Low Cost TFF System for Protein Concentration and Diafiltration

Operating Manual

SciLog, Inc.

Rev. B 12/04

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1.0 AccuTec System Overview

AccuTec TFF* System Includes:

• **Compact, High-Precision Accu** peristaltic pump. Choice of three different motor sizes and multiple different tubing sizes can be used. Can add a second Tandem peristaltic head (piggy-back) to increase flow or eliminate pulsation.

• **Gentle Sample Processing** — **low-shear** pumping action with **Tandem** peristaltic 4-roller pump head.

• **Aseptic Reservoir Vessel** — for Concentration or Diafiltration. Closed system creates vacuum in reservoir to draw process solution in as solution is being drawn out of the reservoir by the pump.

• **Magnetic Stirrer** — powerful, variable speed stirrer with LED in stainless steel enclosure. Use with either 50 ml or 500 ml graduated vessel.

• **Filter Holder** — to hold/organize your Minimate or Pellicon filter cartridge and gauges.

• **Two Pressure Gauges** — to monitor your feed and retentate pressure. If you require monitoring a third pressure, this can also be added. Stainless steel with Luer connectors.

• **Fittings/Tubing Start-up Kit** — includes Male and Female Luer fittings, adapters, barbs, multiple plastic valves, stirrer magnet, tees, clamps reservoir air filters, tubing lengths.

• **Easy Clean-up and Maintenance** — sent to you ready to use. Eliminate cleaning/cross-contamination issues by using low-cost replacement components/tubing.

2.0 System Components:

2.1 Accu Digital Metering Pump.

The Accu provides a low cost, high precision pumping capability with digital pump control and display. The different Accu pump models utilize optically encoded, servo-controlled motors, ensuring a highly reproducible pump performance. They can are generally equipped with SciLog's Tandem peristaltic pump head, or a pair of them piggybacked as shown below. The complete manual for the Accu follows at the end of this system manual.

2.2 Aseptic Reservoir Vessel

Graduated 500 ml vessel made of FDA approved polysulfone is compatible with disinfectant, i.e. isopropyl alcohol, sodium hydroxide. Seals do not contact your process solution. All fluid connections are 316 SS Female Luer with SS tubing lining all fluid channels; no exposed connector threads to contaminate. Optional 50 ml vessel is also available (#090-012).

2.3 Magnetic Stirrer:

Stirrer base contains a powerful, variable speed stirrer motor with LED in a stainless steel enclosure. Use with either 50 ml or 500 ml graduated vessel. Comes with a 120V AC power supply.

2.4 Filter Holder:

A machined grey holder designed for use with Minimate and Pellicon brand filters, assists in keeping the work area organized.

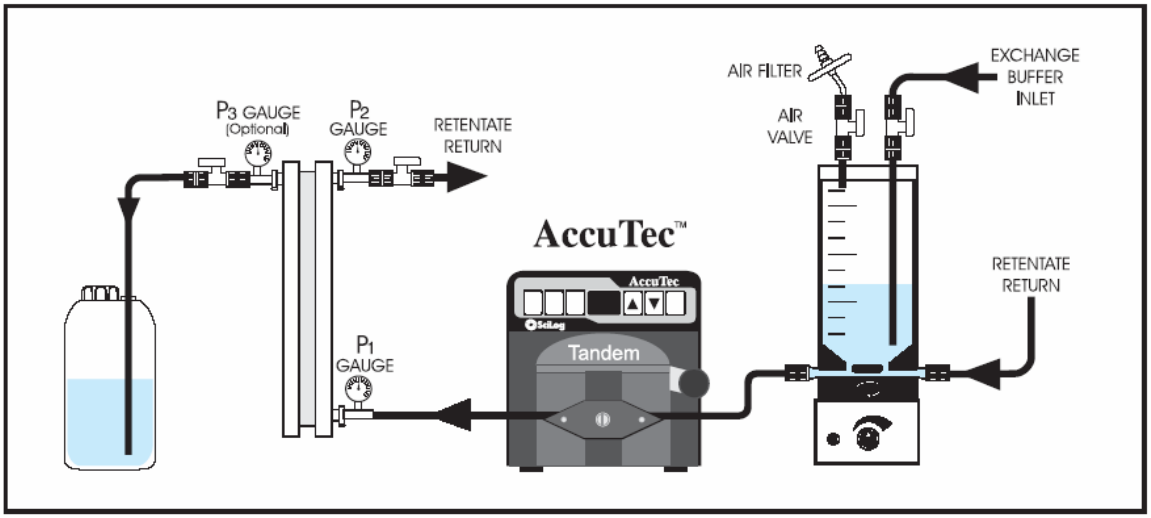
2.5 Pressure Gauges:

Stainless Steel, glycerin filled, 0-45 psi gauges used to monitor Feed and Retentate pressures. Two are included with the system, a third may be purchased separately if desired. Equipped with Luer connectors for ease of use.

2.6 Fittings and Tubing Startup Kit:

This kit contains all needed Luer connectors and valves, a magnetic stir bar, and pinch clamp needed for the system. Silicone tubing appropriate to the pump head purchased is also included to get you started quickly.

3.0 Typical System Layout:



Typical Installation: *(Refer to schematic above)*

1. Remove the caps from the feed and retentate ports of the TFF cartridge.
2. Connect the Pressure Gauges to the feed/retentate ports.
3. Cut a length of tubing long enough to reach from the reservoir, through the pump head to the cartridge, installing appropriate hose-barb Luer fittings on both ends.
4. Connect the tubing to the gauge on the feed port. Install the tubing in the pump head. Connect the other end of the tubing into the reservoir.
5. Cut another piece of tubing, long enough to return from the retentate port to the sample reservoir, and again install hose-barb Luer fittings. Attach the tubing to the retentate pressure gauge and put the other end on the return port of the reservoir. (You may use an upper or lower port for this.) Place the retentate screw clamp on the retentate tubing close to the retentate port (after the pressure gauge if installed). Secure in place but do not tighten to restrict the tubing.
6. Remove one of the filtrate caps. Choose port that is highest in orientation. This allows air to be expelled from the cartridge.
7. Attach a female Luer-to-hose-barb fitting to the filtrate port.
8. Cut a length of tubing long enough to reach from the filtrate port to your filtrate collection vessel. Connect the tubing to the filtrate hose barb.
9. Install a tubing clamp over each piece of tubing where it connects to the hose barb. A standard cable tie, included in the fittings kit, works well for this.

Notes:

1. Do not discard caps that come with your cartridge. They are required for storage.
2. Keep tubing lengths as short as possible to reduce hold-up volume.
3. Feed and retentate ports are interchangeable on some cartridges. Depending on the orientation of the cartridge, choose the port that is at the lowest elevation as the feed port. This allows for air to be easily expelled when liquid is pumped through the cartridge.
4. SciLog strongly recommends the use of pressure gauges or transducers connected on both the feed and retentate ports. If only one gauge is available, it should be used on the feed port. The use of pressure gauges allows accurate adjustment of feed pressures and provide for better reproducibility between process runs. They also help diagnose system problems.
5. Trans-membrane pressure is defined as: [(P1+P2)/2]-P3. As the filtrate line in this simple system is left open, it can be assumed that P3 is zero. A third pressure gauge may be purchased as an optional item if desired.
6. It is encouraged that you refer to the manufacturers user's guide that is included with your filter cartridge. It contains useful information regarding flow rates, sanitation procedures, and filter sizing.

Replacement and Optional Parts:

P/N	Description
090-011A	500 ml Polysulfone Vessel
090-012	50 ml Polysulfone, Polycarbonate Vessel
090-015	Stirrer Base, for use with either Vessel, includes Power Supply
080-108	Tandem 1081 Peristaltic Head, Thin-walled Tubing
080-1082	Tandem 1082 Peristaltic Head, Thick-walled Tubing (Add "Kit" to either head to have piggyback hardware included)
060-076	Filter Holder, Minimate/Pellicon
060-100	Pressure Gauge
060-050	Fittings Kit
090-040	600 rpm Motor Subassembly for Peristaltic Heads
090-027	160 rpm Motor Subassembly for Peristaltic Heads
090-034	8 rpm Motor Subassembly for Peristaltic Heads
400-114	Silicone Tubing, Platinum Cured, Size #14, 0.063" ID
400-116	Silicone Tubing, Platinum Cured, Size #16. 0.125" ID
400-115	Silicone Tubing, Platinum Cured, Size #15, 0.188" ID
400-124	Silicone Tubing, Platinum Cured, Size #24, 0.250" ID

4.0 Selection of AccuTec Model for your Application:

1) Depends on the filter area and the TFF cross-flow rates recommended by the filter manufacturer. Refer to **Table 1** for general selection information. For TFF devices not listed, refer to **Table 2** to help select the pump rate range that covers the cross-flow rate of your TFF filter or to determine optimal pump tube size.

2) Begin with cross-flow rate recommended by the manufacturer (typically 700 ml per sq. ft. of the filter area). Example: If the filter area is 1.0 ft2, , locate the pump rate range that encompasses the cross-flow rate of the filter (in this case 700 ml/min). This would suggest the AccuTec CP-20 with a 600 RPM motor with a Tandem 1082 head. Tubing sizes of #15, #24 or #35 could be used, however the #24 tubing would be preferred since the desired pump rate falls in the mid-range of this tubing.

AccuTec™			PUMP TUBING	TFF FILTER			
MODEL (P/N)	MOTOR (RPM)	PUMP HEAD		NAME	MFG	FILTER AREA (ft^2)	CROSS-FLOW RATE (ml/min)
CP-10 (100-018TEC)	**160**	**TANDEM 1081**	**#14**	*"Minimate"*	Pall	**0.05**	**35 -50**
				"Pellicon XL 50"	Millipore		
			#16	*"LV-Centramate"*	Pall	**0.1 - 0.2**	**70 - 140**
CP-20 (100-0282TEC)	**600**	**TANDEM 1082**	**#24, 35**	*"Centramate"*	Pall	**1.1 - 3.3**	**700 - 2200**
				"Pellicon 2 Mini"	Millipore		
				"Sartocon Slice"	Sartorius	**1.1**	

Table 1

TUBING SIZE	13	14	16	25	17	18	15	24	35
Silicone PT P/N	400-113	400-114	400-116	400-125	400-117	400-118	400-115	400-124	400-135
PharMed P/N	400-313	400-314	400-316	400-325	400-317	400-318	400-315	400-324	
PUMP RATE RANGE *(Nominal values, +/- 5%)*	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min
AccuTec CP-8 *8 RPM*	0.03-0.45	0.1-1.6	0.4-6.4	0.9-12.6	1.1-18.3	1.7-24.3	0.5-13	0.6-20	—
AccuTec CP-10 *160 RPM*	0.5-10	1.7-35	6.3-129	12.5-283	18.5-405	24.7-554	9.6-240	14-412	—
AccuTec CP-20 *600 RPM*	2-34	8.6-132	29-533	49-974	70-1048	103-1515	59-993	85-1348	111-2258
Pump Head Model	*TANDEM 1081*						*TANDEM 1082*		

Table 2

When you are ready to automate and document your TFF processes, SciLog's PureTec™ Automated Purification System is your answer! Call us at 800-955-1993, or refer to www.scilog.com for more information.

ACCU™

High Precision Pump
Optically Encoded, Servo-Controlled

Operating Manual

SciLog, Inc.

Rev. B 11/03

Safety Information:

Be sure to read and observe the following requirements!

Before connecting the ACCU to mains, make sure that the mains voltage corresponds to the voltage rating given on back panel of the pump.

Opening the ACCU cover exposes live parts. Therefore, the cover must not be removed. If repair should be required, return the pump to the factory.

If opening of the ACCU cover is inevitable, the pump must first be disconnected from all voltage sources.

Make sure that the mains plug has been pulled out.

Repair or adjustment of an opened ACCU under voltage must be carried out only by a skilled person who is aware of the hazard involved.

Whenever it is likely that the protection has been impaired, the ACCU must be made inoperative and secured against any unintended operation. The protection is likely to be impaired if, for example:

The ACCU shows visible damage.
The ACCU fails to perform as intended.
After prolonged storage at temperature above 70°C.
After severe transport stresses.

Before re-commissioning the ACCU, a professional routine test according to EN 61010-1 must be performed.

Installation & Start-Up

Installation of the ACCU must be carried out only by trained personnel in accordance with the relevant regulations and this operations manual.

Make sure that the technical specifications and input ratings of the ACCU are observed. See "1.4 ACCU Pump Specifications"

The ACCU must be connected to a properly grounded power supply receptacle.

The ACCU location must not block access to the power disconnect point for the power supply.

The protection provided by this equipment may be impaired, if the ACCU is used in a manner or for purposes not specified by the manufacturer, SciLog, Inc.

Start-up of the ACCU must be carried out only by trained personnel in accordance with the relevant regulations and this operations manual.

Before first start-up, a parameter setting procedure and/or a parameter review must be performed by supervisory personnel.

Maintenance & Cleaning:

The ACCU pump controller is maintenance free. The pump head and associated pump tubing must be flushed with distilled water or 2-propanol (isopropyl alcohol) for at least 5 minutes prior to pump shutdown.

To remove dust, dirt and stains, the outer surfaces of the ACCU may be wiped using a soft, non-fluffing cloth moistened with water. If required, you may also use a mild detergent or 2-propanol.

Electromagnetic Compatibility:

The ACCU meets the following generic standards:

- **Electromagnetic Emission: EN 50081-1: 1992**
- **Immunity to Interference: EN 50082-1: 1992**

Description of this Manual:

This operations manual provides following information:

- Safety Requirements
- Product Specifications
- ACCU Hardware
- Pump Head Maintenance / Service

WARNING:

Warning means that ignoring the given instructions may lead to malfunction or damage of the instrument or other equipment and to personal injury.

NOTE:

Note call you attention to important information. *Italics* are used to emphasize certain information.

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Introduction:
The ACCU provides high precision pumping capability with digital pump control.

Please read the following instructions carefully!

Inspections: Unpack the ACCU and accessories carefully from the carton. Crosscheck the contents against your purchase order to verify that all parts are included and undamaged.
Please do the inspection now, even if the ACCU is not used immediately. Many carriers must receive damage claims within seven day of delivery. Please retain all packing material so unit may be shipped safely, if necessary.

SciLog Customer Service: If you need assistance, please call **800-955-1993**

SciLog Customer Service personnel will be able to serve you more efficiently if you have the following information:

- Serial number (back panel).
- Installation procedure you used.
- Concise list of symptoms.
- List of operating procedures and conditions you were using when problem arose.

Warranty Repair: Units covered under warranty will be repaired and returned to you at no charge. If you have any questions about applicability, please contact SciLog.
Non-warranty Repair: For out-of-warranty repair, contact the SciLog Customer Service Department. A SciLog representative will discuss service options with you and can assist in making arrangements to return the equipment, if necessary.
Return Procedure: Before returning any SciLog equipment, contact SciLog to obtain a Return Goods Authorization (RGA) Number. To return a piece of equipment:

- Carefully pack the unit to prevent damage in transit. Check with SciLog regarding the proper method of shipment. SciLog does not assume any responsibility for instrument damages caused by improper packaging. Indicate the RGA Number on the carton or on the packing slip:
- Always insure for the replacement value of the unit.
- Include a description of the symptoms, your name, return address, phone number and purchase order to cover repair costs, return and shipping charges, if your institution requires it. Ship to:

SciLog Inc.
8845 S. Greenview Dr. #4
Middleton, WI 53562-2562

WARRANTY POLICY, PRODUCT RETURNS, ACCEPTABLE USE, AND OTHER RESTRICTIONS

1. WARRANTY AND RETURNS POLICY:

SCILOG, INC. EXPRESSLY WARRANTS THE EQUIPMENT MANUFACTURED BY IT ONLY AS SET FORTH HEREIN. SCILOG, INC. MAKES NO OTHER WARRANTIES, EITHER EXPRESS OR IMPLIED (INCLUDING WITHOUT LIMITATION WARRANTIES AS TO MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE). IN ADDITION, THE FOLLOWING SHALL CONSTITUTE THE SOLE AND EXCLUSIVE REMEDIES OF BUYER FOR ANY BREACH BY SCILOG, INC. OF ITS WARRANTY HEREUNDER.

A. PRODUCT WARRANTY – SciLog, Inc. warrants products it manufactures against defects in materials and workmanship for one (1) year from the date of shipment from SciLog, Inc. in normal use and service. If any products fail to conform to this warranty within the first ninety (90) days of the warranty period, SciLog, Inc. will, at its option, repair or replace such goods returned. If any products fail to conform to this warranty for the remainder of the warranty period, SciLog, Inc. shall furnish necessary replacement parts free of charge.

B. PARTS WARRANTY - SciLog, Inc. warrants service parts against defects in materials and workmanship for ninety (90) days from the date of shipment from SciLog, Inc. in normal use and service. If any service parts fail to conform to this warranty, SciLog, Inc. shall furnish necessary replacement parts free of charge.

C. WARRANTY LIMITATIONS - These warranties are subject to the following conditions:

1. Upon discovery of such non-conformity, SciLog, Inc. will be given prompt written notice with a detailed explanation of the alleged deficiencies.

2. The product or part must be properly installed, operated and maintained in accordance with SciLog, Inc. specifications.

3. The product or part must not be operated above rated load capacity or subject to accident, alteration, misuse, or abuse.

4. The product must not have been repaired or serviced by anyone other than SciLog, Inc. or one of its authorized dealers.

5. SciLog, Inc. shall have a reasonable time to repair or replace the effective product.

6. The buyer is responsible for shipping the product to SciLog, Inc. SciLog, Inc. is responsible for shipping the product back to the buyer.

D. RETURN POLICY - Any item may be returned within thirty (30) days from the date of shipment from SciLog, Inc. If the box is unopened (the original factory seal is intact), SciLog, Inc. will refund the full credit to the buyer. If the box is opened (the original factory seal is not intact), SciLog, Inc. will refund the full credit less a $75 inspection fee and repair labor/parts/materials cost (if applicable) to the buyer. No returns will be accepted after thirty (30) days from the date of shipment from SciLog, Inc. The buyer is responsible for shipping the product to SciLog, Inc.

2. INTELLECTUAL PROPERTY

The sale and delivery of the SciLog, Inc.'s equipment and/or software to Buyer shall in no way transfer to Buyer any right of ownership in any patents, copyrights, trademarks, technologies, designs, specifications, drawings, or other intellectual property incorporated into the equipment and/or software.

3. DISCLAIMER OF DAMAGES

IN NO EVENT SHALL SCILOG, INC. BE LIABLE FOR ANY TYPE OF SPECIAL CONSEQUENTIAL, INDIRECT, INCIDENTAL OR PENAL DAMAGES, WHETHER SUCH DAMAGES ARISE OUT OF OR ARE A RESULT OF BREACH OF CONTRACT, WARRANTY, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE. Such damages shall include but not be limited to loss of profits or revenues, loss of use of the equipment or associated equipment, cost of substitute equipment, facilities, down time costs, increased construction costs or claims of Buyer's customers or contractors for such damages. Buyer agrees that in the event of a transfer, assignment, or lease of the equipment sold hereunder Buyer shall secure for the SciLog, Inc. the protection afforded to it in this paragraph.

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The SciLog, Inc. shall not be liable for any loss, claim, expense or damage caused by, contributed to or arising out of the acts or omissions of Buyer or third parties, whether negligent or otherwise. In no event shall the SciLog, Inc.'s liability for any cause of action whatsoever exceed the cost of the item giving rise to the claim, whether based in contract, warranty, indemnity, or tort (including negligence). Any suit arising hereunder must be commenced within one (1) year from the date in which the cause of action accrues. Except as provided in Article 3, the SciLog, Inc. shall not indemnify any party.

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If SciLog, Inc. provides Buyer with assistance or advice which concerns any parts, products, service supplied hereunder or any system or equipment in which any such part, product or service may be installed and which is not required pursuant hereto, the furnishing of such assistance or advice shall not subject SciLog, Inc. to any liability, whether based in contract warranty, tort (including negligence) or otherwise.

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7. REVISIONS TO THIS POLICY

From time to time the Company may revise the terms of this Agreement. Company will make its best efforts to inform customers of these revisions. The most current revision of these terms may be accessed over the internet by accessing the webpage located at: http://www.scilog.com/warranty

REGISTER YOUR PRODUCT(S) WITH SCILOG, INC. IMMEDIATELY AT:
http://www.scilog.com/register

Phone: 608-824-0500 Fax: 608-824-0509
8845 South Greenview Drive, Suite 4
Middleton, Wisconsin 53562 USA

1.0 ACCU Pump: *Overview*

The ACCU provides a low cost, high precision pumping capability with digital pump control and display. The different ACCU pump models utilize optically encoded, servo-controlled motors, ensuring a highly reproducible pump performance.

Three remote pump control options are available. An external 4-20 mA or 0-5VDC analog signal can be used to proportionally control the ACCU pump output. A serial (RS-232) communications port allows control of multiple ACCU pumps. Utilizing a PC Terminal Mode, up to 32 ACCU pumps can be daisy-chained together and be controlled by a single PC.

The ACCU offers a range of pump head options:
The **CP models** come with the TANDEM ™ dual channel peristaltic pump head which are powered by either an 8 RPM (CP-8), 160 RPM (CP-10) or 600 RPM (CP-20) motor. Two different TANDEM pump heads are available for either thin-walled (TANDEM model 1081) or thick-walled pump tubing (TANDEM model 1082).

The **FM models** come with a FMI rotating, reciprocating piston pump head which are powered by either a 160 RPM (FM-10), 600 RPM (FM-20), 450 RPM (FM-40) or 3400 RPM (FM-50) motor. Three different FMI pump heads are available covering a wide range of pump outputs.

The **MP models** come with a magnetically coupled gear pump head (Micropump™) which are powered by a 3400 RPM (MP-30) motor. Eight different Micropump pump heads are available. Consult Section 1.2 of this manual which summarizes the pump head/motor option in some greater detail.

1.1 PumpSense™: *Pump Overload Protection*

When the operation of a pump head requires an excessive torque, the ACCU pump controller recognizes this condition by stopping the pump and going into a stand –by mode. In the stand-by mode, the pump motor is turned off and **"OL"** is displayed. The "OL" stands for Overload; there is nothing wrong with the ACCU controller, the problem lies with your particular pump head. Check your pump head carefully!

Before continuing with your pumping application, read the next page. Then remove the defective tubing or pump head and either clean the pump head or replace with a functional pump head. The PumpSense™ feature has been implemented as a failsafe device to protect your pump head and motor control circuit from permanent damage. Some examples of situations which may produce pump head failure are:

FMI Pump Heads: "Freezing" of the piston because of crystallization of the fluid in the pump head: Disassemble and clean pump head if necessary. Flush all lines as well as pump head for at least 3-5 minutes after each use to avoid drying out of the liquid inside the pump head. ***Store the pump by installing a short piece of tubing between the pump inlet and outlet. Fill the tubing loop with distilled water or alcohol (IPA).***

Micropump Heads: Misalignment of driving magnet due to excessive fluid viscosity, also freezing of spur gears because of crystallization of fluid inside the pump head: Reduce pump speed and/or pressurize fluid reservoir when dealing with viscous fluids. Disassemble and clean pump head if necessary. Flush all lines as well as pump head for at least 2-3 minutes after each use to avoid drying out of the liquid inside the pump head**. *Store the pump by installing a short piece of tubing between the pump inlet and outlet. Fill the tubing loop with distilled water or alcohol (IPA).***

TANDEM™ Peristaltic Pump Heads: Pump tubing can become frayed when overused. When this happens, the pump tubing tends to wind itself around the pump rotor: ***To avoid this problem, check your pump tubing daily, move the used tube section 2 - 3 inches to the pump discharge side.*** Use only high quality tubing, e.g. Silicone, PharMed or Ultra Long Life C-Flex pump tubing

1.2 Pump Head/Motor Options: *Summary*

ACCU CP-10*:* Comes with a **160 RPM**, optically encoded, servo-controlled motor and a **TANDEM™** Dual Channel Peristaltic Pump Head, two pump head models are available, TANDEM 1081 & 1082. Materials of Construction: Stainless Steel and Noryl high impact resistant plastic, four (4) roller design (stainless steel). Passive pump tube retention, two stainless steel forks automatically engage pump tubing when the TANDEM pump head is closed. The **TANDEM Model 1082** (P/N: 080-1082) is compatible with **thick-walled** (0.093") Masterflex tubing sizes 15 & 24. Optionally, the **TANDEM Model 1081** (P/N: 080-1081) is available and is compatible with **thin-walled** (0.062") Masterflex® pump tube sizes 13, 14, 16, 25, 17 & 18.

ACCU CP-8: Comes with a **8 RPM**, optically encoded, servo-controlled motor and a **TANDEM™** Dual Channel Peristaltic Pump Head providing an accurate, low pump rate capability, otherwise has the same specifications and available options as the ACCU CP-10.

ACCU CP-20: Comes with a **600 RPM**, optically encoded, servo-controlled motor and a **TANDEM™** Dual Channel Peristaltic Pump Head providing an accurate, high pump rate capability, otherwise has the same specifications and available options as the ACCU CP-10.

Additional Options: Two TANDEM pump heads can be mounted together. This "piggy-back" arrangement requires special mounting hardware (P/N: 500-485), to provide a **four-channel pumping capability.**

ACCU FM-10: Comes with a 160 RPM optically encoded, servo-controlled motor. The ACCU FM-10 has a FMI rotating, reciprocating piston pump head. Wetted parts: Ceramic piston and chamber with pump head ports either made out of Kynar or Tefzel. Exception: RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	160RPM	0.022 – 4.0 ml/min.
RHO, 0 – 0.050 ml/stroke	160RPM	0.044 – 8.0ml/min.
RH1, 0 – 0.10 ml/stroke	160RPM	0.088 – 16.0 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (160RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 8 RPM (Stalling Speed)*

ACCU FM-20: Comes with a 600 RPM optically encoded, servo-controlled motor. The ACCU FM-20 has a FMI rotating, reciprocating piston pump head. Wetted parts: Ceramic piston and chamber with pump head ports either made out of Kynar or Tefzel. Exception: RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	600 RPM	0.08 – 15.0 ml/min.
RHO, 0 – 0.050 ml/stroke	600 RPM	0.17 – 30.0 ml/min.
RH1, 0 – 0.10 ml/stroke	600 RPM	0.33 – 60.0 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (600 RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 30 RPM (Stalling Speed)*

ACCU FM-40: Comes with a 450RPM optically encoded, servo-controlled motor. The ACCU FM-40 has a FMI rotating, reciprocating piston pump head. Wetted parts: Ceramic piston and chamber with pump head ports either made out of Kynar or Tefzel. Exception: RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	450RPM	0.06 – 11.2 ml/min.
RHO, 0 – 0.050 ml/stroke	450RPM	0.12 – 22.5 ml/min.
RH1, 0 – 0.10 ml/stroke	450RPM	0.24 – 45.0 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (450RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 22.5 RPM (Stalling Speed)*

ACCU FM-50: Comes with a 3400 RPM, optically encoded, servo-controlled motor and a FMI rotating, reciprocating piston pump head providing a wider pumping range, otherwise has the same specifications and available options as the ACCU FM-40.

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	3400 RPM	0.50 – 85.0 ml/min.
RHO, 0 – 0.050 ml/stroke	3400 RPM	1.00 – 170 ml/min.
RH1, 0 – 0.10 ml/stroke	3400 RPM	1.89 – 340 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (3400 RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 170 RPM (Stalling Speed)*

ACCU MP-30 Models*:* Comes with a **3400 RPM**, optically encoded, servo-controlled motor and a magnetic gear pump head. Materials of construction: stainless steel body, gears are made from Teflon, graphite or Ryton. Pressure rating: 40 – 70 psi.

Pump Head Model:	Max. RPM:	Pumping Range:
Mag. 187, Graphite gears, 40psi,	3400 RPM	5.0 – 60 ml/min.
Mag. 184, Graphite gears, 40psi,	3400 RPM	10 – 140 ml/min.
Mag. 1840, Ryton gears, 50 psi,	3400 RPM	30 – 300 ml/min.
Mag. 040, Teflon gears, 40 psi,	3400 RPM	85 – 1075 ml/min.
Mag. 201, Ryton gears, 50psi,	3400 RPM	150 – 1910 ml/min
Mag. 120, Teflon gears, 50 psi,	3400 RPM	174 – 2170 ml/min.
Mag. 122, Teflon gears, 50 psi,	3400 RPM	309 – 3100 ml/min.
Mag. 200, Ryton gears, 70 psi,	3400 RPM	290 – 3700 ml/min.

1.3 ACCU Pump Specifications: *Software Version 1.5*

<u>Mechanical:</u>
Dimension: **5.75" W x 6.25"H x 11"D**
Weight: **11 lbs.**
Enclosure: **Aluminum / Steel; Corrosion Resistant.**

<u>Electrical:</u>
Power: **110-120 / 220-240 VAC , 60 / 50 Hz, 75 Watts; double fused**
Motor: **Variable speed, 8 RPM, 160 RPM, 450 RPM, 600RPM and 3400 RPM motors at 28 VDC, 3.8 Amps; optically encoded, servo - controlled**.
Motor Encoder: **120 lines per motor revolution.**
Data Entry**: Membrane keyboard**
Display: **Two LED's, 0.5" high**

I/O Ports: **DB 15 (Back Panel)**

1. RS-232 Serial port, **DB15 connector,** pin 2 (Transmit), pin 3 (Receive) & pin 5 (Ground)

2. 4-20 mA input signal**, DB 15 connector**, pin 6 (Ground) & pin 13**, with selection switch (back panel) at** "4-20 mA"

3. 0-5VDC input signal, **DB 15 connector,** pin 6 (Ground) & pin 13**, with selection switch (back panel) at** "0-5VDC"

4. Pump Speed output signal, **DB 15 connector, pulsed output between** pins 7 (Ground) & pin 9**, pulse rate is proportional to pump speed, ~5940 pulses/sec at 99% pump speed, ~3000 pulses/sec at 50% pump speed.**

5. Remote Start/Stop ("Remote"), **closed contact closure (RUN), open contact closure (STOP) between** pin 8 (Ground) & pin 15 **of the DB 15 connector. This function is active when** "REMOTE" **has been selected from the front panel.**

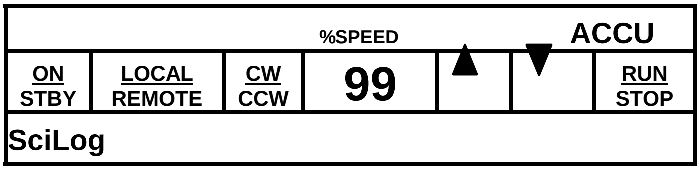
6. Remote CW/CCW Motor Direction ("Remote"), **closed contact closure (CCW), open contact closure (CW) between** pin 7 (Ground) & pin 14**. This function is active when the** "REMOTE" **mode has been selected from the front panel.**

7. Remote Start/Stop ("Local"), **closed contact closure (RUN), open contact closure (STOP) between** pin 8 (Ground) & pin 15 **of the DB 15 connector. This function is active when the** "LOCAL" **mode has been selected from the front panel <u>and</u> the external contact closures (CC across pin 8 & 15) has been exercised, i.e. opening and closing the connected contact closures (CC). The front panel "RUN/STOP" key will be disabled at that point, however, the pump speed selection and the CW/CCW keys are still functional. The front panel "RUN/STOP" key function can be re-established by twice pressing the "LOCAL/REMOTE" key.** *NOTE**: This operational mode should only be used when the ACCU pump is to be controlled (Stop/Start) by a SciLog Smart Pump, i.e. UltraTec or ChemTec.***

8. Foot Switch Start/Stop ("Local"), **foot switch acts as an external contact closure, pump runs at the selected pump speed as long as the foot switch contact is closed, i.e. as long as you step on the foot switch. The pump stops when the foot switch contact is open.**

2.0 Front Panel: *Data Entry & Display*

The front panel is made up of a 2-digit LED display as well as a keypad for entering speed settings and operational parameter. The 2-digit LED displays **% SPEED,** this setting gives the pump speed relative to the motor's maximum RPM.



ON There is no main power switch on the **ACCU**, as long as the pump is plugged into a 110VAC / 220 VAC power source, is either **ON** or in **Standby (STBY)**

STBY Standby Mode, green LED indicates pump is plugged into a power source.

LOCAL The **ACCU** pump is controlled by the speed setting you have selected. The red LED indicates local control. The "Local" setting must also be used when you want to control the **ACCU** via RS-232 serial port (DB15, back panel).

REMOTE The **ACCU** pump is remotely controlled via a voltage (0-5VDC) or current (4-20mA) input generated by an external device, i.e. pH meter/transmitter. The **ACCU** pump rate changes in proportion to the input signal. For example, a 12mA input signal would generate a 50% **ACCU** pump speed, whereas a 20mA input signal would generate a 99% (max.) **ACCU** pump speed. A red LED indicates REMOTE control.

CW / CCW CW stands for a clockwise pumping direction (red LED); CCW stands for counter-clockwise pumping direction.

UP UP-Triangle, press to increase **ACCU** pump speed. Maximum pump speed setting is 99%.

DOWN DOWN-Triangle, press to decrease **ACCU** pump speed. **NOTE:** At speed settings of 5% and below, the pump motor may stall or may behave non-linear.

RUN Press to start the **ACCU** pump motor running. The green LED indicates the pump is in motion.

STOP Press to stop the **ACCU** pump, red LED indicates the pump is stopped.

The **ACCU** can accommodate a range of different motors / speeds: 8, 160, 450, 600 and 3400 RPM motors. For example, when the **ACCU** displays a % SPEED setting of 99 , then a 600 RPM motor runs at 600RPM x .99 = 594 RPM. When the **ACCU** is set at a % SPEED of 10, then a 600 RPM motor runs at 600 x .10 = 60 RPM.

The **ACCU** pump rate is expressed as % of maximum RPM of the pump motor. Different **ACCU** models have different maximum RPMs:

ACCU Model:	**Type:**	**Max. RPM:**	**Pump Range:**
ACCU CP-8	Peristaltic	8RPM	0.02 to 32 ml/min.
ACCU CP-10	Peristaltic	160RPM	0.30 to 554 ml/min.
ACCU CP-20	Peristaltic	600RPM	1.8 to 1820 ml/min.
ACCU MP-30	Mag, Gear	3400RPM	10 to 3700 ml/min.
ACCU FM-10	Piston	160RPM	0.02 to 16 ml/min
ACCU FM-20	Piston	600RPM	0.08 to 60 ml/min.
ACCU FM-40	Piston	450RPM	0.06 to 45 ml/min.
ACCU FM-50	Piston	3400RPM	2.00 to 340 ml/min.

2.1 Manual Mode: *Manual ACCU Operation*

While in the Manual Mode, you have direct, real-time , step by step control of the **ACCU** pump operation. While in this mode, if you run the pump, the pump will continue to run until you manually halt the **ACCU** pump by pressing the STOP key or by pressing the (optional) **ACCU** foot switch pedal. You have real-time control of the pump's functions from the **ACCU** front panel key board while the pump is in the "LOCAL" setting.

> If you experience power outages of more than 1 sec, you are advised to connect the **ACCU** to an Uninterruptible Power Supply (UPS). This precaution is particularly advisable when the **ACCU** pump is used in critical applications or applications that extend over weekends and off-hours.

3.0 Back Panel: *Interface Options & Remote Control of ACCU Pump*

The back panel of the ACCU pump consists of a power inlet receptacle, a slider switch which allows you to select 0-5VDC or 4-20mA analog input signal and a Female DB15 connector labeled **“External Interface”.** This “External Interface” allows you access to number of different remote control capabilities:

1. **RS-232 serial port,** DB15 connector, **pin 2 (Transmit), pin 3 (Receive)** & **pin 5 (Ground)**, allows PC control of your ACCU pump. For single pump control, use Serial Interface Cable (P/N: 080-083). For control of multiple (daisy-chain) ACCU pumps, use PC Connector Kit (P/N: 080-084) and ACCU Serial Connector Kit (P/N: 080-085. One(1) ACCU Serial Connector Kit is required for **each** ACCU in the Daisy-chain. You must select **“Local”** from the ACCU front panel before implementing serial communication between your PC and the ACCU pump. Consult section 3.1of this manual, **“ACCU Serial Communication Protocol”**, section 3.2, **“HyperTerminal Settings”** as well as section 3.3 **“ACCU Daisy-chain:”**

2. **4-20mA analog input signal**, DB15 connector, **pin 6 & pin 13**, with the selection switch (back panel) at the “4-20mA” position; allows proportional pump speed control by an external device, i.e. compositional analyzer. For example, a 12mA input signal received by the ACCU will generate a 50% pump speed, whereas a 20mA input signal will generate a 99% (max.) pump speed. You must select **“Remote”** from the ACCU front panel before implementing proportional pump control. Use Analog Cable (P/N: 080-081) for interfacing the ACCU pump to an external control device capable of generating a 4-20mA analog signal.

3. **0-5 VDC analog input signal,** DB15 connector, **pin 6 & pin 13**, with the selection switch at the “ 0-5 VDC” position; allows proportional pump speed control by an external device, i.e. pH transmitter. For example, a 2.5 VDC input signal received by the ACCU will generate a 50% pump speed, whereas a 5.0 VDC input signal will generate a 99% (max.) pump speed. You must select **“Remote”** from the ACCU front panel before implementing proportional pump control. Use Analog Cable (P/N: 080-081) for interfacing the ACCU pump to an external control device capable of generating 0-5 VDC analog signal.

4. **Pump Speed output signal:** When the ACCU pump motor is running, a pulsed output is provided between **pin 9** (signal) and **pin 7** (ground) of the DB15 connector located at the ACCU back panel. The pulse rate is proportional to pump speed, ~5940 pulses/sec at 99% pump speed, ~3000 pulses/sec at 50% pump speed.

5. **Remote Start/Stop**, *momentary* contact closure (i.e. foot switch) between **pin 8** & **pin 15** of the DB 15 connector labeled “External Interface”. Use ACCU foot switch (P/N: 080-080) or use Analog Cable Kit (P/N: 080-081) to make your own control cable.

3.1 ACCU Serial Communications Protocol:

Multiple ACCU pumps can be controlled (see section 3.2 **"HyperTerminal Settings")** from a PC via the **"External Interface"** ; **pin 2 (Transmit), pin 3 (Receive)** and **pin 5 (Ground)** are used to set up serial communication between your PC and the ACCU pumps on the Daisy-chain. Up to 32 SciLog pumps can be daisy-chained together and controlled from a single PC with a special cable. **RS-232 cables and connectors for establishing single (P/N: 080-083) or multi-pump (P/N: 080-091 & P/N: 080-092) communications are available from SciLog. Contact SciLog if you have need to daisy-chain more than 3 units.**

The ACCU pumps can be remotely controlled with a fixed command set. All commands are preceded by a carriage return and a pump identifier made up of the letter "**P**" followed by a number **0** to **31**.The number indicates the pump address. Valid commands for serial pump control are:

- *** N** — **Turns pump on**
  Example: **P1N** turns pump 1 on

- *** F** — **Turns pump off**
  Example: **P3F** turns pump 3 off

- *** D** — **Sets pump direction**
  Example: P2D0 sets the direction of pump to clockwise. The value after the "D" command defines the direction (**0 = CW; 1 = CCW**)

- *** S** — **Sets pump speed**
  Example: P7S0500 sets the speed of pump 7 to 50%. The 4 digits following the '**S**' command defines the speed.

- *** Z** — **Assigns pump addresses,** auto-address feature
  Example: By sending the command Z1 to the first pump, a pump address P1 is assigned that pump. In multi-pump applications, the pump P1 automatically sends the command Z2 to the second pump in the chain thereby assigning pump address P2 to the second pump. The last pump in the chain echoes the last Z-command, incremented by one , back to the PC

NOTE: **Make sure that all ACCUs in the Daisy-chain are in the "<u>Local</u>" setting. After installing the RS-232 (daisy-chain) cable and implementing the PC Terminal Settings, type "Z1" from your PC keyboard, you now have assigned all pump addresses.**

3.2 PC HyperTerminal Settings:

*The following HyperTerminal setting procedure is intended for PCs with **Window 95/98** software installation: Press the Window 95/98 **START** key in the lower left corner of your screen, select **"Program"** then select and open **"Accessories",** select **"HyperTerminal",** double-click at the HyperTerminal icon.*

1. From the **"Connection Description"** screen, select an icon and enter a file name, i.e. ACCU. **Press "Ok"**

2. From the **"Phone Number"** screen, select **"Direct to Com 2"** in the box labeled "Connect Using", alternatively, select any other available Com Port. **Press "Ok"**

3. From the **"Com 2 Property"** screen, select the following "Port Setting" parameters

Bits per Second:	9600
Data Bits:	8
Parity:	None
Stop Bits:	2
Flow Control:	None

   Press "Ok"

4. Go to **"File"** and open **"Properties",** from the **"ACCU Property"** screen, select the **"Setting"** screen, enter the following:

Terminal Keys:	Select
Emulation:	Auto Detect
Backscroll Buffer:	500

5. While still in the **"Setting"** screen, press **"ASCII Setup"** key & select the following from the "**ASCII Setup"** screen.

Send Line Ends with Line Feed:	Select
Echo Typed Characters Locally:	Select
Line Delay	0 msec.
Character Delay:	0 msec
Append Line Feeds........:	No Selection
Force Incoming...............:	No Selection
Wrap Lines That Exceed .....:	Select

Press "Ok" at the bottom of the "ACCU Setup" screen.
Press "Ok" at the bottom of the "ACCU Property Setting" screen

Appendix "A"

TANDEM Peristaltic Pump Head
Installation & Maintenance

TANDEM™ *Dual Channel Peristaltic Pump Head:*

The TANDEM peristaltic pump head is specifically designed for use with the ACCU system. The TANDEM pump heads (models 1082 & 1081) will provide you with rugged reliability as long as common sense maintenance and good quality pump tubing are used.

For continuous, heavy duty metering applications, the TANDEM 1082 (P/N: 080-1082) together with either #24 or #15 (thick-walled, 0.093” tube wall-thickness) Silicone or PharMed pump tubing is recommended.

The TANDEM pump head is driven by either a 8 RPM, 160 RPM or 600RPM, high-torque motor. The ACCU pump motor is optically encoded and servo-controlled, thus the TANDEM pump head will maintain a constant output over a wide range of metering conditions.

However, when the pump head requires excessive torque because of pump tube failure or “freezing” of the pump head, then the ACCU control software will recognize this condition and go into a stand-by mode. The pump motor is turned off and the LED display will show **“OL”,** indicating a pump overload condition.

Before continuing with your pumping application, remove the defective pump head / tubing and either clean or replace with a functional pump head. This feature (PumpSense™) has been implemented by SciLog to protect your pump motor and electronics.

TANDEM Pump Head: *Installation:*

1. Identify the front and back of the TANDEM. Two 8-32 mounting cap screws, as well as the pump shaft tang extend from the back of the TANDEM pump head.
2. Facing the front of the TANDEM, open the pump head by moving the black loading lever 180° to the left. The upper and lower pump shoe will move in opposite directions, thereby exposing the inside of the upper and lower pump shoe channels.
3. With the TANDEM pump head completely opened, locate the mounting holes for the two 8-32 cap screws inside the <u>lower</u> pump channel.
4. On the front panel of the ACCU, locate the mounting holes and the slotted pump head coupler.
5. Before fastening the TANDEM, align the two mounting screws and pump shaft tang of the TANDEM with the holes and slotted coupler of the ACCU front panel mounting plate.
6. Make sure the TANDEM pump shaft tang is properly seated in the mating slot of the pump head coupler, before fastening the TANDEM to the front panel of the ACCU.

TANDEM™ *Peristaltic Pump Tubing / Rate Selection:*

For most sterile, liquid metering applications above 10.00 ml/min., the TANDEM 1082 together with thick-walled (0.093”), #24 pump tubing is the most useful pump head/tube combination.

For metering applications in the 2.5 to 10 m/min. range, the TANDEM 1082 together with #15 thick-walled-walled (0.093”) pump tubing is the most useful pump head/tubing combination.

For metering applications requiring very low pump rates, the TANDEM 1081 together with #13 or #14 pump tubing is recommended. When used with an 8RPM motor, pump rates as low as 0.01 ml/min. can be achieved.

Note: Select the appropriate pump head, pump motor and pump tubing combination from the table below.

MasterFlex Tubing	13	14	16	25	17	18	15	24	35
Tubing ID*: in	0.03	0.06	0.12	0.19	0.25	0.31	0.19	0.25	0.31
Tubing OD*: in	0.16	0.19	0.25	0.31	0.38	0.44	0.38	0.44	0.50
Tubing Wall*: in	0.06	0.06	0.06	0.06	0.06	0.06	0.09	0.09	0.09
Pump Rate Range*:	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min	ml/min
CP-8 8RPM	0.03 - 0.45	0.10 -1.63	0.43 - 6.38	0.9 - 12.6	1.14 -18.3	1.7 - 24.3	0.5 - 13	0.65 - 20	N/R
CP-120 160RPM	0.5 - 10	1.7 - 35.2	6.3 - 129	12.5 - 283	18.5 - 405	24.7 - 554	9.6 - 240	14 - 412	N/R
CP-200 600RPM	2 - 34	8.6- 132	29 - 533	49 -974	70 - 1048	103 - 1515	59-993	85-1348	111 - 2258
* Nominal Values									
Pump Head Model:			**TANDEM 1081**				**TANDEM 1082**		

TANDEM™ *Pump Tube Installation:*

WARNING**: Do NOT mount or dismount the pump tubing while the ACCU is running.**

1. Open the TANDEM pump head by moving the black loading lever 180° to the left. If you are going to use the upper pump channel, slip the tubing into the upper channel; this is over the pump roller cage. If the lower pump channel is used, feed the tubing through the lower channel; this is under the pump roller cage.

NOTE: When using both upper and lower pump channels simultaneously, the same type of tubing should be used in each channel.

2. Lock the tubing in place by pushing the loading lever 180° to the right. The tube retainer spring will automatically place the correct tension on the pump tubing to prevent tube “walking”.
3. With the TANDEM pump head closed, lightly pull the two ends of the tubing in opposite directions and away from the pump head. This pulling action insures that the pump tubing is taut and within the pump channel.

TANDEM™ *Pump Tube Replacement:*

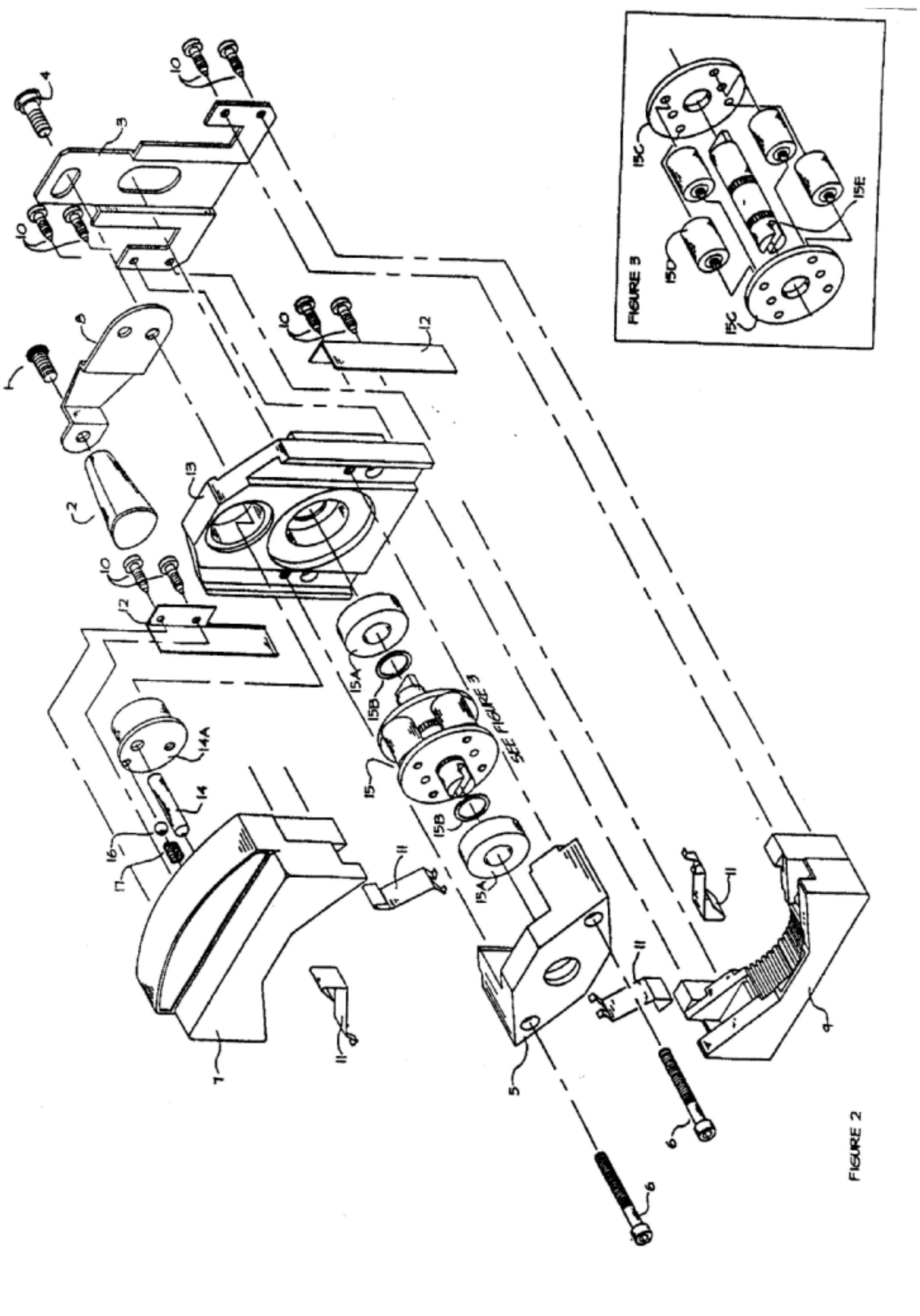
The pump tubing section located in the TANDEM pump head should be advanced at regular time intervals, if the ACCU is heavily used. Only use high-quality SciLog or Masterflex™pump tubing.

WARNING: *When advancing pump tubing, the* ***used pump tube section must be moved to the pump discharge side, i.e. dispensing side.*** *The used pump tube section is weakened and tends to collapse when placed on the suction side of TANDEM pump head.*

TANDEM™: *Pump Tubing / Chemical Compatibility*

Selecting the right pump tube material is crucial to ensure high pump performance. Consider all aspects of your application when choosing your pump tube material: chemical compatibility of the fluid and tubing, operating temperature and pressure as well as cleaning / sterilization requirements. Use the information listed in the Tubing Selection Guide (see section 4.6) to help you in your decision making.

TANDEM™ Dual Channel Peristaltic Pump: *Parts Identification*



TANDEM™ Parts List: Contact SciLog Inc (1-800- 955-1993) to order replacement parts, mention model and serial number of pump head (either TANDEM 1081 or TANDEM 1082) on which the part will be used.

Item	**SciLog P/N**	**Description:**
1	500-330	Pump Lever Stud (1)
2	500-320	Pump Lever Knob (1)
3	500-240	Plate, Lower Cam (1)
4	500-210	Cam, Lower Pump Shoe (1)
5	500-410	Bearing Block, Front (1)
6	500-411	Bearing Block Cap Screw (2)
7	500-420	Pump Shoe, Upper (1)
8	500-310	Lever, Pump (1)
9	500-430	Pump Shoe, Lower (1)
10	500-452	Pump Shoe Screw (8)
11	500-440	Tube Holding Fork (4)
12	500-451	Pump Shoe Bracket (1)
13	500-450	Pump Base (1)
14	500-220	Cam, Upper Pump Shoe (1)
14A	500-230	Cam Shaft/Cylinder (1)
15 (Fig. 3)	500-100	Assembly, Roller Housing, 1081
	500-110	Assembly, Roller Housing, 1082
16	500-250	Cam Shaft, Ball (1)
17	500-260	Cam Shaft, Spring (1)
18	500-412	Pump Body Inserts (2)

Appendix “B”

Magnetic Gear Pump Head Installation & Maintenance

Magnetic Gear Pump Head: *General*

The ACCU MP-30 comes with a Magnetic Gear Pump Head (Micropump Inc.) and is recommended for metering applications requiring pulse-free flow. The Micropump heads are external type gear pumps which produces such pulse-less flow. The spur gears rotate and intermesh inside the pumping chamber, thereby creating a pressure differential between the inlet and outlet of the pump.

NOTE: *An in-line check valve (P/N: 400-530) must be installed on the discharge side of Micropump head in order to avoid back-siphoning of solution between metering or dispensing cycles.* ***Make sure that the discharge port is located <u>above</u> the solution reservoir level.***

WARNING: *The rotating gears of magnetic gear pump heads generate significant shear, thus shear-sensitive solutions, i.e. enzyme or protein preps, should be metered/dispensed with the TANDEM peristaltic pump.*

Only clean fluids, without particulates or abrasives should be dispensed with magnetic gear pump heads. Any particulates or abrasives will rapidly wear down the rotating gears and will decrease pumping capacity. A gear replacement kit is available from SciLog.

WARNING: *Avoid metering of liquids with a viscosity greater than 1000 centipoise; such high viscosity can cause magnetic de-coupling. Reduce the ACCU MP-30 pump speed when metering/dispensing fluids with viscosity greater then 300 centipoise.*

Magnetic decoupling occurs when the torque limit of the driving magnet has been exceeded. Once de-coupling occurs, the driving magnet (this is the magnet fastened to the motor shaft) turns by itself while the driven magnet (inside the pump head) is motionless. Magnetic coupling can be restored by simply stopping the pump, the two magnets will automatically re-align and re-couple.

WARNING: *When your metering/dispensing task is completed, flush distilled water through the pump head for approximately two(2) minutes or until the water appears clear.* ***Do <u>not</u> leave your solution in the pump head when shutting down the ACCU Pump for an extended period of time.***

Micropump Heads: *Installation*

Plumbing: Restrictions in the inlet and discharge lines may cause a loss of pump performance. A restriction can be a valve (some are more restricting than others), small diameter tubing, long length of tubing, and even elbows and sharp turns in the line. It is important to avoid or limit these restrictions whenever possible.

Filtration: damage may occur to the pump head if the fluid being pumped has suspended solids that are abrasive. To prevent this from happening, some type of filter or strainer should be installed. Centrifugal pumps should have a minimum 50 micron mesh filter installed on the inlet. Recommendation for all gear pump is a 5 to 20 micron (depending on the application) rated filter. If the system is a closed recirculating system, place the filter on the discharge side of the pump at the reservoir. It should be noted that filters are restrictions and may affect pump performance. All strainers and filters should have large surface areas to prevent excessive pressure drop.

Fitting Installation: Whether installing hose or pipe fittings, a pipe sealing compound or Teflon tape should be applied to the threads to prevent leakage. Apply sealant or tape sparingly to prevent excess material from dislodging and clogging pump. Two wraps of Teflon tape are sufficient. One quarter turn past finger-tight is usually sufficient to seal the fittings; do not over tighten; one and one half turns past finger-tight is maximum engagement.

Pump Location / Position: All gear pumps should be located with inlet below or as close as possible to the fluid level of the fluid supply.
Centrifugal pumps must be primed before operation; therefore, locating centrifugal pumps below the fluid level will facilitate the flooded pump inlet condition required for priming.
Micropump gear pumps have self-priming capabilities. The ability to self-prime is dependent on the fluid being pumped, your operating system conditions, and the pump model being used. The self-priming capabilities of all gear pumps is greatly increased when the gears are wet.

Micropump Operation:

Magnetic Decoupling: The magnetic attraction that enables the *driving* magnet to turn the *driven* magnet has a torque limit. Magnetic decoupling occurs when the torque limit is exceeded. The two magnets are forced out of their pole to pole alignment and are decoupled. Once decoupling occurs, the driving magnet (which is fastened to the motor shaft) turns by itself with the motor speed increasing to no-load speed, while the driven magnet (and the pumping parts it is connected to) remains motionless.
Decoupling is an inherent feature of magnetic couplings, does NOT indicate a pump failure, and should only occur when the magnet coupling torque limit has been exceeded. Decoupling may often act as a safety feature, preventing inadvertent pump/motor overloads.

Each set of magnets has a torque limit. The point at which this torque limit is reached is called the decouple point. The strength of the magnet does not diminish with time; however, temperature extremes can raise or lower magnet strength and consequently the decouple point. Micropump performance curves show typical decouple points when pumping 70°F water; however, actual decouple points may vary with different fluids, temperatures, and system conditions. With some pump / motor combinations the motor may slow / stall or the flow may become blocked before the decouple point is reached.

Magnet decoupling will result in total non-performance of the pump while the motor appears to be operating normally; however, these exact same conditions may also appear when the magnet coupling is working properly. Due to the quiet, smooth, pulse-free operation of the gear pump, it is often difficult to detect (without disassembly of system and/or pump) when the magnetic coupling and pumping parts are functioning or when they are not. Therefore, it is important to note the possible causes of magnet decoupling:

1. Blockage or restriction in the discharge side of the system.
2. Discharge pressures exceeding the decouple point.
3. Fluid viscosity too high.
4. Foreign particles jamming pumping parts, i.e. gears.
5. Binding or stuck pumping parts. This may occur between pumping cycles as a result of dried residue from the fluid being pumped. Some fluid may require flushing, pump disassembling / cleaning, or simply allowing the fluid to stand in the pump head until residue is dissolved.
6. Centrifugal pumps may have problems with unrestricted, excessive flow rates.

Magnet Re-coupling: After determining that decoupling has occurred, the cause of decoupling must be determined and eliminated.

Once the two magnets decouple, they will not re-couple until the driving magnet is brought to a complete stop. Then the two magnets will automatically align and re-couple. Priming of the pump may also be necessary.

By-Pass Adjustment: Some Micropump gear pumps are equipped with an externally adjustable by-pass. This by-pass is an internal relief valve that permits recirculation of the working fluid when the pre-set pressure is reached. The pressure level at which the by-pass is activated can be adjusted in the field (from 10 psig or 0.7 bar to the maximum differential pressure capability of the pump) with no disassembly required.. The adjustment is made externally with a hex key and can be made while the pump is in operation.

WARNING: *Because the by-pass recirculates the fluid within the pump, heat can be produced as a result. The more fluid that is recirculated via the by-pass, the more heat is produced. At full by-pass the additional heat may result in the fluid in the fluid temperature exceeding the temperature limit of the particular pump head involved. Consequently, Micropump recommends that the pump not be run continuously at full by-pass.*

Dry Running: Dry running is harmful to all Micropump pumps. Although dry running for a short interval (such as when dry lifting to prime a gear pump) may not affect pump performance, extended periods of dry running may cause permanent damage.

Mixed Phase (Gas/Fluid): Micropump gear pump heads can easily handle mixed phase; however, the Series 100 centrifugal pump has difficulty passing gas bubbles and can lose its prime if the gas pocket is large enough. Therefore, you must be certain that air is not being drawn through the inlet.

Reverse Pressure: Series 220, 210, 200, and 180 pumps are pressure-loaded, suction shoe style pumps and cannot operate conventionally under reverse pressure conditions. *Reverse pressure occurs when the fluid pressure coming into the pump is greater than the fluid pressure on the discharge side of the pump*

Appendix “C”

FMI Piston Pump Head
Installation & Maintenance

6.0 Rotating Reciprocating Piston Pumps: *Overview*

What Is It?

A rotating, reciprocating piston pump is a valve-less, positive displacement pump.

How Does It Work?

In this type of pump, the piston simultaneously rotates and moves back and forth inside a cylinder; sucking in the fluid at the inlet, compressing the fluid and then releasing it at the outlet. Pumping rates for this type of pump are varied by either changing the pump motor speed or the length of the piston stroke.

What Is It Used for?

This type of pump is used to dispense small to moderate volumes of fluids with high precision and accuracy, typically 0.2%.

Advantages:

1. High precision even at low Volumes
2. Wetted parts made of inert Materials.
3. Pumps low and high viscosity Fluids
4. “Zero Dead Volume” pump construction.
5. Low and easy maintenance

Disadvantages:

1. Fluid is in contact with pump head.
2. Pump can not run dry for long time.
3. Must flush pump head before leaving pump idle.
4. Pulsating pump output.
5. Pump produces high fluid shear

FMI Pump Heads: *General Information*

The ACCU FM pump models use rotating, reciprocating piston pump heads of various sizes. In a reciprocating pump, the rotating piston moves to and fro inside a cylinder; sucking in fluid at the inlet while compressing and releasing the fluid at the outlet. Flow rates for reciprocating pumps are varied by changing either the **frequency (motor speed)** or the **stroke length**. The FMI pump heads are excellent for precise fluid metering.

The ACCU FM-Models are true metering pumps. They can handle pressures up to 100 psi (Exception: RH00STY and RH00CTC pump heads can handle up 20psi max.).The piston pump heads are appropriate for pumping of suspension, as well as corrosive/non-aqueous liquids and slurries, emulsions, thin solvents, aqueous solutions and non-abrasive semi-solids. The piston pump heads are capable of handling highly viscous fluids. You can easily pump fluids up to 2000 cps. When pumping fluids with a viscosity between 2000 and 10000 cps, you must be sure to apply pressure to the feed reservoir/line to avoid cavitation.

NOTE: *Piston pumps should not be used for pumping biological fluids or liquids containing biological cells or cellular components. Piston pumps generate high local shear in the fluid and produce strong mechanical agitation, which may destroy cells and fragment large molecular weight components, such as DNA or large protein molecules.*

FMI Pump Heads: *Construction / Motors / Pump Rates*

ACCU FM-10: Comes with a 160 RPM optically encoded, servo-controlled motor. The ACCU FM-10 has a FMI rotating, reciprocating piston pump head. Wetted parts: Ceramic piston and chamber with pump head ports either made out of Kynar or Tefzel. Exception: RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi

Pump Head Model:	**Max. RPM:**	**Pumping Range:**
RHOO, 0 – 0.025 ml/stroke	160RPM	0.022 – 4.0 ml/min.
RHO, 0 – 0.050 ml/stroke	160RPM	0.044 – 8.0ml/min.
RH1, 0 – 0.10 ml/stroke	160RPM	0.088 – 16.0 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (160RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 8 RPM (Stalling Speed)*

ACCU FM-20: Comes with a 600 RPM optically encoded, servo-controlled motor. The ACCU FM-20 has a FMI rotating, reciprocating piston pump head. Wetted parts: Ceramic piston and chamber with pump head ports either made out of Kynar or Tefzel. Exception: RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi

Pump Head Model:	**Max. RPM:**	**Pumping Range:**
RHOO, 0 – 0.025 ml/stroke	600 RPM	0.08 – 15.0 ml/min.
RHO, 0 – 0.050 ml/stroke	600 RPM	0.17 – 30.0 ml/min.

RH1, 0 – 0.10 ml/stroke	600 RPM	0.33 – 60.0 ml/min.

Note: *The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (600 RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 30 RPM (Stalling Speed)*

ACCU FM-40 Model: The ACCU FM-40 comes with a **450 RPM** optically encoded, servo-controlled motor and a FMI piston pump head. Materials of Construction: Pump head fittings are either made out of Kynar or Tefzel. Pump piston and body are made out of ceramic. **Exception:** RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi.

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	450RPM	0.06 – 11.2 ml/min.
RHO, 0 – 0.050 ml/stroke	450RPM	0.12 – 22.5 ml/min.
RH1, 0 – 0.10 ml/stroke	450RPM	0.24 – 45.0 ml/min.

Note: The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (450RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 22.5 RPM (Stalling Speed)

ACCU FM-50 Model: The ACCU FM-50 comes with a **3400 RPM**, optically encoded, servo-controlled motor and a FMI piston pump head. Materials of Construction: Pump head fittings are either made out of Kynar or Tefzel. Pump piston and body are made out of ceramic. **Exception:** RHOO pump head model has stainless steel (1/8"ID) piston. "LF" designation refers to a "Low Flow/Low Dead Volume" pump connection, utilizing ¼ - 28 HPLC fittings. All FMI piston pump heads have a maximum pressure rating of 100psi.

Pump Head Model:	Max. RPM:	Pumping Range:
RHOO, 0 – 0.025 ml/stroke	3400RPM	0.50 – 85.0 ml/min.
RHO, 0 – 0.050 ml/stroke	3400RPM	1.00 – 170 ml/min.
RH1, 0 – 0.10 ml/stroke	3400RPM	2.00 – 340 ml/min.

Note: The cited pumping ranges are based on the following assumptions: Maximum pump rate = (Max. Stroke Volume) x (3400RPM); with the stroke vernier setting at 450. Minimum pump rate = Maximum pump rate / 180; stroke vernier setting at 50 and pump motor speed at 170 RPM (Stalling Speed)

FMI Pump Heads: *Installation*

The following are directions to mount a FMI pump head on an ACCU controller. If you purchased the ACCU controller with a FMI pump head already mounted, you can disregard these directions. However, if you purchased your FMI pump head separately, you will need to mount the pump head. The same instructions should also be used when dismounting an old pump head which you may want to replace with a new one:

1. Disconnect the power cable from the ACCU.
2. Remove the two screws (6-32 x ½") from the **underside** of the ACCU. These hold the motor mounting plate in place.

3. Remove the four (6-32 x 3/8”) Philip screws from the face plate at the front of the ACCU.
4. Carefully remove the pump / motor subassembly from the ACCU controller. Disconnect the motor cable (cable connecting the motor to the electronic board) before completely removing the pump / motor assembly from the ACCU controller.
5. Mate the FMI pump head shaft to the flexible pump motor coupling. Fasten the shaft to the coupling (the set screw on the coupling requires a 3/32 hex bit).
6. Fasten the FMI pump head with two screws (8-32 x ½”) to the back of
7. Reconnect the pump motor cable and carefully place the pump / motor assembly back into the ACCU controller.
8. Fasten the motor mounting plate to the underside of the ACCU with the two screws removed in Step 2.
9. Fasten the face plate of the pump/motor assembly to the chassis with the four screws removed in Step 3.
10. Test the ACCU with the FMI pump head in place. Make fluid connections to the pump head. Do not let the pump head run dry without fluid for any prolonged period of time.

FMI Pump Heads: *Stroke Volume Adjustment*

The knurled Adjustment Ring (black decal with markings) on the FMI pump head controls the stroke length and thus controls the output per pump stroke. The Adjustment Ring is factory set at “200,” however, by turning the Adjustment Ring clock-wise, the stroke length and the pump output are reduced. However, it is not recommended to turn the Adjustment Nut below “50”. When turning the Adjustment Nut counter clock-wise from “50” to “450”, the maximum stroke length / volume is obtained. Do not turn the Adjustment Nut above the “450” setting. The maximum stroke volume for the RHOO pump head is 25μl, for the RHO pump head the stroke volume is 50μl while the RH1 pump head has a maximum stroke vole of 100μl.

NOTE: Each graduation on the knurled Adjustment Ring (black decal with markings) represent an adjustment of 1/450th of the maximum stroke volume: 0.055 μl for the RHOO, 0.111 μl for the RHO, 0.222 μl for the RH1 pump head.

FMI Pump Heads: *Connectors and Tubing Selection*

For the ACCU FM-40 and FM-50 with ¼" inlet and outlet ports, use ¼" OD Tubing.
For the ACCU FM-40 with "LF" (Low Flow/Low Dead Volume) ports, use ¼-28 HPLC ferrules & nuts, 1/8"OD x 1/16 ID or 1/16 OD x 1/32 ID Teflon tubing.

FMI Pump Heads: *Operating Tips*

Use Clean Fluids: Abrasives in the pump fluid may damage cylinder and piston surfaces and should therefore be avoided.

Compatible Fluids: Pump only fluids compatible with materials of construction of your pump head.

Wet Operation: The pump fluid provides surface cooling and lubrication to the piston and cylinder of your FMI pump head. Therefore avoid dry pump operation

Pressure: Do not operate the pump against pressure in excess of design specifications (100psi maximum.). Drive pin on piston may bend or break under overload and irreparable damage may result.

FMI Pump Heads: *Cleaning*

Cleaning of Pump Head: Routine flushing with solvent <u>**before**</u> shutdown will suffice for most applications. Set the ACCU for maximum pump speed, let the pump run until solvent appears clear at discharge port. This should be for a minimum of 2 minutes. **Do not leave material in the pump head overnight. Preventive maintenance is very valuable and ensures a long operational pump life.**
CAUTION: ***Ceramic piston / cylinder sets are sensitive to neglect and may "freeze" if allowed to dry out without adequate cleansing.*** Fill a loop of flexible tubing with fluid that will thin or neutralize the last fluid pumped. Then connect one end of the tube to the pump suction port, the other to the discharge port. With the loop positioned above the pump head, the ceramic surfaces and seal areas stay moist and mobile for extended idle periods.
However, if a piston freezes in the cylinder, **Do Not Force It Free!** Be gentle. Try to remove the pump head from the base assembly so the whole pump head can be soaked in a suitable solvent. If the head is not conveniently removable, the tube loop discussed in the previous paragraph may permit solvent to dissolve the "frozen" residue in reasonable time.

FMI Pump Head: *Chemical Compatibility*

FMI pump heads are well known for their robustness and overall chemical compatibility with many process fluids. The materials used in manufacturing FMI pump heads are inert to most chemicals, however, the following exceptions must be observed:

1. When pumping: ***Toluene, Methylethylketone, Acetone, Methanol, Ethanol, Hexyl Alcohol, Isobutyl Alcohol*** *or* ***Isopropyl Alcohol,*** FMI pump heads with **Tefzel (ETFE)** housings must be used: **<u>RH1-CTC</u>**; **<u>RHO-CTC</u>**; **<u>RHOO-CTC</u>.** the "T" in CTC designates Tefzel housing.
2. **Tefzel** has also excellent chemical resistance to most **acids, bases** or **solvents.**
3. **Tefzel** pump heads can be used in pump applications ***<u>not</u>*** exceeding 90°F and 100psi.
4. For pump applications involving fluids ***<u>above</u>*** 90°F, FMI pump heads with **Kynar (PVDF)** housings must be used: **<u>RH1-CKC</u>**, **<u>RHO-CKC</u>**, or **RHOO-CKC,** the "K" in CKC stands for Kynar.
5. **Kynar** has good chemical resistance to most fluids, however**,** Kynar pump heads **must not be used** with ***<u>Acetone</u>, <u>Ketones</u>*** or ***<u>Esters.</u>***

FMI Pump Heads: *Viscosity Effects*

The ACCU FM-40 is capable of pumping high viscosity fluids. *When pumping high viscosity liquids, you should always use large bore tubing (1/4" OD), slow pump rates and large stroke volumes (set knurled Adjustment Ring to "400") in order to avoid pump cavitation.*

The ACCU FM-40 together with either a RHO or RH1 pump head, can handle fluid viscosities up to 2000 cps, and fluid viscosities up to 10000 cps when the fluid reservoir and feed line connected to the pump inlet port are pressurized.