm (1/4 in.) C-Flex tubing x 30 cm (12 in.) and 9.5 mm (3/8 in.) x 15.9 mm (5/8 in.) C-Flex tubing x 30 cm (12 in.)	SteriEnz pouch with injection site assembly 9.5 mm (3/8 in.) MPC body
14.	Base addition	6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 213 cm (84 in.) Reduced to 3.2 mm (1/8 in.) x 6.4 mm (1/4 in.) C-Flex tubing x 30 cm (12 in.)	Plugged
15.	Inoculum addition	6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 15 cm (6 in.) Reduced to 3.2 mm (1/8 in.) x 6.4 mm (1/4 in.) C-Flex tubing x 213 cm (84 in.)	Plugged
16.	Drilled hole sparger 8.9 cm (3.5 in.) disk with 360 x 0.178 mm (0.007 in.) holes	6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 8 cm (3 in.) Connected to check valve and 6.4 mm (1/4 in.) x 11.1 mm (7/16 in.) C-Flex tubing x 97 cm (38 in.)	Kleenpak Emflon 0.2 µm hydrophobic filter connected to 15 cm (6 in.) C-Flex

Custom S.U.B. BPC options

Table 10 lists available custom 500 L S.U.B. BPC system options. Not all options are available for all ports. For additional information, please see the selection guides in the S.U.B. BPC catalog.

Table 10. 500 L Custom 5:1 S.U.B. BPC specifications.

Category	Options/capability	Notes
Tubing type	Thermoplastic elastomers: C-Flex™, PharMed™, PharmaPure™ platinum cured silicone PVC	More information is available in the component selection guide
Tubing size	Ranging from 0.318 to 2.54 cm (1/8–1 in.) ID, in customer-specified lengths	More information is available in the component selection guide
Connectors	Luers, quick connects, SIP connectors, Tri-Clamp, aseptic connectors, sterile connectors, Steam-To, Steam-Through, sample ports, plugs, etc.	More information is available in the component selection guide
Probe ports	Additional ports: second row of four	The reusable probe port connection uses a Kleenpak connector only
Disposable sensors	Pressure sensor: PendoTECH and Finesse Solutions DO and pH: Finesse Solutions and PreSens pH: Mettler Toledo	Choice of qualified sensors available
Additional probe ports	Limited engineer-to-order customization only	Qualified location on second row of probe ports only
Port sizes	Limited engineer-to-order customization only	Dependent on location in BPC and fit with hardware (e.g., 2.54 cm (1 in.) port on harvest line)
Rearrangement of lines on existing ports	Limited customization possible, e.g., moving sample/thermowell port to a probe tube port, or swapping overlay inlet line with supplement line	Dependent on location in BPC and fit with hardware
Sparger	Dual sparger (macro-open pipe or drilled hole and micro-porous frit) standard	Sparger locations are fixed
Diptube lines	Limited customization possible	Length cannot interfere with impeller and shaft
Overlay and sparger line filters	Filter options available from standard component library	Choice of qualified filters available
Vent filters	Standard is Pall or Meissner 0.2 µm exhaust vent filter	Filters must be compatible with available vent filter heater configurations
Vent filter tubing length	Extended filter height above the S.U.B. BPC is make-to-order	Must be compatible with a vent filter bracket option
Filters on media and supplement inlets	Limited engineer-to-order customization only. Choice of filters used to sterilize incoming media or supplements are available	Choice of qualified filters available

External controller options

The HyPerforma S.U.B. offers an open architecture or turnkey system. An open architecture system allows you to use any control system of your choice. The capital investment can be reduced by using a control system already utilized in your facility. A turnkey system is a ready-to-use, out-of-the-box system with a choice of dedicated controls from Finesse Solutions or Applikon. These systems work on Delta V™, Allen Bradley™, or Siemens™ formats. Contact your local sales representative for more information.

Ordering information

Product	Quantity	Cat. No.
S.U.B. hardware unit	1	SUB0500.8400
S.U.B. BPC CX5-14 film	3	SH31076.01
S.U.B. BPC Aegis5-14 film	3	SH31077.01
Bioreactor probe assembly with CPC AseptiQuik™ (nonsterile for use in autoclave)	12	SH30720.02
Heavy-duty tubing clamp	12	SV20664.01
Autoclave tray for autoclaving probe accessories	1	SV50177.01

Auxiliary components supporting the HyPerforma S.U.B. (supplied by end user or requested turnkey)

Necessary for feed strategies, gas flow, DO, and pH control	1	Bioreactor control system
Autoclavable probe (13 mm x 13.5 PG thread with 195-235 mm insertion length)	*	DO probe
Autoclavable probe (13 mm x 13.5 PG thread with 195-235 mm insertion length)	*	pH probe
Tubing welder, steam-in-place, sterilizer, or laminar flow hood	*	Sterile/aseptic connection
Used for fluid transfer between linesets on the containers	*	Stand-alone peristaltic pump
Necessary for temperature controls (not provided)	*	Temperature control unit (TCU)

* Quantity based on needs

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