

FlexiPro™ TFF

VERDOT

- **Multi-purpose processing:**
Ultrafiltration (concentration, diafiltration) and microfiltration
- **GMP system scalable from small-pilot to commercial scale**
- **One instrument; Four FlowKits covering 1.0 – 3,500L/h range**
- **FlowKit installation in >15 minutes**
- **High precision pressure regulation**
- **Low shear**
- **>95% product recovery**
- **User-friendly software**
- **21 CFR Part11 and USP VI Compliant**
- **Complete documentation for regulatory submission**

Scalable single-use tangential flow filtration system for process development, clinical trials and GMP manufacturing

The FlexiPro™ TFF single-use system is adaptable to perform a wide range of filtration processes for ultrafiltration (i.e., concentration, diafiltration, enrichment) and microfiltration (clarification). It is compatible with all filter (e.g., membranes, cassettes or hollow fibers) formats from most manufacturers (Figure 1).

The FlexiPro™ TFF works in combination with adaptor sets and four disposable FlowKit sizes, providing the largest flow rate range (1.0 – 3,500 L/h) on the market within a single system. Each FlowKit is pre-assembled, including the pump heads, sensors and valves, for quick and easy installation in less than 15 minutes.



Figure 1. FlexiPro TFF™ offers single-use flexibility with four FlowKit options

FlowKit Recommended Ranges

	Sample Volume (L)	Membrane S.A. (m ²)	Flow Range (LPH)
VLFK	0.20-10	0.002-0.06	1.0-30
LFK	1-53	0.007-1.0	5.0-170
HFK	5-190	0.05-5.1	25-1150
VHFK	10-1600	0.16-34.0	100-3500*

* Higher flow can be obtained if TMP >0.7 bar

FlowKits

Flowkits are double-bagged and sealed within an ISO 7 clean room with instructions and full traceability file. The FlowKits are available in both non-gamma irradiated and gamma irradiated (>25 kGy) versions.

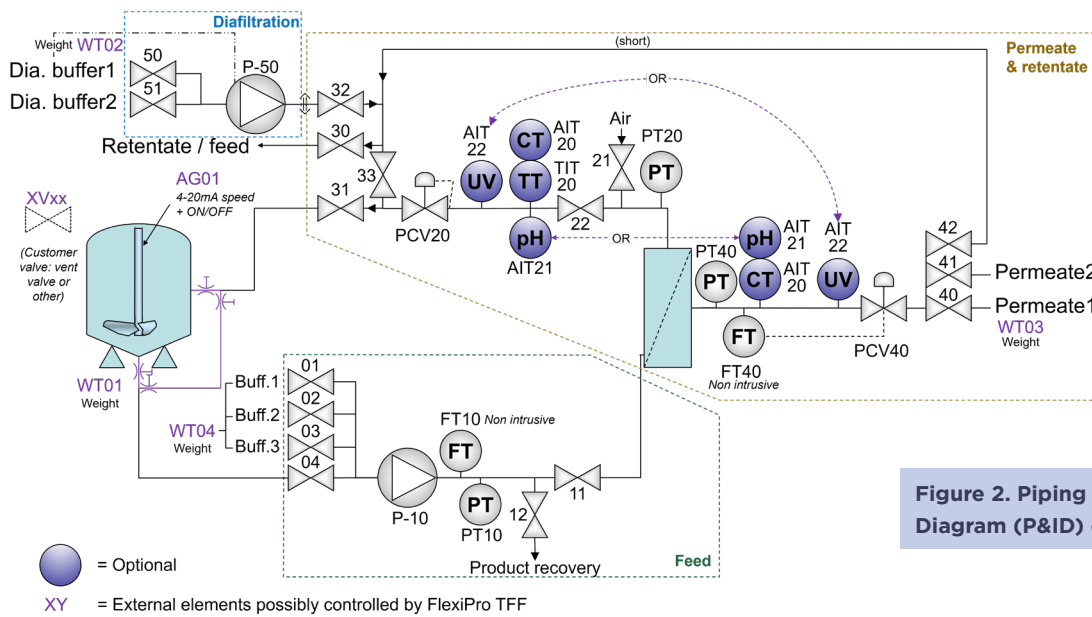


Figure 2. Piping and Instrumentation Diagram (P&ID) of the Installation

Compact Footprint

The FlexiPro™ TFF system is a compact self-contained system that integrates all necessary hardware components. A laptop PC with SCADA software provides the interface to communicate with the PLC. Configuration for DCS integration can be proposed upon request.

The stainless-steel cabinet is IP65 rated provides protection from liquid ingress. On the outside of the system, fluid paths and sensors are secured in routing channels by a transparent door and flow-path channel locks. Lockable caster wheels help prevent the system from moving during use.

Gain precision with Verdot's patented pressure control valves

Precise Regulation of the pressure control valves is critical to ensure constant trans-membrane pressure (TMP). Verdot has developed and patented an unique technology using a high-precision pressure actuator to provide maximum precision over a wide pressure range, up to the maximum system pressure (4bar). The pressure control value is compatible and provide identical pressure stability with all four available FlowKits. The same level of precision is found on the permeate side to regulate flux.

Configurable to your process

Depending on the scale, complexity and type of separation, the need for instrumentation may vary for each application: tank weighing or flowmeter, in-line control of conductivity, pH or UV, etc. The FlexiPro™ TFF system is therefore designed with a base set of instrumentation (2 Flowmeters, 3 Pressures) and optional ones (UV, Cond., pH) and can be interfaced with the 0-10V/4-20mA output of 4 electronic scales for circulation tank, buffer, permeate and diafiltration tanks (Figure 2). The permeate and retentate flow kits are custom built with several options to meet the application need:

- Option I: UV probe on the retentate or permeate section
- Option II: Conductivity, temperature and pH on the retentate section
- Option III: Conductivity, temperature and pH on the permeate section

An adaptor set matching the required FlowKit may need to be installed, if transitioning flow ranges. It can easily be changed within 15 minutes and comprises of the pump head supports, the pressure control valves rollers and supports, and the clamp-on flowmeters (Figure 3).



Figure 3. Adaptor set for the Low Flow Kit (LFK)

Confidence in process pressure / flow parameters no matter the application

Through the use of our patented pressure control valve, high-precision pressure and flow regulation can be achieved as demonstrated in Figure 4. The data shows that the target flow rate is smoothly reached in less than 2 minutes as the target pressure or TMP set point is obtained in less than 30 seconds with less than 2% error.

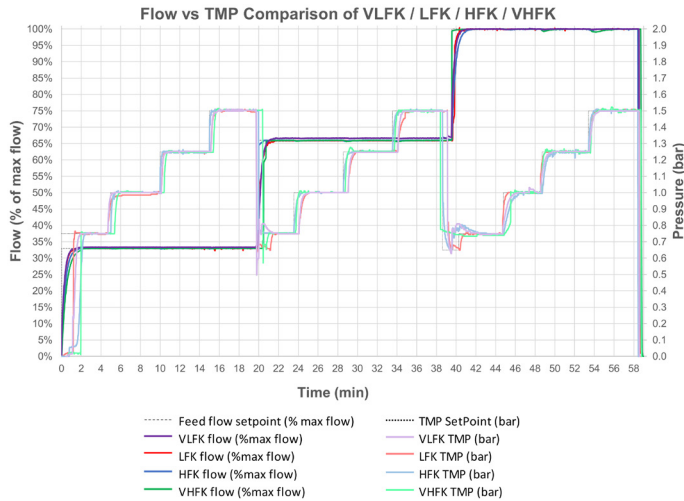


Figure 4. TMP vs. Flow comparison across FlowKit options

Air inlet for integrity tests and >95% product recovery

The FlexiPro™ TFF system hardware encloses a low pressure air inlet on the retentate that can be used for the integrity test with pressure decay method, before and after the filtration. It can also be used for the product recovery, by pushing air through all the circulation loop. A bypass with clamps is proposed for the circulation bag to obtain a full product recovery.

Maintain low shear stress for critical processes

The FlexiPro™ TFF system hardware, including the pressure regulating valves, pumps and fluid path were specifically integrated to ensure low-shear stress conditions required to maintain adenovirus, lentiviral and mRNA product integrity. An internal study with liposomes demonstrated that low shear stress can be maintained even under maximum flow and TMP (Figures 5 and 6).

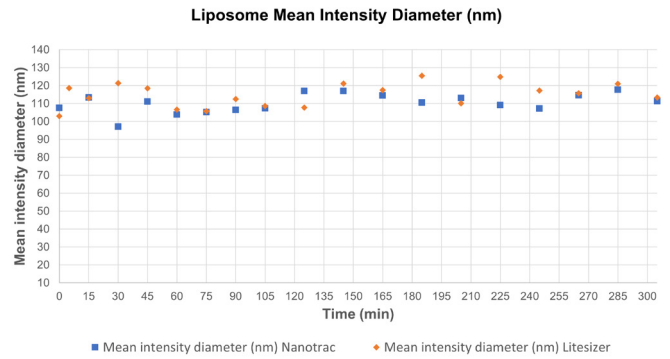


Figure 5. FlexiPro TFF system demonstrates particle size integrity over 5 hour period of circulation at 1.4 bar TMP

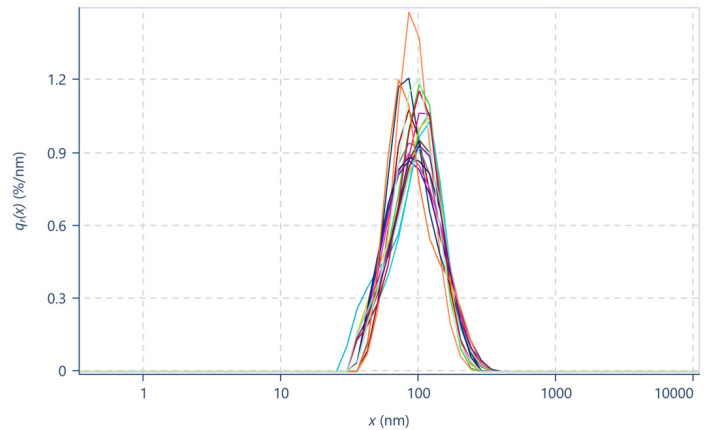


Figure 6. Stable liposome size distribution over 5 hour of circulation at 1.4 bar TMP

User-friendly software

The system controller uses a simple, user-friendly interface for data input and programming commands. The process skid is password protected (with customizable access levels), and all events and actions are recorded in accordance with cGMP compliance guidelines.

The software allows for manual or automated mode of operation. The automated mode includes:

- Multiple step programming;
- Configurable fluid path for each step;
- Wide choice of end step conditions: weights, volume, conductivity, UV, pH, permeate flow, diaf. number;
- Regulation of the pressure control valve based on % opening, Feed pressure, retentate pressure or transmembrane pressure;
- Regulation of the circulation pump based on fixed speed, flow, cross flow or ΔP ;
- Regulation of the flux with permeate regulating valve;
- Control of an external agitation with a %speed set point and on/off command;
- Sensor alarm options;
- U.S. FDA 21 CFR Part 11 compliance;
- Configurable fluid paths.

Full trend review, printing and data export are standard options within the software. Configuration for DCS integration can be proposed upon request.

Specifications

FlowKit	VLFK	LFK	HFK	VHFK
Tubing ID	1/8" 3.2 mm	1/4" 6.4 mm	1/2" 12.7 mm	3/4" & 7/8" 19.1 mm & 22.1 mm
Recirculation Pump (Quattroflow®)**	QF30SU	QF150SU	QF1200SU	QF2500SU*
Void Volume [†]	49 mL	190 mL	767 mL	2240 mL
Maximum Pressure	4 bar			
Temperature Range	2-40°C			
pH Range	3-10 pH. Hamilton OneFerm VP120. Error: $\pm 1.2\%$ FS			
UV (optional)	Kemtrak single use, 0-4.5 Au. Two wavelengths. Error $\pm 0.2\%$ FS			
Conductivity and Temperature (optional)	0-500mS/cm 0-100°C. Error $\pm 4\%$ MV			
Flowmeters (non-product contact)	Levitronix® ultrasonic Error: $\pm 5\%$ MV			
Pressure Probes (non-product contact)	Endress + Hauser Error: $\pm 0.3\%$ FS			
Tubing Material	Silicone or silicone-braided USP Class VI			
Dimensions (HxWxD) without FlowKit	1770 x 1370 x 805 mm			
Power	208-240VAC 50/60Hz 1 or 3 phase available			
Control	PLC: OMRON with OPC UA SCADA: iFix 2023			
PC	Microsoft Windows® laptop			

* Flow >2500 LPH with QF2500SU can be obtained by running two pumps in parallel. Flow >3500 LPH can be obtained if TMP is > 0.7 bar.

** Levitronix® LeviFlow® pumps can be substituted for Quattroflow®

† >95% of the void volume can be recovered through air inlet flush.