# KrosFlo® KR2*i* RPM™ System

## User Guide


DOC0304 eRev. 2.0 10/7/2024

repligen.com



REPLIGEN

The information contained in this document is subject to change without notice.

With respect to documentation accompanying Product Repligen makes no warranty, express or implied. Any and all warranties related to the documentation accompanying Product are expressly disclaimed. Customer shall refer to the terms and conditions of sale governing the transaction for any and all warranties for the Product.

Repligen Corporation shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

No part of this document may be photocopied, reproduced, or translated to another language without the prior written consent of Repligen Corporation.

Products are not intended for diagnostic or therapeutic use or for use *in vivo* with humans or animals.

For further information, please contact Repligen Corporation at www.repligen.com.



### Customer Support

**customerserviceUS@repligen.com**
**analytics-support@repligen.com**
(908) 707-1009

### Repligen Corporation

Process Analytics Offices and Manufacturing Facility
685 Route 202/206
Bridgewater, NJ 08807, USA
**www.repligen.com**

## Contents


**1. Introduction ..... 6**
**2. About this document ..... 7**
**3. Safety precautions ..... 8**
**4. System Specifications ..... 9**
4.1 Computer ..... 12
**5. System Configuration and Major Components ..... 13**
5.1 System Parts List ..... 13
5.2 Pump Drive & Integrated Pressure Monitor ..... 13
5.1 Octopus Cables ..... 13
5.2 Mounting Hardware ..... 13
**6. Materials of Construction ..... 14**
**7. Setup and Operation ..... 15**
7.1 Basic Setup ..... 15
7.2 Manual Mode Setup ..... 15
7.3 Concentration Mode (C. Mode) Setup ..... 16
7.4 C/D and C/D/C Mode Setup ..... 16
7.5 C/D/D/C Mode Setup ..... 17
7.6 CFC Mode Setup ..... 17
7.7 CF/D/C Mode Setup ..... 18
7.8 System Setup Using KrosFlo RPM Software Pump Control Window ..... 19
7.9 Alarms and Stops ..... 19
7.10 Tubing Calibration ..... 19
**8. Pump Head Setup and Operation ..... 20**
8.1 Introduction ..... 20
8.2 Tubing Specifications ..... 20
8.3 KR2i Installation and Removal ..... 20
8.4 KR2i Tubing ..... 22
8.5 KR2i Multi-Channel ..... 23
8.6 KR2i Maintenance ..... 24
**9. FlowVPX Instrument Setup ..... 25**
9.1 Installation and Basic Setup ..... 25
9.1.1 Connecting the FlowVPX Head to the FlowVPX Standard Mount ..... 25
9.1.2 Connecting the FlowVPX Instrument to the Cary 60 Spectrophotometer and Computer ..... 28
9.2 Loading and Unloading the Flow Cell ..... 31
9.2.1 Loading the Flow Cell ..... 31
9.2.2 Unloading the Flow Cell ..... 34
9.3 Software/Firmware Operation ..... 35
**10. Auxiliary Component Setup and Operation ..... 36**
10.1 Auxiliary Scales ..... 36
10.1.1 Installation ..... 36
10.2 Auxiliary Pumps ..... 36
10.2.1 Installation ..... 36
10.2.2 Auxiliary Pump Settings ..... 37
10.3 Automatic Backpressure Valve ..... 37
10.3.1 ABV Installation ..... 37
10.3.2 ABV Settings ..... 37
10.4 KONDUiT ..... 38
10.4.1 System Configuration ..... 38
10.4.2 Basic Setup ..... 38
10.4.3 Maintenance ..... 39
**11. Basic Concepts of Tangential Flow Filtration (TFF) ..... 40**

11.1 Introduction ..... 40
11.2 Concentration ..... 40
11.3 Diafiltration ..... 40
**12. Troubleshooting ..... 41**
**13. Replacement and Auxiliary Parts ..... 42**
**14. Index ..... 45**

## List of tables

Table 1. Explanation of user attention phrases ..... 7
Table 2. Safety precautions for KrosFlo KR2i RPM System ..... 8
Table 3. Performance Specifications ..... 9
Table 4. Electrical Input Specifications ..... 10
Table 5. Physical Specifications ..... 10
Table 6. Environmental Specifications ..... 11
Table 7. Compliance Summary ..... 12
Table 8. Computer Specifications: Included Tablet ..... 12
Table 9. Computer Specifications: Minimum Requirements (If Supplied by User) ..... 12
Table 10. System Parts List ..... 13
Table 11. Materials of Construction ..... 14
Table 12. ACR2-H3I-01N Typical Flow, Pressure, and Vacuum Data – 3 roller pumps ..... 20
Table 13. ACR2-H4I-01N Typical Flow, Pressure, and Vacuum Data – 3 roller pumps ..... 20
Table 14. I/O External Cable Pin Assignments ..... 30
Table 15. KR Jr Tubing Specifications ..... 37
Table 16. Troubleshooting ..... 41
Table 17. Replacement and Auxiliary Parts Information ..... 42

## List of figures

Figure 1. Manual Mode setup configuration ..... 15
Figure 2. Concentration Mode (C. Mode) setup configuration ..... 16
Figure 3. C/D and C/D/C Mode setup configuration ..... 16
Figure 4. C/D/D/C Mode setup configuration ..... 17
Figure 5. CFC Mode setup configuration ..... 18
Figure 6. CF/D/C Mode setup configuration ..... 18
Figure 7. Attaching mounting plate to drive ..... 21
Figure 8. Back of KR2i pump head ..... 21
Figure 9. Position for engaging bayonet feature for horizontal mounting ..... 21
Figure 10. Bayonet feature locked in horizontal pump orientation ..... 21
Figure 11. Pump head in fully closed position ..... 22
Figure 12. Pump head in fully open position ..... 22
Figure 13. Tubing path through pump head—during loading ..... 23
Figure 14. Preparation to mount a second pump head ..... 23
Figure 15. Engaging bayonet of second pump head to bayonet tabs on first pump head ..... 23
Figure 16. Drive with both pump heads locked in position first pump head ..... 23
Figure 17. CTech FlowVPX System: Body ..... 25
Figure 18. FlowVPX Head, logo side down ..... 25
Figure 19. Standard Mount Clamp on FlowVPX Head ..... 25
Figure 20. 5 mm Ball End Driver ..... 26
Figure 21. Clamp Handle installation ..... 26
Figure 22. Rotate Clamp Handle ..... 26
Figure 23. Tighten Mounting Post Clamp Handle ..... 26

Figure 24. Install FlowVPX Head on mounting post ..... 27
Figure 25. Lower FlowVPX Head on mounting post ..... 27
Figure 26. Tighten Standard Mount Clamp Handle (Left) and Repositioning the Clamp Handle (Right) ..... 28
Figure 27. Accessory port in back of Cary 60 spectrophotometer ..... 28
Figure 28. Detector Cable in sample compartment ..... 29
Figure 29. Cary 60 power cable and USB cable, back panel ..... 29
Figure 30. Fiber Optic Coupler threaded splice bushing ..... 29
Figure 31. Connect Power and I/O Splitter Cable (EC0208) to FlowVPX Head ..... 30
Figure 32. FlowVPX I/O cable connections ..... 30
Figure 33. USB Cable (EC0207) to FlowVPX Head ..... 31
Figure 34. FlowVPX USB cable (EC0207) to computer ..... 31
Figure 35. VPT OPC Server desktop icon ..... 31
Figure 36. VPT OPC Server ..... 32
Figure 37. Analytics menu within navigation bar ..... 32
Figure 38. Connect VPT device to software ..... 33
Figure 39. VPT Device Serial Number ..... 33
Figure 40. Loading Flow Cell Start button ..... 33
Figure 41. Loading Flow Cell instructions ..... 34
Figure 42. Unload Flow Cell button ..... 34
Figure 43. Unloading Flow Cell Start button ..... 34
Figure 44. Unloading Flow Cell instructions ..... 35
Figure 45. KR Jr Display in Remote Control Mode ..... 36
Figure 46. Automatic Backpressure Valve ..... 37
Figure 47. Back of KONDUiT, Green Power Indicator Light ..... 38
Figure 48. Front and back of KONDUiT ..... 39

## Abbreviations

| | |
|---|---|
| ABV | Automatic Backpressure Valve |
| CF | Concentration factor |
| CFC | Constant feed concentration |
| CV | Column volume |
| HF | Hollow fiber |
| KF | KrosFlo® |
| KR2i | KrosFlo Research 2 integrated |
| PPE | Personal protective equipment |
| RPM | Real-time Process Management |
| TFF | Tangential flow filtration |
| TMP | Transmembrane pressure |
| VPT | Variable Pathlength Technology |

# 1. Introduction

This user guide provides detailed instructions for the set up and operation of the KR2i RPM Tangential Flow Filtration (TFF) System and auxiliary components. Included are descriptions of potential modes of operation and basic concepts of tangential flow filtration. For questions and further information, please contact your Repligen representative.

The KrosFlo® KR2i RPM™ System is the first Tangential Flow Filtration (TFF) bench-scale system with integrated Real-time Process Management (RPM). The System combines the KrosFlo® KR2i TFF System and the CTech™ FlowVPX® In-line spectrophotometer for real-time concentration measurement and control. The KrosFlo® RPM™ software can execute complicated TFF processes through user-specified set points for the system auxiliary pumps, scales, and backpressure valve.

The system is compatible with both hollow fiber (HF) membrane and TangenX flat sheet cassette TFF modules. The HF modules are ideal for sample concentration, fractionation, and washing while avoiding membrane fouling and maximizing product recovery. TangenX cassettes feature an inner screen that increases turbulence and gives high permeate flux, ideal for applications involving viscous proteins, oligosaccharides, and viruses. Both module types are disposable to eliminate the potential for cross-contamination.

This user guide provides guidance for general use of the KrosFlo KR2i RPM System. For further optimization or troubleshooting support, please contact our Customer Service team:

customerserviceUS@repligen.com
analytics-support@repligen.com
(908) 707-1009

## 2. About this document

This manual uses several different phrases. Each phrase should draw the following level of attention:

**Table 1. Explanation of user attention phrases**

| Phrase | Description |
|---|---|
| WARNING! | Warns users that serious physical injury can result if warning precautions are not heeded. |
| PRECAUTION | Cautions users of potential physical injury or equipment damage if the information is not heeded. |
| IMPORTANT | Indicates information necessary for proper instrument operation. |
| ***Note:*** | Points out useful information. |

## 3. Safety precautions

**Table 2. Safety precautions for KrosFlo KR2i RPM System**

| Symbol | Description |
|---|---|
| DANGER  | High voltages exist and are accessible. Use extreme caution when servicing internal components. Remove power from the pump before any cleaning operation is started. |
| WARNING  | Remove power from the pump before attempting any maintenance. |
| WARNINGS  | • Tubing breakage may result in fluid being sprayed from pump. Use appropriate measures to protect operator and equipment.<br>• Turn drive off before removing or installing tubes. Fingers or loose clothing could get caught in drive mechanism. |
| CAUTIONS  | • Power must be turned off before connecting the external remote control cable to prevent damage to the drive.<br>• Do not contaminate the lubricant in the container, on the shaft or on the seal with foreign material. Failure to observe this precaution may result in damage to the seal and premature failure of the seal.<br>• No foreign matter should be allowed under the gasket on the back of the front plate or under the heads of the screws. Failure to observe this precaution may result in leakage during washdown of the drive.<br>• To avoid electrical shock, the power cord protective grounding conductor must be connected to ground. Not for operation in wet locations as defined by EN61010-1. |
| CAUTION  | Keep fingers away from rotor while pump is in operation. Stop pump before loading or unloading tubing. |
| CAUTION  | Caution, indicates a hazard that may result in personal injury or death if proper operating procedures are not followed. Documentation must be consulted in all cases where this symbol is marked. Do not proceed beyond a [Caution] notice until procedures and conditions of operation are met as specified. |
| CAUTION  | Caution, possibility of shock |

## 4. System Specifications

The tables below outline the performance specifications, electrical requirements, physical attributes, environmental considerations, and compliance information of the major system components. Tubing specifications can be found in section 8.2.

**Table 3. Performance Specifications**

| Specification | Value |
|---|---|
| **KR2i TFF System** | |
| Pump Speed Range | 0.1 to 600 rpm |
| Maximum torque load—Starting | 400 oz-in (29 kg-cm) |
| Maximum torque load—Running | Up to 180 oz-in (13 kg-cm) |
| Speed regulation | Line ±0.1% FS<br>Load ±0.1% FS<br>Drift ±0.1% FS |
| Display | 128 x 64 LCD w/ LED Backlight |
| Pressure Sensor Limits | -9.99 to 75 psi |
| **FlowVPX System** | |
| Qualification Slope Range | 0.10 to 46 Au/mm using NIST-Traceable Slope Standards |
| Qualification Slope Repeatability | ±2% |
| Maximum Pathlength | 5.000 mm |
| Minimum Pathlength Step | 0.001 mm |
| Spectroscopic Engine | Agilent Cary 60 Spectrophotometer |
| Spectrophotometer Wavelength Range | 190–1100 nm |
| **KONDUiT Conductivity, Temperature, and UV Monitor** | |
| Conductivity Range | 0.1 to 100 mS/cm |
| Conductivity Accuracy | 0.1 to 2 mS/cm: ± 0.1 mS/cm<br>2 to 50 mS/cm: ±5% of reading<br>50 to 100 mS/cm: ±5% of reading (typical) |
| Temperature Range | 0–70°C |
| Temperature Accuracy | Better than ±0.2°C (typically better than ±0.1°C) |
| UV Sensor Output signal | 4–20 mA sourcing with 400 Ω maximum at 24 VDC; scaled to 0–2 AU with repeatability of 1% of full scale (0.02 AU) |
| UV Sensor Typical Response Time | 1 second |
| UV Sensor Maximum Zero Shift | <2% of full scale (<0.040 AU) |
| UV Sensor Long-term Output Drift | <5% per month of full scale (<0.100 AU) |

**Table 4. Electrical Input Specifications**

| Specification | Value |
|---|---|
| **KR2i TFF System** | |
| Supply voltage limits | 90–260 $V_{RMS}$ @ 50–60 Hz (Universal Input) |
| Current, Maximum | 2.2 A @ 115 $V_{RMS}$, or 1.1 A @ 230 $V_{RMS}$ |
| **FlowVPX System** | |
| Supply voltage limits | 100–230 VAC @ 50–60 Hz |
| Current, Maximum | 0.6 A |
| **Cary 60 Spectrophotometer** | |
| Voltage | 100–240 VAC |
| Input Frequency | 47–63 Hz |
| **KR Jr Auxiliary Pumps** | |
| Voltage | 24 VDC |
| Current, Maximum | 1.3 A |
| **KONDUiT Conductivity, Temperature, and UV Monitor** | |
| Voltage | 24 VDC |
| Current | 0.625 A |

**Table 5. Physical Specifications**

| Specification | Value |
|---|---|
| **KR2i Main Pump** | |
| Dimensions (L × W × H) | 10.5 in × 8 in × 8 in<br>(267 × 203 × 203 mm) |
| Weight | 13 lb. (5.9 kg) |
| **KR2i Pump Heads** | |
| Mounted dimensions (W x H x D) | 8.8 cm x 12.1 cm x 7.8 cm (3.45" x 4.75" x 3.08") |
| Weight | 1.1 lb (0.5 kg) |
| Housing Materials | Glass-filled polypropylene (PP), polyphenylene sulfide (PPS), nylon (PA) |
| Roller Material | Stainless Steel |
| Bearing Material | Sealed Stainless Steel |
| Rotor material | Stainless Steel |
| **FlowVPX Instrument** | |
| Dimensions *(L × W × H)* | 4” x 4¾” x 9”<br>(102 x 121 x 229 mm) |
| Weight | 4.31 kg (with 3 mm Flow Cell)<br>4.22 kg (with 10 mm Flow Cell)<br>5.54 kg (with 22 mm Flow Cell) |

| | |
|---|---|
| Delivery Fiber Optic Cable Length | 3 m (Optional 6 m Fiber Available Upon Request) |
| **Cary 60 Spectrophotometer** | |
| Dimensions | 22" x 19" x 8"<br>(559 x 483 x 203 mm) |
| Weight | 18.14 kg |
| **KONDUiT Conductivity, Temperature, and UV Monitor** | |
| Dimensions *(L × W × H)* | 7 ¾" x 4 ¾" x 4½" |
| Weight | 1.6 kg |
| Housing Materials | Powder-coated Aluminum, Urethane |

**Table 6. Environmental Specifications**

| Specification | Value |
|---|---|
| **KR2i Main Pump** | |
| Enclosure Rating | IP33 |
| Operating Temperature | 0° to 40°C (32° to 104°F) |
| Storage Temperature | –25° to 65°C (–13° to 149°F) |
| Humidity (non-condensing) | 10% to 90% |
| Altitude | Less than 2000 m |
| Pollution Degree | Pollution Degree 2 |
| **KR2i Pump Heads** | |
| Chemical resistance | Most substances, except strong acids or alkalis, organic solvents, or hydrocarbons |
| Operating Temperature ‡ | 0°C to 40°C (32°F to 104°F) |
| Storage Temperature | -45°C to 65°C (-49°F to 149°F) |
| Humidity | 10% to 90% (non-condensing) |
| Altitude | 2000 m or less |
| **FlowVPX System** | |
| Enclosure Rating | IP65 |
| Operating Temperature | 0°C to 48°C (32°F to 118°F) |
| Operating Humidity (non-condensing) | 15% to 80% |
| Storage Temperature | -34°C to 66°C (-29°F to 150°F) |
| Storage Humidity (non-condensing) | 0% to 95% |
| Pollution Degree | Pollution Degree 2 |
| **KONDUiT Conductivity, Temperature, and UV Monitor** | |
| Operating Temperature | 2°C to 50°C (35°F to 122°F) |
| Storage Temperature | -25°C to 65°C (-13°F to 149°F) |
| Pressure | Rated for up to 75 psi (5 bar) |

*‡ Use in this temperature range for continuous duty operation with no decrease in performance or product life. Pump Heads will work outside this range with some possible reductions in performance or product life.*

**Table 7. Compliance Summary**

| Specification | Value |
|---|---|
| **KR2i TFF System** | |
| ETL | UL 61010-1, CAN/CSA C22.2 No. 61010-1 |
| CE | EN61010-1 (EU Low Voltage Directive)<br>EN61326 (EU EMC Directive) |
| RoHS | Directive 2011/65/EU |
| **FlowVPX System (including Agilent Cary 60)** | |
| ETL | UL 61010-1, CAN/CSA C22.2 No. 61010-1 |
| CE | EN61010-1 (EU Low Voltage Directive)<br>EN61326 (EU EMC Directive) |
| RoHS | Directive 2011/65/EU |
| **KONDUiT Conductivity, Temperature, and UV Monitor** | |
| ETL | Conforms to ANSI/UL Std 61010-1<br>Certified to CAN/CSA Std C22.2 No. 61010-1 This product has been tested to the requirements of CAN/CSA-C22.2 No. 61010-1 second edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements. |
| CE | EN61010-1: (EU Low Voltage Directive)<br>EN61326: (EU EMC Directive) |

## 4.1 Computer

A computer tablet is provided to control the KR2i RPM system.

**Table 8. Computer Specifications: Included Tablet**

| Specification | Value |
|---|---|
| Model | Microsoft® Surface Pro® |
| Dimensions | 11.5" x 7.9" x 0.33"<br>(292 x 201 x 8.5 mm) |

**Table 9. Computer Specifications: Minimum Requirements (If Supplied by User)**

| Specification | Value |
|---|---|
| Operating System | Windows® 10 |
| Processor | i7 |
| Hard Drive | 250 GB (SSD Preferred) |
| RAM | 16 GB |

# 5. System Configuration and Major Components

## 5.1 System Parts List

**Table 10. System Parts List**

| Part Description | Quantity |
|---|---|
| **KR2i TFF System** | |
| KrosFlo® Research 2*i* Pump Drive w/ Integrated Pressure Monitor | 1 |
| Microsoft® Surface Pro® with Installed KrosFlo RPM™ Software Suite | 1 |
| Auxiliary Component Octopus Cable | 1 |
| Pressure Transducer Cable | 1 |
| Power Supply Cable | 1 |
| KrosFlo® Research II Easy-Load Pump Head | 1 |
| KrosFlo 20 kg Scales | 2 |
| KR Jr Pump Head with Cables | 2 |
| KONDUiT | 1 |
| Magnetic Stirrer | 1 |
| **FlowVPX System** | |
| FlowVPX Instrument Essentials Kit | 1 |
| FlowVPX Accessory Kit | 1 |
| FlowVPX Head Assembly | 1 |
| FlowVPX Detector Module | 1 |
| Agilent Cary 60 Spectrophotometer | 1 |
| Flow Cell (Choice of 3 mm or 10 mm Flow Path Diameter) | 2 |

**For replacement part numbers, please see Section 13.**

## 5.2 Pump Drive & Integrated Pressure Monitor

The KR2i TFF system comes with the Digital Pressure Monitor integrated into the Pump Drive as one unit. The internal microprocessor runs both the Pump and Pressure monitor functions.

## 5.1 Octopus Cables

The KR2i TFF system comes with two Octopus Cables: one for the Auxiliary Components, and one for the Pressure Transducers. On the back of the TFF system are two Interface ports for the Octopus Cables.

## 5.2 Mounting Hardware

The KR2i TFF system comes with an attached mounting plate for the Easy-Load Pump Head.

## 6. Materials of Construction

**Table 11. Materials of Construction**

| Contact Surface Material | |
|---|---|
| **KR2i TFF System Process Contact Surfaces** | |
| Tubing / Reservoir Closures | C-Flex® / Pharmapure® |
| Reservoirs | Polypropylene |
| Disposable Pressure Transducers | Polysulfone |
| Plastic Fittings | Polypropylene / Polysulfone |
| **FlowVPX System Process Contact Surfaces** | |
| Flow Path | 316L Stainless Steel |
| Diaphragm Seal | EPDM |
| Detector Window | UV-Grade Fused Silica |
| Adhesive | Medical-Grade Epoxy |
| Single-Use Flow Cell | Polycarbonate, USP Class VI, animal-derived component free (ADCF) |
| | Platinum-cured silicone, USP Class VI, ADCF |
| Cary 60 | N/A |
| **KR2i TFF System Non-Process Contact Surfaces** | |
| KR2i System | 316 Stainless Steel |
| | Hard Coat Anodized Aluminum |
| | Polysulfone |
| | Polypropylene |
| | Polyphenylene Sulfide |
| | Polyester |
| | Nylon |
| **FlowVPX System Non-Process Contact Surfaces** | |
| FlowVPX System | 316/316L Stainless Steel |
| | Stainless Steel Fiber Optic Connector |
| | Polyetheretherketone (PEEK) |
| | Polyphenylsulfone (PPSU) |
| | Medical-Grade Epoxy |
| | Gold-Plated Electrical Contacts |
| Single-Use Flow Cell | Glass-filled nylon |
| | Viton sealant |
| | Torlon PAI |
| | Hydrophobic polyethersulfone with PTFE, USP Class VI |
| Cary 60 | Refer to Agilent documentation for more information. |

# 7. Setup and Operation

## 7.1 Basic Setup

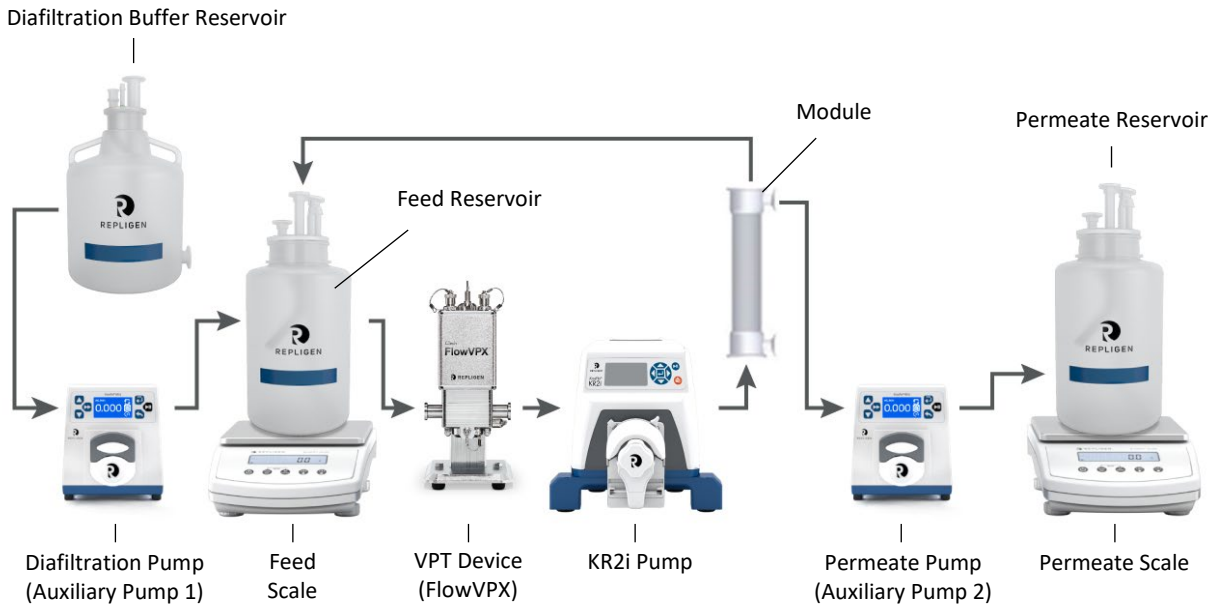
***Note:*** *See Sections 7.2 through 7.7 for Sample Applications.*

1. Mount the TFF system on a flat, horizontal surface with no more than two Pump Heads attached (see section 8.3 for Pump Head Setup details).
2. Connect both Octopus Cables to the back of the TFF system.
3. Connect up to three pressure transducers to the Pressure Transducer Octopus Cable ports, depending on the application.
4. Connect an Automatic Backpressure Valves (ABV's) to the Auxiliary Component Octopus Cable "Valve" (see section 10.3 for ABV Setup details).
5. Connect the FlowVPX to process tubing in between the feed reservoir and the KR2i pump. (See Section 9 FlowVPX setup details.)
6. Connect power cable to the TFF system.
7. Follow guidelines and diagrams in sections 7.2 through 7.7 to determine which Auxiliary Components are required to operate specific Process Modes for manual, semi-automated, and automated processes.
8. If using Auxiliary Pump, configure Auxiliary Pump before starting application (see section 10.2 for Auxiliary Pump Setup details).
9. After connecting Auxiliary Components, power on the TFF system first before powering on Auxiliary Components.
10. Connect TFF flow path to TFF system.
11. Set low- and high-pressure alarms and interlocks as required by the process conditions.
12. Input Concentration Factor/Diafiltration Volume (CF/DV) set-points into the TFF system's Process Mode settings to start application.

***Note:*** *Valves, cables, and the computer are intentionally left out of the diagrams below for visual clarity.*

## 7.2 Manual Mode Setup

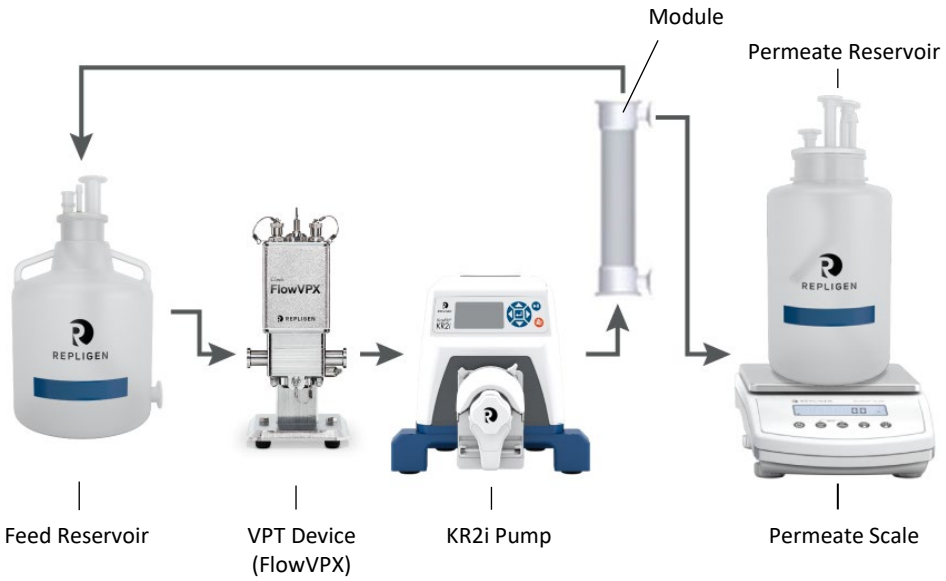
**Figure 1. Manual Mode setup configuration**



1. Any combination of Auxiliary Components is possible in Manual Mode—the only required component is the TFF system pump itself. Diagram above is a full setup with all Auxiliary Components.
2. Auxiliary Scales
    a. Connect up to two scales to the Auxiliary Component Cable's "Feed Scale" and/or "Permeate Scale" ports.

## 7.3 Concentration Mode (C. Mode) Setup

**Figure 2. Concentration Mode (C. Mode) setup configuration.**

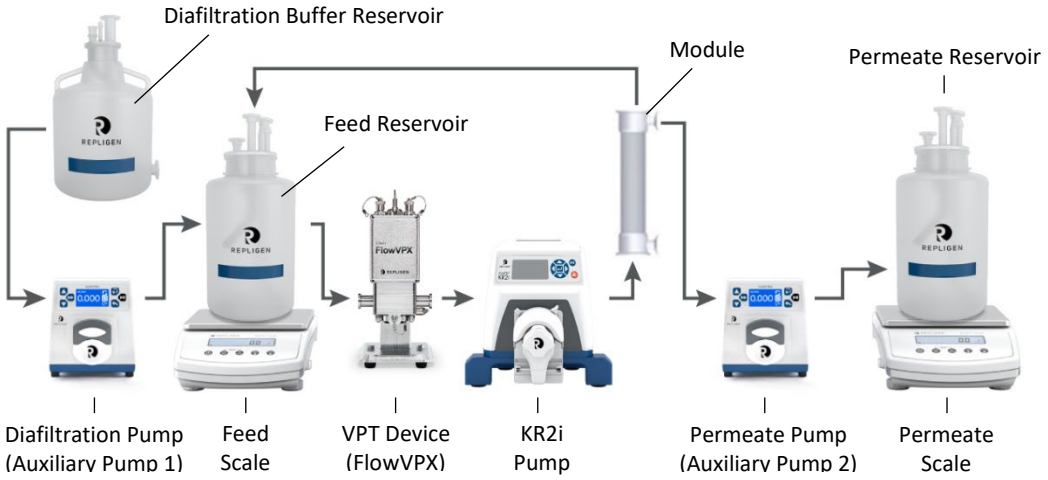



1. Auxiliary Scales
    a. Connect scale to the Auxiliary Component Cable's "Permeate Scale".

## 7.4 C/D and C/D/C Mode Setup

***Note:*** *Permeate Pump is optional and shown in the diagram as an example for applications that require permeate control.*

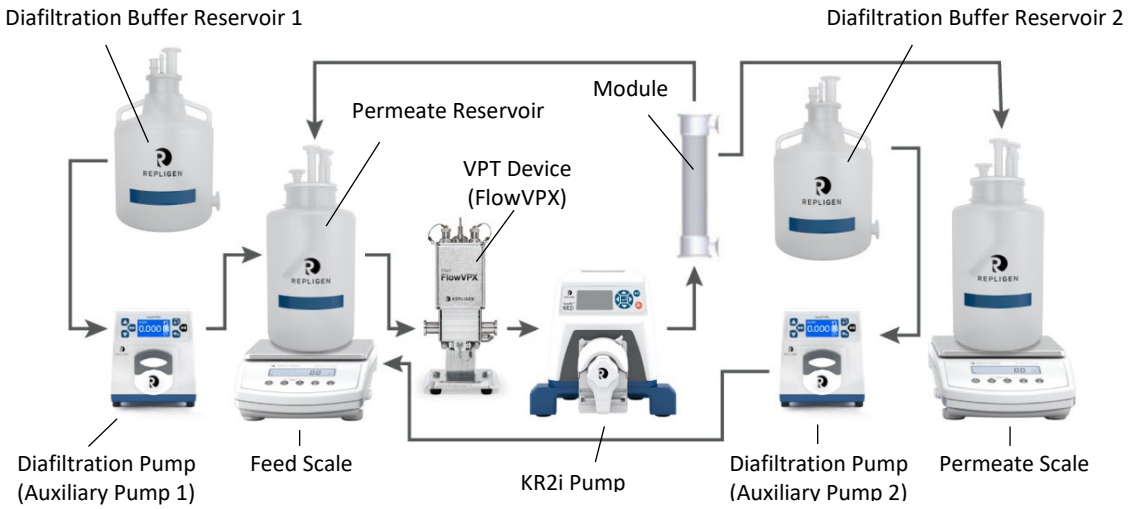
**Figure 3. C/D and C/D/C Mode setup configuration**



1. Auxiliary Pumps
    a. Connect auxiliary pump to the Auxiliary Component Cable's "Auxiliary Pump 1" port and second auxiliary pump to the Auxiliary Component Cable's "Auxiliary Pump 2" port.
    b. Connect Auxiliary pump power cables(s).
2. Auxiliary Scales
    a. Connect first scale to the Auxiliary Component Cable's "Feed Scale" port and second scale to the Auxiliary Component Cable's "Permeate Scale" port.

## 7.5 C/D/D/C Mode Setup

**Figure 4. C/D/D/C Mode setup configuration**

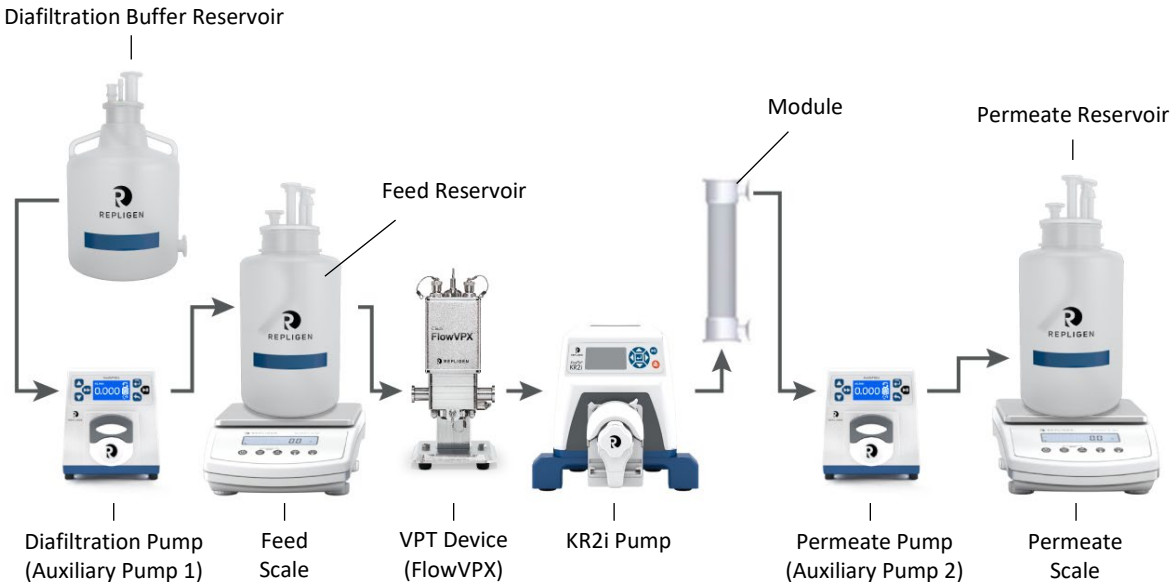



1. Auxiliary Pumps
    a. Connect first auxiliary pump to the Auxiliary Component Cable's "Auxiliary Pump 1" port and second auxiliary pump to the Auxiliary Component Cable's "Auxiliary Pump 2" port.
    b. Connect auxiliary power cables.
    c. Auxiliary Pump 1 will function as Diafiltration Pump 1, and the Auxiliary Pump 2 will function as Diafiltration Pump 2.
2. Auxiliary Scales
    a. Connect first scale to the Auxiliary Component Cable's "Feed Scale" port and second scale to the Auxiliary Component Cable's "Permeate Scale" port.

## 7.6 CFC Mode Setup

***Note:*** *Permeate Pump is optional and shown in the diagram as an example for applications that require permeate control.*

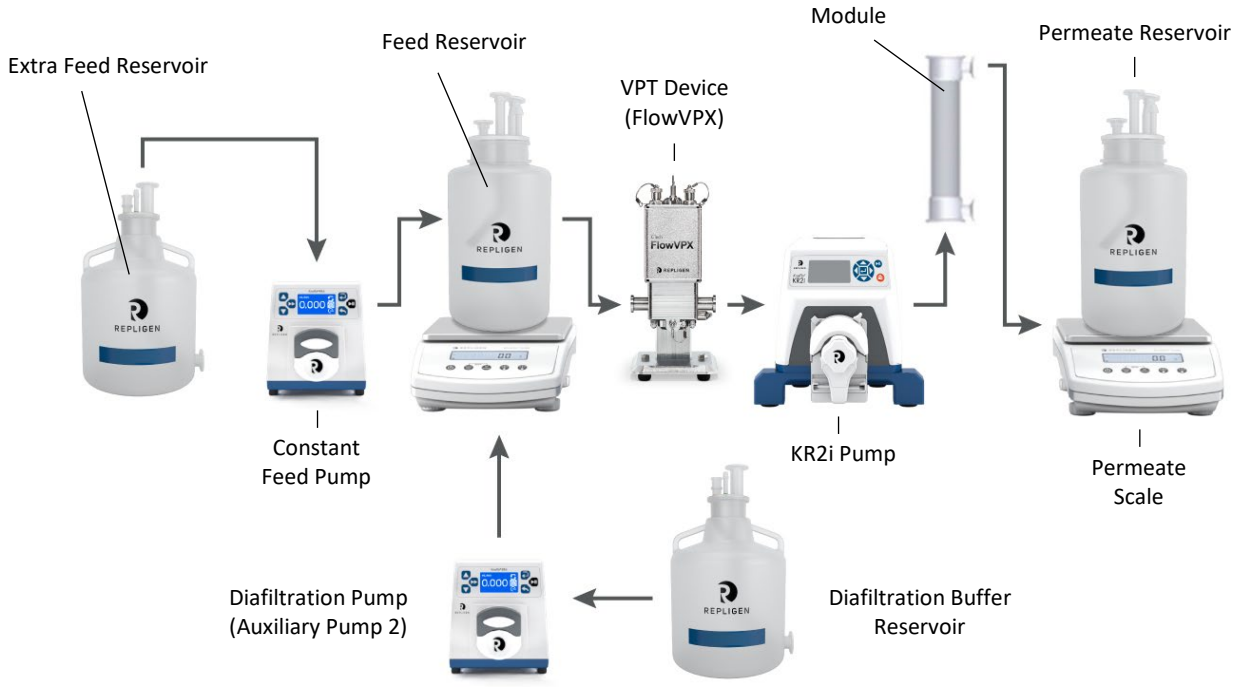
**Figure 5. CFC Mode setup configuration**




1. Auxiliary Scales
    a. Connect first scale to the Auxiliary Component Cable's "Feed Scale" port and second scale to the Auxiliary Component Cable's "Permeate Scale" port.

## 7.7 CF/D/C Mode Setup

**Figure 6. CF/D/C Mode setup configuration**



### 7.8 System Setup Using KrosFlo RPM Software Pump Control Window

The Pump Control Interface can be used to interact with all the features of the system. This screen will appear when the KrosFlo RPM software is opened. When needed, the functions and setpoints are accessible on the main pump display.

### 7.9 Alarms and Stops

The TFF system has a number of safety pressure alarms and stops that may be set in the Alarm Settings menu.

- **Pf Hi Stop**: When Feed Pressure (Pf) value ≥ Pf Hi Stop value, the pump drive will stop running.
- **Pf Hi Alarm:** When Pf value ≥ Pf Hi Alarm value, the pump drive will alarm but continue running.
- **Pf Lo Stop**: When Pf value ≤ Pf Lo Alarm value, the pump drive will stop running.
- **Pf Lo Alarm**: When Pf value ≤ Pf Lo Alarm value, the pump drive will alarm but continue running.
  ***Note:*** *For the Pf Lo Stop and Lo Alarm the feed pressure must first rise above the alarm level to be activated.*
- **Pp Lo Alarm:** When Permeate Pressure (Pp) value ≤ Pp Lo Alarm value, the pump drive will alarm but continue running.
- **Pp Lo Stop**: When Pp value ≤ Pp Lo Stop value, the pump drive will stop running.
- **UV Hi Stop:** When AU value of UV1 is ≥ UV Hi Stop value the system will shut down.
- **UV Hi Alarm:** When AU value of UV1 is ≥ UV Hi Alarm value the pump drive will alarm but continue running.
- **Perm Hi Alarm:** When permeate scale reading is ≥ Perm Hi Alarm value the system will alarm but continue running.
- **Perm Hi Stop:** When permeate scale reading is ≥ Perm Hi Stop value the system will shut down.
- **Feed Hi Alarm:** When feed scale reading is ≥ Feed Hi Alarm value the system will alarm but continue running.
- **Feed Hi Stop:** When feed scale reading is ≥ Feed Hi Stop value the system will shut down.
- **Feed Lo Alarm:** When feed scale reading is ≤ Feed Lo Alarm value the system will alarm but continue running.
- **Feed Lo Stop:** When feed scale reading is ≤ Feed Lo Stop value the system will shut down.
- **Silent Alarm:** Set to “On” to silence alarms, set to “Off” to play alarm sound.

1. To enable an alarm, highlight the alarm value and click Enter.
2. Use the directional keys to set the desired alarm value, then click Enter to save the setting.
3. To disable an alarm, change the value to 0 and TFF system will read the alarm as “OFF”.

### 7.10 Tubing Calibration

***Note****: Condition tubing by running at ½ of maximum flow rate of tubing being calibrated for at least 10-15 minutes before conducting tubing calibration. Tubing calibration cannot be done when pump is in RPM mode.*

1. Select tubing size in Calibration menu.
2. Press CAL, the system set calibration volume will appear.
3. Press START / STOP—the pump will use its stored memory to dispense the specified calibration sample quantity. The pump will stop automatically.
4. Weigh/measure the sample.
5. Use directional keys to correct the volume on the flashing display.
6. Press the Enter key to save the calibration setting. Once calibrated, a lower case "c" appears next to the tubing (e.g., 73c).
7. To confirm tubing calibration, press CHECK to dispense calibration volume using calibrated tubing and weigh dispensed volume.

***Note:*** *If the adjusted calibration is high, "Err" will appear in the display. If this occurs, press the CAL control and repeat the calibration procedure. The microprocessor will retain one special calibration value per tubing size, even when power is turned off. The next calibration will replace the existing value.*

# 8. Pump Head Setup and Operation

## 8.1 Introduction

The Easy-Load and High-Performance Pump Heads are designed to be used with the TFF systems as a simple peristaltic pump system. The Pump Heads accept different tubing sizes for a wide range of flow rates, and the unique designs and automatic tubing retention allow for quick tubing changes.

## 8.2 Tubing Specifications

**Table 12. ACR2-H3I-01N Typical Flow, Pressure, and Vacuum Data – 3 roller pumps**

| MasterFlex® L/S® Tubing | Flow Rate* | | Discharge Pressure* | | Vacuum* @ 600 rpm in (mm) Hg | Suction Lift* @ 600 rpm ft (m) $H_2O$ |
|---|---|---|---|---|---|---|
| | @ 1 rpm mL/rev | @ 600 rpm mL/min | Continuous psig (bar) | Intermittent psig (bar) | | |
| L/S® 13 | 0.06 | 36 | 25 (1.7) | 40 (2.7) | 26 (660) | 29 (8.8) |
| L/S® 14 | 0.22 | 130 | 25 (1.7) | 40 (2.7) | 26 (660) | 29 (8.8) |
| L/S® 16 | 0.8 | 480 | 25 (1.7) | 40 (2.7) | 26 (660) | 29 (8.8) |
| L/S® 25 | 1.7 | 1000 | 20 (1.4) | 35 (2.4) | 26 (660) | 29 (8.8) |
| L/S® 17 | 2.8 | 1700 | 15 (1.0) | 20 (1.4) | 20 (510) | 22 (6.7) |
| L/S® 18 | 3.8 | 2300 | 10 (0.7) | 15 (1.0) | 20 (510) | 22 (6.7) |

**Table 13. ACR2-H4I-01N Typical Flow, Pressure, and Vacuum Data – 3 roller pumps**

| MasterFlex® L/S® Tubing | Flow Rate* | | Discharge Pressure* | | Vacuum* @ 600 rpm in (mm) Hg | Suction lift* @ 600 rpm ft (m) H20 |
|---|---|---|---|---|---|---|
| | @ 1 rpm mL/rev | @ 600 rpm mL/min | Continuous psig (bar) | Intermittent psig (bar) | | |
| L/S® 15 | 1.7 | 1000 | 25 (1.7) | 30 (2.7) | 26 (660) | 29 (8.8) |
| L/S® 24 | 2.8 | 1700 | 25 (1.7) | 30 (2.7) | 26 (660) | 29 (8.8) |
| L/S® 35 | 3.8 | 2300 | 20 (1.4) | 25 (2.4) | 26 (660) | 29(8.8) |
| L/S® 36 | 4.8 | 2900 | 15 (1.0) | 20 (1.4) | 24 (610) | 27 (8.3) |

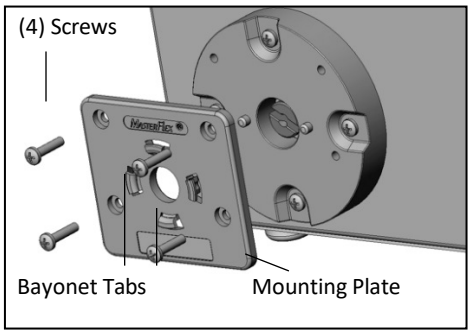
**Specifications are valid for NORPRENE®, PHARMED®, and TYGON® tubing. Values will be less with silicone, C-FLEX®, and Viton®. Flow rate and discharge pressure will vary based on tubing size, formulation, and operating temperature. The tables above are only a guide.*

## 8.3 KR2i Installation and Removal

***WARNING:*** *Stop the pump drive before installing or removing the pump head from the drive.*

1. If mounting plate is not attached to the pump drive, attach it using the provided four Phillips head screws (see Figure 7).

**Figure 7. Attaching mounting plate to drive**




2. Orient the pump head with its back facing the drive and insert the tang on the pump head shaft into the shaft's slot on the drive. Align the bayonet features on the back of the pump head with the bayonet tabs on the front of the mounting plate (see Figures Figure 8–Figure 10).
    - The pump head should be tilted about 30° counterclockwise from the intended installed orientation.
    - Press pump head firmly against the drive and rotate clockwise until no more rotation is possible (see Figure 10). The bayonet lock lever will automatically snap toward the back of the pump, locking it to the mounting plate.

**Figure 8. Back of KR2i pump head**

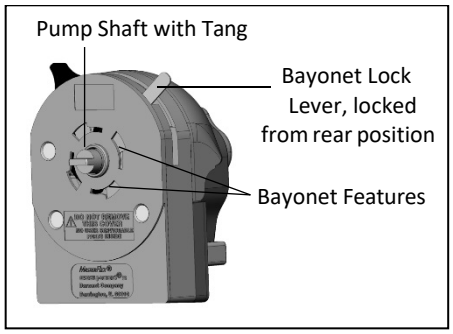



**Figure 9. Position for engaging bayonet feature for horizontal mounting**

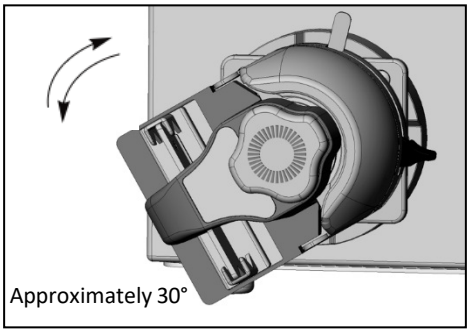
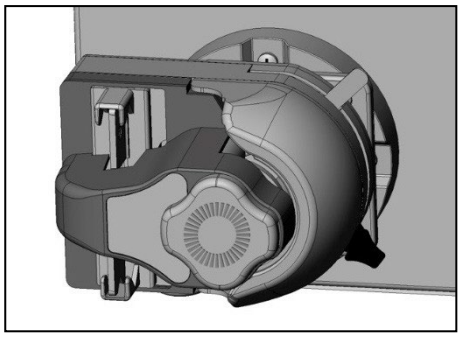
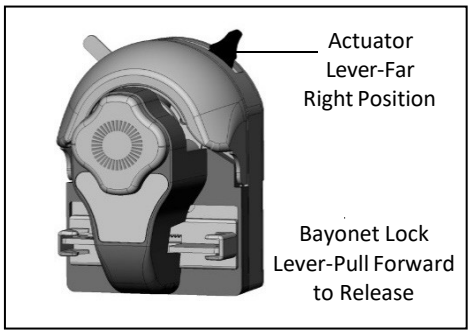



**Figure 10. Bayonet feature locked in horizontal pump orientation**



3. Remove the pump head from the drive by holding the bayonet lock lever forward while rotating the pump head as far as possible in the counterclockwise direction, then pull the pump head away from the drive to detach it. The actuator lever should be in the far right position when removing the pump head (see Figure 11).

**Figure 11. Pump head in fully closed position**



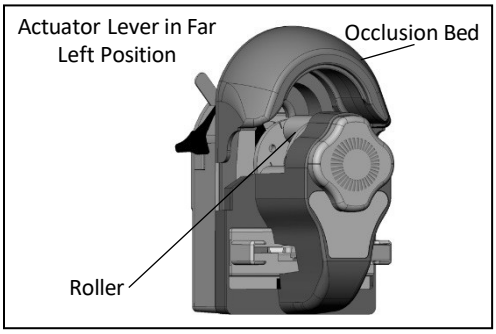

## 8.4 KR2i Tubing

***WARNING:*** *Stop the pump drive before installing or removing tubing from the pump head.*

1. To load tubing, open the pump head by moving the actuator lever counterclockwise (see Figure 11 and Figure 12). Insert a loop of tubing into one open tubing retainer, between the occlusion bed and the rollers and into the other tubing retainer (see Figure 13). Position the tubing so that it is firmly centered against the rollers. While holding the tubing ends, move the actuator lever back to the far clockwise (right) position, as shown in Figure 11. The pump head will automatically grip the tubing. Approximately 5 pounds of force must be applied to the actuator lever to fully close the pump head and place the lever in its locked position (far right position) or to fully open the pump head (far left position).

   ***Note:*** *It is unnecessary to have an end of the tubing free to load or unload tubing from the pump head. A length of tubing may be loaded into the pump without disconnecting it from adjacent devices.*

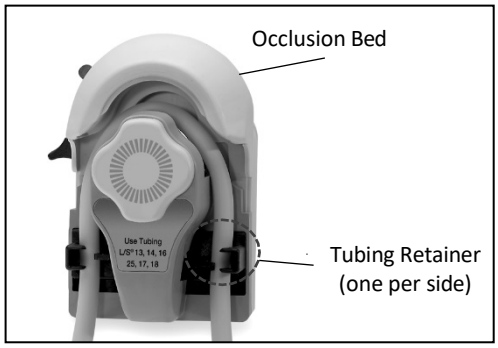
**Figure 12. Pump head in fully open position**




2. Before unloading tubing from the pump head, first turn off the drive. Open the pump head by moving the actuator lever counterclockwise (left), as described above. This will automatically open the tubing retainers, as well as lift the occlusion bed away from the tubing. Pull the tubing away from the pump head.

   ***Note:*** *When pump is not being used, store with actuator lever halfway between far left and far right positions (see Figure 11 and Figure 12).*

**Figure 13. Tubing path through pump head—during loading**




## 8.5 KR2i Multi-Channel

The KrosFlo® Research II Pump Heads can be mounted in tandem. Once the mounting plate is attached to the pump drive, no other mounting hardware is required.

1. Install the first pump head according to the mounting instructions above.
2. To install a second pump head, the cosmetic cover must be removed from the first pump head. Grasp the cover by the notches and pull it off (see Figure 14).
3. Align the second pump head to the first, as if the first pump head were the drive, and continue to follow pump head mounting instructions (see Figure 15 and Figure 16).

***Note:*** *The tubing on the inner pump head(s) can be changed without removing the outer pump head(s) from the drive.*

**Figure 14. Preparation to mount a second pump head**

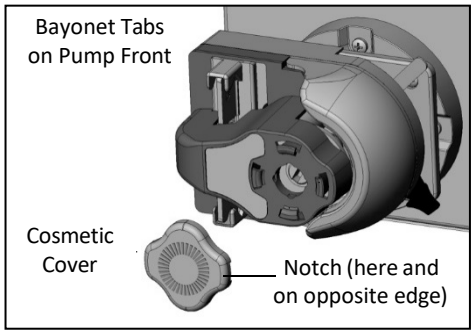



**Figure 15. Engaging bayonet of second pump head to bayonet tabs on first pump head**

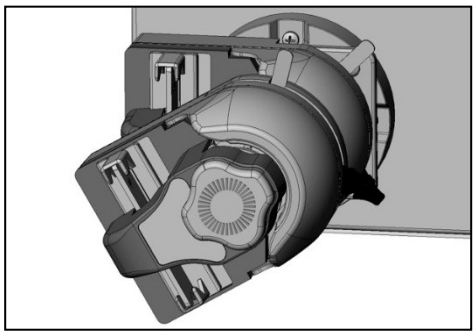
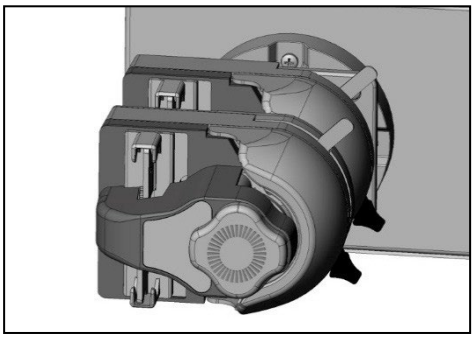


**Figure 16. Drive with both pump heads locked in position first pump head**



***CAUTION:*** *Be sure that the bayonet features on back of each pump head are fully engaged with bayonet tabs on the mounting plate or adjacent pump head before operating pump drive. The bayonet lock lever (see Figure 11) will snap back when bayonet features engage completely.*

### 8.6 KR2i Maintenance

No lubrication is required for the KrosFlo® Research II Pump Head. Only use a mild detergent solution or 70% isopropyl alcohol to clean the pump head. Do not immerse nor use excessive fluid. The pump head requires no maintenance beyond cleaning. There are no user serviceable or replaceable parts inside.

# 9. FlowVPX Instrument Setup

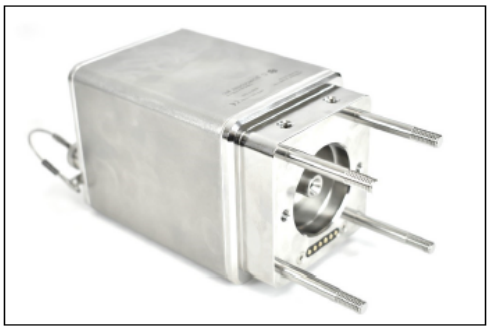
**Figure 17. CTech FlowVPX System: Body**


## 9.1 Installation and Basic Setup

### 9.1.1 Connecting the FlowVPX Head to the FlowVPX Standard Mount

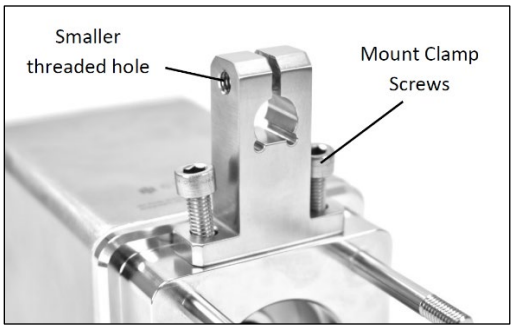
1. Turn the FlowVPX Head on its face (logo side down) so that the two mounting holes are facing up (see Figure 18).

**Figure 18. FlowVPX Head, logo side down**



2. Place the Standard Mount Clamp on the FlowVPX Head and align the holes. Ensure that the smaller threaded hole is facing left (Figure 19).

**Figure 19. Standard Mount Clamp on FlowVPX Head**



3. Insert the mount clamp screws. Tighten with the provided 5 mm ball end driver (Figure 20).

**Figure 20. 5 mm Ball End Driver**


4. Install the Clamp Handle from the right side of the Standard Mount Clamp (Figure 21).

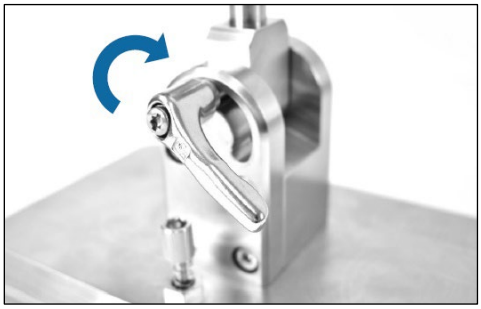
**Figure 21. Clamp Handle installation**


5. Turn until the threaded post on the Clamp Handle starts to appear at the other end (see Figure 22). Do not fully tighten.

**Figure 22. Rotate Clamp Handle**

6. Ensure the mounting post on the Standard Mount is fully vertical. Tighten the Mounting Post Clamp Handle, if not already tightened (Figure 23).

**Figure 23. Tighten Mounting Post Clamp Handle**

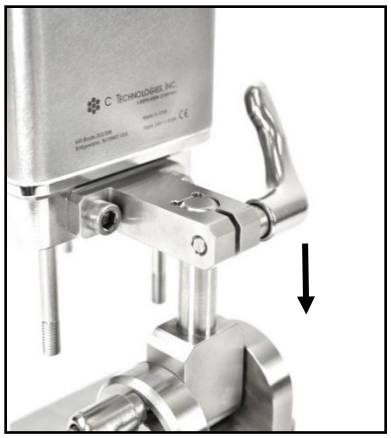


7. Pick up the FlowVPX Head and align the hole in the clamp with the mounting post. Ensure the flattened location on the post aligns with the flattened area on the clamp (Figure 24).

**Figure 24. Install FlowVPX Head on mounting post**

8. Carefully lower the FlowVPX® Head so that the clamp slides over the post on the mounting plate (Figure 25).

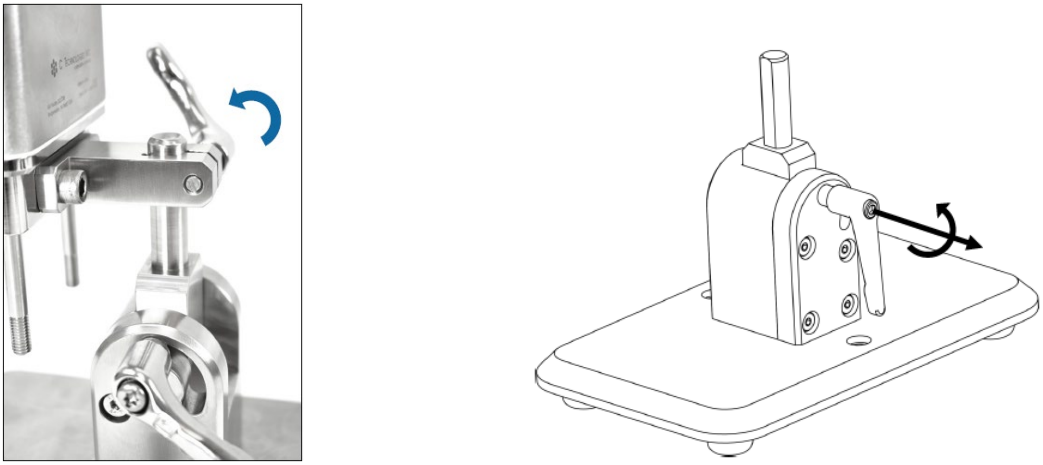
**Figure 25. Lower FlowVPX Head on mounting post**



9. Turn and tighten the Standard Mount Clamp Handle to secure the FlowVPX® Head onto the mounting post (Figure 26).

***Note:*** *The clamp handles can change orientation by pulling out and rotating. This allows them to be repositioned without obstruction.*

**Figure 26. Tighten Standard Mount Clamp Handle (Left) and Repositioning the Clamp Handle (Right)**



***Note:*** *The clamp handles can change orientation by pulling out and rotating. This allows them to be repositioned without obstruction.*

### 9.1.2 Connecting the FlowVPX Instrument to the Cary 60 Spectrophotometer and Computer

1. Pass the Detector Cable (EC0196) and the Delivery Fiber (SMA/hex-nut end) through the open accessory port at the back of the Cary 60 spectrophotometer into the sample compartment (see Figure 27).

**Figure 27. Accessory port in back of Cary 60 spectrophotometer**

2. Connect the black, right-angle plug of the Detector Cable into the wall of the Cary 60 sample compartment (see Figure 28).

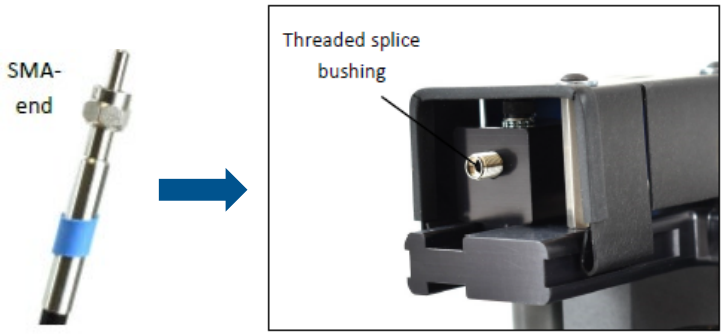
**Figure 28. Detector Cable in sample compartment**

3. Connect the Cary 60 power cable (supplied with the Cary 60) to the back of the Cary 60. Then connect the plug to an approved outlet (see Figure 29).
4. Connect the Cary 60 USB cable, (supplied with the Cary 60) to the back panel of the Cary 60. Connect the other end to a USB port on the computer (see Figure 29).

**Figure 29. Cary 60 power cable and USB cable, back panel**

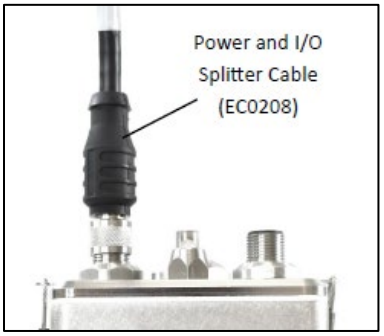

5. Connect the SMA end of the Delivery Fiber to the threaded splice bushing at the back of the Fiber Optic Coupler. Use the hex nut to securely tighten the connection.

**Figure 30. Fiber Optic Coupler threaded splice bushing**



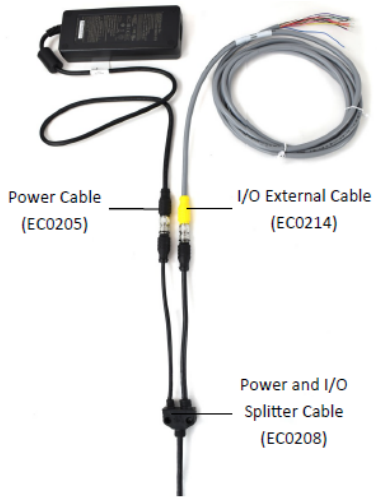
6. Connect the FlowVPX Power and I/O Splitter Cable (EC0208) to the top of the FlowVPX Head (see Figure 31). Connect the FlowVPX Power Cable (EC0205) to one leg of the Power and I/O Splitter Cable (see Figure 32). The FlowVPX Power Extender Cable (EC0205) may be installed between EC0205 and EC0208 as needed.

**Figure 31. Connect Power and I/O Splitter Cable (EC0208) to FlowVPX Head**




7. To utilize the FlowVPX I/O connections, connect the I/O External Cable (EC0214) to the Power and I/O Splitter Cable (see Figure 32).

**Figure 32. FlowVPX I/O cable connections**




***WARNING:*** *Explosion hazard for hazardous locations. Do not connect or disconnect any cabling while energized.*

8. If applicable, connect the I/O External Cable (EC0208) to the DAQ device.

**Table 14. I/O External Cable Pin Assignments**

| Pin No. | Wire Color | Function | Pin No. | Wire Color | Function |
|---|---|---|---|---|---|
| 1 | White | NC*/+24 VDC | 7 | Blue | Digital Out 0 |
| 2 | Brown | NC*/0 VDC** | 8 | Red | Digital Out 1 |
| 3 | Green | DIO Common | 9 | Orange | Digital Out 2 |
| 4 | Yellow | Digital In 0 | 10 | Tan | Analog Ground |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Gray | Digital In 1 | 11 | Black | Analog Out 1 |
| 6 | Pink | Digital In 2 | 12 | Violet | Analog Out 2 |
| | | | - | Bare | Ground |

**With Power Supply (EC0205) and Power/IO Splitter (EC0208).*
***User provided power (24 VDC, 120 W), direct connection to the FlowVPX Head.*

***Note:*** *If providing a 24 VDC power source, connect the I/O External Cable (EC0214) directly to the Power and I/O labeled connector on the top of the FlowVPX® Head.*

**Figure 33. USB Cable (EC0207) to FlowVPX Head**


9. Connect the USB cable (EC0207) to the USB communications connector on top of the FlowVPX® Head (see Figure 33).
10. Connect the FlowVPX USB cable (EC0207) to a USB port on the computer (Figure 34). Make sure the computer is turned on.

**Figure 34. FlowVPX USB cable (EC0207) to computer**

11. Plug the FlowVPX country-specific power cable into an approved outlet.

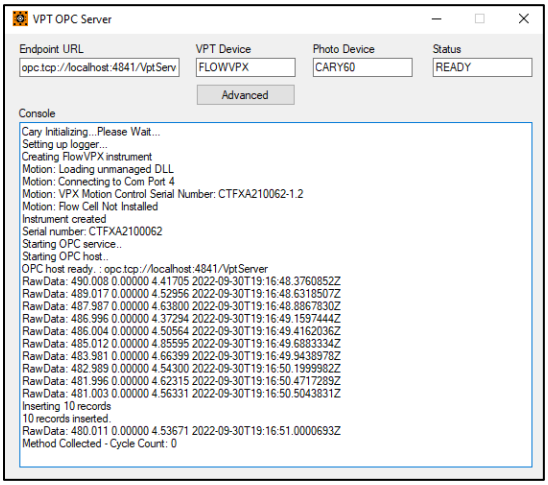
## 9.2 Loading and Unloading the Flow Cell

### 9.2.1 Loading the Flow Cell

1. Open VPT OPC Server and allow the program to run diagnostics.

**Figure 35. VPT OPC Server desktop icon**

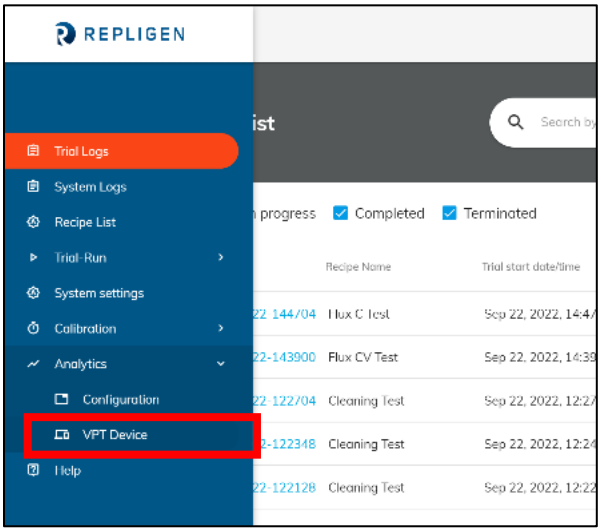
**Figure 36. VPT OPC Server**




2. Once diagnostics have been completed, open KrosFlo RPM Software and login using proper credentials.

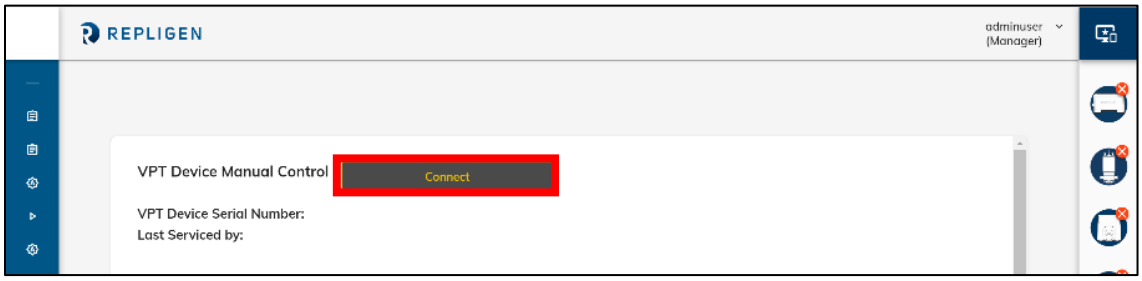
3. Navigate to the blue-ribbon menu and open the Analytics tab. Click VPT Device.

**Figure 37. Analytics menu within navigation bar**




4. Click Connect to establish communication between KrosFlo RPM and the VPT Device.

**Figure 38. Connect VPT device to software**

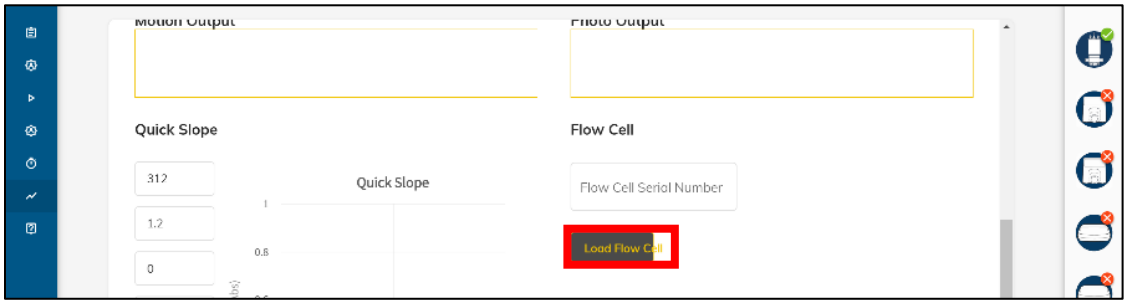



5. After clicking Connect, ensure that the serial number from the VPT device matches the serial number found by KrosFlo RPM Software (VPT Device Serial Number).

**Figure 39. VPT Device Serial Number**

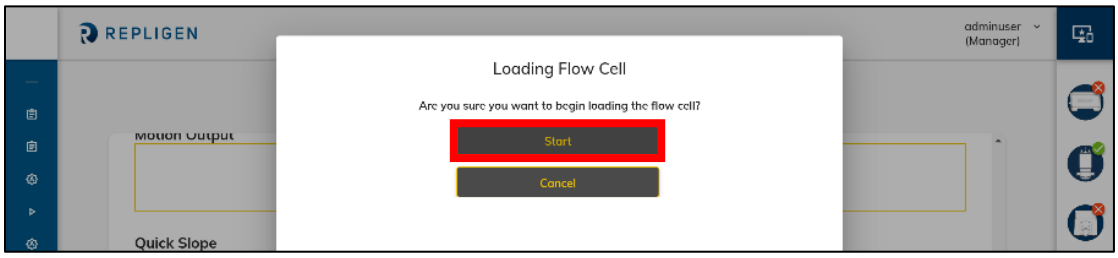

6. Scroll to Flow Cell and click Load Flow Cell.

**Figure 41. Load Flow Cell button**



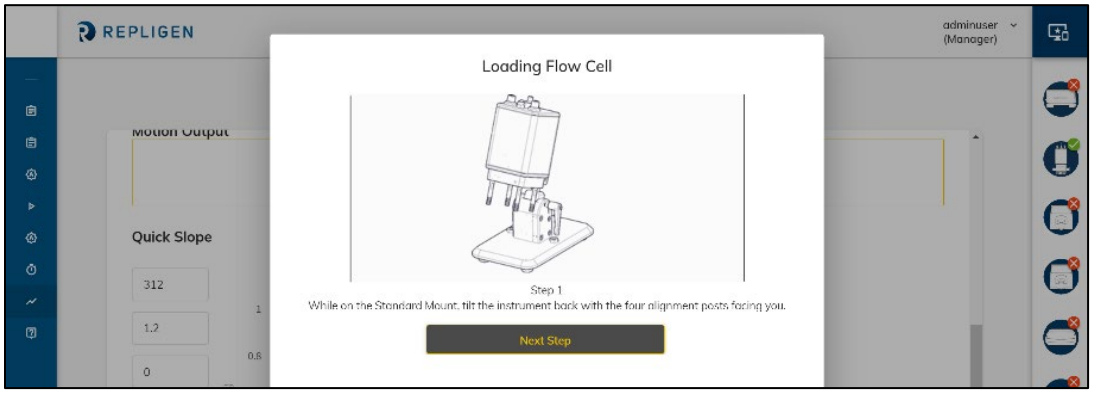

7. Click Start when the Loading Flow Cell pop-up window appears.

**Figure 40. Loading Flow Cell Start button**




8. Follow the onscreen instructions and animations to load a flow cell.

**Figure 41. Loading Flow Cell instructions**

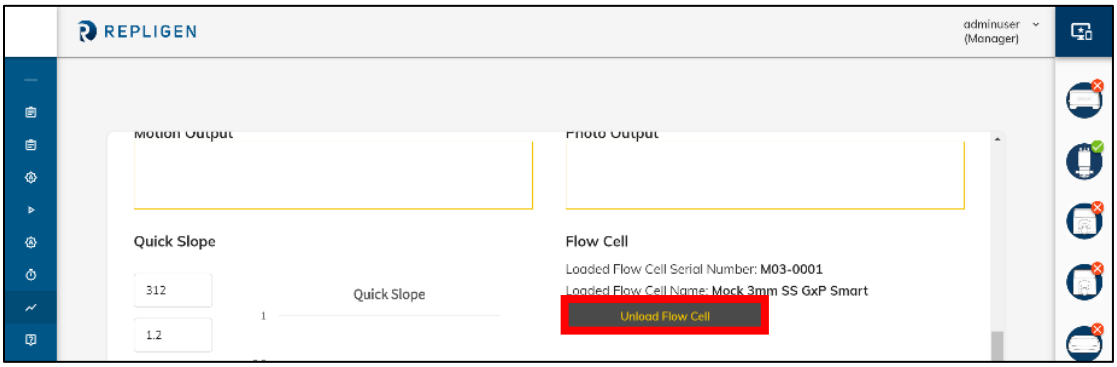



9. Upon completing the loading of the flow cell, the pop-up window will automatically close and return to the previous VPT Device menu. The serial number and flow cell name will automatically populate under the Loaded Flow Cell Serial Number and Loaded Flow Cell Name fields, respectively. A new option to Unload Flow Cell will also appear.

### 9.2.2 Unloading the Flow Cell

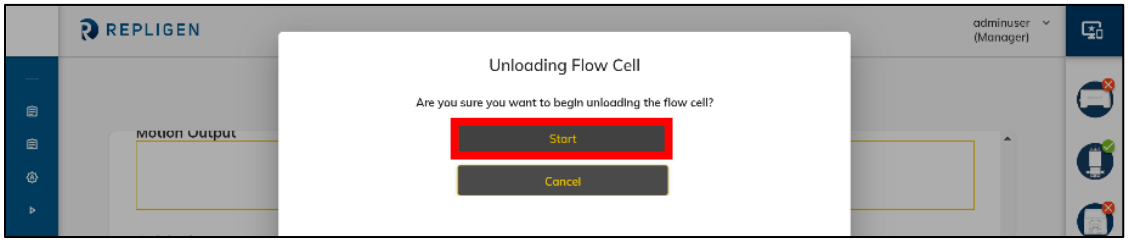
1. To unload the flow cell, click “Unload Flow Cell” from the VPT Device Menu.

**Figure 42. Unload Flow Cell button**



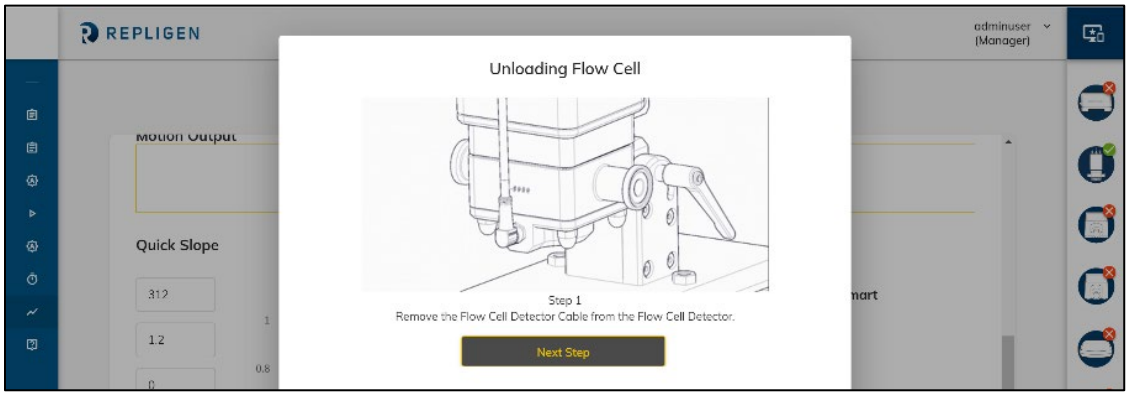

2. Click Start when the Unloading Flow Cell pop-up appears.

**Figure 43. Unloading Flow Cell Start button**




3. Follow the onscreen instructions and animations to unload a flow cell.

**Figure 44. Unloading Flow Cell instructions**




4. Upon completion of unloading the flow cell, the pop-up window will automatically close and return to the previous VPT Device menu. The serial number and flow cell name will be removed automatically.

## 9.3 Software/Firmware Operation

VPT Devices operate through TFF System firmware and software; please contact Repligen Customer Service to ensure latest firmware and software combination has been loaded on TFF System and PC prior to operation.

# 10. Auxiliary Component Setup and Operation

## 10.1 Auxiliary Scales

The TFF systems interface with digital Ultra Precision Surface Acoustic Wave (SAW) auxiliary scales. These SAW scales are dynamic instruments suitable for various TFF processes. For detailed information on the SAW scales, refer to the manufacturer's manual provided with the scale.

### 10.1.1 Installation

1. Carefully unpack scale from shipping carton.
2. Place scale on a level surface and adjust the level legs so that all four legs are touching the surface and leveling bubble is within the circle.
3. Connect the serial connector on the KR2i octopus cable to either the Feed Scale or Permeate Scale.
4. In most cases, the scale will boot up directly to display the weight screen. If not, press the ON/OFF button.
5. For further scale functionality, including calibration, please refer to the manufacturer's manual.

## 10.2 Auxiliary Pumps

The KrosFlo® Research 1 (KR1) and KrosFlo® Junior (KR Jr) peristaltic pumps have both internal and external control modes, enabling them to be auxiliary pumps for the TFF system. The 600 rpm drive on the KR1 can run up to two KrosFlo® Research I Pump Heads.

### 10.2.1 Installation

Up to two auxiliary pumps can be connected to the TFF system's Auxiliary Component Octopus Cable. After connecting the auxiliary pumps to TFF system and the TFF system has been powered on, the Auxiliary Pumps can then be powered on and used in its internal or external modes depending on the TFF process. To have the TFF system control the auxiliary pump, ensure that the auxiliary pump is in remote control mode.

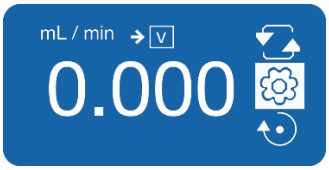
**KR1 (600 RPM)**

To set the KR1 to be remote-controlled, press the “INT/EXT” button until “EXT” shows on the screen.

**KR Jr (300 RPM)**

The KR Jr unit is shipped in remote control mode. If a KR Jr is in remote control mode, a boxed “V” will be seen on the upper left-hand side of the main screen after startup.

**Figure 45. KR Jr Display in Remote Control Mode**




To set the KR Jr to be remote controlled:

1. Enter the Settings Menu (wrench icon)
2. Enter Global Options Menu (paper with lines icon)
3. Enter Remote Control Menu (25-pin connector over box that alternately shows V and mA)
4. Enter Voltage Input Menu (voltmeter icon), then use the Up or Down arrows to highlight the “I” icon and press Enter to activate it.
5. Remote Control On (“I” icon)

***Note:*** *The controls below are only accessible when the auxiliary pumps are in Internal control mode. When in External control mode, the auxiliary pumps are controlled by input from the TFF system.*

**Table 15. KR Jr Tubing Specifications**

| | L/S Precision pump tubing | | | |
|---|---|---|---|---|
| | L/S 13 | L/S 14 | L/S 16 | L/S 25 |
| Silicone tubing P/N | ACTU-E13-25N | ACTU-E14-25N | ACTU-E16-25N | N/A |
| Pharmapure tubing P/N | ACTU-P13-25N | ACTU-P14-25N | ACTU-P16-25N | ACTU-925-25N |
| Inside diameter (nominal) | 0.8 mm (0.03”) | 1.6 mm (0.06”) | 3.1 mm (0.12”) | 4.8 mm (0.19”) |
| Hose barb size | 1.6 mm (1/16”) | 1.6 mm (1/16”) | 3.2 mm (⅛”) | 4.8 mm (3/16”) |
| Flow rate range (mL/min) | 0.005 – 12 | 0.014 –to 42 | 0.05 – 150 | 0.11 – 330 |
| Maximum pressure | 2.7 bar (40 psig) | 2.4 bar (35 psig) | 2.7 bar (40 psig) | 2.4 bar (35 psig) |

### 10.2.2 Auxiliary Pump Settings

In order for the TFF system to control the Auxiliary Pumps properly, input the Auxiliary Pump type and the tubing size being loaded into the Auxiliary Pump pump heads.

## 10.3 Automatic Backpressure Valve

The KrosFlo® Automatic Backpressure Valve (ABV) controls a wide variety of pressure set-points during tangential flow filtration processes when used in conjunction with the TFF System. The valve is designed to pinch flexible tubing to maintain the user-set pressure. One ABV may be connected to the KR2i.

**Figure 46. Automatic Backpressure Valve**

### 10.3.1 ABV Installation

1. Plug in the valve serial port to the serial connector labeled "Valve" on the Octopus Cable. The valve is powered through the octopus connector.
2. Place the tubing through the plunger mechanism by lifting up on the body of the valve and fitting the tubing between the metal bar and the white plastic plunger. The body of the valve can then be turned 180° to close the tubing opening by using the longer stainless steel rods or let the tubing opening remain accessible with the shorter rods.

### 10.3.2 ABV Settings

**Auto Mode Menu**

a. **Mode:** Can be set to Auto or Manual—if set to Manual, settings will switch to Manual Mode Menu.
b. **Set-point:** What pressure set-point the Valve will attempt to reach and maintain
c. **Tubing Size:** Used to determine pinch distance

d. **Control:** Set whether Valve is controlling Feed, Permeate, Retentate, or TMP pressure.
e. **Start Position:** The initial Start position before adjusting pinch distance:
    - Open: no pinching
    - Half: 50% closed based on tubing size
    - Closed: 100% closed based on tubing size
    - Custom: user defined

**Manual Mode Menu**

a. **Mode:** Can be set to Manual or Auto-- if set to Auto, settings will switch to Auto Mode Menu
b. **% Closed:** % of opening closed by pinch
c. **Tubing Size:** Determines pinch distance

## 10.4 KONDUiT

### 10.4.1 System Configuration

The base unit of KONDUiT integrates Conductivity, Temperature, and UV monitoring and automation functionalities into the TFF System. There are 2 combination Conductivity and Temperature inputs (Cond/Temp), 2 UV inputs, and one power supply port.

**Single-use Conductivity/Temperature Flowpath Components**

Combination Conductivity and Temperature in-line flowpath sensors; made of Polysulfone and in assorted hosebarb sizes.

**Optional: UV Photometer**

Available in either 260 nm or 280 nm models; consists of 2 fiber optic cables, 2 optical couplers to connect to flow cell, and power supply.

***Note:*** *UV Photometer cannot be remotely tared; to tare UV Photometer, press "TARE" button on Photometer body.*

**Optional: Single-use UV Flow Path Components**

UV in-line flow path sensors; made of Polysulfone and in assorted hosebarb sizes.

### 10.4.2 Basic Setup

***Note:*** *Prior to assembling KONDUiT, ensure that TFF System has been properly set-up (see Section 7).*

1. Connect KONDUiT Communication Cable to Auxiliary Octopus Cable.
2. Connect KONDUiT Power Cable to KONDUiT Power Port.
    - On back of KONDUiT, green power light on the On/Off button indicates if KONDUiT is receiving power.

**Figure 47. Back of KONDUiT, Green Power Indicator Light**

**Figure 48. Front and back of KONDUiT**


3. Assemble TFF flowpath and place Cond/Temp and/or UV in-line sensors at the correct position in the flowpath; see sensor descriptions below for details.

**Conductivity Sensor**
The sensors can be placed in either the permeate line or the recirculation line when used for the Diafiltration end point control.

***Note:*** *Conductivity sensors need to be filled with the initial starting buffer prior to starting the automated sequence. When the sensor is placed on the permeate line, this buffer should be the same buffer that sample is in. This will eliminate any potential early shutdown of the auto mode.*

If the conductivity setpoint is lower than the starting value, the system will stop the sequence when the lower value is reached.
If the conductivity setpoint is higher than the starting setpoint, the system will stop the sequence at the higher value.
The system will only track in the linear range either positive or negative from the starting conductivity.

**UV Sensor**
For UV alarms, the sensors are usually placed on the permeate line to detect sample breakthrough.

***Note:*** *Fill UV inline sensor with buffer and press the physical "Tare" button on UV box prior to starting the sequence. For UV Diafiltration control on the permeate line the molecule of interest should be detected in the cell prior to starting the automated sequence.*

***Note:*** *Do not place heavy weight on top of UV fiber optic cables; do not fold UV fiber optic cables; fiber optic cables are very fragile.*

4. Connect all sensors to the corresponding ports.
5. After making all connections, wait at least one minute for KONDUiT to establish connection with the TFF System.
6. KONDUiT can be placed behind the KR2i system. No physical buttons or interfaces are necessary on the base unit. The UV photometer has a tare button that needs to be accessible. Cables can be placed in the cable boxes provided with the KR2i system.

### 10.4.3 Maintenance

Periodically clean KONDUiT base with damp cloth and/or mild detergent. Do not immerse or use excessive fluid. Inspect connectors to make sure they are not damaged and they are securely fastened.

# 11. Basic Concepts of Tangential Flow Filtration (TFF)

## 11.1 Introduction

Membranes differentiate components based on size: components larger than the membrane pore are held back by the membrane, while smaller components pass through the membrane structure along with the permeate. Repligen's hollow fiber TFF modules are designed for pressure-driven application.

Tangential Flow Filtration is an efficient way to separate streams that would quickly become plugged if processed by dead-end filtration techniques. Most of the process fluid flows along the membrane surface, rather than passing through the membrane structure. Fluid is pumped at a relatively high velocity parallel to the membrane surface.

Except for water treatment applications, only a small percentage of the tangential flow along the membrane surface ends up as permeate. In most cell and particle separations, only 1–5% of the inlet flow to the membrane device becomes permeate. The remaining 95–99% exits the membrane device as retentate. The retentate is recirculated back to the process reservoir and the module inlet so that another 1–5% can be removed as permeate. This recirculation process continues in rapid succession, generating a significant and continuous permeation rate.

Filtrate flow results in a buildup of retained components on the membrane's inner lumen surface; these may occasionally accumulate into a cake layer instead of being carried away by the sweeping action of the recirculation fluid. This cake layer becomes a membrane barrier, reducing the functional size of the membrane pore and affecting module performance.

Caking is influenced by several fluid variables: degree of solvation, concentration and nature of the solids and solutes, fluid temperature, along with operating variables—such as the solution's velocity along the membrane—and TMP. Controlling this phenomenon by ensuring adequate fluid velocity at the liquid-membrane wall interface will maximize flux, solute passage, and optimize process parameters. Fluid velocity is controlled by the pumping rate. Pumping rate depends on the quantity of fibers in the module and shear rate considerations. Typically, a shear rate of 12000 $s^{-1}$ is used for filtration applications and up to 4000 $s^{-1}$ is used for perfusion applications. However, some certain applications work well at reduced rates while others may require rates that are significantly higher. These are the considerations that the user usually investigates during Research and Development prior to moving to Pilot phase for their applications.

## 11.2 Concentration

Concentration is the reduction of the initial sample volume to a lower, final sample volume. For example, if the process volume is 10 L and needs to be concentrated to 10X, then the final sample volume will be 1 L. The opposite would be a dilution, where the initial sample volume is increased to the final sample volume through the addition of buffer or other medium.

The in-line variable pathlength technology (VPT) spectrophotometer monitors concentration directly in the flow path using absorbance spectroscopy. The VPT device uses the Beer-Lambert law, $A = \varepsilon c l$, to measure the absorbance $A$ at various pathlengths $l$, and then calculate concentration $c$ based on the given extinction coefficient $\varepsilon$. The concentration value is communicated to the TFF system in real time during the process, allowing the system to recognize when the sample has reached the desired concentration.

## 11.3 Diafiltration

Diafiltration is the washing of cells, cell debris, virus, precipitates, proteins, and other materials. This is often done as an efficient method of buffer exchange, for instance. Diafiltration is measured in terms of how many washes the process volume has undergone. If the process volume is 10 L and needs to be washed 5 times, then 50 L of diafiltration buffer must wash through the process volume.

The TFF system's Diafiltration function relies upon feedback from both the Feed and Permeate Scales and the VPT instrument to monitor concentration. The TFF system will add buffer to maintain the concentration as measured by the VPT instrument. Once the desired weight is reached on the Permeate Scale—which would indicate that the desired number of Diafiltration Volumes have washed through the process volume—the TFF system will know that the process volume has been washed the correct number of times.

## 12. Troubleshooting

**Table 16. Troubleshooting**

| Symptom | Diagnosis | Remedy |
|---|---|---|
| Pressure Sensor readings are wrong (either -9.9 psi or >35 psi when no pressure is on them) | Pressure sensor octopus cable not functioning or pressure sensor broken | Replace Octopus Cable and/or pressure sensor |
| Scale not reading properly | Refer to manufacturer's scale manual. | Refer to manufacturer's scale manual. |
| Pump not working correctly | Refer to pump manufacturer's manual, troubleshooting section. | Refer to pump manufacturer's manual, troubleshooting section. |
| Process ending early or late in the DV or CF auto modes | Input for the holdup volumes is wrong | Enter the correct feed holdup and permeate holdup volumes and select if they are empty or full when starting the process |
| Process ending early when using the Conductivity or UV sensors (fixed pathlength sensors for auto modes) | Sensor not full of proper liquid | Conductivity sensor should be filled with same buffer that sample is in when starting the process. UV sensor should be zeroed with the same buffer sample is in. |

For further Technical Assistance, please contact Repligen at analytics-support@repligen.com or (908) 707-1009.

## 13. Replacement and Auxiliary Parts

More information regarding the KrosFlo KR2i RPM System can be found by visiting https://www.repligen.com/products/analytics/rpm-system

**Table 17. Replacement and Auxiliary Parts Information**

| Description | Part number |
|---|---|
| **Auxiliary Pumps** | |
| KR1 Auxiliary Pump, 600 RPM | ACR1-U20-01R |
| KR Jr Auxiliary Pump, 300 RPM | ACJR-U10-R |
| KR2i and KR1 Thin Wall Tubing Pump Head | ACR2-H3I-01N |
| KR2i and KR1 Thick Wall Tubing Pump Head | ACR2-H4I-01N |
| Replacement EZ Load 3-Pump Head Plate | ACR2-MPL-01N |
| **Scales** | |
| Schuler Scale, 20 kg | SCL-0020-SCLR |
| **Backpressure Valve** | |
| Backpressure Control Valve, 0.625" BPCV and Dongle | ACPC-U10 |
| **Pressure Sensors** | |
| Polysulfone Pressure Transducer, MLL x FLL, 0–75 psi, Non-Sterile, 1 per pack | ACPM-799-01N |
| Polysulfone Pressure Transducer, MLL x FLL, 0–75 psi, Sterile, 1 per pack | ACPM-799-01S |
| Polysulfone Pressure Transducer, MLL x FLL, 6–30 psi, Non-Sterile, Calibrated, 25 per pack | ACPM-899-01N |
| Polysulfone Pressure Transducer, MLL x FLL, 6–30 psi, Sterile, Calibrated, 25 per pack | ACPM-899-01S |
| Polysulfone Pressure Transducer, 1/2" TC x 1/2" TC, 0–75 psi, 1 per pack | ACPM-05TC-01N |
| Polysulfone Pressure Transducer, 1/2" TC x 1/2" TC, 0–75 psi, Sterile, 1 per pack | ACPM-05TC-01S |
| Polysulfone Pressure Transducer, 1/2" TC x 1/2" TC, 0–75 psi, Calibrated, 25 per pack | ACPM-05TC-C1N |
| Polysulfone Pressure Transducer, 1/2" TC x 1/2" TC, 0–75 psi, Calibrated, Sterile, 25 per pack | ACPM-05TC-C1S |
| Polysulfone Pressure Transducer, 1" TC x 1" TC, 0–75 psi, 1 per pack | ACPM-10TC-01N |
| Polysulfone Pressure Transducer, 1" TC x 1" TC, 0–75 psi, Calibrated, 25 per pack | ACPM-10TC-C1N |
| Polysulfone Pressure Transducer, 1" TC x 1" TC, 0–75 psi, Calibrated, Sterile, 25 per pack | ACPM-10TC-C1S |
| Polysulfone Pressure Transducer, 1" TC x 1" TC, 0–75 psi, Sterile, 1 per pack | ACPM-10TC-01S |
| **KONDUiT** | |
| KONDUiT Base Unit | ACCD-BR |
| UV Photometer, 280 nm | ACCD-U280 |
| UV Photometer, 260 nm | ACCD-U260 |
| Conductivity Sensor, Single Use, Non-Sterile, PS, 1/4" HB | ACCS-14HB |
| Conductivity Sensor, Single Use, Non-Sterile, PS, 1/2" HB | ACCS-12HB |
| UV Flow Cell, Single Use, 0.5 cm PL, Non-Sterile, PS 1/4" HB | ACUF-14HB |
| UV Flow Cell, Single Use, 0.5 cm PL, Non-Sterile, PS 1/2" HB | ACUF-12HB |

| | |
|---|---|
| **Stir Plates** | |
| Digital Magnetic Stirrer, 1000 RPM, 120/100 V (FS-500 Recommended Use) | ACFS-SP500-120 |
| Digital Magnetic Stirrer, 1000 RPM, 230/100 V (FS-500 Recommended Use) | ACFS-SP500-230 |
| **Fittings Kit** | |
| MicroKros/MidiKros Fittings Kit | ACPX-CD |
| MidiKros TC Fittings Kit | ACPX-T-01N |
| MiniKros Sampler Fittings Kit | ACPX-S-01N |
| MiniKros Fittings Kit | ACPX-N |
| KrosFlo Fittings Kit | ACPX-K |
| KR2i Fittings Kit | ACR2-SKT |
| **Reservoirs** | |
| 50 ml, 4-Port Conical Reservoir, Non-Irradiated, Silicone Tube Set | ACBT-050-S1N |
| 50 ml, 4-Port Conical Reservoir, Irradiated, Silicone Tube Set | ACBT-050-S1S |
| 250 ml, 4-Port Conical Reservoir, Non-Irradiated, Silicone Tube Set | ACBT-250-S1N |
| 250 ml, 4-Port Conical Reservoir, Irradiated, Silicone Tube Set | ACBT-250-S1S |
| 500 ml, 4-Port Conical Reservoir, Non-Irradiated, Silicone Tube Set | ACBT-500-S1N |
| 500 ml, 4-Port Conical Reservoir, Irradiated, Silicone Tube Set | ACBT-500-S1S |
| 1 L Flat-Bottom Reservoir | ACBT-1TC |
| 2 L Flat-Bottom Reservoir | ACBT-2TC |
| 4 L Flat-Bottom Reservoir | ACBT-4TC |
| 10 L Flat-Bottom Reservoir | ACBT-10TC |
| 1 L Single-Use Reservoir | ACBT-1-D |
| 2 L Single-Use Reservoir | ACBT-2-D |
| 5 L Single-Use Reservoir | ACBT-5-D |
| 10 L Single-Use Reservoir | ACBT-10-D |
| **Reservoir Holders** | |
| Conical Bottle Holder, 15–50 ml | ACPX-BHC-50 |
| Conical Bottle Holder, 250–500 ml | ACPX-BHC-500 |
| **Silicone Tubing** | |
| Extended-Life Silicone Tubing, Size 13, 0.03" (0.8 mm) ID, 1/16" Hose Barb | ACTU-E13-25N |
| Extended-Life Silicone Tubing, Size 14, 0.06" (1.6 mm) ID, 1/16" Hose Barb | ACTU-E14-25N |
| Extended-Life Silicone Tubing, Size 16, 0.12" (3.1 mm) ID, 1/8" Hose Barb | ACTU-E16-25N |
| Extended-Life Silicone Tubing, Size 17, 0.25" (6.4 mm) ID, 1/4" Hose Barb | ACTU-E17-25N |
| Extended-Life Silicone Tubing, Size 18, 0.31" (7.9 mm) ID, 3/8" Hose Barb | ACTU-E18-25N |
| **PharmaPure® Tubing** | |
| PharmaPure Tubing Pack, 25', 0.03" ID, 0.16" OD, #13, 1/16" Hose Barb | ACTU-P13-25N |
| PharmaPure Tubing Pack, 25', 0.06" ID, 0.185" OD, #14, 1/16" Hose Barb | ACTU-P14-25N |

| | |
|---|---|
| PharmaPure Tubing Pack, 25', 0.19" ID, 0.375"OD, #15, 3/16" Hose Barb | ACTU-P15-25N |
| PharmaPure Tubing Pack, 25', 0.12" ID, 0.25"OD, #16, 1/8" Hose Barb | ACTU-P16-25N |
| PharmaPure Tubing Pack, 25', 0.25" ID, 0.375"OD, #17, 1/4" Hose Barb | ACTU-P17-25N |
| PharmaPure Tubing Pack, 25', 0.31" ID, 0.44"OD, #18, 3/8" Hose Barb | ACTU-P18-25N |
| **Cables** | |
| KR2i Pressure Octopus Cable - Auxiliary Components | ACR2-CAC |
| KR2i Pressure Octopus Cable - Pressure Transducers | ACR2-CPT |
| KMPi Pressure Octopus Cable - Auxiliary Components | ACM3-CAC |
| Schuler Scale Cable (6 ft) | ACSS-CC-6 |
| **Tools** | |
| Pro PD Torque Wrench, Includes 11/16" Socket Adapter | TX019 |
| Pro Torque Wrench, Includes 1¼” Socket Adapter | TX026 |
| **TangenX Cassette Holders (For SIUS & SIUS Gamma Filters)** | |
| SIUS PD Cassette Holder | TSLDI-2BMC |
| SIUS PD Filter Plate Insert, ½” TC | TFPLS-SA08 |
| SIUS PD Filter Plate Insert, Luer | TFPLS-LVFL |
| Torque Wrench and Socket | TX019 |
| **FlowVPX Flow Cells and Accessories** | |
| 3 mm Non-GxP Flow Cell, Stainless Steel | OC2002-1 |
| 10 mm GxP Flow Cell, Stainless Steel | OC2001 |
| 10 mm GxP Flow Cell, Non-Smart | OC2001-1 |
| 22 mm GxP Flow Cell, Stainless Steel | OC2004 |
| Transmission Tool | ACC-FVPX-FTT |
| System Suitability (XSA) Fibrette | ACC-FVPX-XSA |
| Delivery Fiber | FA-CTI01-PC2D |

## 14. Index

alarm ..... 15, 19, 39
auxiliary pump ..... 6, 15, 17, 18, 36, 37, 42
backpressure valve..... 6, 15, 37, 42
C. Mode..... 16
C/D Mode..... 16
C/D/C Mode ..... 16
C/D/D/C Mode ..... 17
Calibration..... 19
Cary 60 ..... 13, 28, 29
caution ..... 7, 24
CF/D/C..... 18
CFC ..... 17, 18
Concentration ..... 15, 16, 40
Conductivity ..... 38, 39, 41, 42
Diafiltration ..... 15, 17, 39, 40
flow cell..... 33, 34, 35, 38, 44
FlowVPX .....6, 13, 14, 15, 25, 27, 28, 30, 31, 44
hardware setup.....15, 16, 17, 18, 19, 20, 25, 36, 38
KONDUiT..... 13, 38, 39, 42
KR Jr ..... 13, 36, 37, 42
KR1..... 36, 42
KrosFlo RPM Software .....6, 13, 19, 32, 33, 35
note 7, 15, 16, 17, 19, 22, 23, 27, 28, 31, 37, 38, 39
octopus cable.....13, 15, 36, 37, 38, 41, 44
part number..... 14, 42, 44
precautions.....7, 8, 20, 22, 24, 30
process mode ..... 15
RPM mode ..... 19
safety ..... 8, 19
SAW scale ..... 36
shear rate..... 40
specifications ..... 9, 10, 12
UV .....14, 19, 38, 39, 41, 42
VPT.....31, 32, 33, 34, 35, 40
VPT OPC Server..... 31
warning.....7, 8, 20, 22, 30

**Customer Service**

Repligen Corporation
685 Route 202/206
Bridgewater, NJ 08807

analytics-support@repligen.com

(908) 707-1009

DOC0304 eRev. 2.0 10/7/2024





REPLIGEN