



Single-use mixing systems

Xcellerex™ XDUO 2500 Mixer

Xcellerex XDUO 2500 Mixer is a robust, versatile and easy to use 2500 L single-use mixer (Fig 1) that can be used for mixing operations throughout the entire process workflow. Its large volume coupled with exceptional mixing capabilities enables fast and efficient mixing for upstream applications such as cell-culture media preparation and harvest. The intelligent automation and process control capabilities simplify complex and sensitive downstream mixing operations used in purification and separation processes. Finally, you can support large-scale fermenters and bioreactors with efficient and reliable large-scale mixing to fully realize the advantages of single-use.

XDUO 2500 is the first single-use large volume mixer from GE Healthcare's Life Sciences business to support up to 2500 L mixing. This is made possible by a robust design and novel dual impellers mounted inside the disposable bag that can be jointly or independently controlled.

Features and benefits:

- Dual impellers and integrated magnetically coupled¹ drives for faster setup and mixing times; eliminates need for complicated mating of motor and drive systems to storage tanks.
- Ergonomic and intuitive mixer and bag design enables easy handling and accurate installation of mixer bags.
- Automation of pH and temperature for higher accuracy and consistency compared with manual methods.
- Integrated in-line sensors eliminate need to take multiple samples manually and avoid contamination risks.
- Advanced data management allows monitoring, trending, recording, exporting, and printing and is 21 CFR Part 11 compliance-enabled.
- Control is performed locally or remotely for Xcellerex FlexFactory™ (M-station) and other biomanufacturing platforms (X-station), avoiding manual control.



Fig 1. Three views of XDUO 2500 Mixer.

¹ This product uses Pall patented Magnetic Mixer technology. All information on patents can be found at Pall.com/patents.

Wide range of applications

Upstream fed batch applications

- Cell-culture media preparation
- Harvesting
- Intermediate storage and pooling

Upstream perfusion application

- 200 L bioreactor, 1 to 2 media volumes per day up to 10 days

Downstream applications

- Buffer preparation – ultrafiltration/diafiltration (UF/DF)
- pH adjustment
- Viral inactivation
- Dilution skid
- Chromatography pooling
- Homogenization of protein solutions
- Homogenization of vaccine adjuvants
- Intermediate storage and pooling

Application advantages

The range of in-process monitoring and control capabilities of the XDUO 2500 Mixer allows precise configuration for a wide range of application needs—reducing your capital equipment requirements and maximizing your plant efficiency.

- **Automated viral inactivation** with in-line sensors, programmable logic control (PLC), and pumps saves time and minimizes errors.
- **Automated pH adjustment** enables equilibration of cell-culture media and buffer preparation, without sampling or manual addition of titrants.
- **Formulation** in the closed system provides processing with no risk of contamination.

Bag assembly

Xcellerex XDUO 2500 Mixer delivers flexibility with the availability of two standard bag types—Basic and Plus. The bags include varying numbers of tubing lines and connections as well as sampling and sensing capabilities to accommodate a wide array of applications. Custom bag configurations are also available on request.

The bag has two disposable high-strength impellers welded to the bottom of the bag assembly (Fig 2). Key features of the bag and rigid container also permit seamless transitioning between powder-liquid and liquid-liquid mixing applications. The engagement between motor and disposable impeller is via a robust magnetic coupling, imparting high torque and rapid mixing capability to the system. The disengagement between the motor and disposable impeller is via a decoupler mechanism, enabling safe and easy bag removal. Figure 3 shows different views of the Plus Bag Assembly.

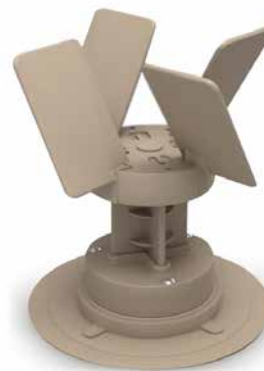
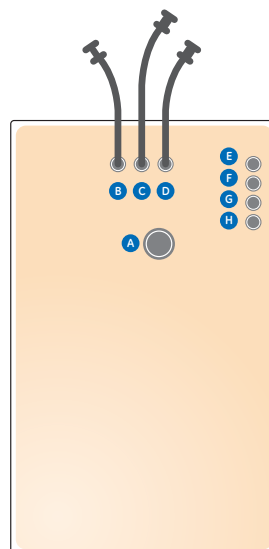
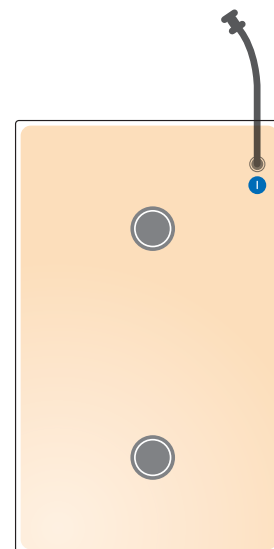


Fig 2. The disposable impeller is welded to the bottom of the bag.

(1) Plus Bag Assembly - top view



(2) Plus Bag Assembly - bottom view



- A: Fill port
- B: 1/8" (3.18 mm) i.d. C-Flex™ tubing
- C: 1/2" (12.7 mm) i.d. C-Flex tubing
- D: C-Flex tubing, 4' (121.9 cm)

- E: 1/8" (3.18 mm) i.d. sample line
- F: Thermowell
- G, H: Probe port
- I: Harvest/drain port

(3) Partially filled bag

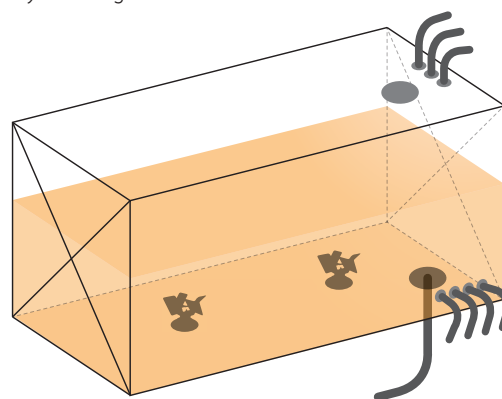


Fig 3. Plus Bag Assembly showing (1) top and (2) bottom views of a folded, empty bag with connectors as well as (3) an image showing a partially filled bag.

Mixing time study using conductivity tests

Different mixing studies were conducted to quantitate the mixing time benefits of using a dual impeller. Conductivity measurement was used to understand the mixing time and the sensor was placed in the central position shown in Figure 4. The center probe is critical for conductivity measurement because it is located away from the impellers and walls and is an excellent indicator of mixing efficiency.

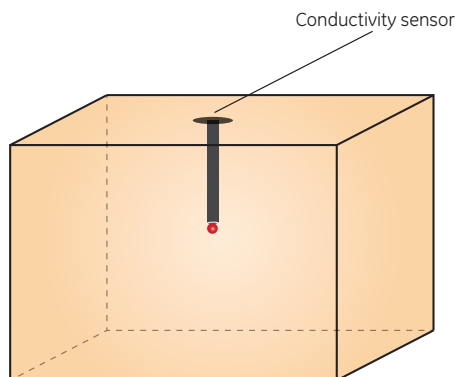


Fig 4. Conductivity probe placement, liquid-liquid and solid-liquid mixing studies.

Liquid-liquid mixing study

In an evaluation of liquid-liquid mixing, five runs were conducted, each consisting of the addition of 5 L of a 2 M NaCl solution in water.

Two ranges of conductivity and mixing speeds were evaluated. Figure 5A shows mixing results at 5250 to 7500 $\mu\text{S}/\text{cm}$ conductivity and 200 rpm (down-pumping); Figure 5B shows mixing results at 2900 to 6900 $\mu\text{S}/\text{cm}$ and 300 rpm (down-pumping). The results show consistent mixing results for all five additions of NaCl solution.

Solid-liquid mixing study

In an evaluation of solid-liquid mixing, five runs were conducted, each consisting of the addition of 5 kg of USP grade NaCl in water.

Two ranges of conductivity and mixing speeds were evaluated. Figure 6A shows results of the mixing at 24 000 to 44 000 $\mu\text{S}/\text{cm}$ conductivity at 200 rpm (down-pumping); Figure 6B shows results of the mixing at 6400 to 26 000 $\mu\text{S}/\text{cm}$ at 300 rpm (down-pumping). Consistent mixing of solid 5 kg of NaCl was observed for each run.

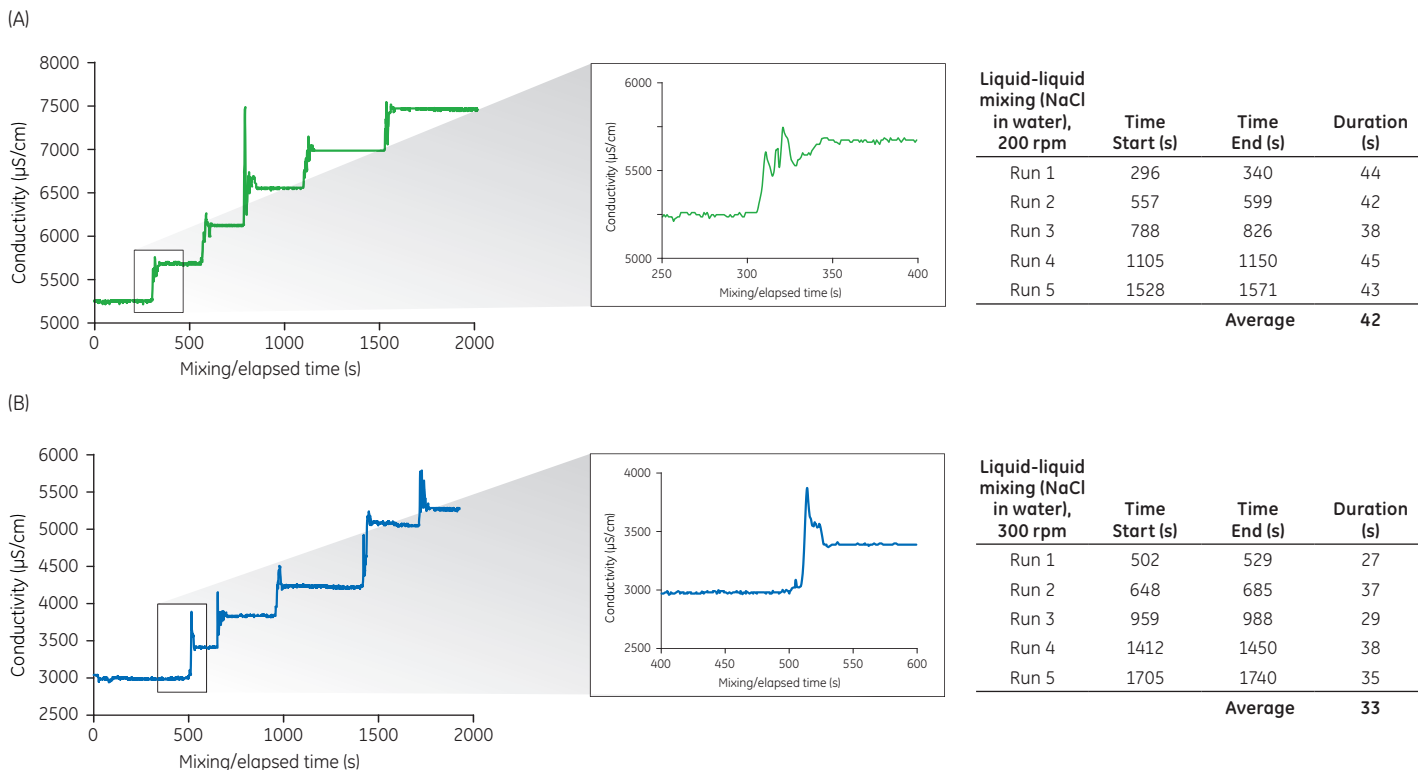


Fig 5. Liquid-liquid mixing study . Five runs were conducted, each consisting of the addition of 5 L of a 2 M NaCl solution to water. Conductivity was measured at (A) 200 rpm and (B) 300 rpm mixing speeds.

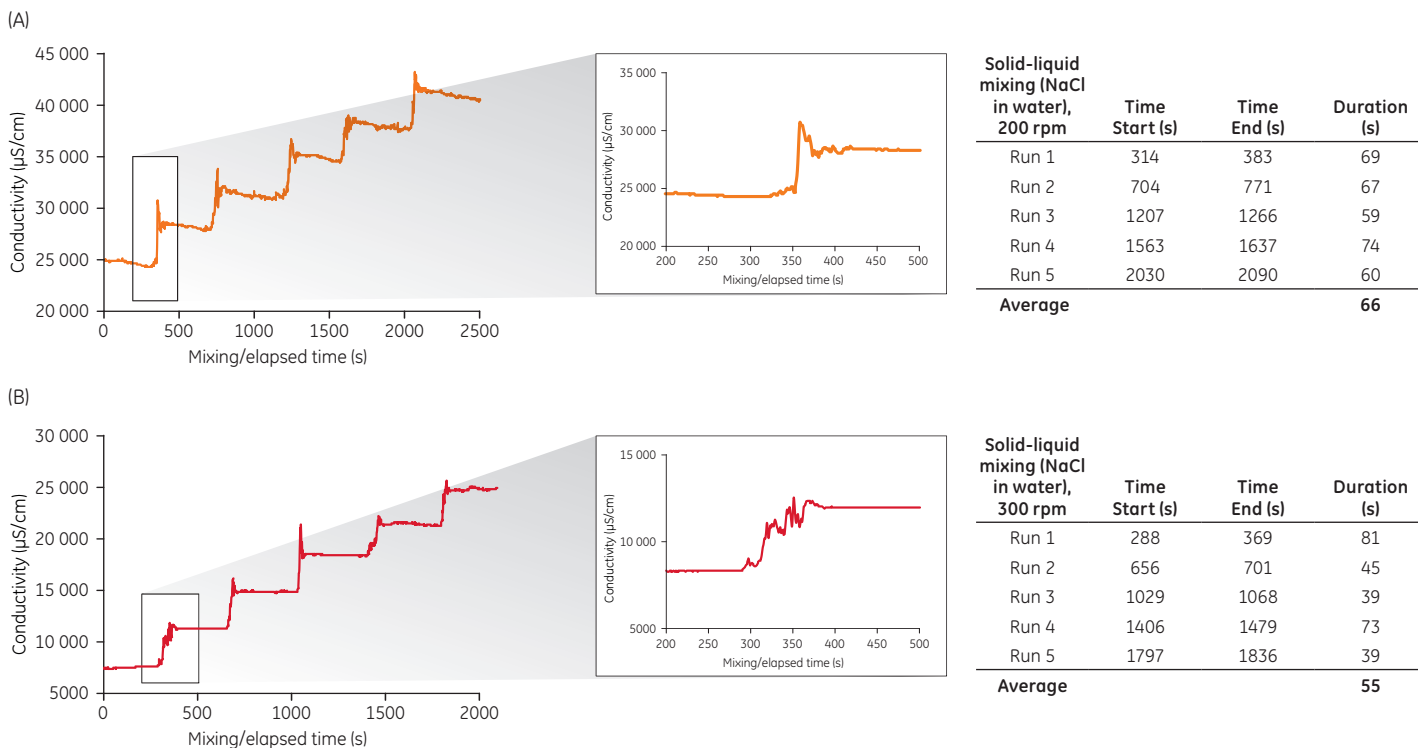


Fig 6. Solid-liquid mixing. Five runs were conducted, each consisting of the addition of 5 kg of USP grade NaCl in water. Conductivity was measured at (A) 200 rpm and (B) 300 rpm mixing speeds.

Heating/cooling performance using temperature mapping

Heating and cooling performance of the five-face jacket was tested with 2500 L water in the mixer. The probe placement at different points for temperature measurements taken in the study is shown in Figure 7. Temperature control unit (TCU) heat transfer fluid was composed of 20% propylene glycol/80% water. The TCU specifically designed for this mixer has 9 kW of heating power and ~ 54 MJ/h (~ 51 180 BTU/h) of cooling power.

The heating test was conducted with a single step ramp-up profile from 2°C to 60°C (TCU set point: 65°C). The cooling test was conducted with a single step ramp-down profile from 60°C to 2°C (TCU set point: -2°C).

Effective heating and cooling performance of 2500 L of water was observed in the study and the results are shown in Figures 8 and 9, respectively. Intermediate heating and cooling performance were derived from the data and are also shown in the figures. The performance can be further optimized by adjusting the propylene glycol/water mix or by optimizing the temperature-range steps.

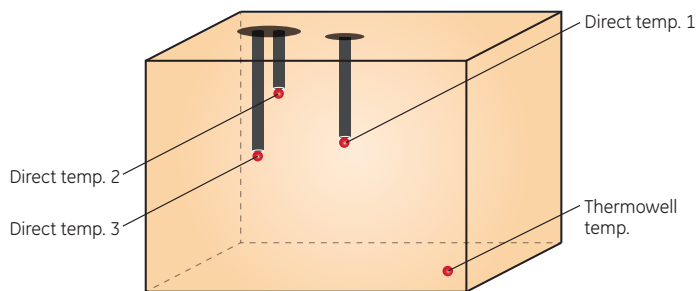
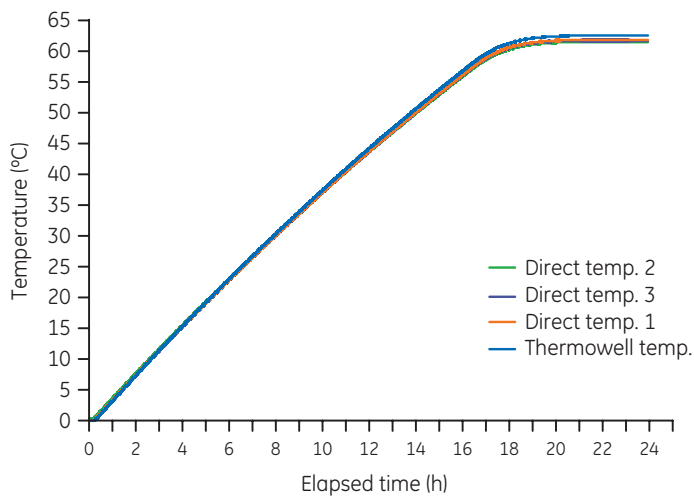


Fig 7. RTD probe placement for thermal performance study.



Heating from 2°C to 60°C, heating rate 3.50°C/h

Elapsed Time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
0.61	2.00	2.10	2.48	2.06
17.00	60.15	59.50	59.20	59.41
dT	16.39	58.15	57.40	56.72
Avg. dT	57.41			

Intermediate heating data

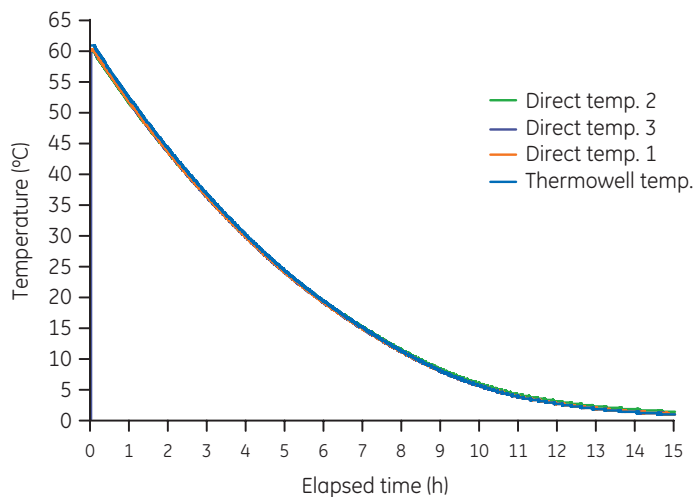
Heating from 2°C to 20°C, heating rate 3.99°C/h

Elapsed time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
0.61	2.00	2.10	2.48	2.06
5.00	19.70	19.60	19.77	19.57
dT	4.39	17.70	17.50	17.29
Avg. dT	17.50			

Heating from 20°C to 60°C, heating rate 3.33°C/h

Elapsed Time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
5.00	19.70	19.60	19.77	19.57
17.00	60.15	59.50	59.20	59.41
dT	12.00	40.45	39.90	39.43
Avg. dT	39.91			

Fig 8. Heating of 2500 L of water in XDUO 2500 Mixer from 2°C to 60°C in 17 h. The curves show measurements made at four separate points in the mixing chamber. Other tables in this figure show intermediate heating data from the 2°C to 60°C heating.



Cooling from 60°C to 2°C, cooling rate -4.84°C/h

Elapsed time (h)	Thermowell Temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
0.00	61.30	60.63	60.34	60.56
12.00	2.55	2.59	2.95	2.57
dT	12.00	-58.75	-58.04	-57.39
Avg. dT	-58.04			

Intermediate cooling data

Cooling from 60°C to 4°C, cooling rate -5.18°C/h

Elapsed time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
0.00	61.30	60.63	60.34	60.56
11.00	3.68	3.69	4.05	3.66
dT	11.00	-57.62	-56.94	-56.29
Avg. dT	-56.94			

Cooling from 60°C to 20°C, cooling rate -6.92°C/h

Elapsed time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
0.00	61.30	60.63	60.34	60.56
6.00	19.31	19.14	19.29	19.08
dT	6.00	-41.99	-41.49	-41.05
Avg. dT	-41.50			

Cooling from 20°C to 2°C, cooling rate -2.76°C/h

Elapsed time (h)	Thermowell temp.	Direct temp. 1	Direct temp. 2	Direct temp. 3
6.00	19.31	19.14	19.29	19.08
12.00	2.55	2.59	2.95	2.57
dT	6.00	-16.76	-16.55	-16.34
Avg. dT	-16.54			

Fig 9. Cooling of 2500 L of water in XDUO 2500 Mixer from 60°C to 2°C in 12 h. The curves show measurements made at four separate points in the mixing chamber. Other tables in this figure show intermediate cooling data from the 60°C to 2°C cooling.

System specifications*

Vessel

Vessel interior (W × H × D)	2083 × 1054 × 1118 mm 82 × 41.5 × 44"
Vessel overall dimensions with I/O panel (W × H × D)	2591 × 1605 × 1260 mm 102 × 63 × 49.6"
Geometry	Cuboid with sloped bottom for full drainability
Vessel main construction material	304 SS ASME Material
Vessel surface finish	Ra ≤ 35 µin, ≤ 1.0 µm
Slope to drain	1.54°, 0.27 mm/meter
Mobility (casters)	Mounted on four clean room casters and push handles
Caster dimensions (ø × W)	Ø 90 × 55, max. load 2000 kg/each
Weight (empty)	1200 kg, 2645 lb
Bag tubing gate	Side port (long face) for bag lines and sensor access
Easy bag access	Two side ports (short face) for bag handling

Jacket

Jacket type	Four sides and bottom—dimple style
Insulation type	Four sides, bottom, and lids on top
Jacket volume	39.5 L
Jacket (design working pressure/test pressure)	0.69/0.88 MPa, 6.9/8.8 bar, 100/130 psig
Burst disk rating	0.52 MPa, 5.2 bar, 75 psig
Compliance	ASME Pressure Vessel Code Compliant
Heat transfer fluid inlet outlet connections	25.4 mm (1") SCH 40 pipe with male NPT thread
Drain ports	Qty 2: 12.7 mm (½") SCH 40 pipe with male NPT thread, 25.4 mm (1") SCH 40 pipe with male NPT thread (shared with inlet)

Agitation

Motor – quantity/type	2 × Siemens SIMOGEAR Bevel Geared AC Motor
Motor - mounting	Bottom integrated with vessel
Motor - power (rating)/requirement	0.75 HP (550 W)/230 V (60 Hz)
Motor drive – type	Dual drive – independent variable frequency control
Motor drive – functionality	Run/stop, forward/reverse, 10 to 300 rpm

* Specifications can change without notice.

Ingress protection

Motor	IP 55
I/O panel	IP 55
Field-mounted instrumentation, sensors	≥ IP 54

Smart control unit

Control Panel	Integrated dual cabinet – high and low voltage
Dimensions (W × H × D)	813 × 406 × 230 mm (enclosure only, not including parts mounted on external surfaces)
Construction material and surface finish	SS 304 ASTM, surface finish : Ra ≤ 35 µin, ≤ 1.0 µm
Automation hardware	Siemens SIMATIC S7-1200 PLC
Automatic pH control	
Pumps	Watson Marlow LF Peristaltic Pump, 520VBM, 190 rpm
Transmitter	Rosemount Analytical Model 1056 Dual Input Analyzer
Automatic temperature control	Jacketed tank and external temperature control unit (optional)
HMI	Siemens SIMATIC 7" HMI comfort panel – touch screen color
Alarms	Factory set and user defined
Communication ports	USB, Ethernet, PROFIBUS™
Remote connectivity	FlexFactory using M-Station. Other biomanufacturing platforms using X- Station.
E-stop	Integrated safety circuit for entire system
Automation compliance	Built to EU Annex 11 regulations, GAMP 5 guidelines

Process analytics

Data monitoring	Real-time instantaneous and trending of all variables
Data recording	Long-term data recording of all variables
Data storage	HMI SD card
File formats	CSV and PDF
Data security	Two-level protection
Data printing	Enabled
Data exporting	Local via USB Flash drive. Remote via PC (with Ethernet and Web browser capabilities)
Audit log	21 CFR Part 11 Enabled

Integrated process monitoring

RTD temperature sensor	Burns Eng., model 22041-07010
pH probe	Hamilton EasyFerm Plus VP 225, P/N 238634 / 00
Conductivity probe	Hamilton Conducell 4USF-PG-120, P/N 23899-4047/99
Load cells	Mettler Toledo 0745A
Summing box	Mettler Toledo Summing Box (61005973)
Sensor installation time	< 30 min

Recommended operating conditions

Ambient operating temperature	5°C to 30°C
Jacket operating temperature	2°C to 60°C
Motor speed	10 to 300 rpm
Volume range	520 to 2500 L
Absolute min. volume:	420 L
Absolute max. volume:	2600 L
Maximum closed-top mixing bag pressure	0.005 MPa, 0.05 bar, 0.7 psig
Continuous operating time	5 d (for bag)
Relative humidity	20% to 95%, noncondensing minimum
Cleaning agents	External surfaces of the system components are compatible with commonly used cleaning methods in GMP and lab environment

Single-use bag specifications

Dimensions (W × H × D)	2083 × 1092 × 1143 mm 82 × 43 × 45"
Maximum volume	2600 L
Nominal volume	2500 L
Minimal (for mixing)	520 L
Hold-up volume	2.5 L
Fluid contact layer (film material)	Low-density polyethylene
Pressure rating (max. operating)	0.005 MPa, 0.05 bar, 0.70 psig
Impeller position	Symmetric
Impeller	Two impellers (four blades each)
Impeller material	Victrex PEEK 450G Natural
Tubing material	C-Flex ADCF
Product recovery	> 99.9%
Sterilization	Dosed at 27.5 to 45 kGy
Bag set-up time	< 10 min for one person < 5 min for two persons

* Specifications can change without notice.

Single-use bag assemblies

Port description	Basic Bag Assembly	Plus Bag Assembly
A: Fill port: 3" (76.2 mm) tri-clamp powder addition port, capped	×	×
B: 1/8" (3.18 mm) i.d. C-Flex tubing 3' (91.4 cm) with Luer lock connection	-	×
C: 1/2" (12.7 mm) i.d. C-Flex tubing, 4' (121.9 cm) with clamp, female MPX connector, plugged	-	×
D: C-flex tubing, 4' (121.9 cm) with clamp, plugged (i.d. indicated)	25.4 mm (1")	25.4 mm (1")
E: Sample line: 1/8" (3.18 mm) i.d. sample line with clamp, and Luer lock connection	×	×
F: Thermowell: for noninvasive temperature sensing	-	×
G, H: Probe port: Female Kleenpak™ Connector port for probe connection	-	×
I: Harvest/drain: 1" (25.4 mm) i.d. C-Flex tubing, 4' (121.9 cm) with clamp, plugged (i.d. indicated)	×	×

To order the XDUO 2500 Mixer or for more information please contact your local sales representative.

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