SYRIXUS®

Syringe Pumps

Installation and Operation Guide

TELEDYNE ISCO
Everywhereyoulook™

Part #69-1263-358

Rev. F December 2023

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne ISCO recommends that you read this manual completely before placing the equipment in service.

Although Teledyne ISCO designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If a problem persists, call or e-mail Teledyne ISCO technical support for assistance. Refer to Section 9.3 "Technical Customer Service Department". Simple difficulties can often be diagnosed over the phone. For faster service, please have your serial number ready.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by technical support, including the use of the Return Material Authorization (RMA) specified. Be sure to include a note describing the malfunction. This will aid in the prompt repair and return of the equipment.

Teledyne ISCO welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne ISCO is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service		
Phone (USA, Canada, Mexico):	(800) 228-4373	
Phone (Outside North America):	(402) 464-0231	
Fax:	(402) 465-3022	
Email:	isco.orders@teledyne.com	
Technical Support		
Phone (Toll Free):	(800) 775-2965	Syringe Pumps & Liquid Chromatography
Email:	IscoService@teledyne.com	
Return Equipment and Other Correspondence		
Mail:	4700 Superior Street, Lincoln, NE 68504-1398	

Warranty and Operation Manuals can be found on our website at: www.teledyneisco.com

Warnings and Cautions

The lightning flash and arrowhead within the triangle is a warning sign alerting you to "dangerous voltage" inside the product.

The exclamation point within the triangle is a warning sign alerting you to important instructions in this manual.

Symboles de Sécurité

Ce symbole signale la présence d'un danger d'électrocution.

Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.

Warnungen und Vorsichtshinweise

Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sie vor „gefährlichen Spannungen" im Inneren des Produkts warnt.

Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.

Advertencias y Precauciones

Esta señal alerta sobre la presencia de alto voltaje en el interior del producto.

Esta señal le advierte sobre la importancia de las instrucciones del manual que acompañan a este producto.

General Product Warnings and Cautions

	**“To prevent damaging the instrument or injuring yourself, it is absolutely necessary that you understand everything in English, above all, technical terms, before operating the instrument. Otherwise, it is necessary for you to receive complete instruction from someone qualified who understands both the instrument and English very well.”**
	**“Um eine Beschädigung des Gerätes oder eine Gefährdung des Anwenders zu vermeiden ist es notwendig, daß dieser vollstandig die englische Sprache und die technischen Bezeichnungen beherrscht. Oder der Anwender muß von einer Person eingeübt werden, die bereits vorher dieses Gerät bedienst hat.”**
	**“Pour empêcher dommage à l’instrument ou blesser vous-même, il faut absolument que vous compreniez tout en anglais, surtout les termes techniques, avant d’actionner l’instrument. Autrement, il faut que vous receviez l’instruction parfaite d’une personne très compétente qui comprend bien les deux l’instrument et anglais.”**
	**“Para prevenir cualquier daño en el instrumento o en el operador, es necesario que el usuario comprenda perfectamente el lenguaje inglés y las términos técnicos intrínsecos, o bien ser formado por una persona que haya trabajado ya previamente con este instrumento.”**

	**“For a forhindre skade på instrumentet eller operatøren er det nødvendig at brukeren har full forståelse for det engelske sprak og tekniske uttrykk Ellers må brukeren få opplæring av en person, som kan engelsk, for instrumentet tas i bruk.”**
	**“För att förhindra skade på instrumentet eller operatören, år det nötvändigt att användaren har fullständiga kunskaper i det engelska språket och dess tekniska termer, eller utbildas av en person, som tidigare brukat instrumentet.”**
	**“For at undgå skade på produktet eller på brugeren er det nødvendigt at brugeren til fulde forstår det engelske sprog for at forstå den tekniske formulering i den engelske manual. I modsat fald skal brugeren modtage træning, inden apparatet tages I drift.”**
	**Laitteelle tai käyttäjälle aiheutuvien vahinkojen välttämiseksi on tärkeää, että käyttäjä hallitsee englannin kielen ja englantilaiset tekniset termit tai on saanut käyttöopastuksen englantia osaavalta henkilöltä.**
	**“Per evitare danni allo struménto od incidenti all’operatore, é necessario che l’utilizzatore abbia una completa conoscensza della lingua inglese oppure che venga istruita da una persona che abbia utilizzato precedentemente questo strumento.”**
	**“Para impedir qualquer dano no aparelho ou ferimentos parao operador, é necessario que o utilizador tenha um conhecimento completo da lingua inglesa e dos respectivos termos técnicos, ou seja, treinado por uma pessoa que tenha esse conhecimento, antes de operar com este aparelho.”**
	“Για την αποφυγη βλαβης του οργανου ‘η τραυματισμου του χρηστη, ειναι απαραιτητο ο χρηστης να γνωριζει καλα την αγγλικα γλωσσα καθως και τους σχετικους τεχνικους ορους, η να εκπαιδευτει απο ατομο το οποιο εχει προν φουμενως εργαστει πανω στο οργανο αυτο.”
	**С цел да избегне повреда на апаратурата или нараняване на оператора е необходимо клиента добре да владее английски език и техническата терминолгия, която е използувана в описанието или да бъде обучен от лице, което е вече работило с такъв апарат.**
	**Figyelmeztetés! A készülék meghibásodásának valamint a kezelö sérülésének megelözése érdekében a felhasználónak feltétlenül értenie kell az angol nyelvet, ezen belül a müszaki kifejezéseket, vagy pedig a használatba vételt megelözöen a készülék kezelésében már gyakarlott személy által történö betanitás szükséges!**

EXPLOSION WARNING

WARNING

Teledyne ISCO SyriXus syringe pumps are NOT EXPLOSION PROOF.

Teledyne ISCO SyriXus Syringe Pump Safety Note When Using a Flammable Fluid

The Teledyne ISCO syringe pumps must be placed within a properly operating vent hood (fume cupboard), when using any flammable liquid at elevated temperatures, or ethane or any other flammable gas. Ensure that all fluid handling connections are completely free of any gas leaks by performing the leak test using CO_2 (for leak test procedures, refer to Technical Bulletin TB05 Field Verification Procedures which can be found at https://www.teledyneisco.com/pumps/technical-bulletins). There must absolutely be **NO** gas leaks present before introducing the flammable vapor. The flow rate, as registered by the pump, should settle to a value below 0.01 mL/min after 15 minutes during a static extraction in a temperature stable, leak-free system.

Important: When using flammable fluids with the Teledyne ISCO SyriXus syringe pumps, ensure that proper safety precautions are followed, and that adequate ventilation is always provided around the pump.

The Teledyne ISCO SyriXus syringe pumps use brush-type drive motors. Minor modifications to the pumps may render them safer, especially in the rare event of catastrophic piston seal failure. **However, these modifications will not make these pumps explosion proof.**

Remove the front and back cylinder covers located on the ball screw tower. This will allow any escaped gas to quickly dissipate away from the pump cylinder area and to reduce the amount entering the motor compartment.

Seal the syringe pump motor compartment with tape and purge the pump lower cabinet with a continuous flow of nitrogen (N_2) gas. This will also reduce the possibility of accumulating an explosive mixture around the motor and relays.

For further information, consult the Teledyne ISCO Customer Service Department using the contact information in Section 9.3 "Technical Customer Service Department".

ATTENTION: Teledyne ISCO does not recommend or support the use of the SyriXus syringe pumps with any flammable gas.

USE THE Teledyne ISCO SyriXus SYRINGE PUMPS IN THESE POTENTIALLY HAZARDOUS APPLICATIONS AT YOUR OWN RISK!

AVERTISSEMENT

Les pompes SyriXus Teledyne ISCO ne sont pas antidéflagrantes.

Note de sécurité sur les pompes seringues SyriXus Teledyne ISCO lors de l'utilisation d'un liquide inflammable

Les pompes seringues Teledyne ISCO doivent être placées dans une hotte ventilée (sorbonne) fonctionnant correctement, lors de l'utilisation de tout liquide inflammable à des températures élevées, ou d'éthane ou de tout autre gaz inflammable. Assurez-vous que toutes les connectiques sont complètement exemptes de toute fuite de gaz en effectuant le test de fuite à l'aide de CO_2 (Cette méthode est détaillée dans le bulletin technique TB05 Field Verification Procedures que vous pouvez trouver sur le lien https://www.teledyneisco.com/pumps/technical-bulletins). Il faut absolument qu'il n'y ait AUCUNE fuite de gaz avant d'introduire le gaz inflammable. À partir d'un système à température stable et sans aucune fuite de gaz, le débit, tel qu'enregistré par la pompe, doit se stabiliser à une valeur inférieure à 0,01 ml/min après 15 minutes lors d'une extraction statique.

Important: Lors de l'utilisation de fluides inflammables avec les pompes seringues SyriXus Teledyne ISCO, assurez-vous que les bonnes précautions de sécurité sont prises et qu'une ventilation adéquate est toujours assurée autour de la pompe.

Les pompes seringues de la SyriXus Teledyne ISCO utilisent des moteurs à charbon. Des modifications mineures apportées aux pompes peuvent les rendre plus sûres, en particulier dans les rares cas de défaillance catastrophique du joint de piston. Cependant, ces modifications ne rendront pas ces pompes antidéflagrantes.

Retirez les couvercles du cylindre avant et arrière situés autour de la vis sans fin à billes. Cela permettra à tout gaz échappé de se dissiper rapidement de la zone du cylindre de la pompe et de réduire la quantité entrant dans le compartiment moteur.

Scellez le compartiment moteur de la pompe seringue avec du ruban adhésif et purgez la partie inférieure de la pompe avec un flux continu d'azote (N2). Cela réduira également la possibilité d'accumuler un mélange explosif autour du moteur et des cartes électroniques.

Pour toute information supplémentaire, consulter le Service Clients de Teledyne ISCO en utilisant les informations données dans le chapitre 9.3 "Service Clients".

Pour l'information supplémentaire, consulter le département de service technique 9.3 "Technical Customer Service Department"**.**

ATTENTION : Teledyne ISCO ne recommande ni ne prend en charge l'utilisation des pompes seringues SyriXus avec des gaz inflammables.

UTILISER LES POMPES SERINGUES Teledyne ISCO SyriXus DANS CES APPLICATIONS POTENTIELLEMENT DANGEREUSES EST À VOS PROPRES RISQUES !

Supercritical Fluid Extraction Laboratory Staff - Warning to Users

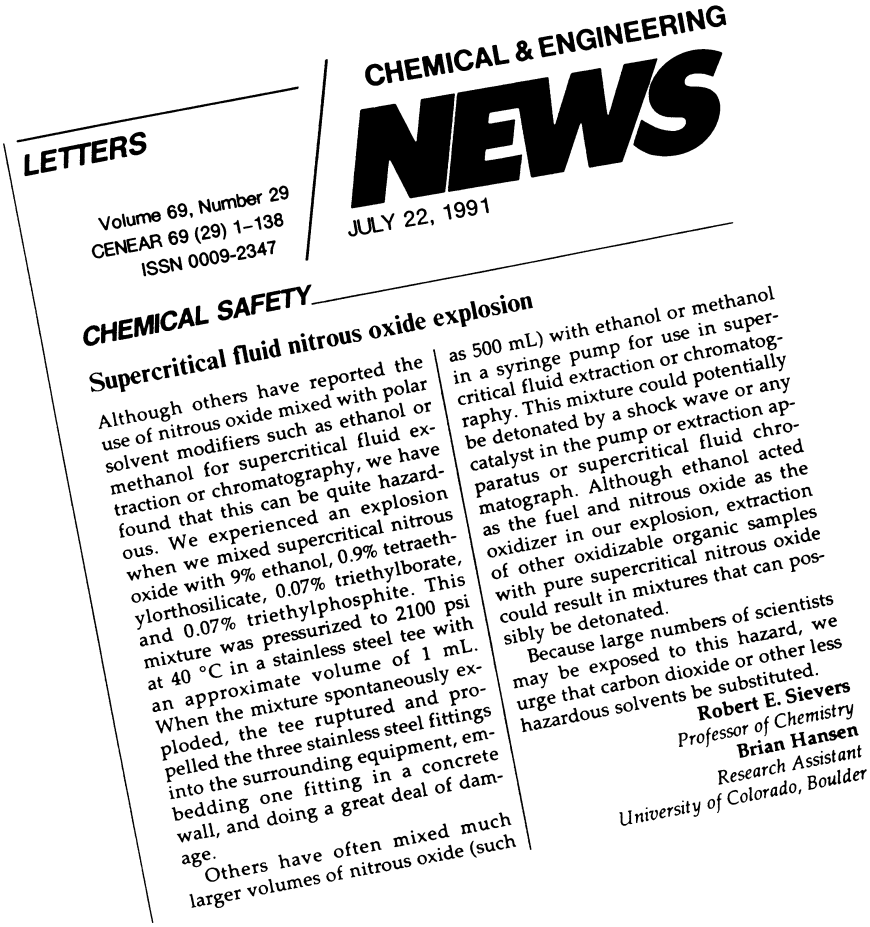
WARNING: PLEASE READ

At the request of our Supercritical Fluid Extraction laboratory staff, we want our customers to be aware of the potential hazards involved with supercritical fluid extraction.

Oxidizing gases, such as nitrous oxide, in contact with organic matrices or flammable modifiers, can detonate under certain conditions. Likewise, flammable fluids, such as methane, under high pressure conditions can present a hazard.

With concern for the safety of our customers, we have designed our equipment to be as safe as possible. However, we do not recommend the use of our instrument with potentially explosive reactions.

The letter below, which appeared in the July 22, 1991 edition of Chemical and Engineering News, is reprinted with permission from Professor Robert E. Sievers and his colleagues at the University of Colorado at Boulder. Even though they were not performing supercritical fluid extraction, it details the problems their lab experienced using nitrous oxide under similar conditions. We add our support for their suggestion to use only carbon dioxide or other less hazardous fluids for supercritical fluid extraction.



LETTERS

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CHEMICAL & ENGINEERING NEWS

JULY 22, 1991

CHEMICAL SAFETY

Supercritical fluid nitrous oxide explosion

Although others have reported the use of nitrous oxide mixed with polar solvent modifiers such as ethanol or methanol for supercritical fluid extraction or chromatography, we have found that this can be quite hazardous. We experienced an explosion when we mixed supercritical nitrous oxide with 9% ethanol, 0.9% tetraethylorthosilicate, 0.07% triethylborate, and 0.07% triethylphosphite. This mixture was pressurized to 2100 psi at 40 °C in a stainless steel tee with an approximate volume of 1 mL. When the mixture spontaneously exploded, the tee ruptured and propelled the three stainless steel fittings into the surrounding equipment, embedding one fitting in a concrete wall, and doing a great deal of damage.

Others have often mixed much larger volumes of nitrous oxide (such as 500 mL) with ethanol or methanol in a syringe pump for use in supercritical fluid extraction or chromatography. This mixture could potentially be detonated by a shock wave or any catalyst in the pump or extraction apparatus or supercritical fluid chromatograph. Although ethanol acted as the fuel and nitrous oxide as the oxidizer in our explosion, extraction of other oxidizable organic samples with pure supercritical nitrous oxide could result in mixtures that can possibly be detonated.

Because large numbers of scientists may be exposed to this hazard, we urge that carbon dioxide or other less hazardous solvents be substituted.

Robert E. Sievers
Professor of Chemistry
Brian Hansen
Research Assistant
University of Colorado, Boulder

Instrument Use Warnings and Cautions

	**CAUTION:** **Avoid spills! Liquids associated with this instrument may be classified as carcinogenic, biohazardous, flammable, or radioactive. Should these liquids be used, it is highly recommended that this application be accomplished in an isolated environment designed for these types of materials in accordance with federal state and local regulatory laws and in compliance with your organization's chemical/hygiene plan in the event of a spill.** **In all cases, when using Teledyne ISCO instrumentation, prudence and common sense must be used.**
	**WARNING:** **Pinch point. This symbol warns you that your fingers or hands will sustain serious injury if you place them between the moving parts of the mechanism near this symbol.**
	**WARNING:** **Avoid hazardous practices! If you use this instrument in any way not specified in this manual, the protection provided by the instrument may be impaired; this will increase your risk of injury.**
	**CAUTION:** **Liquids associated with this instrument may be classified as carcinogenic, biohazardous, flammable, or radioactive. Should these liquids be used, it is highly recommended that this application be accomplished in an isolated environment designed for these types of materials, in accordance with federal, state, and local regulatory laws, and in compliance with your company's chemical/hygiene plan in the event of a spill.** **In all cases, when using Teledyne ISCO instrumentation, prudence and common sense must be used.**
	**WARNING:** **Team lift. To reduce the risk of injury do not attempt to lift this instrument independently. It is highly recommended that a team be used when lifting this instrument.**
	**AVIS:** **Éviter de répandre! Les liquides qui sont pompés dans cet instrument peuvent être cancérigènes, hasards biologiques, inflammables, ou radioactifs. Si vous devez utiliser ces liquides hasardeux, il est très recommandé que vous le faites à l'intérieur d'un environnement isolé conçu pour tels liquides. Cet environnement isolé devrait être construit selon les règlements fédéraux, provinciaux, et locaux, aussi que le plan de votre organisation qui concerne l'évènement d'un accident avec les matières hasardeuses. En tout cas, utilisez toujours l'instrumentation d'Isco avec prudence et sens commun.**

	**ATTENTION:** **Risque de pincement. Ce symbole vous avertit que les mains ou les doigts recevront une blessure sérieuse si vous les mettez entre les éléments en mouvement du mécanisme près de ce symbole.**
	**ATTENTION:** **Éviter les usages hasardeux! Si vous utilisez cet instrument d'une manière autre que celles qui sont specifiées dans ce manuel, la protection fournie par l'instrument peut être affaiblie; cela augmentera votre risque de blessure.**
	**AVIS:** **Les liquides qui sont analysés dans cet instrument peuvent être cancérigènes, hasards biologiques, inflammables, ou radioactifs.** **Si vous devez utiliser ces liquides hasardeux, il est très recommandé que vous le faites à l'intérieur d'un environnement isolé conçu pour tels liquides.** **Cet environnement isolé devrait être construit selon les règlements fédéraux, provinciaux, et locaux, aussi que le plan de votre organisation qui concerne l'évènement d'un accident avec les matières hasardeuses.** **En tout cas, utilisez toujours l'instrumentation d'Isco avec prudence et sens commun.**
	**AVERTISSEMENT:** **Ascenseur d'équipe. Pour réduire le risque de blessure, n'essayez pas de soulevez cet instrument indépendamment. Il est fortement recommandé qu'un équipe être utilisé lors du levage de cet instrument.**

Commonly Ordered Replacement Parts for the SyriXus Series Syringe Pumps

Part	Model	Description	P/N
Cylinder Seals General	65x	0-1379 bar	202-9096-08
	260x	0-655.0 bar	202-9091-06
	500x	0-344.7 bar	202-9091-56
	1000x	0-137.8 bar upper seal	202-9990-25
	1000x	0-137.8 bar lower seal	202-9990-23
Inlet/Outlet Fittings	65x	1/4" F250C Gland	209-0164-02
		1/4" F250C Collar	209-0164-03
		F250C Plug	209-0164-05
	260x	Valco - 1/8" Nut	209-0169-27
		1/16" Nut	209-0094-07
		1/8" Plug	209-0166-80
		1/8" – 1/16" Tubing Reducer	209-0169-42
	500x	1/8" Tubing Connector to 1/8" NPT	209-0161-01
		1/8" Plug	209-0166-80
	1000x	1/4" NPT Plug	209-0168-09

Pre-Assembled Tubing Assemblies for SyriXus Series Syringe Pumps

Model	Description	P/N
65x	Air Valve Tubing	209-0166-71
	Air Valve Collar	209-0164-03
	Air Valve Gland Nut	209-0164-02
260x	Air Valve	60-1268-030
	Electric Valve	60-1268-033
500x	Air Valve	60-1268-031
	Electric Valve	60-1268-032
500xv	Air Valve	69-1263-360 (tubing only)
1000x	Air Valve	60-1268-048
	Electric Valve	60-1268-046

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SyriXus Series Pumps Installation and Operation Guide

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SyriXus Series Pumps Installation and Operation Guide

Section 1 Introduction

1.1 About This Manual

The 260x pumps have 1/8” standard Valco® ports. Pipe thread fittings of 1/4” diameter are used for the 1000x, 3/8” diameter for the 500xv, and 1/8” diameter for the 500x. The 65x uses AE F250C high pressure fittings. Because of these differences, the packages, tubing, and options for different models have different part numbers. Additionally, these pumps are typically used for different applications; therefore, optional kits and accessories may differ.

The installation procedures for the different SyriXus series pump models have been combined where applicable, and separated where necessary, for your convenience.

Optional system configurations may require additional kits and/or software. These additional options are described in their respective sections. This manual contains the following sections:

- Section 1 "Introduction"
- Section 2 "Fluid System Connections and Accessories"
- Section 3 "Basic Programming and Operation"
- Section 4 "Gradient Pumping for Pressure, Flow, and Concentration Modes"
- Section 5 "Continuous Flow Introduction, Installation, and Operation"
- Section 6 "Modifier Addition"
- Section 7 "Modbus Configuration"
- Section 8 "Serial Interface"
- Section 9 "Pump Maintenance, Troubleshooting, and Servicing"

1.2 Specifications

The technical specifications for the SyriXus series syringe pumps are detailed in Table 1-1 65x Technical Specifications through Table 1-5 "1000x Technical Specifications".

NOTE

Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.

Caution

The Teledyne ISCO Syringe Pumps are designed and intended for use with clean liquid or liquified gas working fluids. Working fluids containing solid particulates, such as slurries or suspensions, will cause scratches on the cylinder wall resulting in increased leakage. Any particles present should be softer than Rockwell B80 and/or have a size smaller than 3 µm. Scratches caused by pumping working fluids containing solid particulates will void the warranty. It is recommended to use a 10 µm filter between the fluid inlet port and the reagents source if there is a possibility of particulates being present in the fluid.

NOTE

Syringe Pumps produced by Teledyne ISCO are high pressure pumps designed to deliver very accurate flow rates and volumes at high pressures with nearly no pulses in pressure or flow. The spring-loaded lip seals used in the Teledyne ISCO Syringe Pumps rely on the working pressure to work correctly. Although the spring assists in the sealing at low pressures, increased leakage will result at pressures less than 30 bar, especially in low viscosity fluids. This is more noticeable with new seals that haven't been burnished to the cylinder surface yet. Performance when the application requires very low pressures may be enhanced by operating the pump at a higher pressure and employing a back pressure regulator on the outlet to attain the desired discharge pressure.

NOTE

The wetted materials in Teledyne ISCO Syringe pumps are typically recognized as having superior resistance to corrosion and chemical attack, but no material is resistant to everything. The wetted materials are listed in this manual for both the pump itself [Table 2-7] and the valves [Table 2-4, Table 5-2, and Table 5-5]. Some chemicals (e.g., ammonia) may require using optional seals [Table 2-8] and/or specific valve types. It is the responsibility of the end user to determine if the chemical being pumped is acceptable for use with the wetted materials that exist in the pump.

Table 1-1 65x Technical Specifications		
CYLINDER CAPACITY	67.97 mL	
POWER REQUIREMENTS[a] (Mains voltage line cord is a “Disconnect Device”)	100 ± 10 VAC, 1.5 A maximum 117 ± 12 VAC, 1.5 A maximum 234 ± 23 VAC, 0.75 A maximum } Factory Set	
LINE FREQUENCY	50 or 60 Hz	
LINE VOLTAGE NOISE TOLERANCE	1.7 × nominal rms line voltage, 10 µsecond pulses, any phase angle, random or repetitive	
DIMENSIONS	PUMP Width: 27.2 cm Depth: 46.7 cm Height: 113.0 cm	CONTROLLER Width: 27.2 cm Depth: 30.5 cm Height: 13.6 cm
WEIGHT	PUMP 32.9 kg	CONTROLLER 2.96 kg
FLOW RATE RANGE	0.01 µL/min to 25 mL/min (for any pressure up to 1379 bar)	
FLOW RATE ACCURACY[b]	± 0.3% (maximum 0.25 µL/min seal leakage)	
FLOW RATE DISPLAY RESOLUTION	0.01 µL/min (1.0 µL/min in Constant Pressure Mode)	
ANALOG OUTPUT ACCURACY[c]	± 1% of selected range	
DISPLACEMENT RESOLUTION	2.55 nL /step	
REFILL TIME	1.7 minutes	
REFILL OR DEPRESSURIZATION RATE	0.01 µL/min to 40 mL/min at any pressure from 0 to 1379 bar	
PRESSURE RANGE	0.6895 to 1379 bar (10 to 20,000 psi)	
PRESSURE ACCURACY	± 0.1% of full scale at constant temperature	
PRESSURE REPEATABILITY[d]	± 0.5% of full scale within 48 hours at constant temperature	
ZERO PRESSURE DRIFT	± 0.25% of full scale within 48 hours at constant temperature	
PRESSURE DISPLAY RESOLUTION	6.895 kPa	

ENVIRONMENTAL OPERATING TEMPERATURE RANGE	5 to 40 °C (ambient)
MAXIMUM FLUID TEMPERATURE	100 °C (including pump cylinder and head)
PRESSURE TRANSDUCER OPERATING RANGE	≤ 100 °C (accurate to 71 °C; cable rated to 80 °C)
PRESSURE TRANSDUCER TEMPERATURE EFFECT	Zero (max) 0.0045% Full Scale/°C Span (max) 0.0045% Reading/°C
TEMPERATURE DRIFT	± 0.015% of full scale/°C
HUMIDITY	95% maximum
DEAD (HEADSPACE) VOLUME[e]	1.30 ± 0.020 mL
POLLUTION DEGREE	2
INSTALLATION CATEGORY	II
MAXIMUM ALTITUDE	2000 m

a. Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.
b. Using water at 137.9 bar and a temperature controlled environment at 30 °C. Leakage will be significantly greater at working pressures less than 35 bar.
c. The analog output is an optional accessory.
d. Pressure repeatability specification is based upon re-zeroing pressure transducer every 48 hours. Refer to Section 3.8.11 "ZERO PRESS" in Section 3 "Basic Programming and Operation" for re-zeroing procedure.
e. Volume in and above the piston seal, head clearance at automatic shutoff, and inlet and outlet ports to the fittings.

Table 1-2 260x Technical Specifications		
CYLINDER CAPACITY	266.05 mL	
POWER REQUIREMENTS[a] (Mains voltage line cord is a "Disconnect Device")	100 ± 10 VAC, 1.5 A maximum 117 ± 12 VAC, 1.5 A maximum 234 ± 23 VAC, 0.75 A maximum } Factory Set	
LINE FREQUENCY	50 or 60 Hz	
LINE VOLTAGE NOISE TOLERANCE	1.7 × nominal rms line voltage, 10 µsecond pulses, any phase angle, random or repetitive	
DIMENSIONS	PUMP Width: 27.2 cm Depth: 46.7 cm Height: 101.3 cm	CONTROLLER Width: 27.2 cm Depth: 30.5 cm Height: 13.6 cm
WEIGHT	PUMP 33.1 kg	CONTROLLER 2.96 kg
FLOW RATE RANGE	Refer to Figure 1-1.	
FLOW RATE ACCURACY[b]	± 0.5% (maximum 0.50 µL/min seal leakage)	
FLOW RATE DISPLAY RESOLUTION	1.0 µL/min	
ANALOG OUTPUT ACCURACY[c]	± 1% of selected range	
DISPLACEMENT RESOLUTION	16.63 nL /step	
REFILL TIME	2.5 minutes	
REFILL OR DEPRESSURIZATION RATE	1.0 µL/min to 107 mL/min at any pressure from 0 to 655 bar	
PRESSURE RANGE	0.6895 to 655 bar (10–9,500 psi)	
PRESSURE ACCURACY	± 0.5% of full scale at constant temperature	
PRESSURE REPEATABILITY[d]	± 0.5% of full scale within 48 hours at constant temperature	
ZERO PRESSURE DRIFT	± 0.25% of full scale within 48 hours at constant temperature	
PRESSURE DISPLAY RESOLUTION	6.895 kPa	
ENVIRONMENTAL OPERATING TEMPERATURE RANGE	5 to 40 °C (ambient)	
MAXIMUM FLUID TEMPERATURE	100 °C (200 °C with optional high-temperature transducer and seals)	
TEMPERATURE DRIFT	± 0.15% of full scale/°C	
HUMIDITY	95% maximum	
DEAD (HEADSPACE) VOLUME[e]	2.10 ± 0.020 mL	
POLLUTION DEGREE	2	
INSTALLATION CATEGORY	II	
MAXIMUM ALTITUDE	2000 m	

a. Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.
b. Using water at 137.9 bar and a temperature controlled environment at 30 °C. Leakage will be significantly greater at working pressures less than 35 bar.
c. The analog output is an optional accessory.
d. Pressure repeatability specification is based upon re-zeroing pressure transducer every 48 hours. Refer to Section 3.8.11 "ZERO PRESS" in Section 3 "Basic Programming and Operation" for re-zeroing procedure.
e. Volume in and above the piston seal, head clearance at automatic shutoff, and inlet and outlet ports to the fittings.

Table 1-3 500x Technical Specifications		
CYLINDER CAPACITY	507.38 mL	
POWER REQUIREMENTS[a] (Mains voltage line cord is a "Disconnect Device")	100 ± 10 VAC, 1.5 A maximum 117 ± 12 VAC, 1.5 A maximum 234 ± 23 VAC, 0.75 A maximum } Factory Set	
LINE FREQUENCY	50 or 60 Hz	
LINE VOLTAGE NOISE TOLERANCE	1.7 × nominal rms line voltage, 10 µsecond pulses, any phase angle, random or repetitive	
DIMENSIONS	PUMP Width: 27.2 cm Depth: 46.7 cm Height: 103.9 cm	CONTROLLER Width: 27.2 cm Depth: 30.5 cm Height: 13.6 cm
WEIGHT	PUMP 34.48 kg	CONTROLLER 2.96 kg
FLOW RATE RANGE	Refer to Figure 1-2.	
FLOW RATE ACCURACY[b]	± 0.5% (maximum 1.0 µL/min seal leakage)	
FLOW RATE DISPLAY RESOLUTION	1.0 µL/min	
ANALOG OUTPUT ACCURACY[c]	± 1% of selected range	
DISPLACEMENT RESOLUTION	31.71 nL /step	
REFILL TIME	2.5 minutes	
REFILL OR DEPRESSURIZATION RATE	1.0 µL/min to 204 mL/min at any pressure from 0 to 344.7 bar	
PRESSURE RANGE	0.6895 to 344.7 bar (10–5,000 psi)	
PRESSURE ACCURACY	± 0.5% of full scale at constant temperature	
PRESSURE REPEATABILITY[d]	± 0.5% of full scale within 48 hours at constant temperature	
ZERO PRESSURE DRIFT	± 0.25% of full scale within 48 hours at constant temperature	
PRESSURE DISPLAY RESOLUTION	6.895 kPa	
ENVIRONMENTAL OPERATING TEMPERATURE RANGE	5 to 40 °C (ambient)	
MAXIMUM FLUID TEMPERATURE	100 °C (200 °C with optional high-temperature transducer and seals)	
TEMPERATURE DRIFT	± 0.15% of full scale/°C	
HUMIDITY	95% maximum	
DEAD (HEADSPACE) VOLUME[e]	4.00 ± 0.020 mL	
POLLUTION DEGREE	2	
INSTALLATION CATEGORY	II	
MAXIMUM ALTITUDE	2000 m	

a. Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.
b. Using water at 137.9 bar and a temperature controlled environment at 30 °C. Leakage will be significantly greater at working pressures less than 35 bar.
c. The analog output is an optional accessory.
d. Pressure repeatability specification is based upon re-zeroing pressure transducer every 48 hours. Refer to Section 3.8.11 "ZERO PRESS" in Section 3 "Basic Programming and Operation" for the zeroing procedure.
e. Volume in and above the piston seal, head clearance at automatic shutoff, and inlet and outlet ports to the fittings.

Table 1-4 500xv Technical Specifications		
CYLINDER CAPACITY	507.38 mL	
POWER REQUIREMENTS[a] (Mains voltage line cord is a "Disconnect Device")	100 ± 10 VAC, 5A maximum 117 ± 12 VAC, 5A maximum 234 ± 23 VAC, 2.5A maximum } Factory Set	
LINE FREQUENCY	50 or 60 Hz	
LINE VOLTAGE NOISE TOLERANCE	1.7 × nominal rms line voltage, 10 µsecond pulses, any phase angle, random or repetitive	
DIMENSIONS	PUMP Width: 27.2 cm Depth: 46.7 cm Height: 103.0 cm	CONTROLLER Width: 27.2 cm Depth: 30.5 cm Height: 13.6 cm
WEIGHT[b]	PUMP 44.6 kg	CONTROLLER 2.96 kg
FLOW RATE RANGE	Refer to Figure 1-2.	
FLOW RATE ACCURACY[c]	± 0.5% (maximum 1.0 µL/min seal leakage)	
FLOW RATE DISPLAY RESOLUTION	1.0 µL/min	
ANALOG OUTPUT ACCURACY[d]	± 1% of selected range	
DISPLACEMENT RESOLUTION	25.36 nL /step	
REFILL TIME	1.25 minutes	
REFILL OR DEPRESSURIZATION RATE	1.0 µL/min to 408 mL/min at any pressure from 0 to 344.7 bar	
PRESSURE RANGE[e]	0.6895 to 344.7 bar (10–5,000 psi)	
PRESSURE ACCURACY	± 0.5% of full scale at constant temperature	
PRESSURE REPEATABILITY[f]	± 0.5% of full scale within 48 hours at constant temperature	
ZERO PRESSURE DRIFT	± 0.25% of full scale within 48 hours at constant temperature	
PRESSURE DISPLAY RESOLUTION	6.895 kPa	

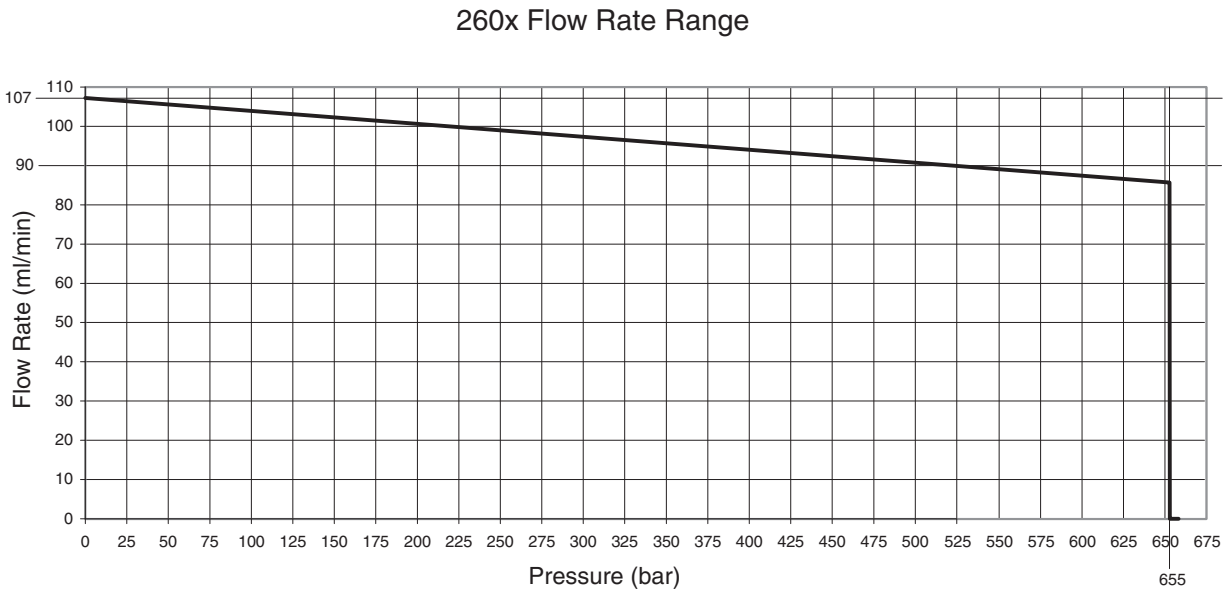
ENVIRONMENTAL OPERATING TEMPERATURE RANGE	5 to 40 °C (ambient)
MAXIMUM FLUID TEMPERATURE	200 °C (with high-temperature package; this includes transducer and seals)
TEMPERATURE DRIFT	± 0.15% of full scale/°C
HUMIDITY	95% maximum
DEAD (HEADSPACE) VOLUME[g]	10.45 ± 0.65 mL
POLLUTION DEGREE	2
INSTALLATION CATEGORY	II
MAXIMUM ALTITUDE	2000 m

a. Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.
b. A team lift is recommended when moving this instrument.
c. Using water at 137.9 bar and a temperature controlled environment at 30 °C. Leakage will be significantly greater at working pressures less than 35 bar.
d. The analog output is an optional accessory.
e. The maximum allowable temperature and pressure are interrelated. Refer to Table 5-2 for details.
f. Pressure repeatability specification is based upon re-zeroing pressure transducer every 48 hours. Refer to Section 3.8.11 "ZERO PRESS" in Section 3 "Basic Programming and Operation" for re-zeroing procedure.
g. Volume in and above the piston seal, head clearance at automatic shutoff, and inlet and outlet ports to the fittings.

Table 1-5 1000x Technical Specifications		
CYLINDER CAPACITY	1015.0 mL	
POWER REQUIREMENTS[a] (Mains voltage line cord is a "Disconnect Device")	100 ± 10 VAC, 1.5 A maximum 117 ± 12 VAC, 1.5 A maximum 234 ± 23 VAC, 0.75 A maximum } Factory Set	
LINE FREQUENCY	50 or 60 Hz	
LINE VOLTAGE NOISE TOLERANCE	1.7 × nominal rms line voltage, 10 µsecond pulses, any phase angle, random or repetitive	
DIMENSIONS	PUMP Width: 27.2 cm Depth: 46.7 cm Height: 103.6 cm	CONTROLLER Width: 27.2 cm Depth: 30.5 cm Height: 13.6 cm
WEIGHT[b]	PUMP 38.5 kg	CONTROLLER 2.96 kg
FLOW RATE RANGE	Refer to Figure 1-3.	
FLOW RATE ACCURACY[c]	± 0.5% (maximum 1.5 µL/min seal leakage)	
FLOW RATE DISPLAY RESOLUTION	1.0 µL/min	
ANALOG OUTPUT ACCURACY[d]	± 1% of selected range	
DISPLACEMENT RESOLUTION	25.38 nL /step	
REFILL TIME	2.5 minutes	
REFILL OR DEPRESSURIZATION RATE	1.0 µL/min to 408 mL/min at any pressure from 0 to 137.9 bar	
PRESSURE RANGE	0.6895 to 137.9 bar (10–2,000 psi)	
PRESSURE ACCURACY	± 0.5% of full scale at constant temperature	
PRESSURE REPEATABILITY[e]	± 0.5% of full scale within 48 hours at constant temperature	
ZERO PRESSURE DRIFT	± 0.25% of full scale within 48 hours at constant temperature	

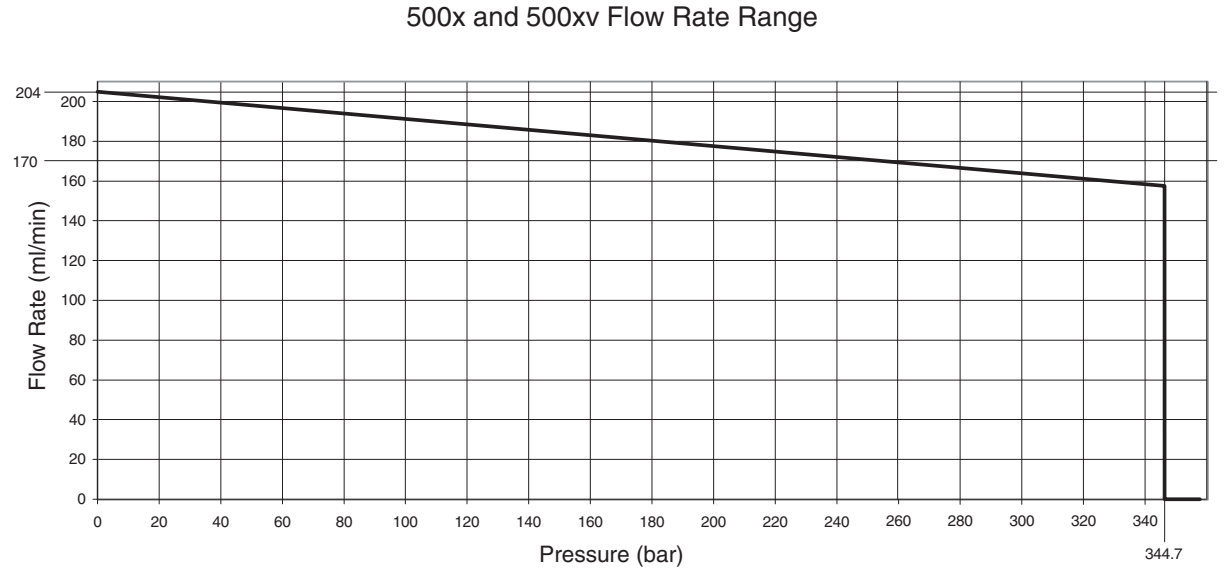
PRESSURE DISPLAY RESOLUTION	6.895 kPa
ENVIRONMENTAL OPERATING TEMPERATURE RANGE	5 to 40 °C (ambient)
MAXIMUM FLUID TEMPERATURE	100 °C (200 °C with optional high-temperature transducer and seals)
TEMPERATURE DRIFT	± 0.12% of full scale/°C
HUMIDITY	95% maximum
DEAD (HEADSPACE) VOLUME[f]	11.0 ± 0.7 mL
POLLUTION DEGREE	2
INSTALLATION CATEGORY	II
MAXIMUM ALTITUDE	2000 m

a. Underwriters Laboratories (UL) has certified all SyriXus series syringe pumps with the exception of the 100 VAC versions.
b. A team lift is recommended when moving this instrument.
c. Using water at 137.9 bar and a temperature controlled environment at 30 °C. Leakage will be significantly greater at working pressures less than 35 bar.
d. The analog output is an optional accessory.
e. Pressure repeatability specification is based upon re-zeroing pressure transducer every 48 hours. Refer to Section 3.8.11 "ZERO PRESS" in Section 3 "Basic Programming and Operation" for re-zeroing procedure.
f. Volume in and above the piston seal, head clearance at automatic shutoff, and inlet and outlet ports to the fittings.



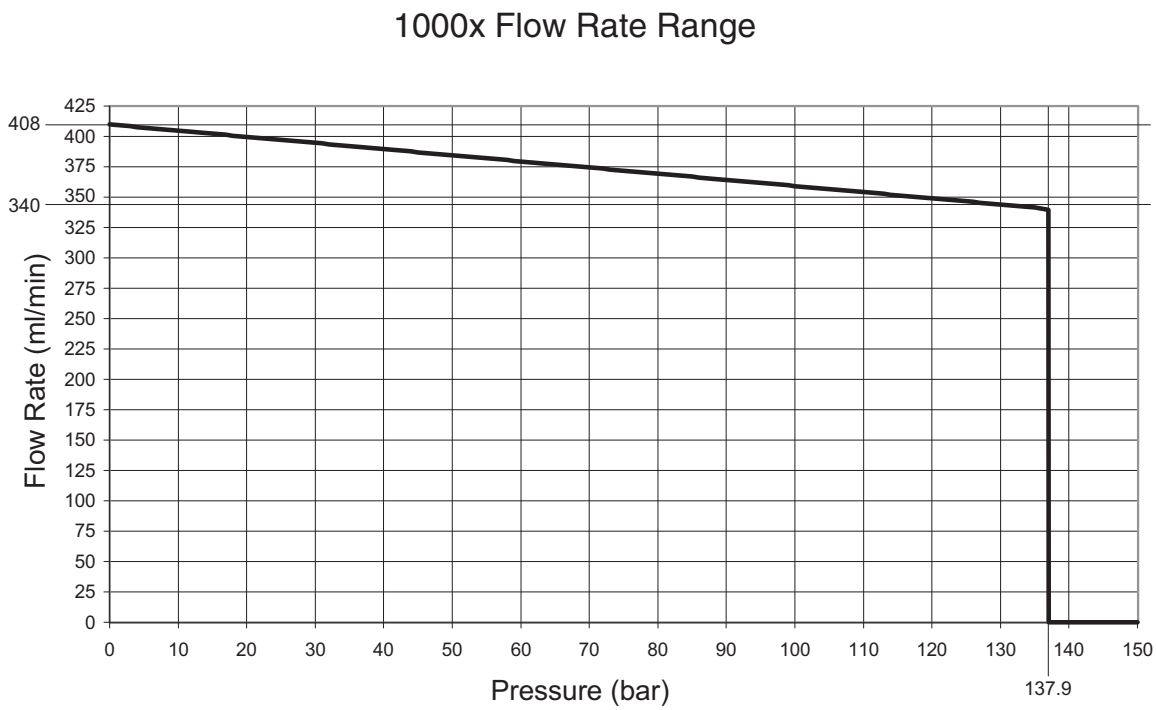
Flow Rate (mL/min)	Max. Pressure (bar)
0.001 to 90	517.1
90 to 107	(107.23 mL/min – flow rate) × 30

Figure 1-1 260x flow rate range



Flow Rate (mL/min)	Max. Pressure (bar)
0.001 to 170	258.6
170 to 204	(204.9 mL/min – flow rate) × 7.4

Figure 1-2 500x and 500xv flow rate range



Flow Rate (mL/min)	Max. Pressure (bar)
0.001 to 340	137.9
340 to 408	(409.8 mL/min – flow rate) × 1.9756

Figure 1-3 1000x flow rate range

1.3 Unpacking

After removing the pump, controller, and accessories from the shipping carton, examine them for signs of shipping damage. Be sure no internal parts have shaken loose in transit. If there is any shipping damage, file a claim with the delivering carrier immediately.

Compare the contents of the boxes with the enclosed packing slip. If there are shortages, contact Teledyne ISCO immediately using the information in 9.3 "Technical Customer Service Department".

1.4 Controls and Indicators

The pump controller regulates all pumping functions. It is designed to sit on top of the pump base, but may be located elsewhere, according to safety and convenience. Programming and setup are performed using the keypad on the front panel. The controller front panel is shown in Figure 1-4 and described in Table 1-6 "Pump Controller Front Panel Label". Table 1-7 "Pump Controller Key Functions" explains the key functions.

The rear panel of the pump controller contains several input and output connectors, explained in Table 1-8 "Pump Controller Rear Panel Connectors", and shown in Figure 1-5.

The only operational control on the pump itself is the power switch, shown in Figure 1-7. The rear panel has several connectors, described in Table 1-9 "Pump Rear Panel Connectors", and shown in Figure 1-6.

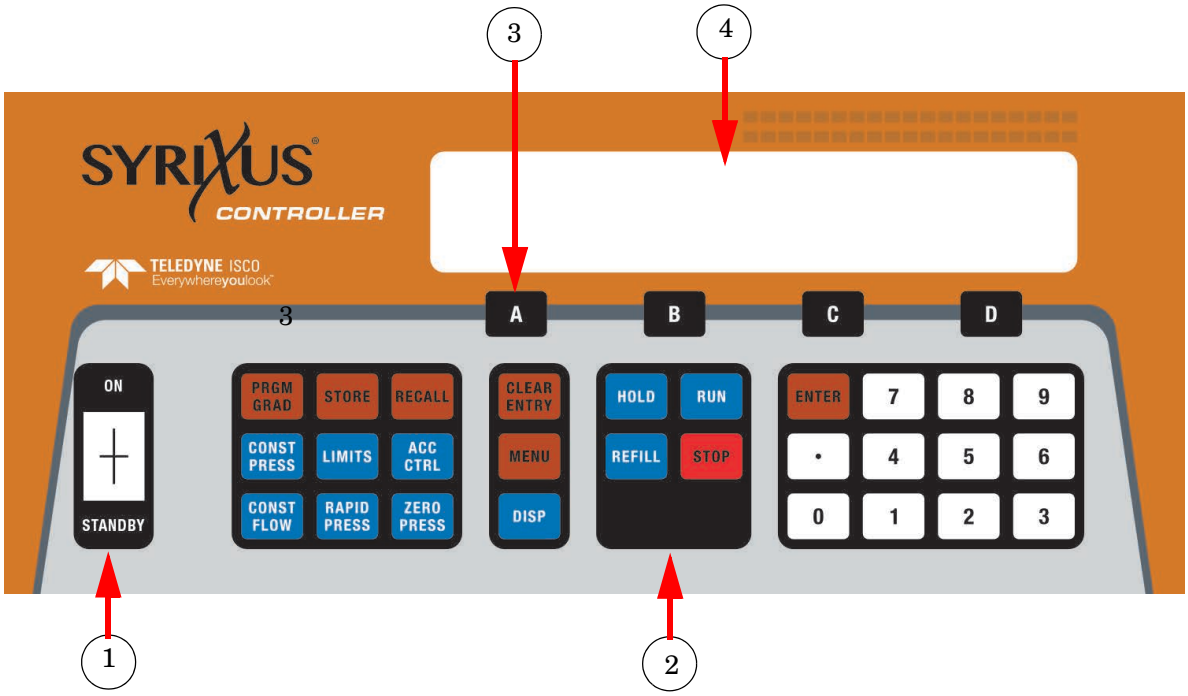


Figure 1-4 Pump controller key functions

Table 1-6 Pump Controller Front Panel Label

Figure 1-4 #	Connector	Description
1	On/Standby switch	Turns instrument OFF and ON. (Does not disconnect power.)
2	Programming keypad	Used to program controller.
3	Softkeys	Labeled A, B, C, and D; used to select menu items displayed directly above them.
4	Liquid crystal display	40 Characters × 4 line.

Table 1-7 Pump Controller Key Functions	
Key	**Description**
ON/STANDBY	Two-position toggle switch turns controller on and activates drive motor to maintain position. Standby disables the drive motor and halts the controlling processor.
A, B, C, D	Softkeys; used to select displayed options.
PRGM GRAD	Program gradient: Puts pump in Gradient Mode and accesses the soft-key driven gradient programming.
CONST PRESS	Constant pressure: Puts pump in Constant Pressure Mode.
CONST FLOW	Constant flow: Puts pump in Constant Flow (rate) Mode.
STORE	Stores the current program in nonvolatile memory and exits Program-ming Mode.
LIMITS	Displays and allows changes to the maximum and minimum pressure and flow rate limits.
RAPID PRESS	Rapid pressure: Allows rapid pressurization to the stable pressure point and then switches automatically to Constant Flow. (Available in Constant Flow Mode only.) NOTE: This feature is automatic, *i.e.* RAPID PRESS is pressed only once and the user does not enter a pressure; although, entering a target pressure may speed equilibration.
RECALL	Replaces the current program with one recalled from nonvolatile memory.
ACC CTRL	Accessory control: Manually operates accessories such as valves.
ZERO PRESS	Zero pressure: Sets pressure display to zero. Active only from -750 to +750 psi.
CLEAR ENTRY	Clear the last digit entered from the numeric key.
MENU	Accesses software to set operational modes, units, and other optional parameters.
DISP	Activates dispense mode (refer to Section 3.10.3 "Dispense Mode").
HOLD	Freezes the program clock. The unit will continue at the current gradi-ent parameters.
REFILL	Turns ON pump drive motor to move piston downward at a rate previously programmed.
RUN	Turns on pump drive motor to move piston upward in a previously pro-grammed mode, such as “CONSTANT FLOW” or “CONSTANT PRESSURE.”
STOP	Stops the drive motor.
ENTER	Enters selected values to memory.
NUMBER KEYS	These keys are used to make menu selections and enter values when setting parameters.

NOTE

For more information on the keypad, refer to Section 3.8 "Front Panel Keys".

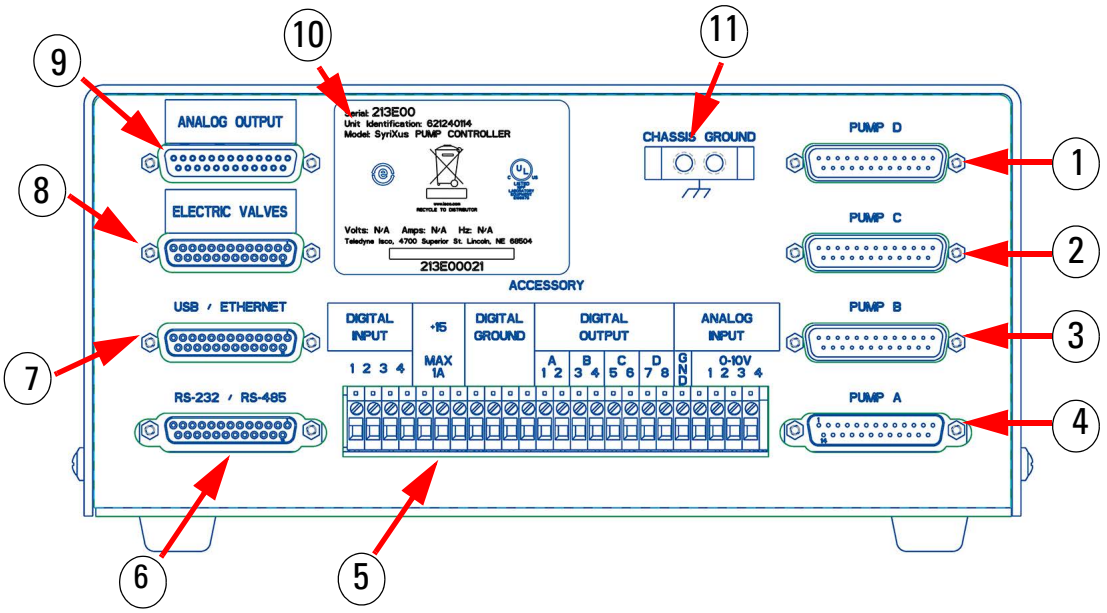


Figure 1-5 Pump controller rear panel connectors

Table 1-8 Pump Controller Rear Panel Connectors

Figure 1-5 #	Connector	Description
1	PUMP D	This connector is only used during multiple pump operation. The control cable from the rear panel of the fourth pump is attached to this connector.
2	PUMP C	This connector is only used during multiple pump operation. The control cable from the rear panel of the **third** pump is attached to this connector.
3	PUMP B	This connector is only used during multiple pump operation. The control cable from the rear panel of the **second** pump is attached to this connector.
4	PUMP A	This plug connects the control cable from the pump rear panel. This connection should be secured with the thumbscrews. **IMPORTANT**: The pump A connector is the only input power connector on the rear panel of the controller. During single-pump operation, the pump must be attached to this connector to supply power to the controller. **WARNING: Do not connect or disconnect the control cable when the pump is connected to the mains voltage.**
5	ACCESSORY	These terminals allow connection of input and output signals (such as analog controls and external RUN/STOP).

Table 1-8 Pump Controller Rear Panel Connectors (Continued)		
Figure 1-5 #	**Connector**	**Description**
6	RS-232/RS-485	This serial port connector may be used with an RS-232 or RS-485 cable to place the pump under remote control. Refer to Section 8 "Serial Interface" for RS-232 and Section 7 "Modbus Configuration" for RS-485 pin connections.
7	USB/ETHERNET [a]	Optional circuit provides USB and Ethernet functionality. Refer to Section 8 "Serial Interface" for USB pin connections and Section 7 "Modbus Configuration" for Ethernet pin connections
8	4-20mA OUTPUT[a]	Optional circuit provides 4-20mA current loop output and additional digital inputs and outputs.
	ANALOG OUTPUT[a]	Optional circuit provides flow rate and volume outputs. Refer to 3.14 "Analog Flow Rate and Volume Output Options".
	ELECTRIC VALVES[a]	Optional circuit provides motor drive for valve operation.
	12-CH OUTPUT[a]	Additional circuit provides flow rate, pressure, and volume outputs.
9	DIGITAL I/O[a]	Optional circuit provides additional digital inputs and outputs.
	ANALOG OUTPUT[a]	Optional circuit provides flow rate and volume outputs. Refer to 3.14 "Analog Flow Rate and Volume Output Options".
10	SERIAL TAG	This tag indicates the serial number of the instrument.
11	CHASSIS GROUND	Ground point for high static or remote controller installations.

a. Connectors based on installed optional circuit board configuration.

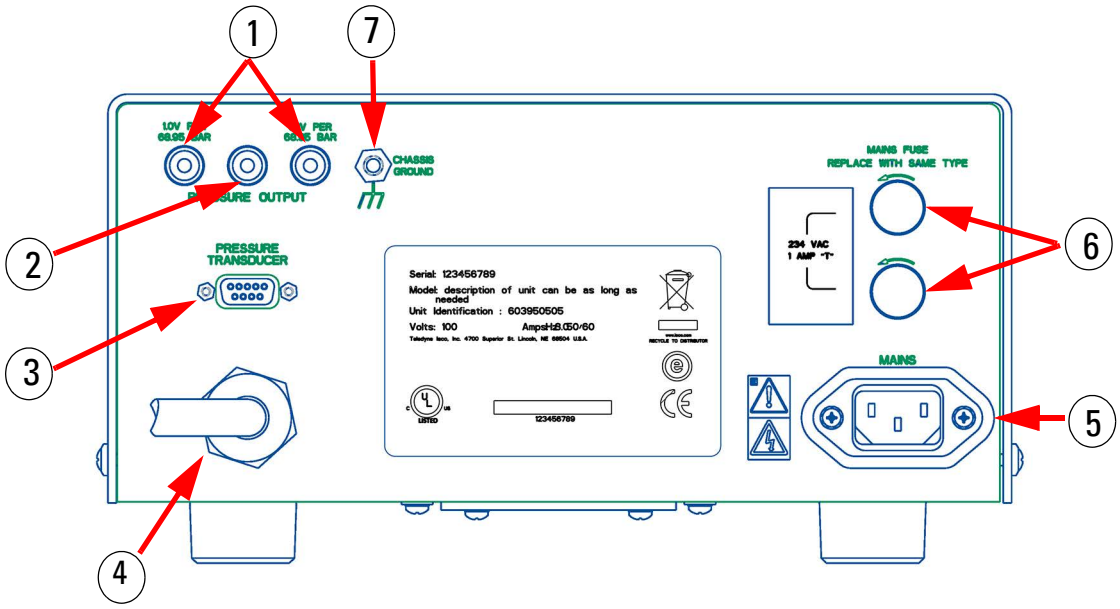


Figure 1-6 Pump rear panel connectors

Table 1-9 Pump Rear Panel Connectors				
Figure 1-6 #	**Connector**	**Description**		
1	Pressure outputs	Two red binding post/banana jacks providing pressure output voltages.		
		Pump	**Left Jack VDC/psi**	**Right Jack VDC/psi**
		65x	1.0 V/2000 psi	0.1 V/2000 psi
		All others	1.0 V/1000 psi	0.1 V/1000 psi
2	Ground	A black binding post/banana jack providing a connection to circuit common.		
3	Pressure transducer	The pressure transducer cable must be plugged in for the pump to operate.		
4	Control cable	This cable connects the pump to the controller.		
5	Mains	IEC power connector with EMI filter.		
6	External Fuses[a]	Limits pump current drawn from main power supply. Replace with same type: (“T” time delay fuses) 1) 2.0 Amp for 100/117 volt operation 2) 1.0 Amp for 234 volt operation To remove, rotate cap counterclockwise.		
7	Chassis ground	Ground point for high static installations.		

a. Internal fuses not replaceable by the operator: F101: 4.0 Amp “T”, F102 & F104:1.5 Amp “T”, and F103: 0.75 Amp “T”.

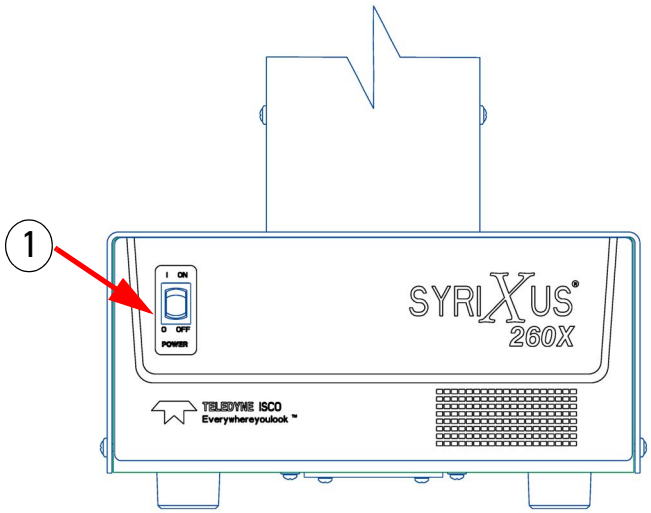


Figure 1-7 Pump front panel controls

Table 1-10 Pump Front Panel

Figure 1-7 #	Connector	Description
1	Mains power switch	Disconnects power from the pump circuits for setup changes, such as connecting the controller. "1" = mains power is applied to the pump circuitry. "0" = mains power is removed from the pump circuitry.

1.5 Electrical Connections

The pump controller may be placed on top of the pump, or wherever safety and convenience dictate. Power is supplied to the pump controller through the control cable.

Caution

All connections between the pump and controller should be made BEFORE the pump is connected to mains power.

1. Connect the pressure transducer cable (which originates from the top of the pump cylinder) to the nine pin sub-D PRESSURE TRANSDUCER connector on the pump rear panel (Figure 1-6). Be sure to tighten the thumbscrews.
2. Connect the control cable (which originates from the first or only pump rear panel) to the PUMP A connector on the rear panel of the controller (Figure 1-5) and tighten the thumbscrews. This cable must be plugged into the PUMP A connector.

NOTE

There are four PUMP connectors on the rear of the controller. Only the PUMP A connector is wired to supply power to the controller; therefore, one pump must be attached to this connector.

3. Check the serial number tag to make sure the voltage rating of the pump is correct.
4. Connect the line cord to the MAINS connector on the back of the pump.

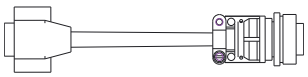
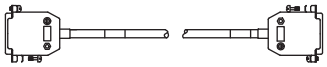
1.5.1 Cabling

For all systems, connect the control cable of the pump module (Pump A for multiple-pump systems) to the connector labeled PUMP A on the rear panel of the controller. Subsequent pumps in multiple-pump systems can be connected to controller connectors PUMP B, PUMP C, and PUMP D. Cable part numbers and lengths are listed in Table 1-11 "Cable Part Numbers and Lengths".

NOTE

The transducer cable (refer to Figure 1-8 and Figure 1-9) must be plugged into the pressure transducer connector on the rear panel of the pump module for the pump to operate.

Table 1-11 Cable Part Numbers and Lengths

Description	Length	P/N
USB and TCP/IP use cable package	-	60-1247-168
Pump controller connect cable (refer to Figure 1-9).	7 ft (2.1 m)	(attached to pump)
Pump module transducer cable (refer to Figure 1-8).	4 ft (1.2 m)	
65x Pump module transducer cable 	4.5 ft (1.4 m)	69-1244-413
Extension cable for pump controller connect 	10 ft (3 m)	68-1020-210

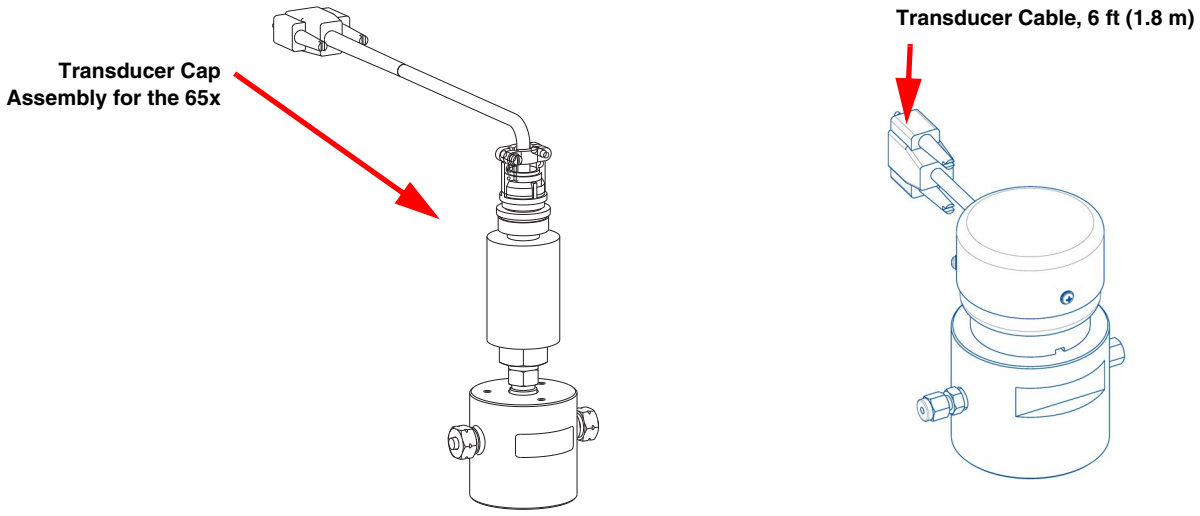


Figure 1-8 Syringe pump cylinder cap: Attach to pressure transducer connector on back of pump.

Caution

The pressure transducer cable length is always 6 feet (1.8 m). Never attempt to extend the length of this cable.

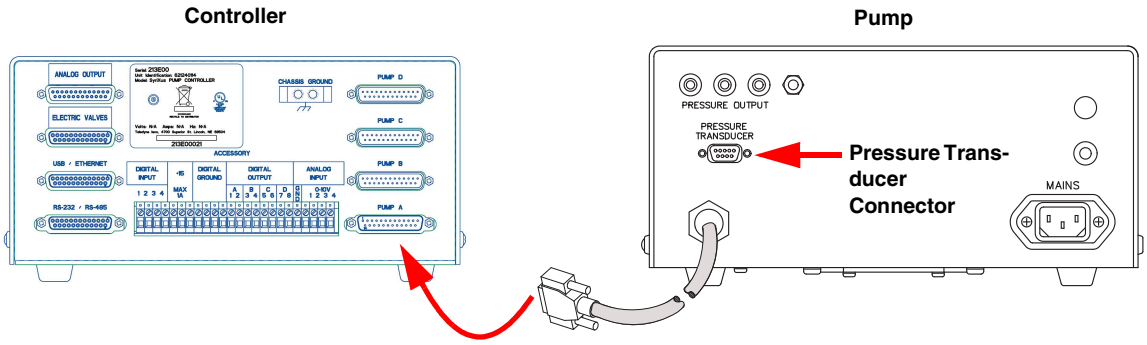


Figure 1-9 Connecting the pump and controller

NOTE

The FIRST (or ONLY) pump must be connected to ‘PUMP A’.

Caution

Never make **any** cable connections while the pump is powered ON.

1.6 Preliminary Checkout

After the electrical connections have been completed, follow this brief test of the pump's operation:

NOTE

Preliminary checkout of the pump is performed without fluid in the pump.

If adding a new pump to the controller, a hard and soft reset need to be completed. Refer to Section 9.5 "Resetting the System".

Caution

Always maintain clearance behind the pump such that the MAINS power cord can be unplugged at any time.

1. Before connecting the line cord, make sure the voltage rating on the serial tag matches your outlet's voltage. Plug in the line cord. Turn the pump power switch ON. Turn the controller ON/STANDBY switch ON.
2. The display will briefly show the software revision on the first line and the pump model(s) connected to the controller.

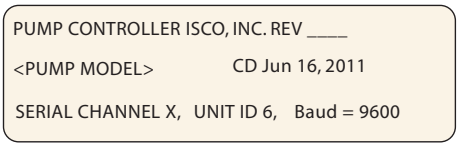


Figure 1-10 Status Screen

3. Check the upper left corner of the controller screen. The current pump mode will appear in a two-letter abbreviation, *e.g.* CF for Constant Flow. This will be followed by a lowercase letter indicating the current pump, *e.g.* "a" indicates that pump A is the current pump. The current pump is the one for which parameters are being shown.
   - If a pump other than pump A is currently selected:

     In the lower right corner of the screen, directly over softkey D, are the words "SELECT PUMP."

     Press MENU > 2 > A to select pump A. The display will automatically switch to the run screen, showing "a" in the upper left corner.

4. Press MENU to display Menu 1.

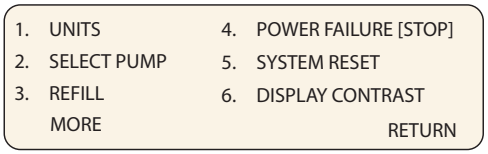


Figure 1-11 Menu 1

5. Press 1 for UNITS.
6. In the Units menu, select the desired units to display for pressure. For example, press 3 to select PSI for the pressure units.
7. In the Units menu, select the desired units to display for flow. For example, press 5 to select ML/MIN for the flow units. The first line of the display will show the selected units.
8. Press PREVIOUS (D) to return to Menu 1.
9. Press RETURN (D), to exit Menu 1.
10. Press CONST FLOW to set the pump mode to Constant Flow. CFa will be displayed in the upper left corner of the screen.
11. Press FLOW RATE (A). The words ENTER FLOW RATE should flash on the display. Use the numeric keys to enter a flow rate of 10 mL/min and press ENTER.

NOTE

If you make an error, press 'clear entry' to delete it.

12. Press RUN. Observe the flow rate displayed on the first line. After a few moments, the setpoint and flow rate display should match.
13. Once the setpoint and flow rate match, press STOP.
    a. If three or fewer pumps are connected, you will be prompted to press A to stop pump A, B to stop pump B, C to stop pump C, or D to stop all pumps. Alternatively, pressing the STOP key a second time will stop all pumps.

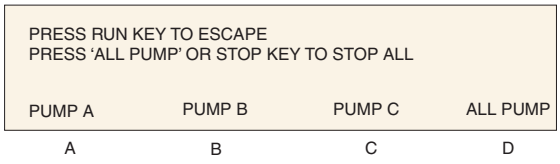


Figure 1-12 Three pump stop menu

b. If four pumps are connected to the controller, you will be prompted to press A to stop pump A, B to stop pump B, C to stop pump C, D to stop pump D, or STOP a second time, to stop all pumps.

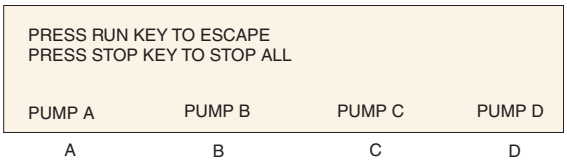


Figure 1-13 Four pump stop menu

If you encounter any problems during the preliminary checkout, please contact the Teledyne ISCO Customer Service Department using the information in Section 9.3 "Technical Customer Service Department".

NOTE

In the event of an emergency, turn OFF the controller switch. This will cause all pumps to immediately stop.

Section 2 Fluid System Connections and Accessories

2.1 Introduction

This section discusses general fluid system connections, and the installation of fluid connection accessories, temperature/pressure control accessories, and optional kits and attachments.

DANGER

RISK OF INJURY. THIS EQUIPMENT PRODUCES HAZARDOUS PRESSURES. USE APPROPRIATE TUBING AND CONNECTIONS AS INSTRUCTED.

NOTE

When operating at flow rates at or below 500 µL/min, it is strongly suggested that an insulating cover or temperature control jacket be installed. Refer To Section 2.4.1 "Temperature Control Jacket".

2.2 Fluid System Connections

All SyriXus series syringe pump models connect similarly, but with varying port sizes. Take care to follow procedures provided to ensure safety and proper operation.

2.2.1 Ports

There are two ports in the pump standard cylinder cap. Either port can serve as the inlet or outlet. As shown in Figure 2-1, you may plug one port and use a single port as both the inlet and outlet.

Table 2-1 Standard Port Information

1000x - 1/4” NPT	500x - 1/8” NPT
260x - 1/8” Valco	65x- 1/4” F250C
500xv - 3/8” NPT	

Additionally, the 500xv has a center fill port on the top of the cylinder cap through which material can be added or to which accessories can be attached.

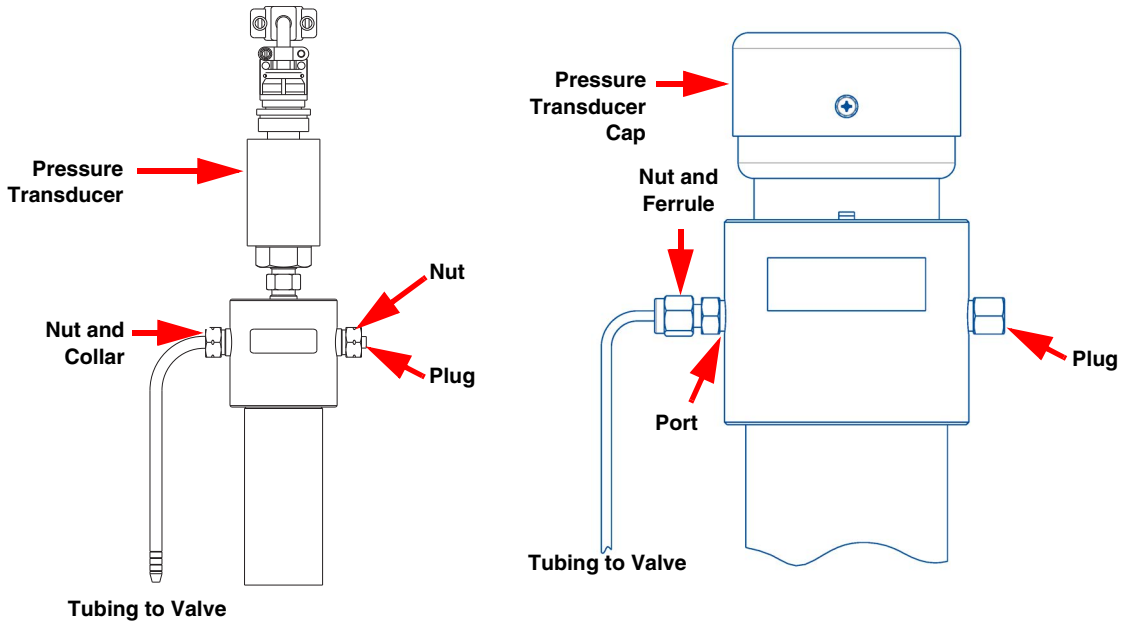


Figure 2-1 Liquid system plumbing connections (65x on left)

2.2.2 Installation Tips

- Be sure to keep the tubing as straight as possible at the end, as this will make it easier to install the ferrules.
- Be sure to cut the ends of the tubing squarely.
- Do not leave burrs on the ends of the tubing.
- When installing ferrules on the tubing, ensure the tubing extends beyond the ferrule to allow for proper crimping.
- If the connection leaks, re-tighten fittings.
- Push the tubing completely into the port before tightening the nut.
- When connections are made to the cylinder cap, the pressure reading may be affected. If the pressure no longer reads zero, release all pressure inside the pump, then press ZERO PRESSURE on the front panel of the controller to readjust.

NOTE

The 65x uses F250C ports, not NPT ports. Do not use pipe tape on the 65x ports.

2.2.3 Tubing Requirements

The tubing must be cut squarely to prevent possible problems. Square ends are easier to insert through the ferrule and will decrease dead volume.

Purchased Cut Tubing

Electrochemically machined steel tubing should be used throughout the plumbing system. Electrochemically machined tubing has flat, burr-free ends, and is free of cutting residues. This tubing is available pre-cut through many chromatographic supply distributors in assorted lengths.

Cutting the Tubing

A less desirable alternative is to purchase a tubing cutter designed to handle steel tubing. For quick fixes, the tubing may also be cut by hand.

Caution

Wear goggles to perform the following procedure.

Tools Required

- Fine jewelers file
- Protective eyewear
- Two pairs of pliers

1. Using the jewelers file, score the tubing around its entire circumference.
2. Secure the tubing with pliers on either side of the score line with approximately 1.5 mm between each pair of pliers and the score line. Do not squeeze the tubing too tightly, as this will flatten or deform its exterior.
3. Bend the tubing back and forth to crack it at the score line.
4. It may be necessary to deburr the outer tubing ends with the file. Make sure the tubing ends are clean and the inner bore is clear before installing the cut tube.

NOTE

It is often impossible to remove a burr that blocks the inner bore.

2.2.4 Installing the 65x Fitting

F250 Fitting and Connection

Refer to Figure 2-2 for components and fittings for the SyriXus 65x.

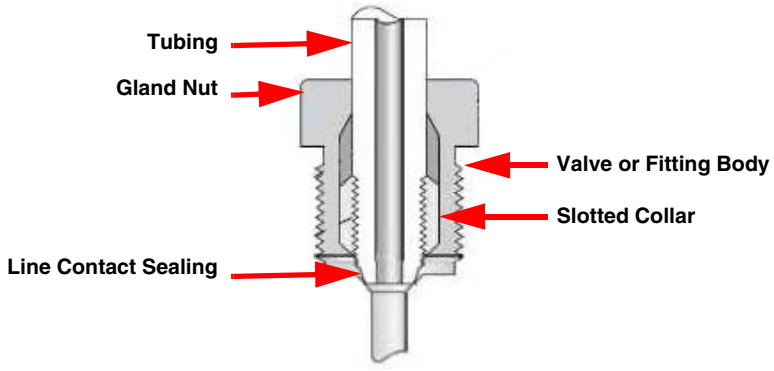


Figure 2-2 SyriXus 65x Fitting

1. Lubricate male threads (outside threads) of gland nut with a metal-based thread lubricant. Slip the gland nut onto threaded end of the tubing, oriented as shown in Figure 2-2. Avoid getting metal-based lubricant on the threads of the tubing.
2. Apply a small amount of process-tolerable lubricant (such as silicone grease) on the cone tip and threads of the tubing to assist with the sealing process.
3. Thread the collar onto the tubing until two or three threads near the cone on the tubing protrude from the collar. Do not get grease or thread lubricant on the outside surface of the collar or the inside surface of the gland nut.

NOTE

The collar has left hand threads.

4. Insert the tubing and collar into the F250C port, then thread the gland nut into the port until it is finger tight. Once assembled, the tubing should not be loose.

Caution

Do not twist or rotate the tubing in the port while tightening the gland nut.

5. Using a torque wrench, tighten the gland nut to 25 ft-lb (33.9 N·m). Avoid overtightening.

2.2.5 Draining Overflow

The drip tray outlet on the pump cylinder provides a means of draining fluid from seal leakage. Use a section of 1/4” ID flexible tubing to divert the leakage away from the pump.

To install the drain tube, push one end of the tubing over the end of the drip tray outlet, as shown in Figure 2-3.

NOTE

The 1000x has two drain tube outlets, one for the drip tray, and one for the splash pan, located at the bottom of the pump (refer to Figure 2-4). The 1000x also includes a wash gland as a standard feature (refer to Section 2.2.6 "Cylinder Washing - Wash Gland" for details). The wash gland tubes can also be used as lines for draining away fluid.

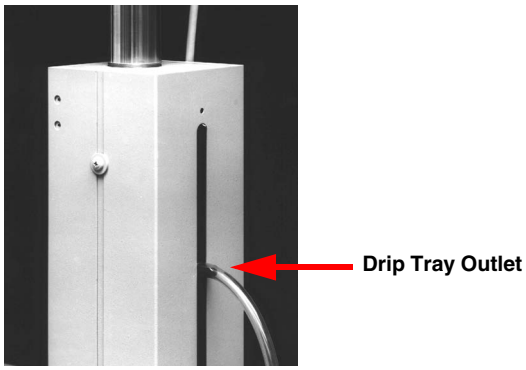


Figure 2-3 Drain tube installation

2.2.6 Cylinder Washing - Wash Gland

A thin film of liquid wets the inside of the cylinder each time the piston travels up the cylinder. The lowest flow rates are conducive to the most abrasive or corrosive pumping environments, as the deposited film remains on the inside of the cylinder wall for the longest time.

The SyriXus 1000x syringe pump is equipped for cylinder washing, with two 1/8” tubes on the back to feed and drain the wash gland, as shown in Figure 2-4.

A small pump can be used to deliver the wash fluid through one of the two tubes to rinse the cylinder and seals. The second tube drains the wash fluid to waste. If the system is configured to recirculate the wash fluid, ensure that you change the wash fluid at regular intervals.

Select a wash fluid that will best flush the cylinder of any residue left by the pumped fluid, yet will not damage the seals.

Caution

The pressure in the wash gland and line should NEVER exceed the system pressure or the wash pressure limit as labeled on the pump. Units with a wash pressure limit label can be damaged if the pressure is exceeded.

NOTE

If the primary pump seal fails, the pressure of the delivery fluid will be exerted on the secondary (wash gland) seal. During operation, the unused wash gland outlet should always be uncapped and routed for either recirculation or drainage.

Detailed information about pumping salt solutions and brines is available in Technical Bulletin TB04 Pumping Salt Solutions and Brines.

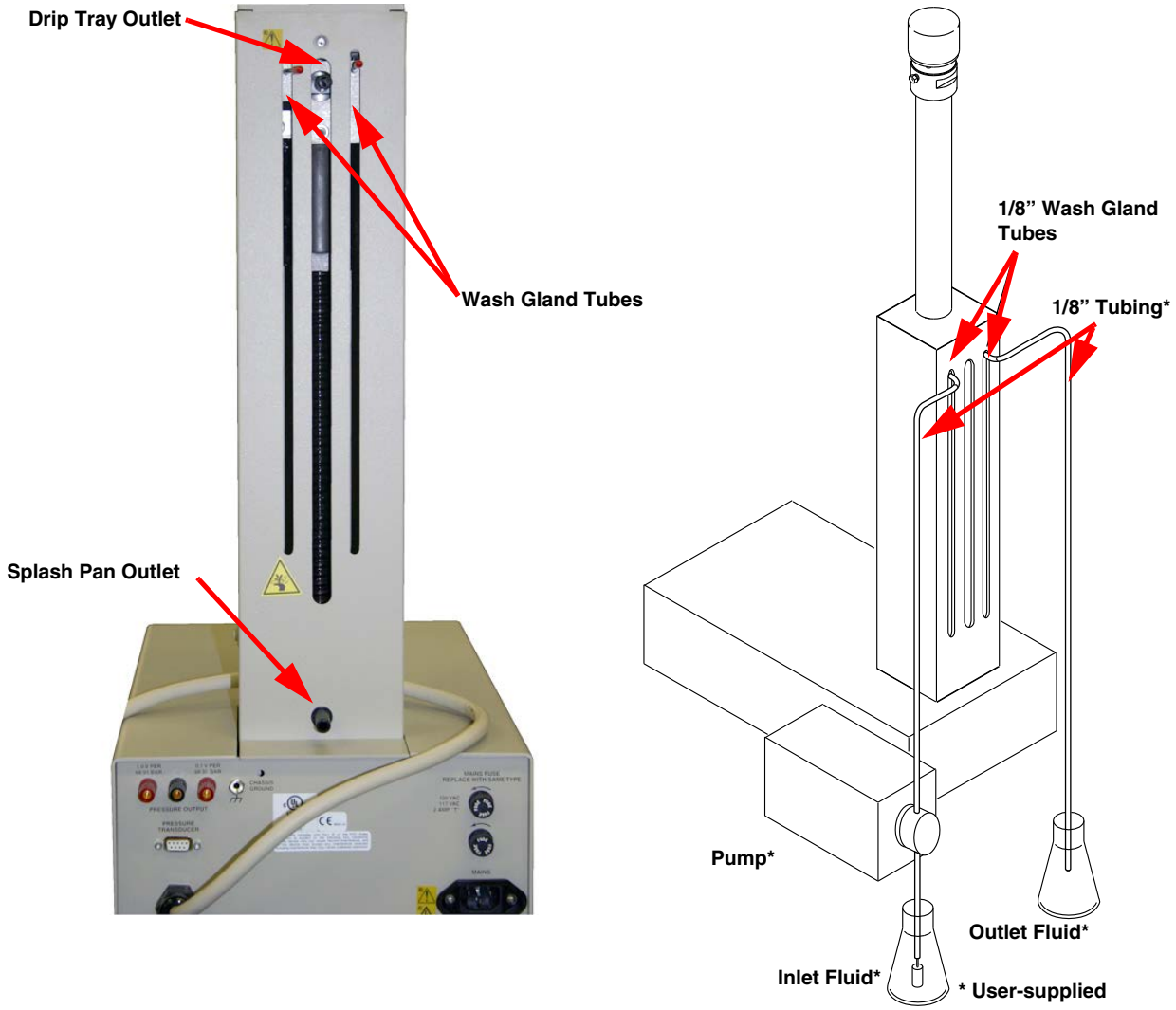


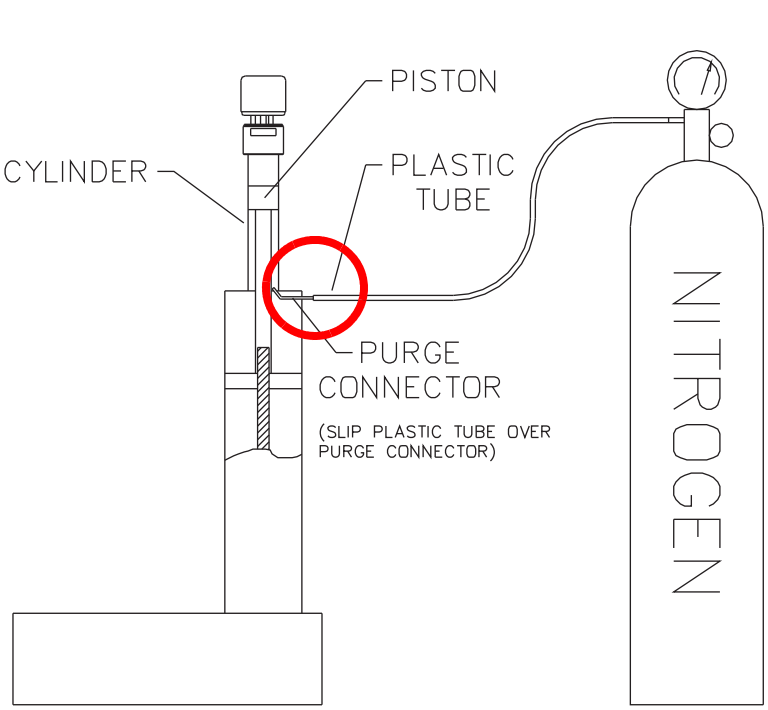
Figure 2-4 Drain tube installation and wash gland connection

2.2.7 Cylinder Washing - Nitrogen Purge

All pumps that do **not** have a wash gland are equipped with a purge connector tube near the top of the pump body. The purge connector enables the pump cylinder beneath the piston to be purged with nitrogen, reducing the presence of atmospheric oxygen below the piston. This feature is most useful when pumping fluids that are flammable. Figure 2-5 shows a typical connection to the purge tube on the back of the pump.

To Purge with Nitrogen

1. Attach gas supply by slipping the plastic tube over the purge connector, as shown below.
2. Regulate the nitrogen supply to slightly above atmospheric pressure.



Close-up of Nitrogen Purge Tube

Figure 2-5 Purge connector installation

2.2.8 Flushing Pumps with External Transducers

When changing pumped liquids in the Model 65x or other models with external transducers, flush the pump to prevent cross-contamination or difficulties with incompatible fluids.

In comparison to other SyriXus pumps, those with external transducers have a greater dead volume space due to transducer and tubing differences. This dead volume space increases the possibility of residual liquid being held in the pump. Also, the external transducer may retain residual liquid. Dead volumes are listed in the specification tables found in Section 1 "Introduction".

To flush the pump, remove the transducer and its tubing from the top of the pump.

Caution

Never immerse the transducer in solvent.

Using nitrogen, blow out any liquid that remains inside the cylinder, transducer port, and tubing. Using shop air pressure is not recommended due to the possibility of compressor oil being present in the air.

WARNING

Liquids expelled by compressed gases may cause injury. Wear eye protection. Certain liquids also may require other personal protective equipment. Refer to the applicable Safety Data Sheet (SDS) for more information.

2.3 Fluid Connection Accessories

The optional accessories discussed in this section are used to make fluid connections from the pump(s) to another apparatus.

When making fluid connections that use ferrules, be sure to use the ferrules provided in the kit. Push the tubing completely into the connector and finger-tighten. Then tighten with a wrench to clamp the ferrules onto the tubing.

2.3.1 Manual Refill Kit

The optional manual refill kit provides a high pressure, two-way valve that connects to the pump inlet to a fluid reservoir. The kit contains all tubing and hardware necessary for valve installation. Kit components and connections are shown in Figure 2-6.

Kit Installation

1. To attach the two-way valve to the pump housing, use the valve spacer block and screws provided.
   a. For the 500x pump, screw the male adapter into the inlet port of the pump.
2. Connect the pre-bent stainless steel tubing from the valve to the pump inlet. Use the nut and ferrule to connect the tubing at the inlet and the valve fittings to connect the tubing at the valve.
3. Connect the PTFE refill tubing (with the filter) to the port of the two-way valve, using the nuts and ferrules supplied.

NOTE

When connecting to pressurized sources in supercritical fluid applications, use the stainless steel tubing **without** a filter. An inline filter is contained in the CO_2 connection package (refer to Technical Bulletin TB08 CO2 Applications and Technical Notes.

DANGER

RISK OF INJURY. THIS EQUIPMENT PRODUCES HAZARDOUS PRESSURES. PLEASE UTILIZE APPROPRIATE TUBING AND CONNECTIONS AS NOTED IN THE MANUAL.

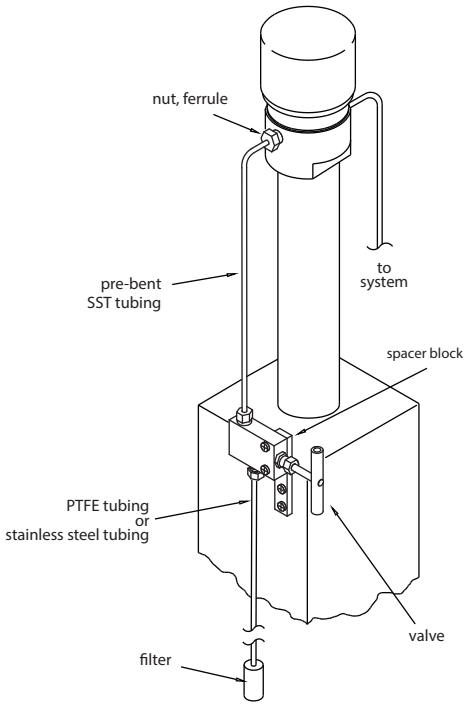


Table 2-2 Manual Refill Kits	
Pump Model	**Part Number**
1000x	68-1247-117
500x	68-1247-083
260x	68-1247-077
65x	68-1247-127

Table 2-3 Manual Refill and Outlet Packages	
Pump Model	**Part Number**
1000x	60-1267-022
500x	60-1267-021
260x	60-1267-021
65x	60-1267-023

Table 2-4 Wetted Materials in Manual Refill Valve Package	
Manual Valves	316 SST, 17-4 pH SST, PTFE
Tubing and Fittings	304 SST, PTFE

Figure 2-6 Refill kit installation

2.3.2 Manual Outlet Valve Kit

The optional manual outlet valve kit provides manual control of the pump outlet port by connecting a shutoff valve between the pump and the rest of the system.

Kit installation

1. Attach the two-way valve using the spacer block and pan-head screws.
   a. For the 500x pump, screw the male adapter into the pump outlet.
2. Connect the pre-bent length of stainless steel tubing to the outlet port on the pump using the nut and ferrule. Connect the other end to the top port on the valve using the valve fitting.

NOTE

For the 500x, this piece of tubing should be cut to the proper length for connection to your system. Due to the wide variety of applications for this model, fittings to connect the tubing to your system are not provided in the kit.

NOTE

When nuts are torqued to the cylinder cap ports, the pressure reading may be affected. If the pressure no longer reads zero, release the pressure in the cylinder and press ZERO PRESS. Refer to Section 3.8.11 "ZERO PRESS" for instructions.

3. Use the valve fittings to attach stainless steel tubing to the top port of the two-way valve.
   a. For the SyriXus 260x, connect the reducing union to the other end of this tubing.
4. Connect the stainless steel tubing between the valve's bottom port and your apparatus. Cut to the desired length.

DANGER

RISK OF INJURY. THIS EQUIPMENT PRODUCES HAZARDOUS PRESSURES. PLEASE UTILIZE APPROPRIATE TUBING AND CONNECTIONS AS NOTED IN THE MANUAL.

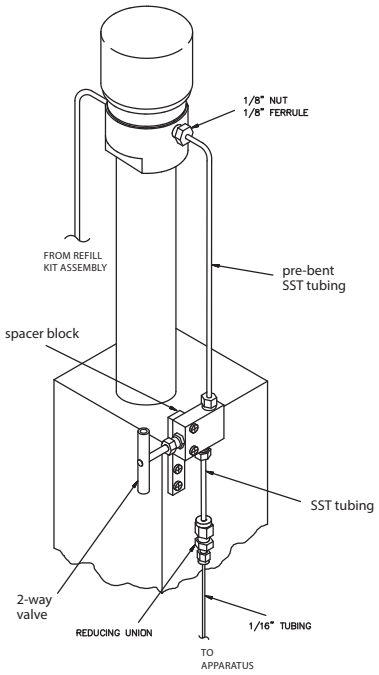


Figure 2-7 Outlet valve package connection

Table 2-5 Manual Outlet Valve Kits

Pump Model	Part Number
1000x	68-1247-118
500x	68-1247-082
260x	68-1247-078
65x	68-1247-126

2.4 Temperature and Pressure Controls

Some applications, such as those with very low flows, may require additional measures to maintain steady rates.

2.4.1 Temperature Control Jacket

The optional cylinder temperature control jacket assists in maintaining cylinder temperatures (-30 to 100 °C) by circulating liquids, such as water or water/ethylene glycol solution, through the 1/4" upper and lower hose connectors.

WARNING

If hot fluid is circulated in the temperature control jacket, the jacket surfaces will become hot. Use thermal protection if the thermal solution is greater than 25 °C (95 °F)

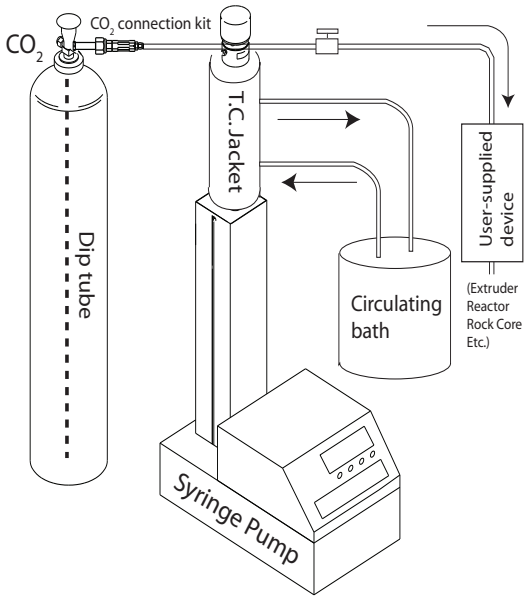


Figure 2-8 System with temperature control jacket installed

A temperature control jacket is very useful for SFC applications where cylinder cooling facilitates filling with fluids such as liquid CO_2. The jacket can also be used with a circulating temperature-controlled bath to keep the fluid inside the pump at a constant temperature. This may be necessary when operating at very low flow rates (below 500 µL/min), where temperature fluctuation can cause flow variations.

When pumping gases, especially those that change phase during compression (like CO_2 or alkane gases), a thermal jacket is recommended to remove the heat buildup resulting from compression work. This heat buildup can cause poor refills and difficulties in maintaining working fluid parameters such as density. Typically the temperature control jacket fluid is maintained at a temperature below room temperature, but the exact temperature chosen would be application dependent.

Table 2-6 Temp. Control Jacket Packages	
Description	**Part Number**
Temperature Control Jacket Packages for:	
65x	68-1268-029
260x	68-1268-005
500x, 500xv, 1000x	68-1247-115
O-rings (2) for Temperature Control Jackets:	
260x	202-2062-11
500x, 500xv	202-2723-59
1000x	202-2062-35

2.4.2 Removing the Pump Cylinder

Installing a temperature control jacket on a pump or replacing the O-rings will require the partial disassembly of the pump. The jacket surrounds the pump cylinder and the pump cylinder functions as the inside wall of the fluid containment. Normally, this involves removing the pump cylinder and cylinder cap together as a unit.

1. Run the pump until the display shows CYLINDER EMPTY. It may be necessary to turn OFF auto-refill so that the pump stops when the cylinder is empty. Refer to Section 3.4.3 "Refill" for instructions on how to turn auto-refill ON or OFF.
2. Disconnect the fluid fittings from the cylinder cap.
3. With the pump inlet and outlet ports open to the air, press REFILL on the controller. The pump should stop and display CYLINDER FULL when the piston is at the bottom of the cylinder.
4. Toggle the STANDBY switch on the controller, turning OFF the controller display.
5. Toggle the POWER switch on the front of the pump to turn OFF the pump.
6. Unplug the pump from the MAINS power.
7. Disconnect the TRANSDUCER cable from the back of the pump and wrap the cable around the cylinder cap. On pumps with external transducers, it is possible to disconnect the cable from the transducer instead.
8. Remove the front cover from the pump tower (if necessary) and locate the cylinder locking screw near the base of the cylinder on the front side.
9. Using a 1/8” Allen wrench, loosen the set screw locking the cylinder about two turns. Do not remove this set screw.
10. Unscrew the cylinder from the cylinder mount. It will take several revolutions of the cylinder to completely unthread it.

NOTE

When the pump is new, the cylinder usually unscrews without much difficulty. Pumps that have been used for a while will be a little harder to unscrew the cylinder. A strap wrench or the wrench kit available from Teledyne ISCO can be used to assist with removing the cylinder. Instructions for using this wrench package will be provided in Section 2.4.3 "Using the Wrench Package".

WARNING

DO NOT USE A COMMON TOOL WITH TEETH (a monkey wrench or water pump pliers, for example) TO REMOVE THE CYLINDER. Doing so will damage the cylinder, resulting in leakage of the temperature control fluid. Such damage is not repairable and will require cylinder replacement.

11. If the wrench package was used to remove the cylinder, remove the wrench package clamps before taking the cylinder off.
12. When the pump cylinder is free of the threads, hold the pump cylinder with both hands and pull the cylinder **straight up** and off the piston and push rod.

NOTE

Some working fluid may spill out when the cylinder is removed. It may be helpful to wrap an absorbent cloth around the base of the cylinder to collect this fluid when the cylinder is pulled off.

2.4.3 Using the Wrench Package

As mentioned above, sometimes the cylinder is difficult to rotate, especially if salt buffers have accumulated in the cylinder threads. The wrench package available from Teledyne ISCO will make this task easier without damaging the cylinder.

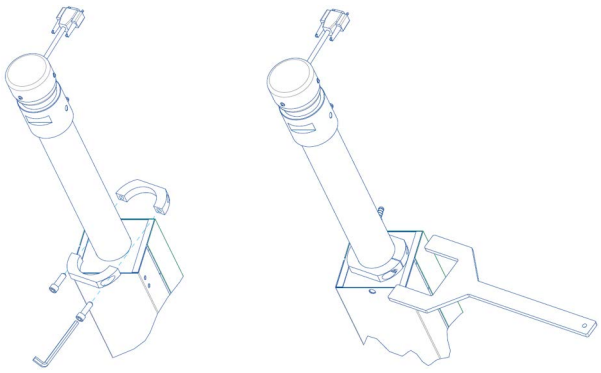


Figure 2-9 Secure screws with the 1/4" hex wrench

13. Select the proper size of cylinder holder clamps from the wrench package.
14. Position the cylinder holder clamps about 1/8” (3 mm) to 1/4” (6 mm) above the cylinder mount as shown in Figure 2-9.
15. Install the 5/16-18 Cap Screws (part of the wrench package) to hold the two parts of the cylinder holder together.
16. Tighten the 5/16-18 cap screws with the 1/4” hex wrench (supplied with the Wrench Kit).
17. Using the proper size wrench (supplied with the Wrench Kit), unscrew the cylinder from the cylinder mount several revolutions as shown in Figure 2-9.
18. Once it is sufficiently loose, finish unscrewing the cylinder by hand. Do not slide the cylinder up yet.
19. Using the 1/4” hex wrench, remove the cylinder holder clamps.
20. When the pump cylinder is free of the threads, hold the pump cylinder with both hands and pull the cylinder **straight up** and off the piston and push rod.

WARNING

Do not slide the cylinder off the piston with the cylinder holding clamps installed. Doing so may result in scratches to the inside of the cylinder or on other internal components.

2.4.4 Installing the Temperature Control Jacket

With the cylinder off of the pump, the temperature control jacket can now be installed. Observe that one end of the jacket has a set screw to hold the jacket in position.

1. If the temperature control jacket has been previously used, inspect the jacket for damage. The jacket is not repairable, and if broken, it must be replaced.
2. Inspect that a new O-ring is installed inside the jacket bore in BOTH ends. Table 2-6 "Temp. Control Jacket Packages" lists the O-ring sizes for each of the pump models.
3. Lubricate the O-rings with soapy water or light oil to ease the assembly of the jacket onto the cylinder.
4. Starting from the end of the jacket WITHOUT the locking set screw, install the jacket onto the cylinder using a twisting motion.

NOTE

It is important that the temperature control jacket is installed with the locking set screw located on the end **away** from the cylinder cap

5. Position the jacket so that it touches the bottom of the cylinder cap.

Caution

Be careful not to damage the O-rings in the jacket when pushing them over the threads of the cylinder. Apply a small amount of soapy water or light oil to the O-rings before installing the jacket to ease installation.

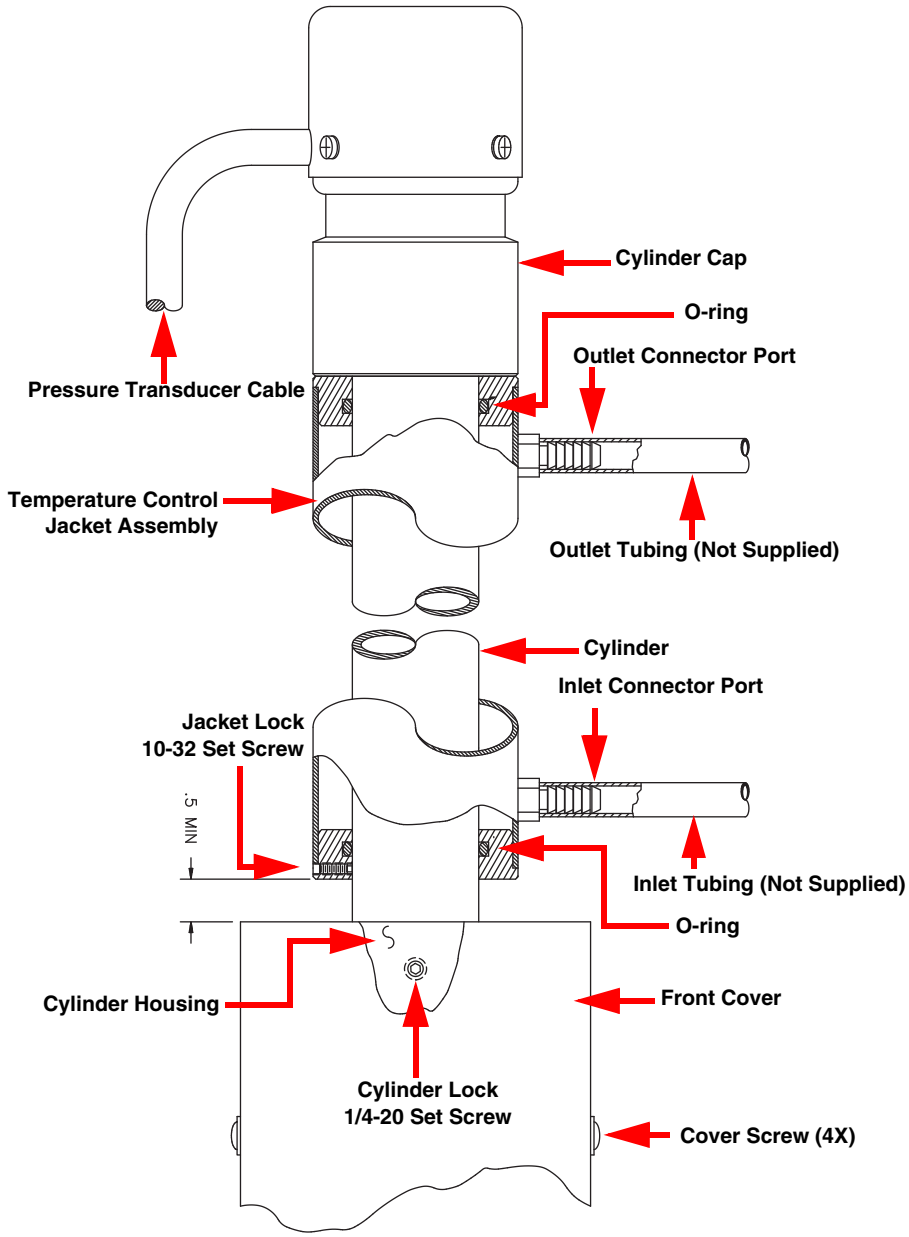


Figure 2-10 Temperature control jacket installation

Reassembling the Pump

Refer to Figure 2-10 for the following steps.

1. Lower the cylinder/temperature control jacket assembly over the piston and push rod assembly.

NOTE

To avoid seal damage, ensure that the cylinder is aligned straight with the piston before lowering. This step is much more difficult if the piston is not fully lowered.

2. Screw the assembly into the cylinder housing until the cylinder is snug against the piston and no longer turns.
3. Unscrew the cylinder a minimum of half a turn.

NOTE

Do not unscrew the cylinder more than one full turn from snug position in the previous step.

4. Line the inlet and outlet cylinder cap ports up as before. Rotate the jacket on the cylinder so that the jacket ports are oriented in the desired direction and lock the jacket to the cylinder by tightening the set screw.
5. Lock the cylinder by tightening the lock screw.
6. Replace the front cover and adjust both covers so they are flush with the cylinder housing.
7. Reinstall tubing.
8. Reconnect the pump pressure transducer cable.
9. Turn the pump ON and check for leaks.

2.5 Seal Options

The pump contains four seals and a wear ring.

- Transducer seal - The transducer seal is gold-plated to press into minute gaps between the surfaces of the transducer flange and the shelf of the cylinder cap.

NOTE

The metal transducer seal prevents fluid leakage around the transducer. It is not user replaceable and requires special procedures to install correctly.

NOTE

The 65x and high temp models do not have a transducer seal.

- Cylinder cap seal - The cylinder cap seal maintains the pressure within the cylinder.
- Piston seal - The piston seal maintains the pressure within the cylinder.
- Wiper seal - The wiper seal cleans the inside of the cylinder. In the model 1000x pump, the wiper seal faces the same direction as the piston seal to prevent leakage of the wash gland fluid. All other models have the bottom seal facing down as shown in Figure 2-11.
- Wear ring - The wear ring supports the seal against movement within the cylinder and keeps the piston centered in the cylinder bore.

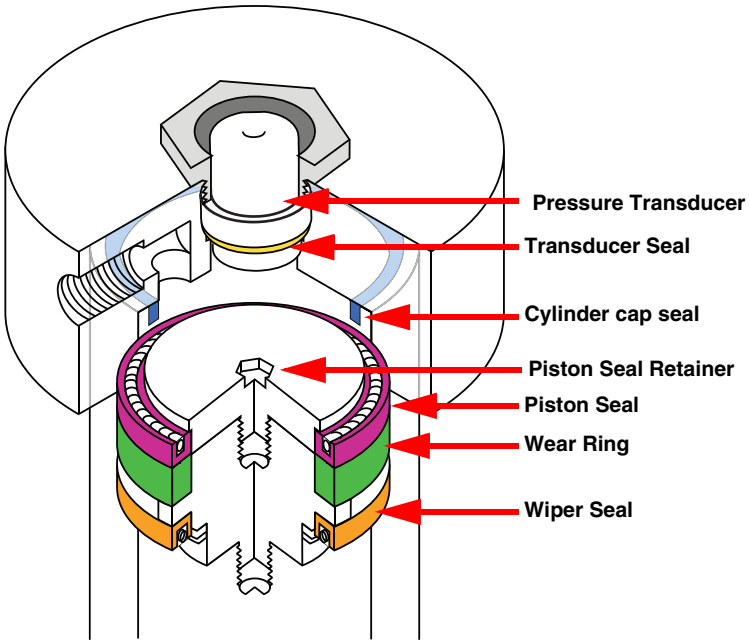


Figure 2-11 Inside the pump cylinder: wetted materials

SyriXus series syringe pumps are available in two metal variants. The 1000x, 500x, 500xv, 260x and 65x use Nitronic® stainless steel for the cylinder. The 260x and 500x are also available with Hastelloy® cylinders. The wetted materials variants are factory installed, conversion from one variant to the other is not supported.

Table 2-7 Wetted Materials in SyriXus Series Pumps

Nitronic® Stainless versions	Nitronic stainless steel, PTFE, 316 stainless steel, Hastelloy, gold, titanium, PEEK
Hastelloy® versions (260x and 500x only)	Hastelloy C276, PTFE, gold, titanium, PEEK

The standard seals for each pump model satisfy the requirements of most applications, including those that use carbon dioxide, such as SFE. However, certain solvents and/or conditions require special cylinder seals to facilitate the application. Table 2-8 "Seal Selection Chart" is provided to assist in selecting the correct seal for your pump and application requirements.

Table 2-8 Seal Selection Chart

Seal Type	Max Pressure	Seal Description	65x	260x[a]	500x/ 500xv	1000x
GENERAL/SFE CARBON DIOXIDE	0-689.5 bar 0-1379 bar	Black, PTFE graphite filled	202-9096-08	202-9091-06	202-9091-56	upper seal 202-9990-25 lower seal 202-9990-23
	This is our standard seal. It is good for most applications, particularly those using organic solvents, such as: LC, SFC, and SFE.					
HIGH TEMPERATURE	0-689.5 bar	Black, PTFE graphite fiber reinforced high temperature compound		202-9091-09	202-9093-56[b]	upper seal 202-9990-28 lower seal 202-9990-27
	This seal is best suited for applications which require higher temperatures. Its chemical compatibility is similar to that of the general seal.					
LOW PRESSURE	0-137.9 bar	Black, PTFE graphite filled single point contact		202-9092-06	202-9092-56	N/A
	This seal may provide better sealing at lower pressure. Its chemical compatibility is similar to that of the general seal.					
AQUEOUS	0-689.5 bar	White-translucent, ultra-high molecular weight polyethylene		202-9094-06	202-9094-56	N/A
	This seal has better wetting properties, making it a good choice for aqueous solutions. It is also the best choice for electrochemical detection. **NOTE: This seal requires a special break-in procedure before installation. Refer to Section 9.10.2 "Piston Seal Break-In (Aqueous Seals Only)".**					
AMMONIA (NH_3) NITRIC ACID	0-275.8 bar	White, virgin PTFE		202-9091-07	202-9091-57	upper seal 202-9990-26 lower seal 202-9990-24
	This is the only seal recommended for ammonia.					

a. The SyriXus 260x accessory package for the standard pump (not high temperature) comes with both the 202-9091-06 and 202-9094-06 seals. Not all accessory packages come with replacement seals.

b. The maximum allowable temperature and pressure are interrelated for the 500xv. Higher temperatures will reduce the maximum allowable working pressure. Refer to Table 5.2 for details.

NOTE

The seal leakage specification applies to the Low Pressure seal type under the specified conditions only. Optional seals, particularly the High Temperature seals and the Aqueous seals, may exhibit greater seal leakage.

Section 3 Basic Programming and Operation

3.1 Introduction

This section will familiarize you with the SyriXus series pump controller and describe operating the pump under each of the various Modes: Constant flow, Constant Pressure, Dispense, and Refill.

Pump setup and operation is regulated by the SyriXus series controller. Operating parameters are entered via the keypad on the front panel of the controller. Operating selections are displayed as menu items on the controller screen or are associated with a dedicated key on the controller keypad. Operating modes such as CONST FLOW, CONST PRESS, DISP, and REFILL all have dedicated keys.

WARNING

UL (Underwriter Laboratories) has certified the SyriXus series Controller and Pumps on the basis that explosive chemicals or chemicals that could become explosive under pressure are NOT used. The instruments are not explosion proof. Use extreme caution when pumping hazardous fluids.

3.2 General Controller Information

The following information is intended to familiarize you with the controller operation. Once you have become familiar with the keypad and the main menu, you will find it easy to direct the pumping operations required for your applications.

If you make an incorrect entry, press CLEAR ENTRY to delete your last keystroke. If you have entered a Programming Mode but do not wish to make any changes, press ENTER to keep the current setting, or press softkey D to return to the previous screen.

3.2.1 Controller Models

The SyriXus series controller and the standard D series controller are very similar and can be used interchangeably for many models. When the pump models and controller model are mixed, the display on the controller identifying some of the pump models will not show the pump model as expected.

NOTE

Neither the SyriXus series controller, nor the D series controller, can be used with the HL pump series.

When the SyriXus controller is connected to a D series pump, the model numbers are displayed as shown in Table 3-1 "SyriXus Series Controller to D Series Pump".

Table 3-1 SyriXus Series Controller to D Series Pump

D Series Pump Model	Model Name Displayed
1000D	1000x
500D	500D
500HV	500D
260D	260D
260HP	260x
100DX	100DX
65D	65x
65DM	65DM
65HP	65HP

When a D series controller is connected to a SyriXus series pump, the model numbers are displayed as shown in Table 3-2 "D Series Controller to SyriXus Series Pump".

Table 3-2 D Series Controller to SyriXus Series Pump

SyriXus Series Pump Model	Model Name Displayed
1000x	1000D
500x	500HP
500xv	500HP
260x	260HP
65x	65D

The pump and controller combinations shown in Table 3-2 "D Series Controller to SyriXus Series Pump" will function as described in the pump's user manual without any loss of performance. The only minor difference is the pump model name displayed on the controller for certain combinations.

If the controller software is not able to function with the attached pump, the controller will display "UNKNOWN PUMP TYPE" instead of the pump model. When this happens, use the controller that came with the pump. The 30D, for example, uses its own controller.

NOTE

All pumps connected to a single controller must be of the same generation. A single controller cannot properly operate a mixture of D-Series and SyriXus pumps.

3.2.2 Rates, Units, and Limits

- To allow pump operation to be tailored to your application, both the pressure and flow rate units may be set by the user. Refer to Section 3.4.1 "Flow and/or Pressure Units of Measure".
- The pump also allows for user programmed refill, as well as pumping rates. Refer to Section 3.4.3 "Refill".
- The system protection limits may also be set by the user, refer to Section 3.8.7 "LIMITS".

3.2.3 Programming Screens

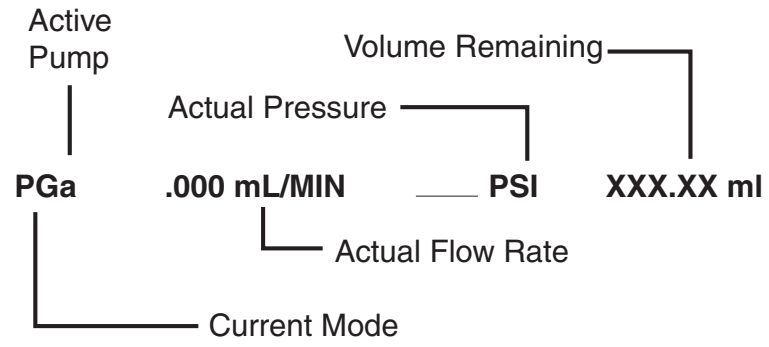
The programming screens are divided into separate menus. These menus are accessed when different features are being programmed. For complete information about programming menus, refer to Section 3.3 "Main Menus" through Section 3.7 "Menu Four".

3.2.4 Run Screens

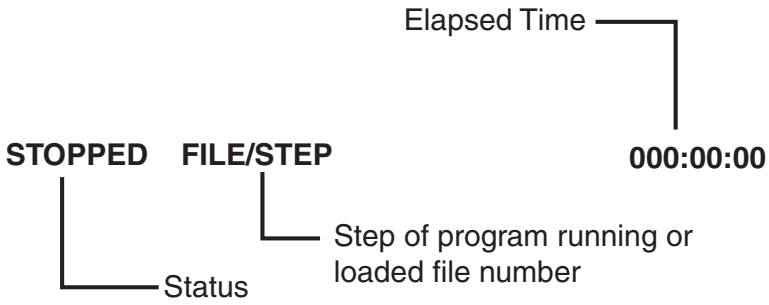
The run screen is shown once a program has been loaded and the pump is running.

The run screen, which is determined by your program selections, displays current information about pump operation. The following sections explain the display line-by-line.

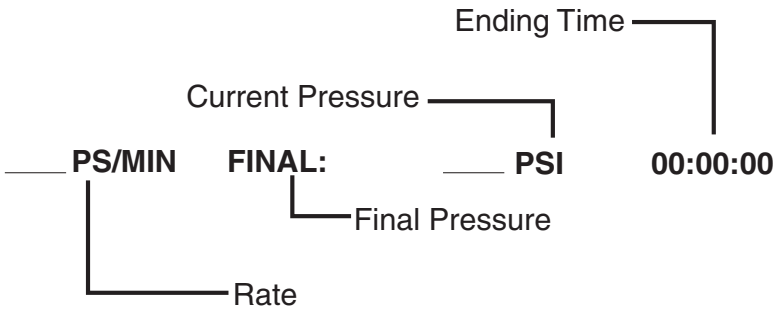
- Line One - Regardless of mode, the first line of the run screen is always the same.



- Line Two - The second line varies slightly depending on the operating mode. A file or step will only be displayed when operating in the Gradient Mode.



- Line Three - Line three varies depending on the mode; the rate and units are set by the user, so these will vary depending on your programming requirements. The ending time will always be displayed on this line.



- Line Four - Line four varies depending on the mode. The options presented on this line are softkey selectable, i.e. you use the softkeys (A - D) located below the display to choose the option.

3.2.5 Selecting Operating Parameters

There are four ways to program the system from a menu screen:

- Menu Selection - The number keys are used to select from listed menu items.
- Softkey Selection - The softkey programming options appear on the fourth line of the screen. To either toggle or select an option, press the softkey, A-D, directly below that option.
- Keypad Selection - The programming keys are located on the left side of the keypad. The pump mode, limits, and refill are all options that may be selected from the keypad.
- Value Selection - The number keys are used to enter all numeric values required for pump operation. When a numeric value is required, a message will blink, prompting to enter an appropriate value.

3.3 Main Menus

There are four primary menu screens. Access Menu 1 by pressing MENU. To move forward and back between Menus 1, 2, 3, and 4, or to return to the run screen, use softkeys A (MORE) and D (PREVIOUS/RETURN).

Use the number keys to select a menu option. Selecting a menu option displays the programming parameters for that option in menu format.

NOTE

To exit a menu when multiple pumps are connected, press the STORE, RECALL, CLEAR ENTRY OR MENU key.

3.4 Menu One

Menu 1 provides programming options for units of measure, pump selection, refill settings, power failure response, system reset, and display contrast adjustment.

To save all settings and return to the main menu, press RETURN (D).

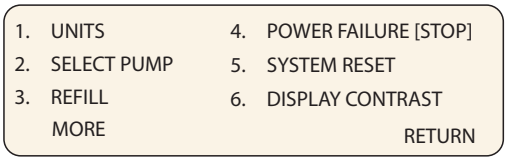


Figure 3-1 Menu 1 program selections

3.4.1 Flow and/or Pressure Units of Measure

Displayed units are user-selectable by selecting menu 1 item 1.

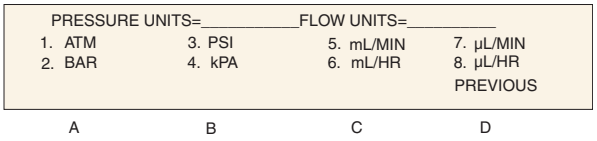


Figure 3-2 Units menu

- Use numbers 1-4 to select the pressure units (ATM, BAR, PSI, kPa). The units selected will be displayed on the first line after PRESSURE UNITS=.
- Use numbers 5-8 (mL/MIN, mL/HR, µL/MIN, µL/HR) to set the flow rate units. The selected units will be displayed on the first line after FLOW UNITS=.

3.4.2 Pump Selection (if Multiple Pumps)

If multiple pumps are connected to a single controller, the SELECT PUMP option selects the pump (A, B, C, or D) whose current state and settings appear on the display.

The letter of the current pump will appear in lower-case in the upper left corner of the run screen.

NOTE

When multiple pumps are connected, the UNITS selected for one pump will apply to all of the pumps.

3.4.3 Refill

The refill option allows you to set the refill rate or set the pump to automatically refill when a certain volume is reached.

NOTE

This feature may be less desirable when pumping liquefied gases or volatile fluids. During refill, the cylinder must be able to aspirate the refill reagent from the solvent reservoir, which will be less effective if the cylinder is not empty and the fluid is highly compressible or changes phases.

Press MENU > REFILL (3). The auto refill menu will appear.

NOTE

If more than one pump is connected to the controller, pump B, pump C, and pump D will be displayed on the fourth line, depending on how many pumps are attached. To select a pump, press the softkey under the pump designation.

To Set Auto Refill Volume

1. Press '1' to set the volume for pump A (or the currently selected pump). Refer to Section 3.4.2 "Pump Selection (if Multiple Pumps)".

   The units to the right of the symbol will blink, indicating that you should enter a volume. Use the number keys to enter an appropriate value and then press ENTER.

To Set Refill Rate

1. Press '3' to set the refill rate for the designated pump. The refill rate can also be changed from the main screen while the pump is refilling.
2. A message will blink on the screen prompting to enter the selected refill rate.
3. Enter the desired rate with the number keys and press ENTER.
4. To save and exit the refill menu, press D, PREVIOUS.

Disable / Enable Auto Refill

The first line will display 'OFF' or 'ON', indicating whether or not this feature is enabled for pump A (or the currently selected pump). Press '4' to toggle this feature OFF or ON for each pump.

NOTE

Auto refill can be set independently for each pump.

If AUTO REFILL is ON, the pump will automatically switch to Refill Mode when the volume reaches the auto refill mark. After refilling, pumping will resume in the programmed mode. The ACCESSORY outputs, which drive powered valves, will switch in sequence.

Unless otherwise specified, the pump will refill to full cylinder capacity. To specify a smaller refill volume, press '2' and enter the desired volume. Press '5' to toggle this feature OFF or ON for each pump.

NOTE

The system can also be programmed to refill a pump based on an external analog input voltage, with a range of 0 to 11.5 volts. Information about this feature is provided in Section 3.12.3 "External Control for Refill".

3.4.4 Power Failure [STOP]

This feature allows you to set the activity of the pump in the event of a power failure. Press '4' to toggle this feature between [STOP] (to remain stopped after power is restored) or [CONT] (to automatically resume after power is restored).

NOTE

In a multiple-pump system, this action is applied to all connected pumps.

3.4.5 System Reset (Restore Default Settings)

To restore default program settings, press '5'. To continue with the reset, press CONTINUE (A); to cancel the reset, press DO_NOT (D).

Caution

Resetting the system erases all programs and user settings.

This is a basic reset. For information about performing a "hard" reset, refer to Section 9.5.2 "Hard Reset".

3.4.6 Display Contrast

From the menu, you can adjust the screen brightness for your lighting conditions and viewing angle.

Use softkeys B, DOWN, or C, UP to reduce or increase the brightness.

3.5 Menu Two

Menu 2 provides programming options for serial communication, pump status, external control, multiple pump operation, volume reset, and valve control.

To save all settings and return to the main menu, press PREVIOUS/RETURN (D).

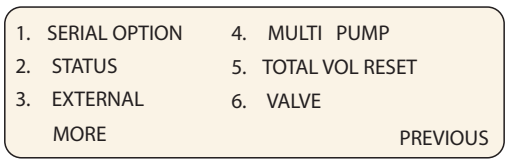


Figure 3-3 Menu 2 program selections

3.5.1 Serial Option

The serial option menu allows you to set the baud rate and the unit identification number.

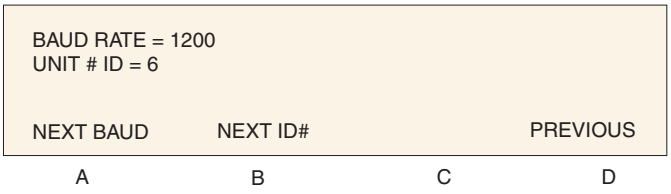


Figure 3-4 Serial option menu

- Use softkey A, NEXT BAUD, to scroll through the available baud rates. These are: 300, 1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, and 115.2K.
- Use softkey B, NEXT ID#, to scroll through the available ID numbers. These are 1-7. Six is the default, as this is the unit identifier used by the Teledyne ISCO LabVIEW™ software.

For information on serial control, refer to Section 8 "Serial Interface".

3.5.2 Pump Status

This option displays the controller software revision, and model of connected pump(s).

- The first line displays the revision of the software.
- Lines 2, 3, and 4 display the type of pump connected to the A, B, C, and D pump connectors, respectively.

This screen is also momentarily displayed automatically each time the pump controller is switched ON.

3.5.3 External Control

The pump pressure or flow rate operation can be controlled externally with an analog voltage. Complete instructions for this feature are provided in Section 3.12 "External Control - Analog".

3.5.4 Multiple Pumps

One controller can control up to four pumps at once, either together or independent of each other.

Complete information about using the MULTI PUMP feature is provided in Section 3.9 "Control of Multiple Pumps" and Section 5.5 "Continuous Flow Mode".

3.5.5 Total Volume Reset

This option resets the total volume display of multi-pump pair AB or multi-pump pair CD to zero when operating in Continuous Flow or Modifier Addition Mode.

The total volume feature displays the sum of all the volumes delivered by a pump pair in Continuous Flow Mode since the last reset. Refer to Section 5.5.1 "Defining Operation".

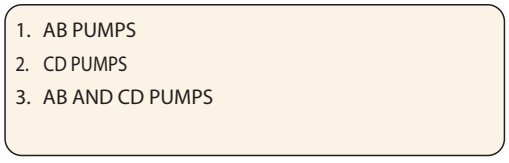


Figure 3-5 Total volume reset

3.5.6 Valve

This feature identifies the type of valves (1. ACTIVE [air], 2. PASSIVE or 3. ELECTRIC 2 WAY) being used for the flow operation. Valves are set to 'active' by default. If 1. ACTIVE or 3. ELECTRIC 2 WAY is selected, the controller will match the pressure more closely between the pumps, before switching delivery pumps.

If ball valves (500xv only) are being used and no check valve is in the supply reservoir tubing, the No Check Valve option (refer to Section 5.5.4 "No Check Valve") should be used to create a timed delay after valve open/closure, before switching delivery pumps. This delay is to accommodate the slower opening/closing ball valves.

The number for the selected valve type will be blinking. Press ‘1’, ‘2’, or ‘3’ to select the correct valve type.

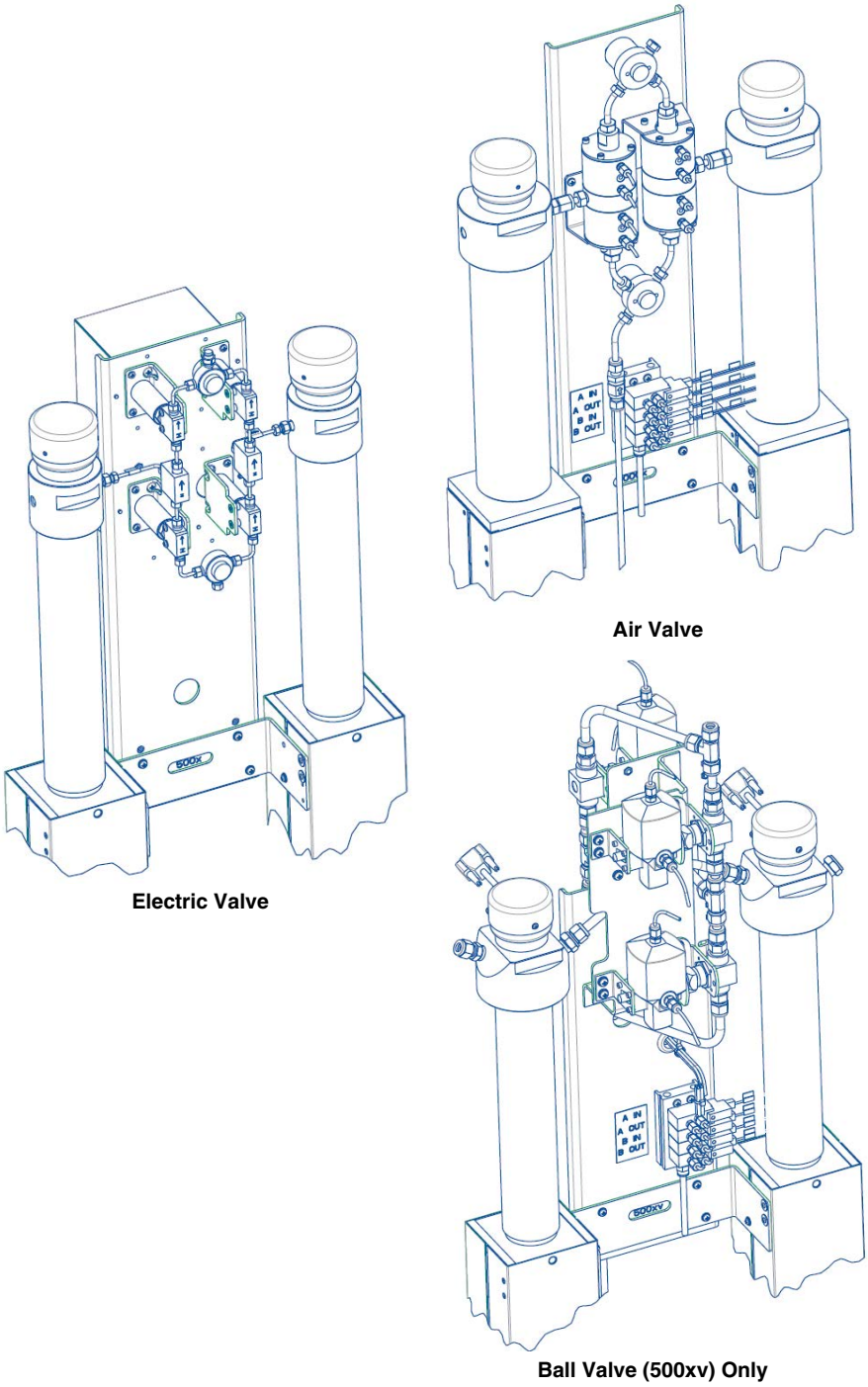


Figure 3-6 Types of valves

3.6 Menu Three

Menu 3 provides programming options for poor fills, diagnostics, pressure calibration, alternative pressure inputs, pressure control setting, and pressure setpoint tolerance.

To save all settings and return to the main menu, press PREVIOUS/RETURN (D).

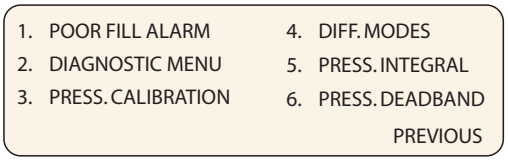


Figure 3-7 Menu 3 program selections

3.6.1 Poor Fill Alarm

In Constant Pressure Mode, this feature allows you to set a fill point as a percentage of pump volume. If this volume percentage is not reached after a refill and re-pressurization, the system issues an alarm and stops the pump.

3.6.2 Diagnostic Menu

This selection displays an additional menu containing testing options for the system. Refer to Section 9.6 "Diagnostic Menu" for a complete explanation of how to use the diagnostic menu.

3.6.3 Pressure Calibration

This is a stored psi value to ensure optimal operation of the pressure transducer. On most pumps, this value, known as the “midpoint adjustment,” can be found on a tag on the transducer cable (Figure 3-8).

NOTE

The midpoint adjustment value is individual to each pump, and is stored within the controller software. Therefore, this value must be re-entered if the controller or pump is switched, controller is reset, or if a pump is plugged into a different port on the controller.

Standard calibration for the transducer is a two-point adjustment, at zero and maximum pressure. The midpoint adjustment number is the difference between the pressure at half maximum, as read by a pressure gauge with a precision of 0.25% accuracy, and the syringe pump transducer output.

Figure 3-8 Location of transducer midpoint value

Press CALA, CALB, CALC, or CALD to select the correct pump, enter the calibration number, and press ENTER.

3.6.4 Diff. Modes

This feature allows the use of other analog inputs for pressure input to the pump. The standard pressure transducer **MUST** be connected to pump in order for this feature to work.

- Press '1', OFF, to turn OFF this feature.
- Press '2', 0 to 50 ANLG1, to use a 5 volt 50 psi transducer on ANALOG INPUT 1 of the ACCESSORY connector.
- Press '3', Custom ANLG1, to use 5 volt custom pressure transducer on ANALOG INPUT 1 of the ACCESSORY connector.
- Press '4', 500 ANLG2, to use a 5 volt 500 psi pressure transducer on ANALOG INPUT 2 of the ACCESSORY connector.
- Press '5', 5000 ANLG3, to use a 5 volt 5000 psi transducer on ANALOG INPUT 3 of the ACCESSORY connector.

3.6.5 Pressure Integral

The pressure control algorithm can be adjusted by turning OFF the integral compensation. This may be desirable at very low flow rates or during static tests. Under these conditions pressure control may be more stable with integral compensation OFF. If the pressure integral compensation is OFF, there will be a pressure error proportional to the delivery flow rate. For this reason, the pressure integral is normally turned ON except for very low flow rates.

This feature is ON by default. Press '1', '2', '3', or '4' for the associated pump A, B, C or D to toggle the feature OFF.

3.6.6 Pressure Deadband

This feature prevents pump pressure 'hunting' when delivering at low flow rates (<0.25 mL/min for all models). When this function is ON, the pump pressure may exceed the setpoint by up to 3 psi without the piston backing up to reduce the pressure. If the pump pressure exceeds the setpoint by more than 3 psi, the motor will reverse the piston until the 3 psi dead band maximum is reached. No dead band is allowed if the flow rate is above 0.25 mL/min when the pressure error is negative (pressure below the setpoint).

If the 3 psi positive pressure error is not acceptable at low flow rate, toggle the dead band feature OFF by pressing '1', '2', '3', or '4' for the associated pump A, B, C or D. This feature is ON by default.

3.7 Menu Four

3.7.1 Modbus Options

The Modbus RTU and TCP communications protocols are supported. Complete information about using Modbus RTU and Modbus TCP communication is provided in Section 7 "Modbus Configuration".

3.8 Front Panel Keys

In addition to the menu options, certain functions and modes are selectable from the front panel keyboard.

3.8.1 CONST PRESS and CONST FLOW

These keys place the system in Constant Pressure Mode or Constant Flow Mode, respectively. Information for these operating modes can be found in Section 3.10 "Operating Modes".

3.8.2 PRGM GRAD

This key is used to place the pump system in Gradient Mode. For complete information about gradient programming, refer to Section 4 "Gradient Pumping for Pressure, Flow, and Concentration Modes".

3.8.3 HOLD

The HOLD key is used while a gradient is running. When HOLD is pressed, the program clock freezes and current gradient parameters are maintained.

To resume the gradient, press the HOLD key again or the RUN key.

3.8.4 RECALL

The RECALL key can only be used when the pump(s) are stopped or when in HOLD Mode. The RECALL key is used to recall a previously programmed gradient. When you select this option, the controller automatically loads the gradient and switches the pump to program Gradient Mode.

1. Press RECALL and use the number keys to enter the number name of the gradient you wish to recall. Press ENTER.
2. If you enter a number of a gradient that does not exist, the controller briefly displays the message “FILE NUMBER DOES NOT EXIST.” It then assumes you will be creating a new gradient under that number and displays the program gradient run screen.

3.8.5 STORE

The STORE key is operational in the programmed Gradient Mode. It is used to save the program gradient parameters and exit the Programming (parameter entry) Mode.

3.8.6 REFILL

The REFILL key manually places the pump in Refill Mode.

3.8.7 LIMITS

The controller allows the user to set the minimum and maximum flow rate limits, the minimum and maximum pressure limits, and the maximum rate the pump will run while controlling the pressure in Constant Pressure Mode.

- When using a single controller to operate multiple pumps, you need to select the appropriate pump before setting any pump parameters. The available pumps will be displayed above the softkeys. These selections correspond with the connector that the pump control cable is plugged into, on the rear panel of the pump controller. To select a pump, press the softkey under the pump designation. The top line of the screen will indicate the currently selected pump.
- The maximum and minimum limits you set cannot exceed the pump specifications.

To set the limits

1. Press LIMITS. To display the Limits menu, enter the number of the limit you wish to program. One of five limit setpoint menus will appear: MAX PRESS, MIN PRESS, MAX FLOW, MIN FLOW, or FLOW LIMIT. The MAX PRESS limit setpoint menu is shown in Figure 3-10.

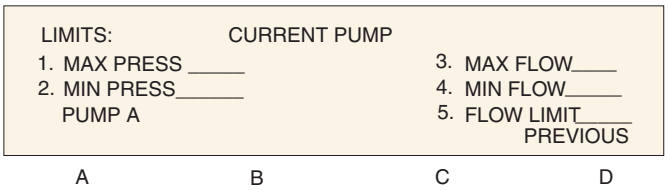


Figure 3-9 Limits menu

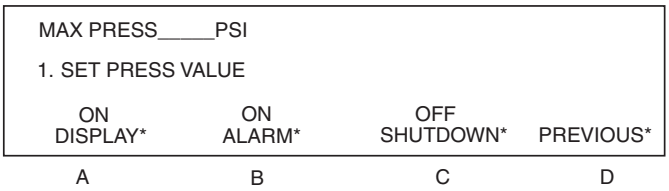


Figure 3-10 Limits setpoint (Max Press) menu

NOTE

These features are discussed in "*Limits Programming Options*" in Section 3.8.7 "LIMITS".

2. Press the number 1 key to set the value. A message will blink on the right side of the screen, prompting you to enter the selected limit.
3. Enter the desired limit setpoint, using the number keys.
4. Press ENTER to save the value.

NOTE

The pump can be set to shut off or not shutoff dependent on this limit condition by pressing softkey C under shutdown. This will toggle this option to ON.

5. To exit the limit menu, press the softkey 'D', PREVIOUS. If four pumps are connected, press STORE, RECALL, or CLEAR ENTRY to exit the limits menu.
6. Once all the limits have been set, press softkey 'D', PREVIOUS, to return to the main menu.

Limits Programming Options

In addition to setting the upper and lower limits, the pump also allows the user to specify whether they want:

- The alarm message displayed
- An alarm to sound when the limit is reached
- The pump to shut down when the limit is reached

These features are set using the softkeys 'A' - 'C', which toggle the feature ON and OFF.

NOTE

The Max Press (maximum pressure) display ON and alarm ON options cannot be disabled.

- Display

  When a limit has been exceeded, this feature causes the display to automatically flash an OVER or UNDER LIMIT message. To turn OFF this function, press softkey 'A' once to toggle to:

  OFF
  DISPLAY

- Alarm

  When a limit has been exceeded, this feature causes the pump to automatically beep a warning. To turn OFF this function, press softkey 'B' once to toggle to:

  OFF
  ALARM

- Shutdown

  When a limit has been exceeded, this feature causes the pump to shut down. To turn OFF this function, press softkey 'C' once to toggle to:

  ON
  SHUTDOWN

Flow Rate Limit for Pressure Control

When the pump is controlling pressure (CONSTANT PRESSURE MODE), the flow rate is not user-controlled, and may range up to the maximum flow of the pump. In some cases, it is desired to limit the rate of pumping during system pressurization. This can be done by selecting limit '5', FLOW LIMIT. The FLOW LIMIT value is used as the upper range of flow rate during pressure control. This limit is not the same as the MAX FLOW limit, which is a threshold above when the pump is stopped, or an alarm is activated as selected by the operator.

To save your changes and return to the main menu, press softkey 'D', PREVIOUS.

3.8.8 RAPID PRESS

This option is available when operating in the Constant Flow Mode and in the two-pump concentration Gradient Mode. It allows rapid pressurization to a stable pressure point and then switches automatically to the Constant Flow setpoint. This is helpful when you are operating at a low flow rate but wish to rapidly pressurize a solvent.

1. Press CONST FLOW to put the pump in Constant Flow Mode, or enter a two-pump concentration gradient.
2. Press RAPID PRESS.
3. The controller will display maximum flow rate and target pressure setting. If these values are correct, press 'D' to continue rapid pressurization.
4. If you know approximately what the pressure will be when the system is stable, enter this value as a target pressure. Press 'A' and enter the desired pressure value. This should shorten the time required to stabilize the system pressure.

NOTE

While pressurizing some working fluids (such as CO_2), heat will be generated because of compression work. Use of a temperature control jacket (described in Section 2.4.1 "Temperature Control Jacket") for cooling, will reduce the time required to stabilize the system pressure.

5. If you would like to limit the maximum flow rate during the rapid pressurization phase, press 'B' and enter the desired flow rate limit.
6. Press 'D' to continue rapid pressurization.

3.8.9 DISP

The DISP key activates Dispense Mode, for applications such as reactant feed and batch delivery, where a specified volume is pumped. Refer to Section 3.10.3 "Dispense Mode" for programming steps.

3.8.10 ACC CTRL

The ACC CONTROL key will allow you to manually operate accessories (such as valves) via the Digital Output terminals on the back of the controller.

1. Press ACC CTRL.
2. From the accessory control menu, use the number keys 1-8 (1-A INLET, 2-A OUTLET, 3-B INLET, 4-B OUTLET, 5-C INLET, 6-C OUTLET, 7- D INLET, 8- D OUTLET) to toggle the desired valve open or closed. (Numbers 1-8 represent digital output terminals 1-8, respectively).
3. To exit, press PREVIOUS (D).

3.8.11 ZERO PRESS

The ZERO PRESSURE key will correct pressure sensor drift. Before pressing ZERO PRESS, the pump should have port fittings installed, and be depressurized.

1. Open a valve, or loosen a fitting other than one on the pump, to ensure the cylinder pressure is actually zero.
2. Press ZERO PRESS. The display will show the current pressure and ask if you want to zero the pressure.
3. Press 'A', 'B', 'C', or 'D' to zero the desired pump.

   or,

   If the pump is not depressurized, press DO_NOT (D) to exit the zero pressure operation. If four pumps are connected, press the STORE, RECALL OR CLEAR ENTRY key.

3.9 Control of Multiple Pumps

When using multiple pumps, there are four multi-pump operating modes of delivery and one Independent Mode:

- Continuous flow in Constant Flow Mode
- Continuous flow in Constant Pressure Mode
- Modifier addition in Constant Pressure Mode
- Modifier addition in Continuous Flow, Constant Pressure Mode
- Independent Mode

3.9.1 Multi-Pump Operation

A SyriXus series continuous flow pumping system in Constant Flow Mode will consist of two syringe pumps and a valve package, all regulated by one controller. Installation and operating instructions for this system are provided in Section 5 "Continuous Flow Introduction, Installation, and Operation".

Two pumps regulated by one controller can be used to create a modifier addition system. This arrangement will require user supplied hardware (tubing, fittings and valves) to implement. For additional information on modifier addition systems, refer to Section 6 "Modifier Addition".

In these modes, the softkeys toggle between the options described in Table 3-3 "Key Functions in the Multi-Pump Mode".

Table 3-3 Key Functions in the Multi-Pump Mode

Key	Display Option	Description
A	NORMAL	Uses a finer (slower) pressure match control when switching from one pump to the other.
	FAST	Uses a coarser (faster) pressure match control when switching from one pump to the other.
B	NORMAL PRESS	Uses pressure matching when switching from one pump to the other
	LOW PRESS	Uses no pressure matching when switching from one pump to the other.
C	DELIVER	Sets the pump into the Delivery Mode of operation.
	RECEIVE	Sets the pump into the Receive Mode of operation.
6	MIN/MAX POINTS	Sets the fill and refill marks that are used with both Continuous Flow Modes. Sets the NCV feature On/Off. Refer to Section 5.5.4 "No Check Valve".

3.9.2 Independent Control of up to Four Separate Pumps

A SyriXus series syringe pump controller can run up to four syringe pumps independently of each other in either Constant Pressure, Constant Flow Mode, Dispense Mode, or any combination of the three. To set up this option, use the following procedure.

1. Press MENU.
2. Press softkey 'A', MORE.
3. Press number '4', MULTI PUMP. The multi-pump menu will appear.
4. Press number '1' for pumps A or B, press number '2' for pumps C or D.
5. Press number '4', INDEPENDENT. The controller will set the pumps to Independent Mode. Number 4 will blink, indicating that Independent Mode is selected.
6. Select the HOLD PRESS or NORMAL mode of operation. Press softkey 'A' to toggle between the two modes.
   - HOLD PRESS

     In Constant Pressure Mode, after the pump is empty, if the outlet pressure rises past the setpoint, the pump will restart and run the system down to the setpoint pressure. This process will function until the cylinder is full.
   - NORMAL

     This feature shuts the system down if a pump runs empty in Constant Pressure Mode.

     Once the pumps have been set to this mode, they will operate independently from one another. Each pump will operate at its defined limit and rate. Independent Mode is the default setting for the pump.

     When you select a command such as STOP or REFILL, the display will prompt you to designate which pump to stop or refill. Only the designated pump will stop, while the other pumps will continue to run.

In an emergency situation, toggling the On/Standby switch will cause all pumps to immediately stop. Also, pressing the stop key on the controller twice will cause all pumps to stop.

7. Return to the run screen by pressing 'D' three times. Then press D (SELECT PUMP). The display will show each pump's information and allow you to select any pump for programming changes.

3.10 Operating Modes

The pump has three Deliver Modes and one Refill Mode.

NOTE

When using a single controller to operate multiple pumps independently, you need to select the appropriate pump run screen before selecting a mode. To select the appropriate pump, press SELECT PUMP (D) and an intermediate screen will be shown. Press the softkey for the appropriate pump, the run screen for that pump will appear.

- Constant Flow

  Refer to Section 3.10.1 "Constant Flow". This mode is used when the flow rate must remain constant during the pumping operation.
- Constant Pressure

  Refer to Section 3.10.2 "Constant Pressure". The Constant Pressure Mode is used when the application of fixed pressure throughout the pumping operation is required. The pump will maintain the desired pressure by positive or negative displacement of the piston.
- Programmed Gradient

  Refer to Section 4 "Gradient Pumping for Pressure, Flow, and Concentration Modes". In the programmed Gradient Mode, the pump can provide the following types of gradient:
  - Two-pump concentration gradient on pumps A and B
  - Single-pump linear pressure gradients on pump A
  - Single-pump flow programs on pump A

NOTE

One pump must be connected to “Pump A” and powered ON for the controller to work.

- Dispense

  For applications requiring delivery of a specific volume. Refer to Section 3.10.3 "Dispense Mode".
- Refill

  Refer to Section 3.4.3 "Refill". You can set the refill rate and change it when in Refill Mode.

3.10.1 Constant Flow

To set Constant Flow operation, use the following procedure:

1. Press CONST FLOW. “CFa” will be displayed in the upper left corner of the screen. This denotes that you will be defining constant flow parameters for pump A. If you wish to define parameters for pump B, C, or D, press softkey D, select pump, and then press softkey ‘A’, ‘B’, ‘C’, or ‘D’ to select pump A, B, C, or D respectively.

NOTE

If the main menu is displayed, you must press ‘D’ under CONST FLOW.

2. Press ‘A’ to change the flow rate. The words ENTER FLOW RATE will flash on the screen.
3. Use the number keys to enter the desired flow rate.

NOTE

If you make an error, press CLEAR ENTRY to delete one character at a time.

4. Press ENTER once the desired flow rate is displayed.
5. Press RUN to begin pump operation.

3.10.2 Constant Pressure

Programming a Constant Pressure operation only requires a few keystrokes. Use the following procedure:

1. Press CONST PRESS; CPa will be displayed in the upper left corner of the screen. This denotes that you will be defining Constant Pressure parameters for pump A. If you wish to define parameters for pump B, C, or D press softkey ‘D’, select pump, and then press softkey ‘A’, ‘B’, ‘C’, or ‘D’ to select pump A, B, C, or D respectively.

NOTE

If the main menu is displayed, you must press softkey D under RETURN before pressing CONST PRESS.

2. Press the softkey ‘A’ to indicate to the program that you wish to enter the pressure. The words “ENTER PRESSURE” will flash on the screen.
3. Use the number keys to enter the desired pressure.

NOTE

If you make an error, press CLEAR ENTRY to delete one character at a time.

4. Press ENTER once the desired pressure is displayed.
5. Press RUN to initiate pump operation.

3.10.3 Dispense Mode

For applications such as reactant feed and batch delivery where a specified volume is pumped, use Dispense Mode. Dispense Mode flow rate begins at zero, ramps up to level out at the programmed flow rate, then ramps back down to zero, delivering a precise specified volume. The slope rate and run time are dependent upon the pump model being used.

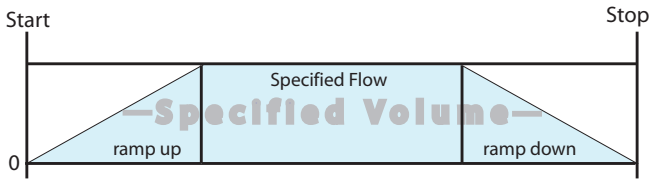


Figure 3-11 Depiction of dispense mode sequence

NOTE

For time-controlled delivery, you must run the pump in standard Gradient Mode, as described in Section 4 "Gradient Pumping for Pressure, Flow, and Concentration Modes".

- In order to access Dispense Mode control, the pump must be in Constant Flow Mode. Press CONST FLOW to enter this mode. Toggle Dispense Mode OFF or ON by pressing DISP. Note that pressing the DISP key while in Constant Pressure Mode has no effect.
- To adjust the flow rate, press FLOWRATE (A), enter the desired rate using the number keys, and press ENTER.
- To specify the volume of the batch delivered, press VOLUME (C), enter the desired volume using the number keys, and press ENTER.
- To dispense the batch, press RUN. The sequence runs once, then stops. To repeat the sequence, press RUN again.

NOTE

When the system is in Dispense Mode, all Gradient Modes, Constant Pressure Mode, auto-refill, and serial control are unavailable until Dispense Mode is turned OFF.

3.11 External Control

The pump can be externally controlled for pressure or flow rate operation with an analog voltage or through the serial interface.

The serial interface allows you to control the pump operation from a compatible personal computer or laptop that has an RS-232-C serial output. The serial interface accepts English command words from the computer, like Constant Pressure, Refill, etc. For more information, refer to Section 8 "Serial Interface".

3.12 External Control - Analog

The syringe pump can be controlled externally by analog voltage in either Constant Flow or Constant Pressure Mode. The input range is 0 – 11.5 volts (for all pumps), with a resolution of 5000 increments per volt.

NOTE

The input range for the 4-20ma option is set to 4-20ma instead of 0-11.5 volts.

3.12.1 Wire Connections

Two wires are required for analog control. The analog common or ground wire should be connected to the GND terminal under ANALOG INPUT of the ACCESSORY connector on the controller rear panel. Multiple analog common or ground wires can be attached to the single ground terminal. Refer to Figure 1-5 (item 5) to locate these connectors. The analog control or input wire should be connected to terminal 1 under ANALOG INPUT.

- If two pumps are used with the controller, the second analog control or input wire should be connected to terminal 2 under ANALOG INPUT.
- If three pumps are used with the controller, the third analog control or input wire should be connected to terminal 3 under ANALOG INPUT.
- If four pumps are used with the controller, the fourth analog control or input wire should be connected to terminal 4 under ANALOG INPUT.
- When using one of the Multi-pump Operation Modes, only the ANALOG INPUT terminal 1 should be connected to control the A-B pump pair and ANALOG INPUT terminal 3 should be connected to control the C-D pair.

NOTE

For the 4-20ma input option, the negative output wire connects to DIGITAL GROUND. The positive output wire connects to ANALOG INPUT 1-4.

Resistors

HL_f 4-20mA syringe pump controllers manufactured after September 2023 include two external 499 ohm, 1/2 W, 1% tolerance resistors with insulated leads. One resistor is installed between the digital input 3 and +15 V accessory terminals; the other resistor is installed between the

digital input 4 and +15 V accessory terminals. The +15 ports can still be used to connect an air valve package, but the resistors should not be removed.

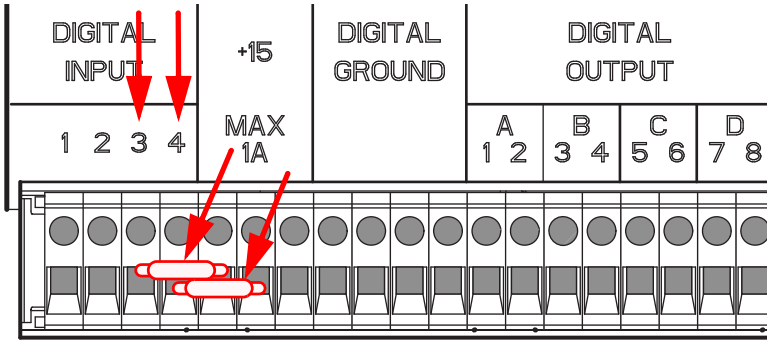


Figure 3-12 External resistor locations

For proper operation, these resistors are required when only pump A or pumps A and B are connected. However, some pump configurations will require removal of one or both of these resistors as indicated by a blank "Resistor digital input" entry in the following table.

Table 3-4 External Resistor Configuration

Pump(s) connected				Resistor digital input	
A	B	C	D	3	4
X				X	X
X	X			X	X
X	X	X			X
X		X			X
X		X		X	
X		X	X		
X	X	X	X		

3.12.2 Preparation

Before programming the controller to accept the analog signal, you must know the maximum flow rate (Constant Flow) or the maximum pressure (Constant Pressure).

NOTE

The high and low limits you enter cannot exceed the pump specifications: Normal input = 10V.

NOTE

For the 4-20ma input option the negative output wire connects to DIGITAL GROUND. The positive output wire connects to ANALOG INPUT 1-4.

To determine the analog voltage range, use the formula explained below:

$$FS \times \left(\frac{V}{U}\right) = Vmax$$

where:

- FS = Maximum flow rate or Maximum pressure (Full Scale): This is the same value entered when setting LIMITS, as described in Section 3.8.7 "LIMITS", as described for MAX PRESS or MAX FLOW.
- V = Volts per unit of flow or pressure
- U = Incremental unit of flow or pressure
- Vmax = Maximum input voltage

NOTE

For the 4-20ma input option the maximum flow or pressure sets the limit at 20ma. No other formula applies.

3.12.3 External Control for Refill

The refill option allows you to set the refill rate, or set the pump to automatically refill when a certain volume is reached. From Menu 2, the system can be programmed to automatically refill a pump based on an external analog signal, with a range of 0 to 11.5 volts.

- To access this feature, press MENU > MORE (A) > EXTERNAL (3).

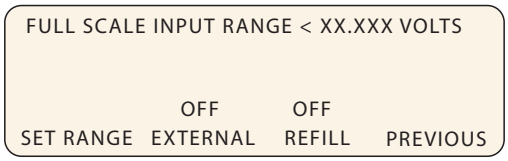


Figure 3-13 External control for refill menu

- To set the full-scale value (maximum 11.5 volts), press SET RANGE (A), enter the desired value, and press ENTER.
- To place the pump under external control, press EXTERNAL (B). The feature will toggle from OFF to ON.
- To SET the external control for refill, press REFILL (C). The feature will toggle from OFF to ON.

3.12.4 Calculation Examples

- Flow Rate - If MAX FLOW is set at 25 mL/min in the LIMITS menu and the desired scale factor is 5.0 volts per 20 mL/min, do the following to determine the analog voltage range:

$$25 \times \left(\frac{5}{20}\right) = 6.25$$

In this example, the analog voltage range would be 0.0–6.25 volts.

- Pressure - If MAX PRESS is set at 510.2 ATM in the LIMITS menu and the desired scale factor is 2.0 volts per 100 ATM, do the following to determine the analog voltage range:

$$510.2 \times \left(\frac{2}{100}\right) = 10.204$$

In this example, the analog voltage range would be 0.0–10.204 volts.

NOTE

If the controller is equipped with 4-20ma input, then the low signal is 4ma (stop) and high signal is 20ma (run).

3.12.5 Setup

First, select the desired operating mode by pressing CONST PRESS or CONST FLOW.

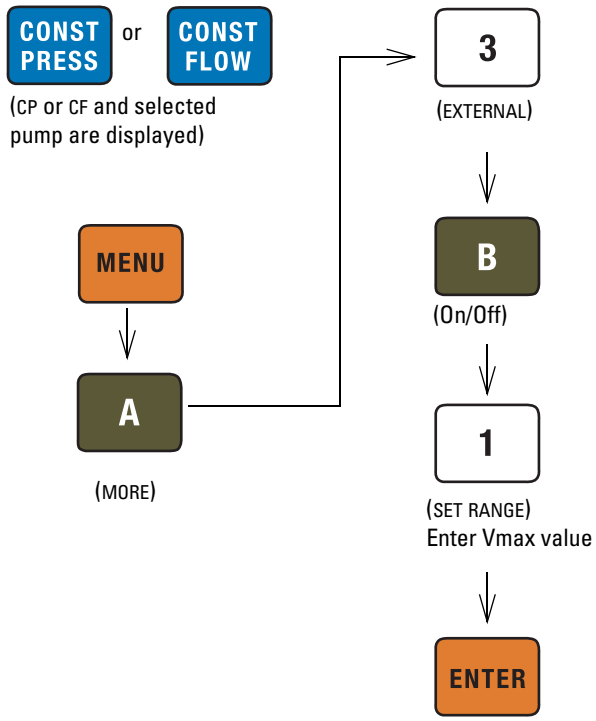


Figure 3-14 Button sequence for external control setup

When the FULL SCALE INPUT RANGE entry field is flashing, pressing the STOP key once will exit the Entry Mode and discard the digits entered.

3.13 Remote RUN/STOP

The SyriXus series syringe pump RUN/STOP function can be externally controlled by a switch contact closure or TTL input. The input voltage is 5 volts and is internally pulled high (RUN). The input is level sensitive (must remain high for RUN or low for STOP) and must be high for normal operation of serial (RS-232) control.

To enable the remote RUN/STOP feature, press MENU > MORE> (A) > EXTERNAL > (3) > DIGITAL (A) ON. Then press RUN or force the RUN/STOP pin low to enable the pump. Thereafter, the RUN/STOP pin will control operation. Pressing STOP on the front panel will override the RUN/STOP pin.

3.13.1 Wire Connections

Two wires are required for external RUN/STOP control. The digital common or ground wire should be connected to one of the four DIGITAL GROUND terminals of the ACCESSORY connector on the controller rear panel. Refer to Figure 1-5. The control wire should be connected to terminal 1, under DIGITAL INPUT. If an electrically isolated relay is used, one relay terminal should be connected to digital ground and the other to terminal 1, under DIGITAL INPUT.

- If two pumps are used with the controller, the second control wire should be connected to terminal 2, under DIGITAL INPUT.
- If three pumps are used with the controller, the third control wire should be connected to terminal 3, under DIGITAL INPUT.
- If four pumps are used with the controller, the fourth control wire should be connected to terminal 4, under DIGITAL INPUT.

NOTE

For the 4-20ma option, the negative current wire is connected to DIGITAL GROUND and the positive should be connected to DIGITAL INPUT

3.14 Analog Flow Rate and Volume Output Options

The analog output option provides for analog monitoring of the syringe pump flow rate. If two or less pump modules are connected to the controller, pump volume delivered can also be monitored via analog output. These outputs are often used with analog based plant or process monitoring equipment.

3.14.1 Voltage Analog Output

Output voltage for pressure is located on the back panel of the pump module via standard banana jacks. Refer to Figure 1-6.

If the analog output board is installed at the factory, the output connection is the female 25-pin Sub-D connector located on the rear panel of the controller, under the 4-20mA Output label. Refer to Figure 1-5.

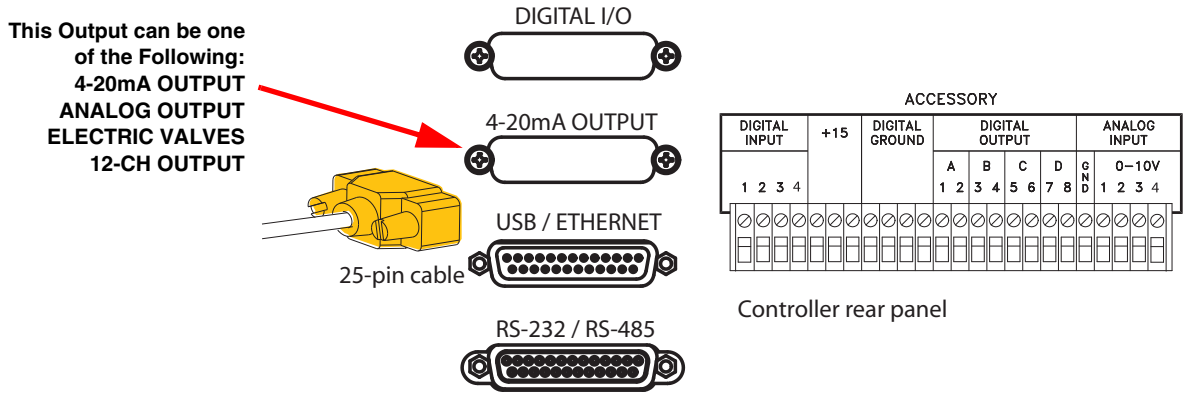


Figure 3-15 Analog voltage output connection, rear panel

Voltage analog outputs are optional and can be pre-installed at the factory. This option has a total of four outputs for monitoring flow rate with selectable ranges from 0 to 5V, -5 to +5V, and 0 to 10V. The default range at installation is 0 to 10V. To adjust the range, remove the top cover of the controller (9.7.1 *Controller Case Top Removal*) and move the jumper to a new range (Figure 3-16). Each output can be set to a different range. Each output can be set to a different range.

The top of the selected range is the same maximum value entered for MAX FLOW when setting LIMITS, as described in Section 3.8.7 "LIMITS" of this manual. For example: if the output range is 5V and the preferred output scale is 1 volt per 10 mL/min, MAX FLOW is set at 50 mL/min. MAX FLOW cannot exceed the pump specification.

A controller running one to two pumps can also output cylinder volume on the remaining outputs. The volume output range is not adjustable. Full scale is equal to one pump stroke.

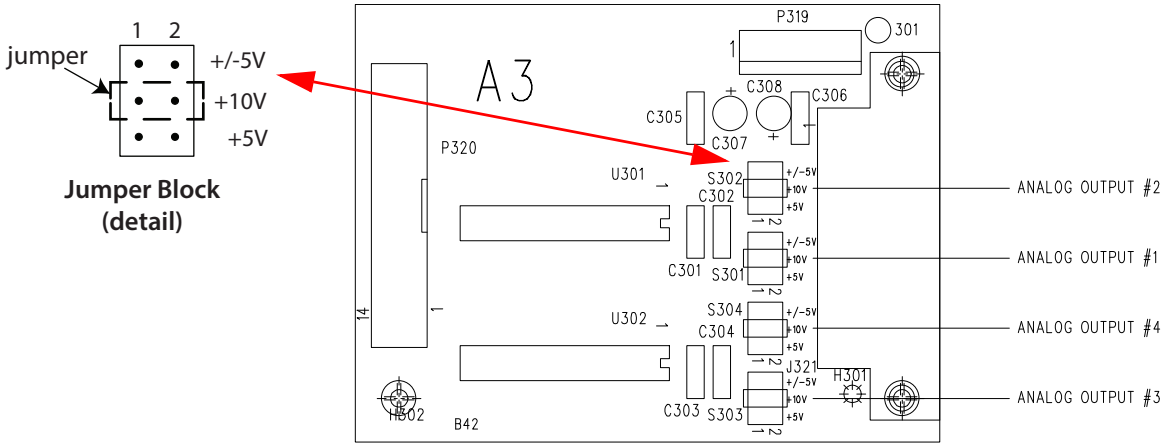


Figure 3-16 Output range selection jumpers

Table 3-5 Analog Output Options (Connections to Female 25 Pin Sub-D)

Pin No.	Description	1 or 2 Pump Function	3 Pump Function
1	Chassis (earth)	—	—
2	Analog common	—	—
3	Analog common	—	—
4	Analog common	—	—
5	Analog common	—	—
14	Output #1	Flow Rate A	Flow Rate A
15	Output #2	Flow Rate B	Flow Rate B
16	Output #3	Volume A	Flow Rate C
17	Output #4	Volume B	Volume B

3.14.2 Current Loop Output

The pump controller can be configured to provide a 4-20mA current loop output. The 4-20mA analog output board is pre-installed at the factory. The board initially contains three output cards, for flow rate, pressure, and volume for Pump A. Additional cards can be factory installed (up to a total of 12) when the controller is initially purchased. Refer to Table 3-6 "Analog Output Signal/Sub-D Pins for 4-20mA" for connections for the 4-20mA and 0-10v 12 channel outputs.

NOTE

Connections to the controller DB-25 are the same as shown in Figure 3-15. Refer to Table 3-6 "Analog Output Signal/Sub-D Pins for 4-20mA" and Table 3-7 "Analog Output Signal/Sub-D Pins for 0-10 VDC" for cable connections to your equipment.

Table 3-6 Analog Output Signal/Sub-D Pins for 4-20mA

Pin #	Channel	Data Type/Pump
14	1	Pump A Flow Rate
1		Pump A Flow Rate (Signal Return)
15	2	Pump A Pressure
2		Pump A Pressure (Signal Return)
16	3	Pump A Volume Remaining
3		Pump A Volume Remaining (Signal Return)
17	4	Pump B Flow Rate
4		Pump B Flow Rate (Signal Return)
18	5	Pump B Pressure
5		Pump B Pressure (Signal Return)
19	6	Pump B Volume Remaining
6		Pump B Volume Remaining (Signal Return)
20	7	Pump C Flow Rate
7		Pump C Flow Rate (Signal Return)
21	8	Pump C Pressure
8		Pump C Pressure (Signal Return)
22	9	Pump C Volume Remaining
8		Pump C Volume Remaining (Signal Return)
23	10	Pump D Flow Rate
10		Pump D Flow Rate (Signal Return)
24	11	Pump D Pressure
11		Pump D Pressure (Signal Return)
25	12	Pump D Volume Remaining
12		Pump D Volume Remaining (Signal Return)

Table 3-7 Analog Output Signal/Sub-D Pins for 0-10 VDC		
Pin #	**Channel**	**Data Type/Pump**
1	1	Pump A Flow Rate
14		Pump A Flow Rate (Signal Return)
2	2	Pump A Pressure
15		Pump A Pressure (Signal Return)
3	3	Pump A Volume Remaining
16		Pump A Volume Remaining (Signal Return)
4	4	Pump B Flow Rate
17		Pump B Flow Rate (Signal Return)
5	5	Pump B Pressure
18		Pump B Pressure (Signal Return)
6	6	Pump B Volume Remaining
19		Pump B Volume Remaining (Signal Return)
7	7	Pump C Flow Rate
20		Pump C Flow Rate (Signal Return)
8	8	Pump C Pressure
21		Pump C Pressure (Signal Return)
9	9	Pump C Volume Remaining
22		Pump C Volume Remaining (Signal Return)
10	10	Pump D Flow Rate
23		Pump D Flow Rate (Signal Return)
11	11	Pump D Pressure
24		Pump D Pressure (Signal Return)
12	12	Pump D Volume Remaining
25		Pump D Volume Remaining (Signal Return)

Section 4 Gradient Pumping for Pressure, Flow, and Concentration Modes

4.1 Introduction

Gradient pumping is used in applications requiring time-controlled or rate-controlled delivery of a specific volume at a set flow rate or pressure, or a two-pump flow concentration.

All Teledyne ISCO syringe pump models can be used in Gradient Mode, but SyriXus model 65x requires special hardware for this mode. Contact Teledyne ISCO Customer Service using the information in 9.3 "Technical Customer Service Department".

You can program the controller to increase or decrease pressure or flow during different steps within a single program by entering a specific value at the beginning and end of each step.

RISK OF INJURY. THE PRESSURE PRODUCED COULD BE 700 BAR. PLEASE UTILIZE APPROPRIATE TUBING AND CONNECTIONS NOTED IN THE MANUAL.

4.1.1 Tools and Parts for Single-Pump System

- Open-end wrenches: 1/4”, 5/16”, 7/16”, 3/8”
- Manual Refill Valve Kit - Refer to Table 4-1 "Manual Refill Valve Kits"
- Manual Outlet Valve Kit - Refer to Table 4-2 "Manual Outlet Valve Kits"

4.1.2 Tools and Parts for Dual-Pump System

- Open-end wrenches: 1/4”, 5/16”, 7/16”, 3/8”
- Manual Refill Valve Kit - Refer to Table 4-1 "Manual Refill Valve Kits" (two kits required)

Table 4-1 Manual Refill Valve Kits	
Pump Model	**Part Number**
1000x	68-1247-117
500x	68-1247-083
260x	68-1247-077
65x	68-1247-127

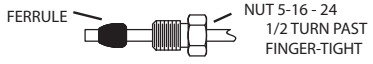
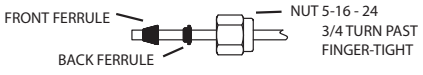
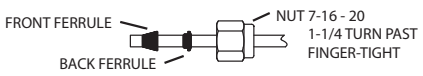
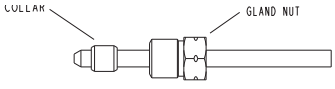
Table 4-2 Manual Outlet Valve Kits	
Pump Model	**Part Number**
1000x	68-1247-118
500x	68-1247-082
260x	68-1247-078
65x	68-1247-126

Table 4-3 Wetted Materials
316 stainless steel, 17-4 stainless steel, PTFE, nylon (65x only)

4.2 Connecting the System

The syringe pump has two ports at the top of the cylinder. One port is used as the inlet for filling the pump, and the other as the outlet (either port may be used as inlet or outlet). Inlet and outlet connections to each pump must be made identically. Standard plumbing connections vary between pump models. Refer to Table 4-4 "Swaging Detail" for standard port information.

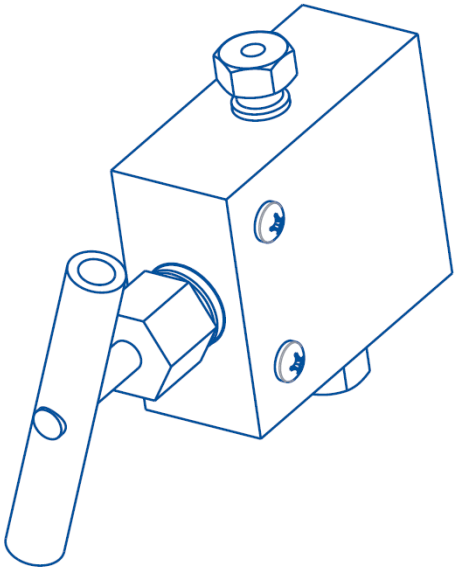
When making fluid connections that use ferrules, be sure to use the ferrules supplied for that pump by Teledyne ISCO. Push the tubing completely into the connector and finger-tighten. Then tighten with a wrench to clamp the ferrules onto the tubing.

Table 4-4 Swaging Detail		
260x	1/8” Valco	
500x	1/8” NPT	
1000x	1/4” NPT	
65x	1/4” F250C	

NOTE

SyriXus series 260x and 65x have a direct connection, as shown in Figure 4-2 and Figure 4-3. Valve kits for other models include male adapter fittings.

A gradient pumping system includes high-pressure, two-way valves that connect the pump inlets to fluid reservoirs, and the pump outlets to the gradient mixer (dual-pump system) or other apparatus (single-pump system). Each refill kit and outlet valve package contains one two-way valve shown in Figure 4-1. The user will need to provide the necessary hardware for the application.



Two-Way Valve

Figure 4-1 Two-way valve

Following installation, the tubing connections must be tested for leaks before any program is run. If a leak is found, tighten the connection slightly. If the leak persists, swage the connection again with a new ferrule. For leak test procedures. refer to Technical Bulletin TB05 Field Verification Procedures.

4.2.1 Inlet Connections

Valve components and connections are shown in Figure 4-2.

1. Mount the inlet valve on the pump housing with the spacer block and screws provided.
2. Connect the pre-bent SST tubing from one port of the valve to the pump inlet. Use the nut and ferrule to connect the tubing at the inlet and the valve fittings to connect the tubing at the valve.
3. Connect the PTFE refill tubing (with the filter) to the other port of the valve, using the nuts and ferrules supplied.

NOTE

When connecting to pressurized sources in supercritical fluid applications, use the stainless steel tubing without a filter. An inline filter is contained in the CO_2 connection package (refer to Technical Bulletin TB08 CO2 Applications and Technical Notes.

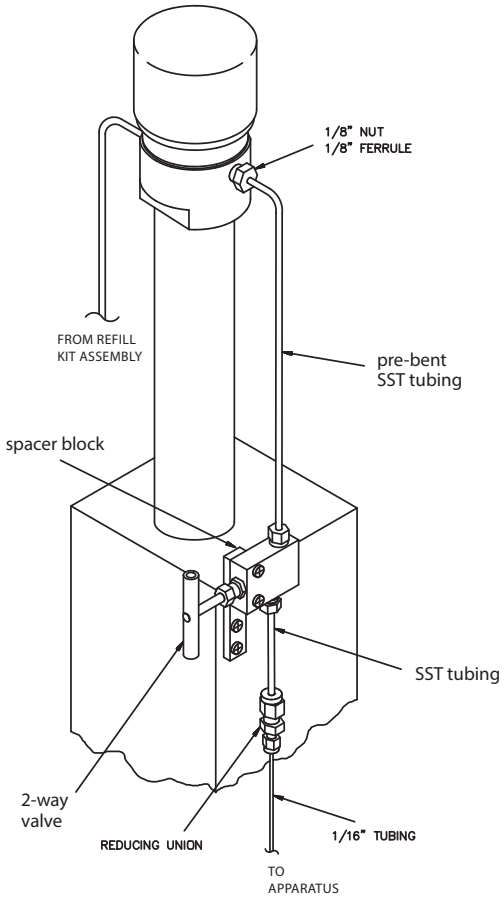


Figure 4-2 Pump inlet connections

4.2.2 Outlet Connections

Valve components and connections are shown in Figure 4-3.

1. Mount the two-way outlet valve on the side of the pump housing opposite the refill valve, with the spacer block and screws provided.
2. Connect the pre-bent SST tubing between one port of the valve and the pump outlet. Use the nut and ferrule to connect the tubing at the outlet and the valve fittings to connect the tubing at the valve.
3. Connect the 5.1 cm length of 1/8” tubing to the other port of the valve, using the valve fittings.
4. Connect the 1/8” side of the reducing union to the tubing.

5. Connect the 1/16” side of the reducing union to the 1.5 m length of 1/16” tubing. This tubing may be cut to an appropriate length.

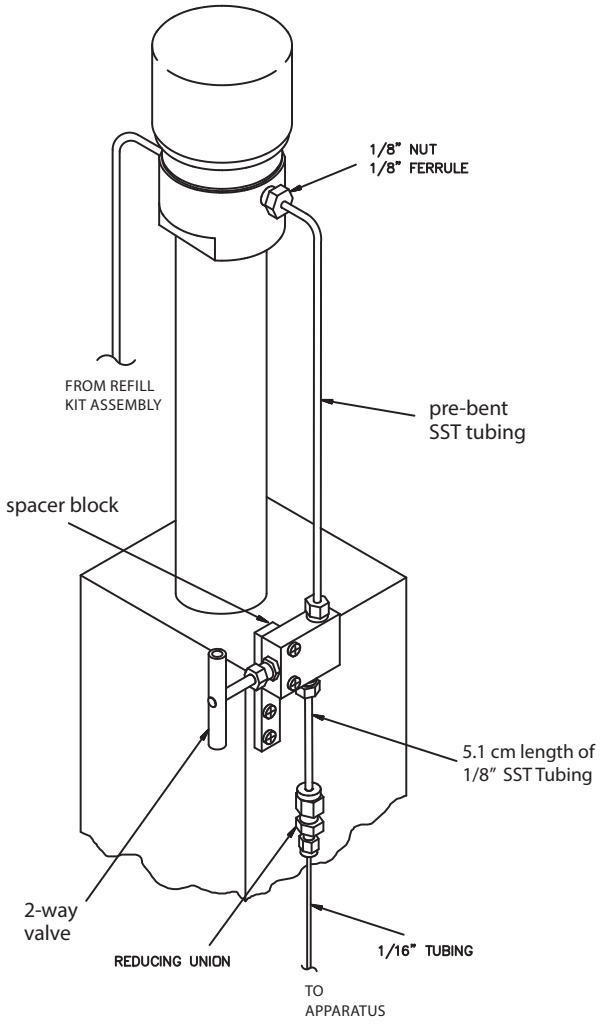


Figure 4-3 Pump outlet connections

4.2.3 Dual-Gradient System Connections

Connection of the dual-gradient system requires two refill valve kits and a gradient mixer.

NOTE

The user supplied static mixer must have a pressure rating greater than the maximum rated pressure of the pump. The static mixer can be replaced by a user-supplied dynamic mixer.

Solvents are fed from each pump through the inline filters and check valves, and into the static mixer, where they are mixed and fed into your system apparatus. User supplied components are required. A suggested mixing arrangement is shown in Figure 4-4 and Figure 4-5.

NOTE

Teledyne ISCO does not provide applications support for this process.

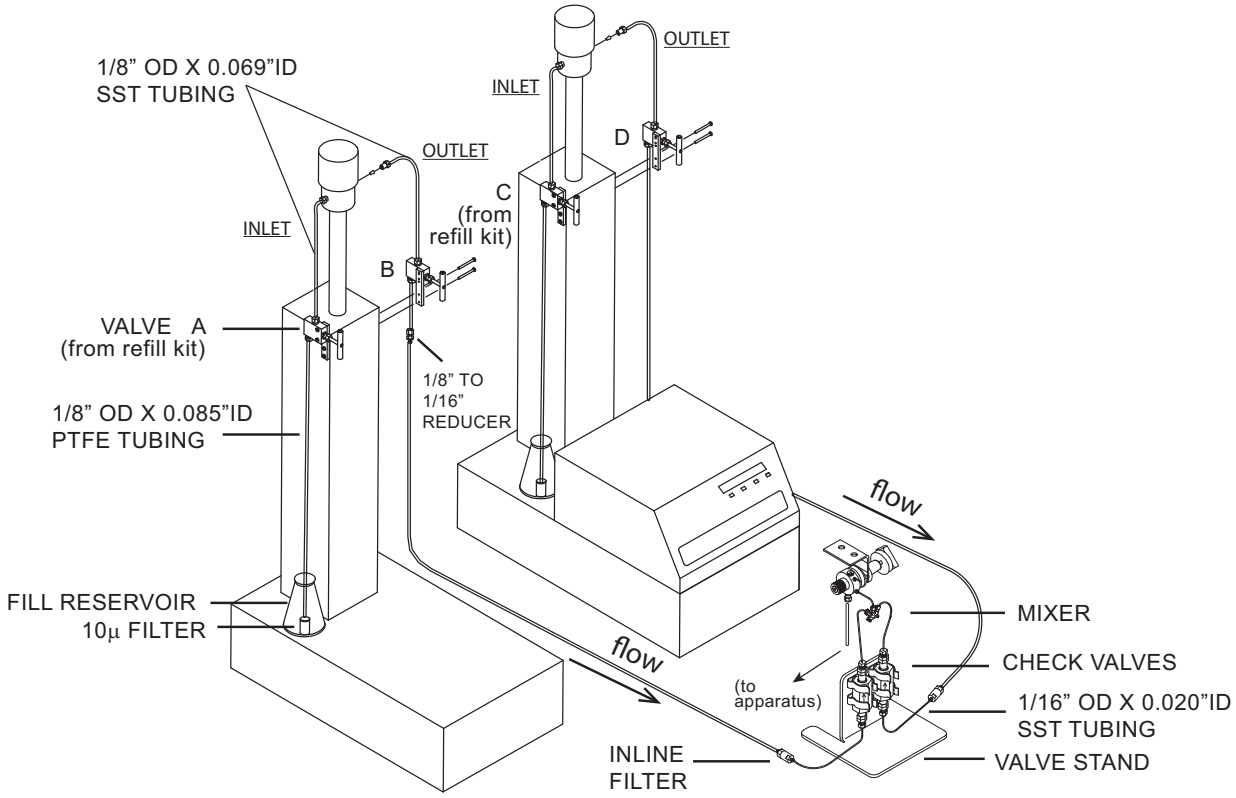


Figure 4-4 Dual-gradient system connections
(Inlet valves (A & C) are from refill valve kits)

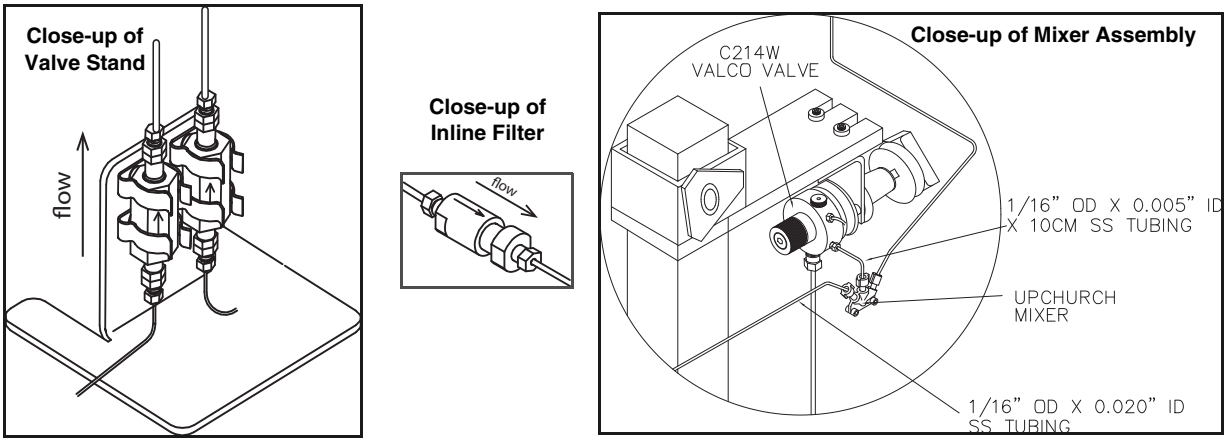


Figure 4-5 Dual-gradient connection detail

4.3 Single-Pump Gradient Programming

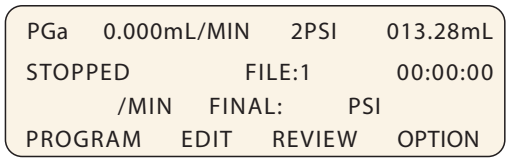
A single-pump gradient program is based on either pressure or flow, and controlled by either time duration (in minutes) or rate of change (units per minute).

The controller's memory can contain a total of up to 200 steps. One program can contain from 1 to 200 steps.

When operating in Gradient Mode, any connected pumps not used for gradient are inoperable.

1. To access the gradient programming menus, press PRGM GRAD, select PRESSURE (2) or FLOW (3), and CONTINUE (C).

   The home screen will appear, with either PG (Pressure Gradient) or FG (Flow Gradient) in the upper left corner.

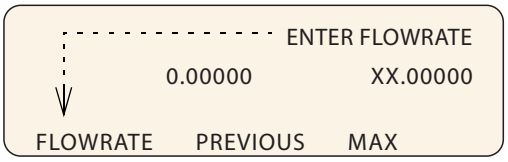


2. Press PROGRAM (A).
3. At the prompt, enter a file number between 1 and 99. This is the file name of your program, and can be the name of a new program you are creating, or a stored program you want to edit or run. Press ENTER.

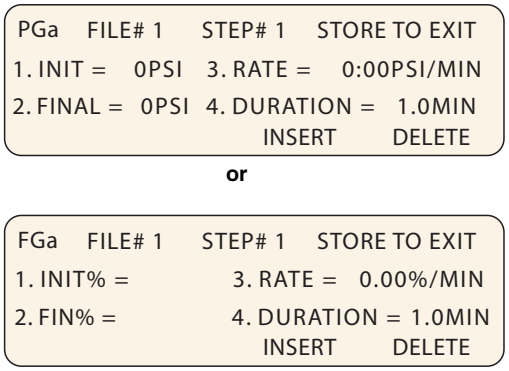
NOTE

If a selected stored program is in a different mode than that of the controller selected in Step 1, a brief notification will appear, displaying the controller's mode and the file's mode. If you attempt to run the program without changing the mode of either it or the controller, the program will not run, and the same message will be displayed.

4. To enter the flow rate for this program, either press FLOWRATE (A) and use the number keys and Enter, or for maximum possible flow, simply press MAX (C).



5. To proceed to the programming screen, press STEP FWD (B). The programming screen will appear, with the file number and step number at the top of the screen.



6. To set the initial pressure or flow for this step, press INIT (1) to activate this parameter. Use the number keys to enter the desired value, then press ENTER to save it.
7. To set the final pressure or flow for this step, press FINAL (2) to activate this parameter. User the number keys to enter the desired value, then press ENTER to save it.
8. Set either the desired RATE (3) of change or DURATION (4) in minutes. Once one value has been set and saved, the other will automatically appear.

NOTE

DURATION in minutes can have a resolution of 0.1, with a maximum of 9,999 minutes per step.

9. If you want to add another step to the file program, press INSERT (C).
10. The step number will increase by one, and the default initial value will be the final value entered for the previous step. Edit as desired.
11. When programming is complete, press the STORE key to save the file and return to the home screen.
12. To start the program, press RUN two times.

NOTE

When a gradient run is started, digital output ‘8’ of the controller ACCESSORY connector will toggle from high to low (open to closed) for one second.

NOTE

An entire gradient program can be removed only by deleting each of its steps one at a time, as discussed in 4.5 "Review, Revise, & Hold Options". When the last remaining step is deleted, the entire file is removed.

4.4 Dual-Pump Concentration Gradient Programming

Two-pump concentration gradients enable proportionate use of two different fluids that combine at the mixer (refer to Figure 4-4 and Figure 4-5).

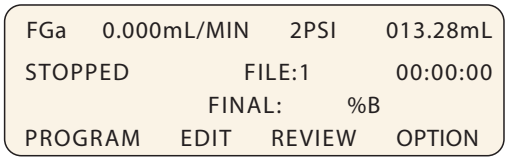
This type of pumping uses flow mode (FG) only. A single-pump gradient program is based on either pressure or flow, and controlled by either time duration (in minutes) or rate of change (units per minute).

The controller's memory can contain a total of up to 200 steps. One program can contain from 1 to 200 steps.

When operating in Gradient Mode, any connected pumps not used for gradient are inoperable.

1. To access the gradient programming menus, press PRGM GRAD, then DUAL SYSTEM GRADIENT (1) and CONTINUE (C).

   The home screen will appear, with FG (Flow Gradient) in the upper left corner.

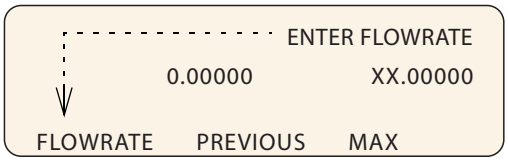


2. Press PROGRAM (A).
3. At the prompt, enter a file number between 1 and 99. This is the file name of your program, and can be the name of a new program you are creating, or a stored program you want to edit or run. Press ENTER.

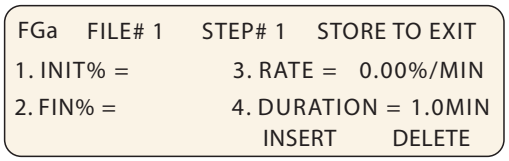
NOTE

If a selected stored program is in a different mode than that of the controller selected in Step 1, a brief notification will appear, displaying the controller's mode and the file's mode. If you attempt to run the program without changing the mode of either it or the controller, the program will not run, and the same message will be displayed.

4. To enter the flow rate for this program, either press FLOWRATE (A) and use the number keys and Enter, or for maximum possible flow, simply press MAX (C).



5. To proceed to the programming screen, press STEP FWD (B). The programming screen will appear, with the file number and step number at the top of the screen.



6. To set the initial pressure or flow for this step, press INIT (1) to activate this parameter. Use the number keys to enter the desired value, then press ENTER to save it.
7. To set the final pressure or flow for this step, press FINAL (2) to activate this parameter. User the number keys to enter the desired value, then press ENTER to save it.
8. Set either the desired RATE (3) of change or DURATION (4) in minutes. Once one value has been set and saved, the other will automatically appear.

NOTE

DURATION in minutes can have a resolution of 0.1, with a maximum of 9,999 minutes per step.

9. If you want to add another step to the file program, press INSERT (C).
10. The step number will increase by one, and the default initial value will be the final value entered for the previous step. Edit as desired.
11. When programming is complete, press the STORE key to save the file and return to the home screen.
12. To start the program, press RUN two times.

NOTE

When a gradient run is started, digital output '8' of the controller ACCESSORY connector will toggle from high to low (open to closed) for one second.

The flow rates and ramp rate for Pump A in each step will be in direct opposite proportion to the values set for Pump B (INIT%B, FIN%B, and RATE).

NOTE

An entire gradient program can be removed only by deleting each of its steps one at a time, as discussed in the next section, Section 4.5 "Review, Revise, & Hold Options". When the last remaining step is deleted, the entire file is removed.

4.5 Review, Revise, & Hold Options

While in the programming menu, you can also:

- Delete - To delete the current step, press DELETE (D). A deleted step cannot be recovered. Used repeatedly, this command can be used to delete an entire file.
- Review - To review existing program steps, press STEP BACK (A) or STEP FWD (B).
- Add New - To add a new step between two existing steps, navigate through the program to the step just before your addition. Press INSERT (C) and program the new step.

NOTE

The initial value of the next step will default to the final value of the new step, and may need to be edited if a different initial value is needed.

- While Running - A gradient program can be reviewed or edited while it is running. Simply press EDIT (B) or REVIEW (C) to begin. If a new step duration is shorter than the elapsed time for that step, the program will proceed to the next step. If the total flow rate is changed, the program will immediately start using the new rate.

  To return to the run screen, press RETURN (D).
- Hold - You can hold a running gradient in its current state while retrieving a different program file to run in its place. Press Hold and then Recall to access the new program.

  This feature is used mainly in applications where it is necessary to keep the system pressurized during method changes.
- External Start - When a gradient program is in Hold Mode, a momentary low on digital input '2' of the controller ACCESSORY connector will start the program.

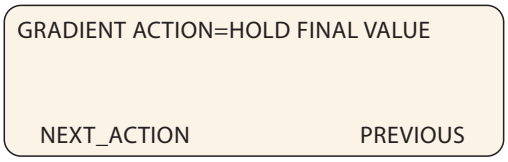
4.6 Program Conclusion

When a gradient program reaches the end, there are four selectable actions the system can then perform:

- Hold the final value (example shown below)
- Stop after the final step
- Return to the initial value and hold it
- Return to the initial value and repeat the program

While the system is in Gradient Mode, these options can be edited at any point before or after gradient programming, and while a gradient is running.

To access the options menu, from the home screen, press OPTIONS (D).



To scroll through the four options, press NEXT_ACTION (A). When you have reached the desired option, press PREVIOUS (D) to save and exit.

Section 5 Continuous Flow Introduction, Installation, and Operation

5.1 Introduction

A SyriXus series continuous flow pumping system consists of two syringe pumps and a valve accessory package regulated by one controller. This system allows you to continuously deliver liquefied gas or liquid under Constant Flow or Constant Pressure Mode.

Continuous flow can be used in either of three modes: continuous Constant Pressure, continuous Constant Flow or Receive Mode. These modes assume positive displacement of the piston, with the exception of continuous Receive Mode (for detailed information about Receive Mode, refer to Technical Bulletin TB02 Constant Pressure Pump Operation for Receive Mode.

In any syringe pump continuous flow system, a flow irregularity occurs at the time of switchover from one pump module to the other. This flow irregularity can be measured as a pressure fluctuation. Teledyne ISCO pressure fluctuation at switchover is ~0.35 bar (at system backpressures from 6.9 bar to the single-pump maximum).

Before programming continuous flow, appropriate valves must be connected, the pumps must contain fluid, and there must be backpressure for operation. Specific installation instructions for the valve packages are supplied with the valve package.

5.2 Continuous Flow Air Valves

Air valves generally open and close faster and are less prone to error and component wear, making them suitable for industrial use and other applications where the system will be constantly running; however, they require a user-supplied pressurized air source of 80 to 115 psi (5.5 to 7.9 bar).

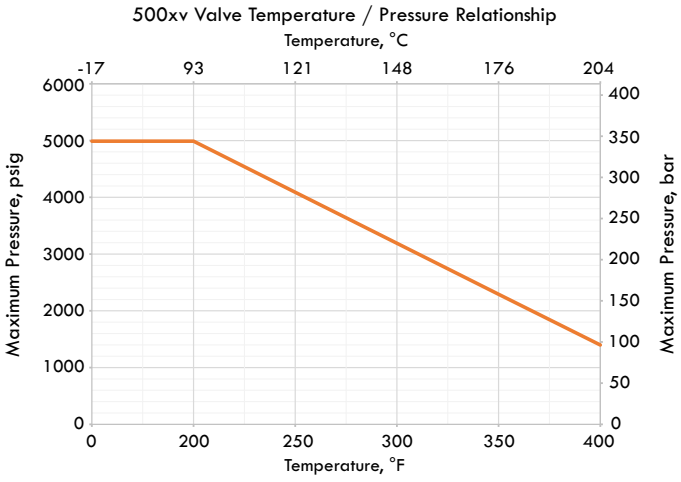
Table 5-1 Air Valve Package Numbers

Model	Type	Part Number
1000x	Dual Air Valves	60-1267-016
	Single Air Valve	60-1267-017
500x/260x	Dual Air Valves	60-1267-014
	Single Air Valve	60-1267-011
500xv	Dual Air Valves	60-1267-020
65x	Dual Air Valves	60-1267-018
	Single Air Valve	60-1267-019

Table 5-2 Continuous Flow Technical Specifications-Air Valves		
Pressure fluctuation at switchover	5 psi (0.35 bar), at system backpressures from 100 psi (6.9 bar) to the single-pump maximum. Higher fluctuation occurs at pressures below 100 psi.	
Minimum required backpressure	50.76 psi (3.5 bar)	
Maximum system backpressure	The single-pump maximum. Valves rated to 10,000 psi [689.5 bar] (65x to 20,000 psi [1379 bar])	
Air supply source pressure	80 to 115 psi (5.5 to 7.9 bar)	
Maximum temperature	Maximum system fluid temperature 320 °F (160 °C) Maximum valve assembly temperature 150 °F (65 °C)[a]	
Maximum flow rate (mL/min)		
Liquids: 65% of the single-pump maximum rate	1000x	265.2
	500xv	132.6
	500x	132.6
	260x	69.55
	65x	19.50
Wetted materials in valve package		
Air valves	Hastelloy, FFKM elastomer, and PTFE	
Tubing and fittings	Hastelloy, gold	

a. The pressure and temperature ratings for the ball valve used in the 500xv continuous flow system are interrelated. This relationship, shown in Table 5-3, affects the SyriXus 500xv only.

Table 5-3 Valve Pressure and Temp. Rating Relationship	
Temperature °F (°C)	Pressure psig (bar)
0 (-17) to 200 (93)	5000 (344)
250 (121)	4100 (282)
300 (148)	3200 (220)
350 (176)	2300 (158)
400 (204)	1400 (96.4)



5.2.1 Continuous Flow Air Valves Overview

The single air valves are designed to be installed on either side of a single pump. A bracket at the bottom is inverted and the air supply lines are rearranged to accomplish this. Instructions for mounting the valve on either side are provided with the valve assembly, and are also available at www.teledyneisco.com. The single valve assembly allows the pump to continuously operate, but the fluid flow is interrupted when the cylinder becomes empty and the pump refills. Delivery resumes once the cylinder is refilled.

The dual air valve packages are installed between two pumps and provide continuous flow with minimal interruption. When the delivering pump approaches empty, the other pump gradually takes over fluid delivery allowing the first pump to refill. When the second pump approaches empty, the first pump gradually takes over fluid delivery allowing the second pump to refill. This cycle repeats continuously until the fluid supply reservoir is empty or until the user (or external programmed control) stops the pump.

Except for the 500xv, all SyriXus series pumps are available with either single or dual air valves. Because of its specific purpose, the 500xv is only available with the dual air valve package.

5.2.2 Air Valve Installation

An installation instruction sheet is provided with each valve package with specific details related to the valve assembly. The various valve packages are installed similarly, with slight differences in tubing connections. The 500x / 260x valve package also includes steps to properly attach the mounting bracket.

DANGER

RISK OF INJURY. THE PRESSURES PRODUCED COULD BE MORE THAN 1400 BAR. PLEASE UTILIZE APPROPRIATE TUBING AND CONNECTIONS NOTED IN THIS MANUAL.

To install the air valve package, refer to the installation guide supplied with the valve assembly. A copy of this guide can also be downloaded from the Teledyne ISCO website. Figure 5-1 represents the SyriXus 500x pump valve assembly; the other SyriXus series pump models will be similar.

1. Select the proper pump tubing for the pumps being attached to. These pump tubing assemblies are labeled and have the fittings and ferrules already attached.
2. Place the pumps in the position where they are to be used. The pumps are awkward to move once the valves have been installed.
3. Loosely attach the tubing lengths between the valve ports and the pumps.
4. While supporting the valve assembly, align the screw holes in the mounting bracket and loosely insert the screws and washers provided (six places).

5. Adjust the position of the valve assembly and then tighten the screws and fittings.
6. Trim the reagent supply tubing to the desired length, and then attach the tubing to the check valve.
7. Attach the air supply line to the bottom of the actuator. The supply air pressure should be 80 to 115 psi [550 to 790 kPa].
8. Connect the actuator wires to the controller using Table 5-4 "ALL Dual Air SyriXus Pumps - Conversion Table for A-B Pump Pair and C-D Pump Pair".

One controller can operate up to two pairs of pumps and control the valves at the same time. The black wires of the valve assembly on the first pair of pumps need to be attached to the DIGITAL OUTPUT connectors labeled ‘A’ and ‘B’; and the black wires on the second pair of pumps and valve assembly need to be attached to the ‘C’ and ‘D’ connectors. Refer to Table 5-4 "ALL Dual Air SyriXus Pumps - Conversion Table for A-B Pump Pair and C-D Pump Pair" to identify which wire goes to which port.

NOTE

When only one pair of pumps is attached, the actuator wires MUST be connected to the DIGITAL OUTPUT connectors labeled ‘A’ and ‘B’; and the pumps MUST be attached to the ‘PUMP A’ and ‘PUMP B’ connectors. Refer to Figure 1-6 for identification of the controller back panel connectors.

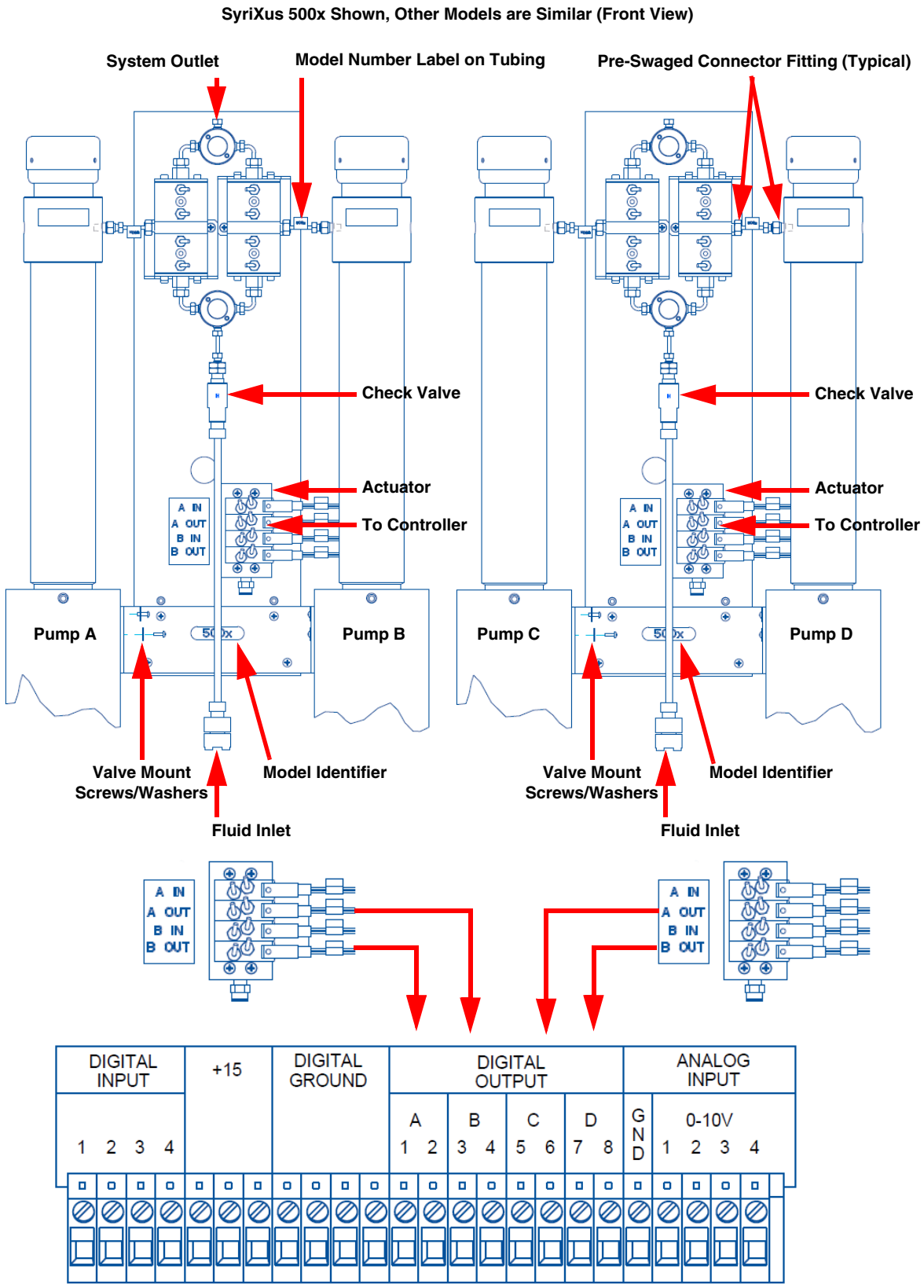


Figure 5-1 Controller Accessory Connector

Table 5-4 ALL Dual Air SyriXus Pumps - Conversion Table for A-B Pump Pair and C-D Pump Pair					
A-B Pump Wire Pair	**Digital Output**	**+15 wires (Red)**	**C-D Pump Wire Pair**	**Digital Output**	**+15 Wires (Red)**
A1	A1	+15	A1	C5	+15
A2	A2	+15	A2	C6	+15
B1	B3	+15	B1	D7	+15
B2	B4	+15	B2	D8	+15

NOTE

Teledyne ISCO has historically identified the pump to the **left** of the dual valve assembly as 'A' ('C') and the one to the **right** of the valve assembly as 'B' ('D') when facing the front of the equipment. The valve control software assumes this arrangement, and the pumps must be plugged into the connectors on the back of the controller corresponding to this identification.

The black wires on the actuator are labeled 'A1', 'A2', 'B1' and 'B2' and the red wires are labeled '+15'. If the labels are missing or damaged, refer to Figure 5-2 to identify the wires.

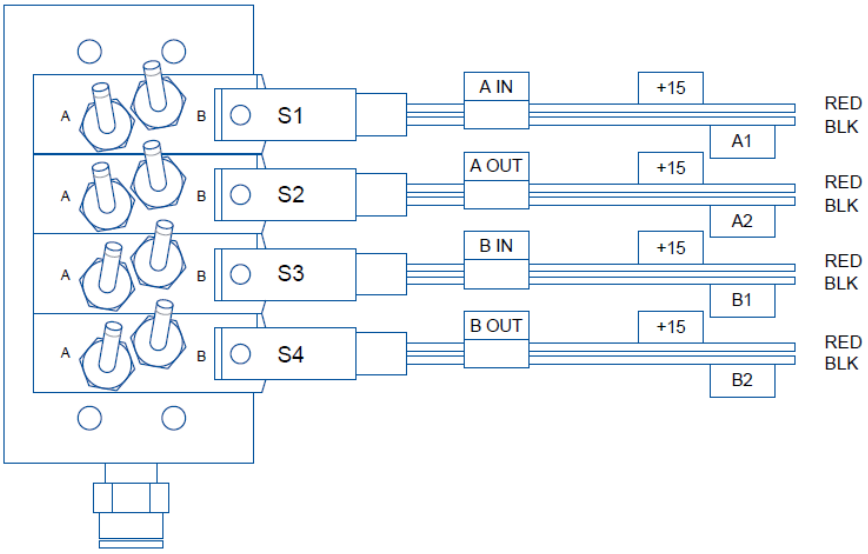


Figure 5-2 Actuator wire labels

All dual air valve packages have the controller connection wires labeled as 'A' and 'B'. When two pairs of pumps are employed, the wires on the valve actuator for the second pair of pumps labeled 'A' connect to the digital output connectors labeled 'C' with the pump connected to the PUMP C port. In the same manner, the wires on the valve actuator labeled 'B' connect to the digital output connectors labeled 'D' with the pump connected to the PUMP D port.

NOTE

NEVER connect two or more black wires from the valve actuators to the same DIGITAL OUTPUT port on the controller. All black wires must be connected to a digital output corresponding to the port to which the pump is connected.

Refer to Section 3.5.6 "Valve" for information on manually actuating the valves to test your installation and electrical connections.

5.3 Continuous Flow Electric Valves

Electric valves provide the best positive valve closure and are most commonly used in non-flammable liquefied gas applications, such as CO_2. Electric valves use brush type electric motors that can be an ignition source. Using electric valves with flammable fluids is not recommended or supported by Teledyne ISCO. The electric valve option is only available for the SyriXus 260x, 500x and 1000x. Electric valves require the pump controller to be equipped with a valve driver board.

The same electric valve assembly is used for the SyriXus 260x, 500x and 1000x, simplifying the valve selection for the end user. An identifying marking on the valve assembly indicates what model the valve has been configured for, but the valve assembly can be reconfigured for other models as the user's needs require. Reconfiguration consists of repositioning the mounting bracket and using the appropriate tubing. Instructions on reconfiguring the valve assembly are included with the valve package.

NOTE

The max flow rate for the 1000x electric valve system will tend to have a lower percentage flow rate due to port size restrictions, with a maximum flow rate equal to that of the 500x electric valve system (refer to Table 5-6 "Continuous Flow Technical Specifications - Electric Valves").

Table 5-5 Electric Valve Packages

Model	Type	Part Number
1000x/500x/260x	Dual Electric Valves	601-2670-15
	Single Electric Valve	601-2670-11

Table 5-6 Continuous Flow Technical Specifications - Electric Valves		
Pressure fluctuation at switchover	5 psi (0.35 bar), at system backpressures from 100 psi (6.9 bar) to the single-pump maximum. Higher fluctuation occurs at pressures below 100 psi (6.9 bar).	
Minimum required backpressure	50.76 psi (3.5 bar)	
Maximum system backpressure	The single-pump maximum. Valves rated to 10,000 psi [689.5 bar]	
Maximum temperature	Maximum system fluid temperature 300 °F (150 °C) Maximum valve assembly temperature 150 °F (65 °C)	
Maximum flow rate (mL/min)		
Liquids: 65% of the single-pump maximum rate.	1000x	132.6[a]
	500x	132.6
	260x	69.55
Wetted materials in valve package		
Valves	Hastelloy®, silicon nitride, Inconel®, Vespel®	
Tubing and fittings	Hastelloy, gold	

a. Dual 1000x pumps flow rate: 265.2 mL/min.

5.3.1 Continuous Flow Electric Valves Overview

The single electric valves are designed to be installed on either side of a single pump. A bracket at the bottom is inverted and the pump tubing is repositioned to accomplish this. The single valve assembly allows the pump to continuously operate, but the fluid flow is interrupted when the cylinder becomes empty and the pump refills. Delivery resumes once the cylinder is refilled.

The dual electric valve packages are installed between two pumps and provide continuous flow with minimal interruption. When the delivering pump approaches empty, the other pump gradually takes over fluid delivery allowing the first pump to refill. When the second pump approaches empty, the first pump gradually takes over fluid delivery allowing the second pump to refill. This cycle repeats continuously until the fluid supply reservoir is empty or until the user (or external programmed control) stops the pump.

NOTE

When working with liquefied gases, the first indication that the reservoir is becoming empty is a poor refill of the SyriXus pump (less than about 50% of full volume after pressurizing). Poor refills will ultimately result in insufficient time for the pump to stabilize its pressure before being called to take over delivery; which will result in an alarm.

5.3.2 Electric Valve Installation

An installation instruction sheet is provided with each valve package with specific details related to the valve assembly. The valve package installation is very similar between the pump models, with slight differences in tubing connections.

WARNING

Do not use the electric valve package when pumping ammonia. Permanent damage to the valve will result. Use the air valve package or the manual refill kit instead.

The electric valve package is supplied with the mounting bracket and pump tubing unattached. Parts for the other models are included in the package but are not used. These parts should be kept so that the valve can be mounted on other pump models should the need arise.

DANGER

RISK OF INJURY. THE PRESSURES PRODUCED COULD BE MORE THAN 700 BAR. PLEASE UTILIZE APPROPRIATE TUBING AND CONNECTIONS NOTED IN THIS MANUAL.

To install the electric valve package, refer to the installation guide supplied with the valve assembly. A copy of this guide can also be downloaded from www.teledyneisco.com. Figure 5-3 represents the elevated temperature SyriXus 260x pump valve assembly; the other SyriXus series pump models will be similar.

1. Select the proper pump tubing for the pumps being attached to. These pump tubing assemblies are labeled and have the fittings and ferrules already attached.
2. Attach the mounting bracket as appropriate for the pump model being used, following the installation guide in the pump package.
3. Place the pumps in the position where they are to be used. The pumps are awkward to move once the valves have been installed.
4. Loosely attach the tubing lengths between the valve ports and the pumps.
5. While supporting the valve assembly, align the screw holes in the mounting bracket and loosely insert the screws and washers provided (six places).
6. Adjust the position of the valve assembly and then tighten the screws and fittings.
7. Trim the reagent supply tubing to the desired length, and then attach the tubing to the check valve.
8. Connect the cable below the motor housing on the back of the valve assembly to the controller ELECTRIC VALVE connector. Refer to Figure 1-6.

One controller can operate only one valve assembly (either the single valve assembly or the dual valve assembly) when the electric valve option is used.

THE ELECTRIC VALVE OPTION USES DC SERVO MOTORS THAT CAN GENERATE A SPARK WHEN RUNNING. THE ELECTRIC VALVE IS NOT TO BE USED IN ENVIRONMENTS THAT MAY BE FLAMMABLE OR EXPLOSIVE. THE ELECTRIC VALVE OPTION IS NOT RATED OR CERTIFIED FOR HAZARDOUS LOCATION USAGE.

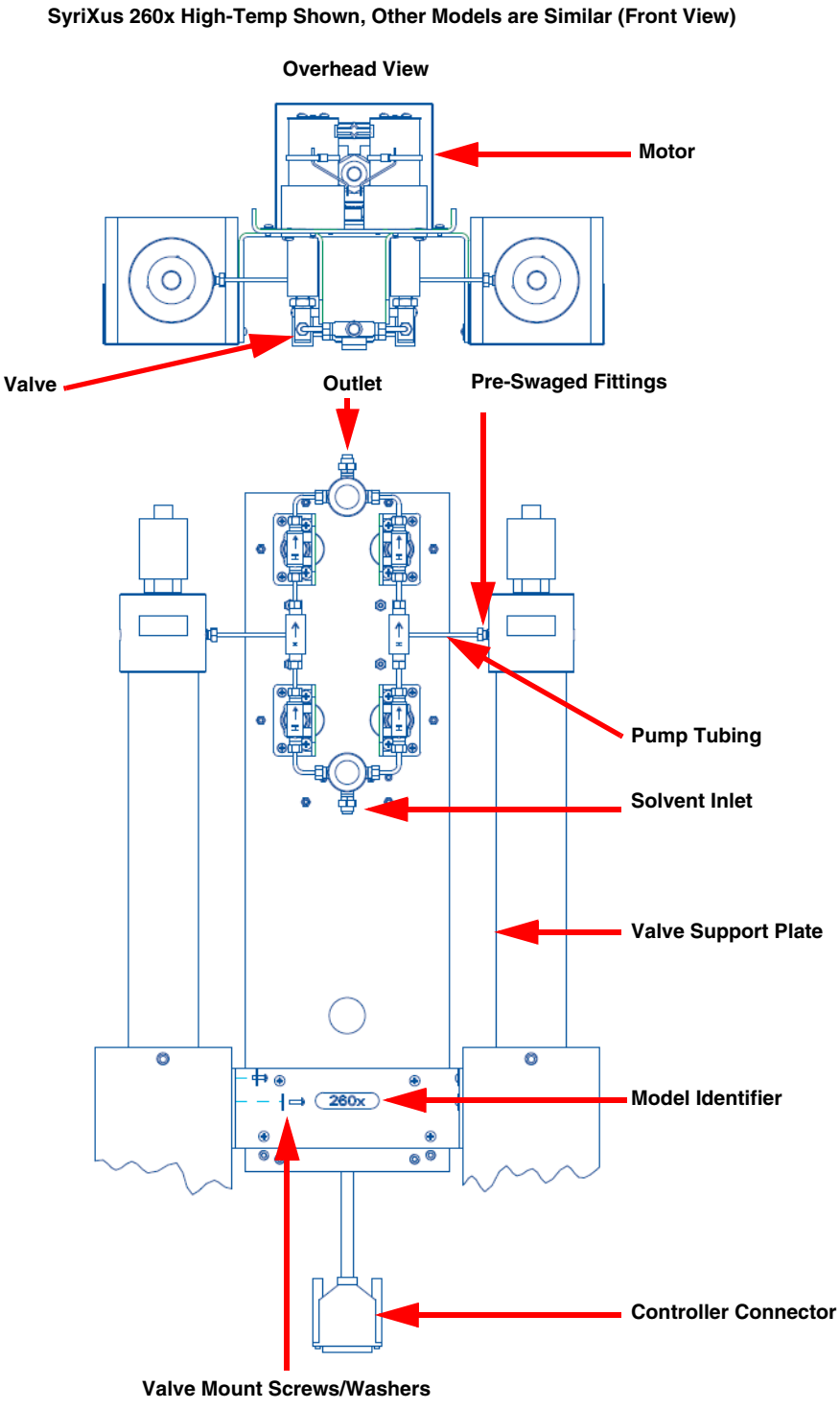


Figure 5-3 Electric valve installation

5.4 User Supplied Valves

Users may also choose to supply their own valves. The following information is necessary to choose the appropriate valves to work with Teledyne ISCO Continuous Flow software.

- Check valves

  Do not use spring-loaded check valves if refilling at atmospheric pressure; the pump seals are not designed to draw against a vacuum. The balls in Teledyne ISCO check valves are closed by gravity.

- Powered valves

  These are electrically triggered from the pump controller and could be air or electrically actuated. Digital outputs 1-4 provide signals for control of four two-way valves. One wire for each valve is connected to its specific connector on the rear of the controller. A second wire for each valve connects to ground. The signal provided is an open collector which functions as a switch open for closure of the fluid path. A switch closure (low) signals opening of the fluid path.

Table 5-7 "Accessory Control Digital Outputs" shows the relationship between the digital output, pump valve location, and the fluid path status for the ACCESS CTRL connections. Refer to the accessory control connections on the rear panel of the pump controller.

Table 5-7 Accessory Control Digital Outputs

Digital Output	Pump Valve Location	Fluid Path Status
1	A	Inlet (open or closed)
2	A	Outlet (open or closed)
3	B	Inlet (open or closed)
4	B	Outlet (open or closed)
5	C	Inlet (open or closed)
6	C	Outlet (open or closed)
7	D	Inlet (open or closed)
8	D	Outlet (open or closed)

Alternate connections can be made to drive low power 12-15 V relays or electric valves. Assume two wires per relay or valve. The first wire is connected to the appropriate digital output on the back of the pump controller. The second wire can be connected to the +15 V connector, to supply a maximum of 200mA for switching of relays or valves. Observe correct polarity if the valve or relay is polarized.

NOTE

If the valves selected operate at higher than 12-15V or use more than 200mA, a 12V relay requiring no more than 200mA MUST be used and the user must supply the required power to the valve.

5.5 Continuous Flow Mode

Once your valve package has been properly installed and you have ensured that fluid connections are leak-free, the system is ready for operation.

NOTE

Teledyne ISCO convention is to name the pumps “pump A” and “pump B,” reading from left to right.

Before running in Continuous Flow Mode, become familiar with Independent Mode, which allows the controller to operate two pumps independently and simultaneously. You must operate the two pumps manually for initial setup (i.e. refill and purging of air). If the Teledyne ISCO air valve package is used, the air valves are switched through ACCESS CTRL. When air valves are used, lights on the air valve actuator indicate which valves are open.

Table 5-8 Key Functions in the Multi-Pump Mode

Key	Display Option	Description
A	NORMAL	Uses a finer (slower) pressure match control when switching from one pump to the other.
	FAST	Uses a coarser (faster) pressure match control when switching from one pump to the other.
B	NORMAL PRESS	Uses pressure matching when switching from one pump to the other.
	LOW PRESS	Uses no pressure matching when switching from one pump to the other.
C	DELIVER	Sets the pump into the Deliver Mode of operation.
	RECEIVE	Sets the pump into the Receive Mode of operation.
6	OTHER OPTIONS	Sets the fill and refill marks that are used with both Continuous Flow Modes. Sets the No Check Valve feature to ON/OFF. Refer to Section 5.5.4 "No Check Valve".

5.5.1 Defining Operation

- Select Pump - This menu allows you to select any pump to display its run screen (program and operation data) and to make program changes.
- Valve specification - To prevent pressure fluctuation at switchover, you must specify the type of valve package you are using.

NOTE

If you are using Ball Valves (500xv only) and are not using a check valve in the supply reservoir tube, it may be necessary to turn the No Check Valve option on. Refer to Section 5.5.4 "No Check Valve" for additional information.

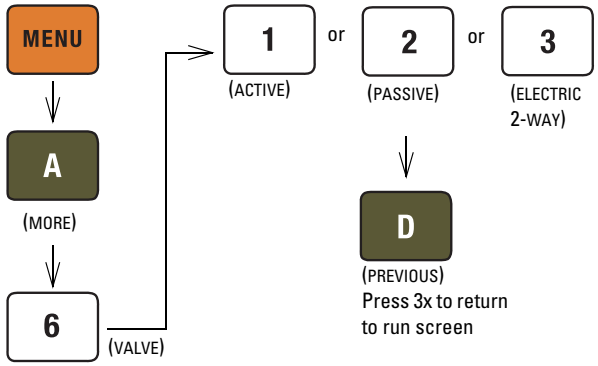


Figure 5-4 Keystrokes to specify valve type

- Volume totalizer - The total volume delivered is displayed in liters at the top right corner of the screen. Refer to Figure 5-5 to reset the volume totalizer to zero.

  The volume totalizer feature displays the sum of the volume delivered from the pump pair since the last volume reset.

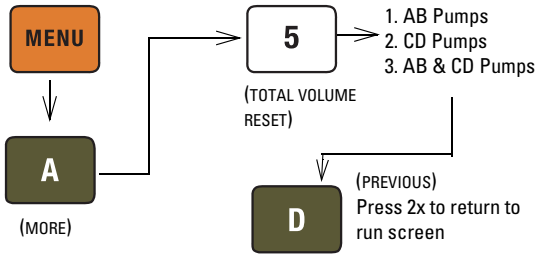


Figure 5-5 Keystrokes to reset volume totalizer

5.5.2 Constant Flow Mode

Continuous Flow Mode is found under the multi-pump options on Menu 2. Once you have accessed the multi-pump options, select Constant Flow Mode or Constant Pressure Mode.

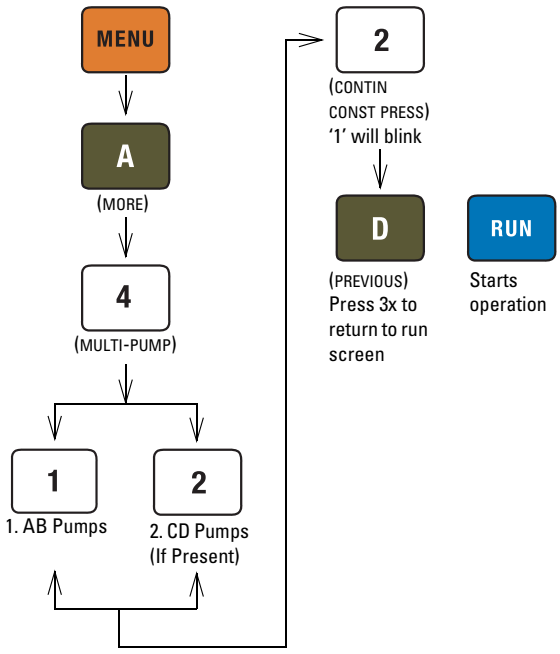


Figure 5-6 Keystrokes to set up constant flow

5.5.3 Constant Pressure Mode

Continuous Pressure Mode is found under the multi-pump options on Menu 2. Once you have accessed the multi-pump options, select Constant Flow mode or Constant Pressure Mode.

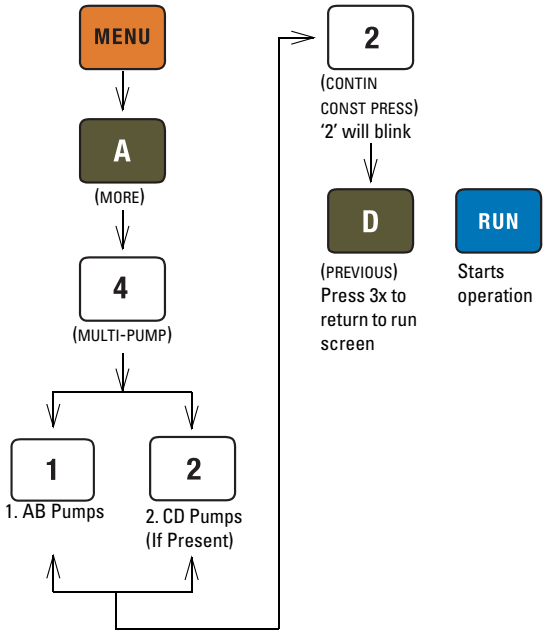


Figure 5-7 Keystrokes to set up constant pressure

5.5.4 No Check Valve

All Teledyne ISCO SyriXus series syringe pump models can use SyriXus series syringe pump controllers. Depending on the controller software version that is installed, some standard Teledyne ISCO D series pump controllers can also be used; however, the pump model name on the controller will not be shown properly. (Refer Section 3.2.1 "Controller Models".)

Teledyne ISCO pumps are normally operated with a check valve in the refill line to prevent backflow into the working fluid source reservoir when the inlet valve is opened. This backflow results from the pressurized fluid on the pump side of the inlet valve causing fluid to flow backward through the inlet valve into the supply reservoir when the valve is opened.

To limit fluid backflow from the pump to the supply reservoir, one of the following approaches are generally used.

1. The most common technique is to install a check valve in the supply line. This approach works well with most common liquids, but more viscous fluids are difficult to aspirate through a check valve.
2. Another method is to pressurize the supply reservoir (perhaps with a pressure pot), but this involves more hardware and is typically cumbersome to work with.
3. A typical approach is to delay the opening of the inlet valve to allow the pressure to equalize across the valve before it is opened. Teledyne ISCO syringe pumps provide a NO CHECK VALVE (NCV) software feature to implement this delay.

   The NO CHECK VALVE (NCV) feature controls the opening of the inlet valves such that, just prior to refill, the pump is depressurized to a user specified value (pressure point) or for a user specified time-out period (time point). This action reduces the pressure in the cylinder before the inlet valve is opened.

NOTE

The check valve approach is generally required when the viscosity of the working fluid is low, when working with gases or when the working fluid changes phases when depressurized (like liquefied CO_2). In these cases, the depressurization of the pump may lead to insufficient refills.

When the working fluid is viscous (more than 150 centipoise), the check valve on the supply fluid inlet may create an undesirable restriction during refill. The NO CHECK VALVE (NCV) feature in the SyriXus series controller allows the SyriXus series pumps to be more smoothly operated without the refill check valve installed.

NOTE

A check valve is not usually used with Ball Valves because of the imposed flow resistance. It is recommended to turn ON the NCV feature before operating the valves.

The 500xv syringe pump was designed for use with more viscous fluids and is the model most frequently used without a refill check valve. The NO CHECK VALVE (NCV) feature is functional with all SyriXus series pump models.

Almost all syringe pumps are used with fluids that are less viscous. As such, all SyriXus series controllers are shipped with the NO CHECK VALVE (NCV) feature turned OFF. If the check valve is removed from the inlet tubing, this feature can be readily enabled using the key-strokes shown in Figure 5-8.

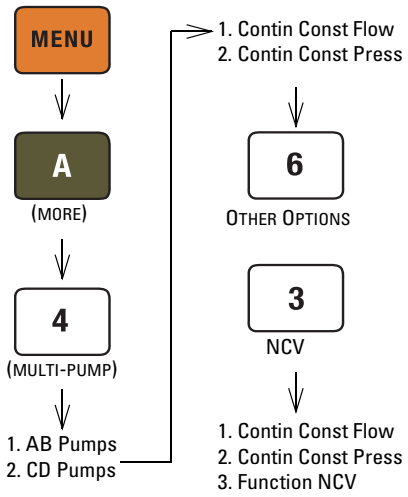


Figure 5-8 No Check Valve Setting to ON

In Figure 5-8, when the '4' key (Multi-Pump) is pressed and the "AB" or "CD" (if present) pump pair is selected, more than the two 'CONTIN CONST' options will be displayed. The NOCHECK VALVE option only applies to the two 'CONTIN CONST' options. For the other pump arrangements, or if the pumps are not in 'CONTIN CONST' Mode, option '6' (OTHER OPTIONS) will not be displayed.

When the '3' key (NCV) is pressed as shown in the above figure, three choices are displayed.

1. PRESSURE POINT – changes the pressure that the pump is to decrease to before the inlet valve is opened. The default (50 psi) is generally reasonable for most laboratory liquids but can be set to any pressure between 10 and 250 psi.

2. TIME POINT – changes the time delay between the end of the pump stroke and the opening of the inlet valve. The default is 5 seconds but can be set to any value between 1 and 99 seconds.
3. FUNCTION NCV – toggles the No Check Valve option ON or OFF.

To enter the Pressure Point or Time Point:

1. Press the '1' key (for Pressure Point) or '2' key (Time Point) to enter the settings mode for that option.
2. Using the keypad, enter the desired value between 010 and 250 for the pressure point, or between 1 and 99 for the time point.
3. Press the 'ENTER' key to store your selection.
4. Press the '3' key to toggle the NCV option ON or OFF. The last value set is the mode that will be used.
5. Use the 'D' softkey (PREVIOUS) repeatedly to return to the main screen and exit the menu function.

With the NCV feature turned ON, there should be a noticeable delay between the end of the pump delivery and the opening of the inlet valve.

5.5.5 To Run or Stop

This menu setting allows the operator to run or stop both pairs of pumps simultaneously.

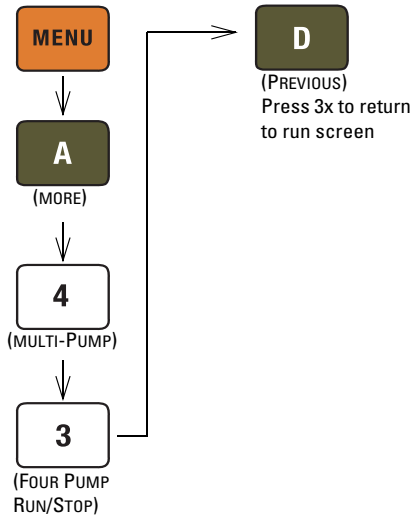


Figure 5-9 Keystrokes to Run or Stop the pumps

NOTE

Before pressing "run", ensure that "on cont flow" is displayed on the screen, and that the set flow rate/pressure is correct.

Always verify the valve settings before running a program. If a controller is reset or moved to a different power source, it will revert back to default settings (Active).

5.5.6 Tips for Running Continuous Flow

Liquids Checklist

1. Degas liquids if appropriate.
2. Purge air from the system:
   a. Fill both pumps completely by pressing REFILL and selecting each pump to fill.
   b. Route the outlet to waste or reservoir and press RUN. Press STOP when fluid comes out of the outlet.
   c. Open the valves to atmosphere by pressing ACC CTRL, then selecting each valve to open.
   d. Zero the pressure in each pump by pressing ZERO PRESS and selecting each pump to zero.
   e. Connect the outlet tubing and fill each pump once more.
3. Reset total volume (refer to Figure 5-5).

Liquefied Gases Checklist

1. Open the valves to atmosphere by pressing ACC CTRL, then selecting each valve to open.
2. Zero the pressure in each pump by pressing ZERO PRESS and selecting each pump to zero.
3. Fill both pumps completely by pressing REFILL and selecting each pump to fill.
4. Pressurize both pumps by pressing RAPID PRESS. Maximum flow rate and target pressure value will be displayed. Press 'D' to continue pressurization.
5. Reset total volume (refer to Figure 5-5).

NOTE

Using a temperature control jacket for cooling is recommended when pumping liquefied gases in continuous mode. These fluids tend to create heat as a result of compression work, which can lead to performance issues over time.

6. Equilibration - When the pumps begin running, the system will go through an equilibration phase, during which both pumps must be full and delivering fluid.
7. Additional guidelines - Become familiar with the following guidelines:
   - Pressure limits for continuous Constant Flow Mode are set by the limits of pump A for the A-B pair and pump C for the C-D pair.

- Temperature changes can cause pressure fluctuations. For available temperature control options, contact Teledyne ISCO.
- For correct overpressure response, shutdown must be set to ON under PUMP LIMIT options.
- Enter the same refill rate separately for pumps A, B, C, and D.

  The refill rate should always be as high as possible to allow time for refill and repressurization before the next switchover.

Section 6 Modifier Addition

6.1 Overview

Pumping systems using a modifier (usually a solvent) may have different configurations, depending on the application, including:

- Two separate pumps, one delivering a primary reagent or solvent and the other delivering a modifier through a mixing device to one or more user-provided extractors.
- A dual-pump system in Constant Pressure Mode pumping supercritical fluid, with a third pump delivering the modifier.

In both configurations, the purpose is to dispense a mixture with a programmable v/v ratio. Modifier concentrations of up to 100% can be programmed. Both fluids need to pass through one-way check valves before they meet and are blended in a user supplied mixing device. This mixing device can be as simple as a fluid tee, or more elaborate containing machined features to enhance mixing. Often, this mixing device is incorporated into the user's application system.

This section describes a possible technique to create a modifier addition using user supplied tubing, fittings and hardware. Because of the wide range of possible arrangements, these parts are not provided by Teledyne ISCO.

DANGER

RISK OF INJURY. THE PRESSURE PRODUCED COULD BE UP TO 1400 BAR. PLEASE UTILIZE APPROPRIATE TUBING CONNECTIONS AS NOTED. ALL USER SUPPLIED COMPONENTS MUST BE RATED FOR PRESSURES HIGHER THAN THE SPECIFIED MAXIMUM PRESSURE OF THE PUMPS.

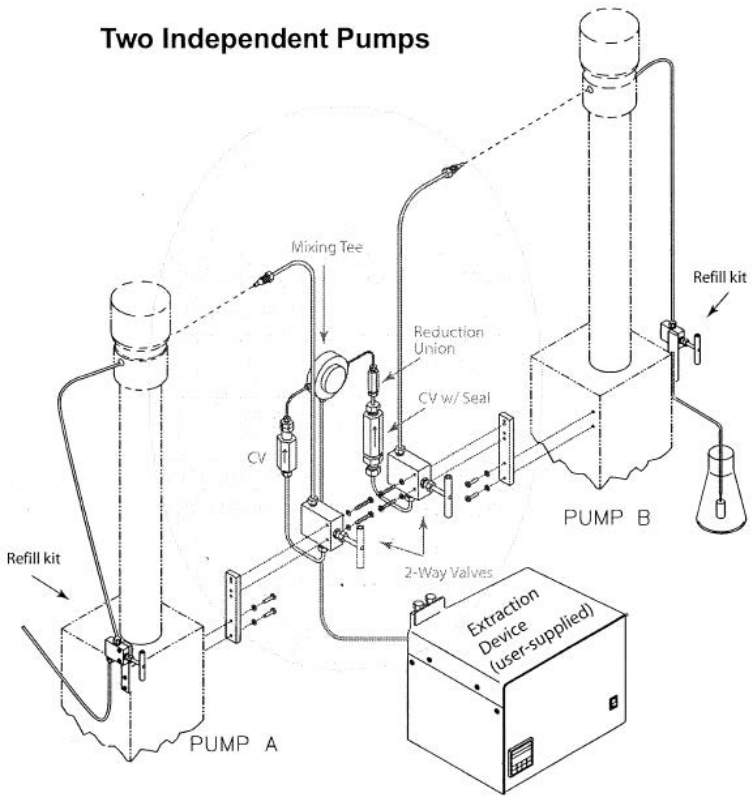
NOTE

The configurations described in this section apply to SyriXus 260x, 500x and 1000x pumps that use Valco or SSI fittings. The SyriXus 65x pump can be configured and operated in a similar manner. However, due to the higher operating pressure and the AE F250C fittings, the 65x requires hardware that is not listed in this section. Contact Teledyne ISCO customer service for details on configuring a 65x pump for this type of operation.

6.1.1 Example of Hardware

The first step is to collect the required hardware. This hardware would include inline check valves rated for the maximum pressure of the pumps, a mixing device (possibly a simple fluid tee), along with tubing and fittings to connect the components together.

6.1.2 Two Independent Pumps



This method involves two SyriXus series pumps (preferably of the same model) and a controller.

1. Attach one manual refill kit (available from Teledyne ISCO) to each of the pumps as shown.
2. Attach one manual outlet kit to each of the two pumps (also available from Teledyne ISCO).
3. Using metal tubing, attach a user supplied check valve to each of the outlet ports on the outlet valves as shown. Observe the flow direction marked on the check valves.
4. Connect the check valves using metal tubing to the mixing device (a mixing tee is shown).
5. Connect the outlet of the mixing device to your system extraction device.
6. Using appropriate tubing, connect the refill valve inlet to the fluid reservoirs.
7. Follow the procedures in Section Section 1.5 "Electrical Connections" to connect the controller to the pumps.
8. Perform a preliminary checkout of the pumps as described in Section 1.6 "Preliminary Checkout".
9. Fill the pumps with fluid.

Figure 6-1 Modifier addition components installation (Two-pump configuration)

NOTE

The pump with the primary working fluid needs to be connected to the PUMP A electrical connector on the controller, and the pump being used for the modifier needs to be connected to the PUMP B electrical connector on the controller.

NOTE

When working with a modifier that boils at room temperature, a pressurized reservoir for the modifier fluid may be useful to reduce or prevent vaporization.

6.1.3 Continuous Flow System

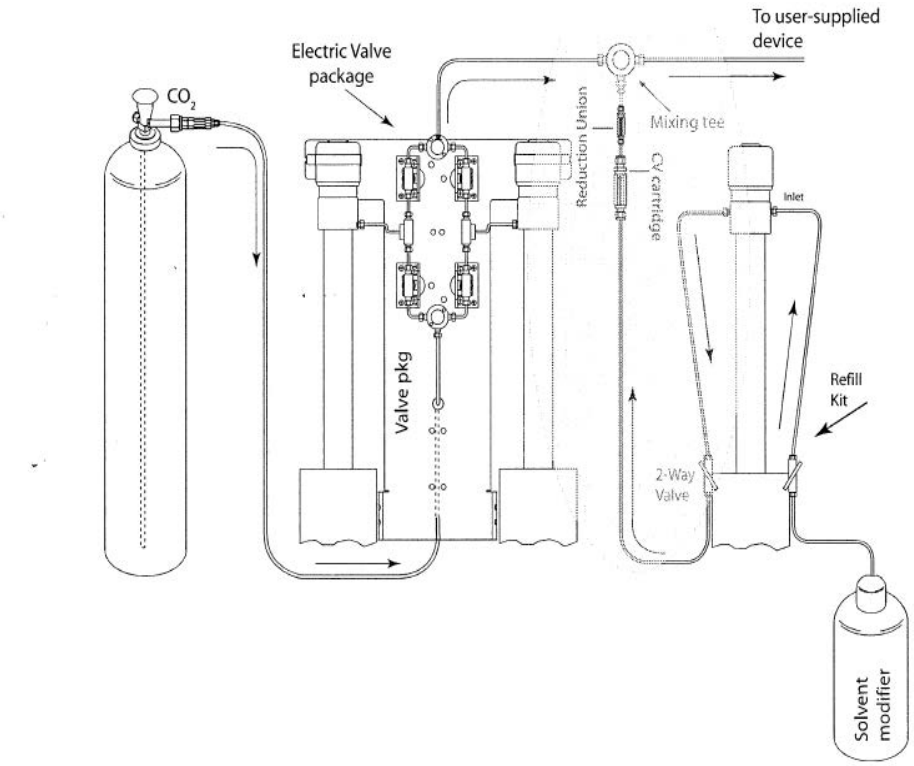


Figure 6-2 Modifier addition kit installation (continuous flow)

NOTE

The modifier pump is a single pump. When modifier pump cylinder is empty, the system stops. The cylinder must be manually refilled before the system can run again.

When working with supercritical CO_2 as the primary working fluid, it is not uncommon to desire that the CO_2 is supplied continuously without interruption to maintain a liquid fluid state and stabilize the fluid parameters, such as density. Supercritical CO_2 is very compressible and generates considerable heat while being pressurized. The pressurizing action may cause fluid parameters (like density and temperature) to become less predictable. Using a continuous flow pumping arrangement may prove to be desirable.

NOTE

Using a temperature control jacket for cooling is highly recommended when pumping liquefied gases in Continuous Mode. These fluids tend to create heat as a result of compression work which can lead to performance issues over time.

Typically, electric valves are preferred in this arrangement as they tend to close more securely. The Teledyne ISCO electric valve option described earlier is well suited to this application. The two pumps related to the continuous flow need to be attached to the PUMP A and PUMP B electrical connections as described in Section 5.4 "User Supplied Valves". The valve cable must be attached to the electric valve control board.

NOTE

Continuous flow modifier addition is not recommended with the SyriXus 65x pump model. To use a 65x, either the air valve option would be employed, or a user provided electric valve arrangement would be required.

Configurations for supercritical CO_2 is performed in much the same way as with two independent pumps, except that only one check valve, one refill kit and one manual outlet valve is needed. Also, the modifier pump must be connected to the PUMP C connector on the controller.

NOTE

When working with supercritical CO_2 (or other liquefied gases), the use of a temperature control jacket for cooling is recommended.

6.1.4 Modifier Mode Setup

When first setting up a system for Modifier Addition Mode, the pumps should be zeroed and filled. To accomplish this, the pumps should first be placed under independent control - Constant Pressure Mode.

NOTE

Once the modifier system is operating, the system does not need to be zeroed before subsequent refilling.

1. If the pumps are running, press the STOP key once.
2. Press MENU > MORE (A).
3. Press '4' - MULTI-PUMP, to display the multi-pump menu.
4. Press '4' - INDEPENDENT to designate that the pumps be operated under independent control. The number '4' will blink, indicating that Independent Mode has been selected.
5. Press 'D' - PREVIOUS, twice to return to the main menu.
6. Press CONST PRESS.

To Zero the Pumps

1. Place the pumps in Independent Control - Constant Pressure Mode, as detailed above.
2. Be sure the pumps are stopped.
3. Disconnect the inlet tubing from the inlet valve of pump A.
4. Select '2' pump Independent Control/Constant Pressure Mode. Refer to Section 5.5 "Continuous Flow Mode".
5. Open the inlet valves of each pump.
6. Run both pumps empty.
7. Zero the pressure on each pump.
8. Reconnect the pump A inlet tubing to the inlet valve.

To Fill Pump B with Modifier

1. Place the pumps in Independent Control - Constant Pressure Mode, as previously explained. Be sure the pumps are stopped.
2. Close the pump B outlet valve and open the pump B inlet valve.
3. Press REFILL. Press softkey 'B' to designate that pump B is the active pump (the pump being refilled). Pump B will fill with modifier.
4. After pump B has filled, press run and deliver 5-10 mL of modifier back through the inlet valve, to ensure all air is purged from the pump, before pressing stop.
5. Close the inlet valve.

NOTE

When using the pumps with liquefied CO_2, make sure you purchase CO_2 in a 'dip-tube' CO_2 tank. Helium headspace tanks will maintain super critical pressures as the tank empties.

To Fill Pump A with Supercritical Fluid (Helium Head-Space Tank)

1. Place the pumps in Independent Control - Constant Pressure Mode, as detailed above.
2. Be sure the pumps are stopped.
3. Close the pump A outlet valve before opening the tank supply valve and pump A inlet valve.
4. Press REFILL. Press softkey 'A' to designate that pump A is the active pump (the pump being refilled). Pump A will fill with pressurized fluid.
5. After pump A has refilled, wait 15 seconds before closing the tank supply valve and pump A inlet valve. This will allow time for the flow into the pump to complete.

6.1.5 Two-Pump Operation

Pump A delivers supercritical fluid while pump B meters modifier. Both fluids pass through one-way check valves before they meet and are blended together in a mixing tee. Modifier concentrations of up to 100 percent (v/v) are programmable via the controller. When the concentration requires a higher percentage of modifier than the other fluid, it may be desirable to put the modifier in pump A to be delivered as the primary fluid.

Both pumps operate in Constant Pressure Mode and will flow up to their maximum rate to maintain the set pressure. When Modifier Addition Mode is selected and RUN is pressed, pump A pressure is ramped at its maximum flow rate to the set pressure while pump B waits at a lower pressure (3.5 bar).

Pump B minimum pressure can be increased if the modifier boils at room temperature and 3.5 bar.

Once pump A has reached the set pressure, the controller will enter a Hold Mode and wait for a pressure drop. The start of EQUILIBRATION is signaled by opening the extractor inlet, or pressing RUN.

NOTE

Flow must then be started through the system by opening all valves! The modifier pump will not equilibrate properly without flow.

Pump B pressure is then slowly ramped upward until its check valve is detected as open. At this point, the controller exits EQUILIBRATION Mode and displays the message RUNNING.

When RUNNING is displayed, the controller monitors pump A piston movement, and calculates the pump B piston movement required to deliver the correct ratio of modifier. If pump A cannot maintain the set pressure, as when the extraction cartridges are initially filling or pump A is refilling, the controller reverts to EQUILIBRATION and pump B pressure is dropped below that of pump A to avoid delivery of incorrect modifier concentrations. Once the pump A set pressure is reestablished, the system will re-equilibrate.

When pump B needs refilling, it must first be placed under independent control, as you must run it to return 5-10 mL of modifier back through the valve to be sure that the cylinder is free of air.

NOTE

To properly equilibrate the pumps, they both must be delivering fluid.

When preparing your system for modifier operation, if you are connecting pump A to a CO_2 tank, you will need to use stainless steel tubing and appropriate CO_2 connecting fittings. These parts should be available from your CO_2 provider.

6.2 Programming

Once the pressure has been zeroed and the pumps are filled, you are ready to set up your modifier addition parameters. You will need to place the pumps in Modifier Addition Mode, set the pressure limits (under the limits option on the main menu) and designate the percent of modifier (found under % pump on the run screen) to be added. If your modifier boils at 3.5 bar at room temperature, you may want to increase the minimum pressure for pump B to prevent vapor (the default minimum pressure is 3.5 bar).

Before operation in Modifier Addition Mode, zero and fill the pumps under Independent Control/Constant Pressure Mode.

Once the pumps are ready, place them in Modifier Addition Mode:

Press MENU > MORE (A) > MULTI-PUMP (4), and select CONTIN MODIFIER (5).

6.2.1 Minimum Modifier Pressure Setting

The default setting for the minimum modifier pump pressure is 50 psi (3.5 bar). This can be changed to a value appropriate for the type of modifier being used.

If there is no need to change minimum pressure, press PREVIOUS (D) three times to return to the main menu. The screen will display the words PRESSURE MODIFIER.

NOTE

The minimum pressure must be below the system minimum pressure or the pump B outlet valve must be closed whenever the system pressure is below the MIN MOD pressure.

To change the minimum pressure: Press MIN MOD PRESS (B).

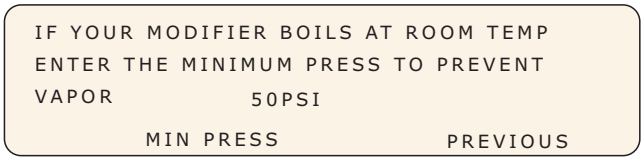


Figure 6-3 Minimum modifier pressure screen

Select MIN PRESS (B). 'ENTER MIN PRES' will flash. Type the desired pressure value and then press ENTER.

Press PREVIOUS (D) four times to return to the main menu. The screen will display the words PRESSURE MODIFIER.

6.2.2 Modifier Concentration

To set the modifier concentration, press % PUMP (C), or %PUMP B or C. Use the numeric keys to enter the desired percentage of modifier and press ENTER to save the value.

To Select the Limits

1. Once Modifier Addition Mode has been selected, the desired pressure limits must be set. Select number '2', LIMITS, from the main menu.
2. The pump for which the limits are being set will be shown on the top left of the display, LIMITS: PUMP A. If it is displaying any pump other than pump A, press 'A'. LIMITS: PUMP A will then be displayed.
3. Press '1' to select LIMITS and then '1' again to set the MAX pressure limits. Enter the desired maximum pressure using the numeric keypad and press ENTER to store the value. Then press D, PREVIOUS, to return to the limits menu.
4. If you need to change the minimum pressure limit, press '2', MIN. Enter the desired minimum pressure using the numeric keypad and press ENTER to store the value.
5. Press 'D', PREVIOUS, to return to the Limits menu.
6. Continue pressing 'D' to return to the run screen.
7. MODIFIER ON will be displayed above softkey 'B', and % PUMP will be displayed above softkey 'C'. To designate the desired modifier concentration, press 'C'. Then use the numeric keys to enter the desired percentage of modifier. Press ENTER to save the desired value.
8. Open the outlet valves of both pumps if they are not open.
9. Press RUN.
10. When the pressure for Pump A is established, the message "HOLD: PRESS RUN" will be displayed.
11. Open the extractor inlet valves.
12. The message "EQUILIBRATE" will be displayed on the controller screen. If the controller does not display "EQUILIBRATE," press RUN. While this message is displayed, no modifier will be delivered.
13. Immediately open the extractant outlet valve(s).

NOTE

Flow MUST be established through the system at or before the time "EQUILIBRATE" is displayed. To properly equilibrate the pumps, they must be delivering fluid.

14. Once the message RUNNING is displayed, modifier will be delivered at the selected rate.

6.3 Refilling

Once your modifier addition system is running, you will occasionally need to refill the pumps. The system must be stopped while the pumps are refilling. Pump A, the "CO_2" pump, may be refilled simply by designating the pump to be refilled and then pressing REFILL (refer to Section 6.3.1 "Refill the CO_2 Pump"). Pump B, "the modifier pump", may also be refilled in this manner. However, if you wish to ensure that air is purged from pump B, it must be placed under independent control before refilling. Once under independent control, the pump should be run until 5-10 mL of modifier is delivered back to the source (refer to Section 6.3.2 "Refill Pump B (the Modifier Pump)").

6.3.1 Refill the CO_2 Pump

1. Press STOP.
2. Close the outlet valves of both pumps.
3. Press REFILL, and press 'A' to designate pump A.
4. As soon as the pump pressure drops below the known tank pressure, open the tank supply valve and the pump A inlet valve.
5. After pump A has refilled, the message CYLINDER FULL will be displayed on the controller front panel. Wait 15 seconds before closing the tank supply valve and the pump A inlet valve, to allow the flow into the pump to stabilize.
6. Open the outlet valves of both pumps.
7. Press RUN.
8. When A pressure is established, the message HOLD: PRESS RUN will be displayed.
9. Open the extractor inlet valves.
10. The message EQUILIBRATE will be displayed on the controller screen. If the controller does not display EQUILIBRATE, press RUN. While this message is displayed, no modifier will be delivered.
11. Immediately open the extractant outlet valve(s).

NOTE

Flow MUST be established through the system at or before the time EQUILIBRATE is displayed. To properly equilibrate the pumps, they must be delivering fluid.

12. Once the message RUNNING is displayed, modifier will be delivered at the selected rate.

6.3.2 Refill Pump B (the Modifier Pump)

1. Press STOP.
2. Close the outlet valves of both pumps.
3. Take the pumps out of Modifier Addition Mode by pressing softkey 'B' under the word MODIFIER. The word ON will change to OFF.
4. Open the inlet valve of pump B.
5. Press REFILL, and press 'B' to designate Pump B.

6. After pump B has filled, press CONST FLOW and set the desired purging flow rate. Press RUN and deliver 5-10 mL of modifier back through the inlet valve. This ensures that all air is purged from the pump.
7. Press STOP> B.

6.3.3 Start Modifier

1. Return to Constant Pressure Mode by pressing D, SELECT PUMP, and then 'A'.
2. Place the pump in Modifier Addition Mode by pressing softkey 'B' under the words MODIFIER. The word OFF will change to ON above MODIFIER.
3. Open the outlet valves of both pumps if they are not open.
4. Press RUN.
5. When pump A pressure is established, the message HOLD: PRESS RUN will be displayed.
6. Open the extractor inlet valves.
7. The message EQUILIBRATE will be displayed on the controller screen. If the controller does not display EQUILIBRATE, press RUN. While this message is displayed, no modifier will be delivered.
8. Immediately open the extractant outlet valve(s).

NOTE

Flow MUST be established through the system at or before the time EQUILIBRATE is displayed. To properly equilibrate the pumps, they must be delivering fluid.

9. Once the message RUNNING is displayed, modifier will be delivered at the selected rate.

Section 7 Modbus Configuration

7.1 Overview

Modbus is a simple command/response mechanism to 'read from' and 'write to' specific memory locations called 'registers'. A register is a holding place for a piece of digital information within the equipment. For more information on Modbus, please refer to the following documents which can be found on the www.modbus.org website: Modbus Application Protocol Vol. 1 and Modbus Over Serial Line Vol. 1 and Modbus Messaging on TCP/IP.

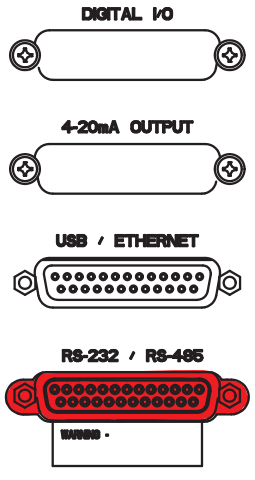
The SyriXus series syringe pump controller supports the Modbus RTU and Modbus TCP/IP protocols.

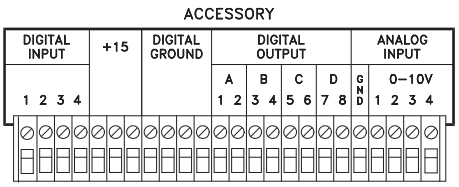
7.1.1 Modbus RTU

The Modbus RTU protocol implementation uses a 2-wire RS-485 connection. The RS-485 connections are located on the DB25 connector labeled RS-232/RS-485. Teledyne ISCO recommends connecting the ground reference wire as shown in Figure 7-1. The matching connection is a D-Subminiature 25-pin standard plug, such as a TE Connectivity AMP connector (P/N 747912-2) from an electronic parts supplier.

WARNING

Connecting devices to energized circuits may cause personal injury or property damage. Power must be removed from the pump before connecting external devices.





Pin on DB25-shell	RS-485 2-Wire
18	DATA (B)+
11	DATA (A)-
7	GND

Figure 7-1 RS-485 Connection

7.1.2 Modbus TCP/IP

The Modbus TCP/IP protocol implementation uses an Ethernet connection. The Ethernet connections are located on the optional DB25 connector labeled USB/Ethernet. Use optional cable (P/N 60-1244-488) and coupler (P/N 149-9052-00) to connect to your Ethernet.

Table 7-1 Modbus TCP/IP Protocol

Pin on DB 25 Casing	Ethernet	RJ-45
2	Transmit +	1
14	Transmit -	2
15	Receive +	3
17	Receive -	6
22	Vgnd	4+5
23	Vgnd	7+8

NOTE

Due to the variability of communications used to remotely control pumps, it is strongly recommended that a system integrator be consulted by the end user. Teledyne does not offer support to interface with external control systems.

7.1.3 Modbus Configuration Options

To access the Modbus configuration settings, press:

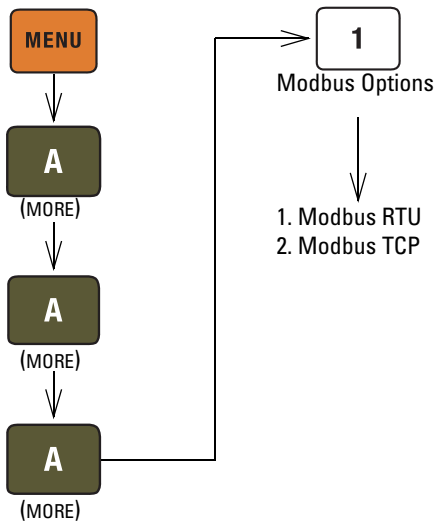


Table 7-2 Modbus TCP/IP Configuration Options	
Item	**Description**
IP Address	Internet protocol address of device (Default 192.168.1.200)
Subnet Mask	Subnet mask (Default 255.255.255.0)
Gateway	Gateway (Default 0.0.0.0)
Port	TCP port (Default 502)

Table 7-3 Modbus RTU Configuration Options		
Item	**Value**	**Description**
Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	Communication Speed (Default 19200)
Slave ID	1-247	Device address (Default 1)
Parity	Even 1 Stop Bit, Odd 1 Stop Bit, None 1 Stop Bit, None 2 Stop Bit	Communication parameters (Default Even 1 Stop Bit)
Word Order	Big Endian, Little Endian	Word order for 32-bit integers and IEEE-754 floating point numbers. Big Endian: AB CD; Little Endian CD AB. (Default Big Endian)
Character Time	Min: Baud Rate dependent Max: 999ms	Time to transmit single character t1. Used to calculate interframe and intercharacter space t1.5, t3.5 (50 m sec default)

Table 7-4 Supported Modbus Function Codes	
Function Code	**Description**
01	Read Discrete Output Coils
03	Read Analog Output Holding Registers
05	Write Single Discrete Output Coil
15	Write Multiple Discrete Output Coils
16	Write Multiple Analog Output Holding Registers

Table 7-5 Exception Responses		
Exception Code	**Name**	**Description**
01	Illegal Function	Function code received is not supported.
02	Illegal Data Address	Data address received is not an allowable address.
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the addressed location. This may indicate a fault in the structure of the remainder of a complex request, such that the implied length is incorrect. Does NOT mean data value is outside the expectation of the controller.

Table 7-6 Coils					
Register	**Address**	**Type**	**Size**	**Description**	
00001	0	R/W	1 BIT	0: Stop Pump A	1: Run Pump A
00002	1	R/W	1 BIT	0: Stop Pump B	1: Run Pump B
00003	2	R/W	1 BIT	0: Stop Pump C	1: Run Pump C
00004	3	R/W	1 BIT	0: Stop Pump D	1: Run Pump D
00005	4	R/W	1 BIT	Link Run/Stop operation of multi-pump pair AB & multi-pump pair CD	
				0: Disable	1: Enable
00006	5	R/W	1 BIT	0: Stop Pump A if in Refill	1: Run Pump A in Refill
00007	6	R/W	1 BIT	0: Stop Pump B if in Refill	1: Run Pump B in Refill
00008	7	R/W	1 BIT	0: Stop Pump C if in Refill	1: Run Pump C in Refill
00009	8	R/W	1 BIT	0: Stop Pump D if in Refill	1: Run Pump D in Refill
00010	9	R/W	1 BIT	1: Pump A in Constant Pressure Mode	
00011	10	R/W	1 BIT	1: Pump B in Constant Pressure Mode	
00012	11	R/W	1 BIT	1: Pump C in Constant Pressure Mode	
00013	12	R/W	1 BIT	1: Pump D in Constant Pressure Mode	
00014	13	R/W	1 BIT	1: Pump A in Constant Flow Mode	
00015	14	R/W	1 BIT	1: Pump B in Constant Flow Mode	
00016	15	R/W	1 BIT	1: Pump C in Constant Flow Mode	
00017	16	R/W	1 BIT	1: Pump D in Constant Flow Mode	
00018	17	R/W	1 BIT	1: Pump A & Pump B in Independent Mode	
00019	18	R/W	1 BIT	1: Pump A & Pump B in Continuous Flow Constant Flow Mode	
00020	19	R/W	1 BIT	1: Pump A & Pump B in Continuous Flow Constant Pressure Mode	
00021	20	R/W	1 BIT	1: Pump A & Pump B in Modifier Addition Mode	
00022	21	R/W	1 BIT	1: Pump A & Pump B & Pump C in Continuous Modifier Addition Mode	
00023	22	R/W	1 BIT	1: Pump C & Pump D in Independent Mode	
00024	23	R/W	1 BIT	1: Pump C & Pump D in Continuous Flow Constant Flow Mode	
00025	24	R/W	1 BIT	1: Pump C & Pump D in Continuous Flow Constant Pressure Mode	
00026	25	R/W	1 BIT	0: Multi-pump pair AB in Delivery Mode	1: Multi-pump pair AB in Receive Mode
00027	26	R/W	1 BIT	0: Multi-pump pair AB in Low Press operation	1: Multi-pump pair AB in Normal Press operation
00028	27	R/W	1 BIT	0: Use Fast (coarser) pressure match control for multi-pump pair AB	1: Use Normal (finer) pressure match control for multi-pump pair AB
00029	28	R/W	1 BIT	0: Multi-pump pair CD in Deliver Mode	1: Multi-pump pair CD in Receive Mode
00030	29	R/W	1 BIT	0: Multi-pump pair CD in Low Press operation	1: Put multi-pump pair CD in Normal Press operation
00031	30	R/W	1 BIT	0: Use Fast (coarser) pressure match control for multi-pump pair CD	1: Use Normal (finer) pressure match control for multi-pump pair CD

Table 7-6 Coils (Continued)					
Register	**Address**	**Type**	**Size**	**Description**	
00032	31	R/W	1 BIT	1: Activates the automatic rapid pressurization cycle (Constant Flow Mode only) for Pump A	
00033	32	R/W	1 BIT	1: Activates the automatic rapid pressurization cycle (Constant Flow Mode only) for Pump B	
00034	33	R/W	1 BIT	1: Activates the automatic rapid pressurization cycle (Constant Flow Mode only) for Pump C	
00035	34	R/W	1 BIT	1: Activates the automatic rapid pressurization cycle (Constant Flow Mode only) for Pump D	
00036	35	R	1 BIT	1: Pump A is Equilibrating	
00037	36	R	1 BIT	1: Pump B is Equilibrating	
00038	37	R	1 BIT	1: Pump C is Equilibrating	
00039	38	R	1 BIT	1: Pump D is Equilibrating	
00040	39	R	1 BIT	1: Pump A is in Hold (clock stopped)	
00041	40	R	1 BIT	1: Pump B is in Hold (clock stopped)	
00042	41	R	1 BIT	1: Pump C is in Hold (clock stopped)	
00043	42	R	1 BIT	1: Pump D is in Hold (clock stopped)	
00044	43	R	1 BIT	1: Pump A & Pump B in Concentration Gradient	
00045	44	R	1 BIT	1: Pump A in Pressure Gradient	
00046	45	R	1 BIT	1: Pump A in Flow Gradient	
00047	46	R/W	1 BIT	1: Controller in Local Operation	
00048	47	R/W	1 BIT	1: Controller in Remote Operation	
00049	48	R/W	1 BIT	1: Controller in External Operation	
00050	49	R/W	1 BIT	1: External Refill control enabled	
00051	50	R/W	1 BIT	1: Zero pressure sensor offset for Pump A	
00052	51	R/W	1 BIT	1: Zero pressure sensor offset for Pump B	
00053	52	R/W	1 BIT	1: Zero pressure sensor offset for Pump C	
00054	53	R/W	1 BIT	1: Zero pressure sensor offset for Pump D	
00055	54	R/W	1 BIT	0: Pressure Integrator for Pump A OFF	1: Pressure Integrator for Pump A ON
00056	55	R/W	1 BIT	0: Pressure Integrator for Pump B OFF	1: Pressure Integrator for Pump B ON
00057	56	R/W	1 BIT	0: Pressure Integrator for Pump C OFF	1: Pressure Integrator for Pump C ON
00058	57	R/W	1 BIT	0: Pressure Integrator for Pump D OFF	1: Pressure Integrator for Pump D ON
00059	58	R/W	1 BIT	0: Pressure Deadband for Pump A OFF	1: Pressure Deadband for Pump A ON
00060	59	R/W	1 BIT	0: Pressure Deadband for Pump B OFF	1: Pressure Deadband for Pump B ON
00061	60	R/W	1 BIT	0: Pressure Deadband for Pump C OFF	1: Pressure Deadband for Pump C ON
00062	61	R/W	1 BIT	0: Pressure Deadband for Pump D OFF	1: Pressure Deadband for Pump D ON
00063	62	R/W	1 BIT	0: AUTO REFILL A OFF	1: AUTO REFILL A ON
00064	63	R/W	1 BIT	0: AUTO REFILL B OFF	1: AUTO REFILL B ON

Table 7-6 Coils (Continued)					
Register	**Address**	**Type**	**Size**	**Description**	
00065	64	R/W	1 BIT	0: AUTO REFILL C OFF	1: AUTO REFILL C ON
00066	65	R/W	1 BIT	0: AUTO REFILL D OFF	1: AUTO REFILL D ON
00067	66	R/W	1 BIT	0: AUTO FILL A OFF	1: AUTO FILL A ON
00068	67	R/W	1 BIT	0: AUTO FILL B OFF	1: AUTO FILL B ON
00069	68	R/W	1 BIT	0: AUTO FILL C OFF	1: AUTO FILL C ON
00070	69	R/W	1 BIT	0: AUTO FILL D OFF	1: AUTO FILL D ON
00071	70	R/W	1 BIT	0: DIGITAL OUTPUT BIT 1 HIGH	1: DIGITAL OUTPUT BIT 1 LOW
00072	71	R/W	1 BIT	0: DIGITAL OUTPUT BIT 2 HIGH	1: DIGITAL OUTPUT BIT 2 LOW
00073	72	R/W	1 BIT	0: DIGITAL OUTPUT BIT 3 HIGH	1: DIGITAL OUTPUT BIT 3 LOW
00074	73	R/W	1 BIT	0: DIGITAL OUTPUT BIT 4 HIGH	1: DIGITAL OUTPUT BIT 4 LOW
00075	74	R/W	1 BIT	0: DIGITAL OUTPUT BIT 5 HIGH	1: DIGITAL OUTPUT BIT 5 LOW
00076	75	R/W	1 BIT	0: DIGITAL OUTPUT BIT 6 HIGH	1: DIGITAL OUTPUT BIT 6 LOW
00077	76	R/W	1 BIT	0: DIGITAL OUTPUT BIT 7 HIGH	1: DIGITAL OUTPUT BIT 7 LOW
00078	77	R/W	1 BIT	0: DIGITAL OUTPUT BIT 8 HIGH	1: DIGITAL OUTPUT BIT 8 LOW
00079	78	R/W	1 BIT	0: Disable Dispense Mode A	1: Enable Dispense Mode A
				Only configure if in Constant Flow Mode	
00080	79	R/W	1 BIT	0: Disable Dispense Mode B	1: Enable Dispense Mode B
				Only configure if in Constant Flow Mode	
00081	80	R/W	1 BIT	0: Disable Dispense Mode C	1: Enable Dispense Mode C
				Only configure if in Constant Flow Mode	
00082	81	R/W	1 BIT	0: Disable Dispense Mode D	1: Enable Dispense Mode D
				Only configure if in Constant Flow Mode	
00083	82	R/W	1 BIT	1: Reset total volume delivered by multi-pump pair AB	
00084	83	R/W	1 BIT	1: Reset total volume delivered by multi-pump pair CD	
00085	84	R/W	1 BIT	1: Pressure Units = ATM	
00086	85	R/W	1 BIT	1: Pressure Units = BAR	
00087	86	R/W	1 BIT	1: Pressure Units = kPa	
00088	87	R/W	1 BIT	1: Pressure Units = PSI	
00089	88	R/W	1 BIT	1: Flow Units = mL/min	
00090	89	R/W	1 BIT	1: Flow Units = mL/hr	
00091	90	R/W	1 BIT	1: Flow Units = µL/min	
00092	91	R/W	1 BIT	1: Flow Units = µL/hr	
00093	92	R/W	1 BIT	0: Overpressure Alarm OFF	1: Overpressure Alarm ON
00094	93	R/W	1 BIT	0: Overpressure Display OFF	1: Overpressure Display ON
00095	94	R/W	1 BIT	0: Overpressure Shutdown OFF	1: Overpressure Shutdown ON
00096	95	R/W	1 BIT	0: Underpressure Alarm OFF	1: Underpressure Alarm ON

Table 7-6 Coils (Continued)					
Register	**Address**	**Type**	**Size**	**Description**	
00097	96	R/W	1 BIT	0: Underpressure Display OFF	1: Underpressure Display ON
00098	97	R/W	1 BIT	0: Underpressure Shutdown OFF	1: Underpressure Shutdown ON
00099	98	R/W	1 BIT	0: Overflow Alarm OFF	1: Overflow Alarm ON
00100	99	R/W	1 BIT	0: Overflow Display OFF	1: Overflow Display ON
00101	100	R/W	1 BIT	0: Overflow Shutdown OFF	1: Overflow Display ON
00102	101	R/W	1 BIT	0: Underflow Alarm OFF	1: Underflow Alarm ON
00103	102	R/W	1 BIT	0: Underflow Display OFF	1: Underflow Display ON
00104	103	R/W	1 BIT	0: Underflow Shutdown OFF	1: Underflow Shutdown ON
00105	103	R/W	1 BIT	0: Poor Fill Alarm A OFF	1: Poor Fill Alarm A ON
00106	105	R/W	1 BIT	0: Poor Fill Alarm B OFF	1: Poor Fill Alarm B ON
00107	106	R/W	1 BIT	0: Poor Fill Alarm C OFF	1: Poor Fill Alarm C ON
00108	107	R/W	1 BIT	0: Poor Fill Alarm D OFF	1: Poor Fill Alarm D ON
00109	108	R/W	1 BIT	1: Stop all motor and reset flow rate and pressure setpoints to default.	
00110	109	R	1 BIT	0: Transducer of Pump A not connected	1: Transducer of Pump A connected
00111	110	R	1 BIT	0: Pump A not at upper flag limit	1: Pump A at upper Flag Limit (Empty)
00112	111	R	1 BIT	0: Pump A not at lower flag limit	1: Pump A at lower flag limit (Full)
00113	112	R	1 BIT	1: Pump A is overpressure	
00114	113	R	1 BIT	1: Pump A is underpressure	
00115	114	R	1 BIT	1: Motor failure Pump A	
00116	115	R	1 BIT	0: Transducer of Pump B not connected	1: Transducer of Pump B connected
00117	116	R	1 BIT	0: Pump B not at upper flag limit	1: Pump B at upper Flag Limit (Empty)
00118	117	R	1 BIT	0: Pump B not at lower flag limit	1: Pump B at lower flag limit (Full)
00119	118	R	1 BIT	1: Pump B is overpressure	
00120	119	R	1 BIT	1: Pump B is underpressure	
00121	120	R	1 BIT	1: Motor failure Pump B	
00122	121	R	1 BIT	0: Transducer of Pump C not connected	1: Transducer of Pump C connected
00123	122	R	1 BIT	0: Pump C not at upper flag limit	1: Pump C at upper Flag Limit (Empty)
00124	123	R	1 BIT	0: Pump C not at lower flag limit	1: Pump C at lower flag limit (Full)
00125	124	R	1 BIT	1: Pump C is overpressure	
00126	125	R	1 BIT	1: Pump C is underpressure	
00127	126	R	1 BIT	1: Motor failure Pump C	
00128	127	R	1 BIT	0: Transducer of Pump D not connected	1: Transducer of Pump D connected
00129	128	R	1 BIT	0: Pump D not at upper flag limit	1: Pump D at upper Flag Limit (Empty)
00130	129	R	1 BIT	0: Pump D not at lower flag limit	1: Pump D at lower flag limit (Full)
00131	130	R	1 BIT	1: Pump D is overpressure	
00132	131	R	1 BIT	1: Pump D is underpressure	

Table 7-6 Coils (Continued)				
Register	**Address**	**Type**	**Size**	**Description**
00133	132	R	1 BIT	1: Motor failure Pump D
00134	133	R	1 BIT	1: POOR FILL A ERROR
00135	134	R	1 BIT	1: POOR FILL B ERROR
00136	135	R	1 BIT	1: POOR FILL C ERROR
00137	136	R	1 BIT	1: POOR FILL D ERROR
00138	137	R	1 BIT	1: VALVE ERROR
00139	138	R	1 BIT	DIGITAL IN 1
00140	139	R	1 BIT	DIGITAL IN 2
00141	140	R	1 BIT	DIGITAL IN 3
00142	141	R	1 BIT	DIGITAL IN 4

Table 7-7 Holding Registers						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40001	0	R/W	FLOAT	2	Pressure setpoint for Pump A in Constant Pressure Mode.	ATM; BAR; kPa; PSI
40003	2	R/W	FLOAT	2	Pressure setpoint for Pump B in Constant Pressure Mode.	ATM; BAR; kPa; PSI
40005	4	R/W	FLOAT	2	Pressure setpoint for Pump C in Constant Pressure Mode.	ATM; BAR; kPa; PSI
40007	6	R/W	FLOAT	2	Pressure setpoint for Pump D in Constant Pressure Mode.	ATM; BAR; kPa; PSI
40009	8	R/W	FLOAT	2	Pressure setpoint for multi-pump pair AB in Continuous Flow Constant Pressure Mode.	ATM; BAR; kPa; PSI
40011	10	R/W	FLOAT	2	Pressure setpoint for multi-pump pair CD in Continuous Flow Constant Pressure Mode.	ATM; BAR; kPa; PSI
40013	12	R/W	FLOAT	2	Flow rate setpoint for Pump A in Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr
40015	14	R/W	FLOAT	2	Flow rate setpoint for Pump B in Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr
40017	16	R/W	FLOAT	2	Flow rate setpoint for Pump C in Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr
40019	18	R/W	FLOAT	2	Flow rate setpoint for Pump D in Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr
40021	20	R/W	FLOAT	2	Flow rate setpoint for multi-pump pair AB in Continuous Flow Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr

Table 7-7 Holding Registers (Continued)						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40023	22	R/W	FLOAT	2	Flow rate setpoint for multi-pump pair CD in Continuous Flow Constant Flow Mode.	mL/min; mL/hr; µL/min; µL/hr
40025	24	R/W	FLOAT	2	Refill flow rate for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40027	26	R/W	FLOAT	2	Refill flow rate for Pump B.	mL/min; mL/hr; µL/min; µL/hr
40029	28	R/W	FLOAT	2	Refill flow rate for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40031	30	R/W	FLOAT	2	Refill flow rate for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40033	32	R/W	FLOAT	2	Maximum pressure setpoint for Pump A.	ATM; BAR; kPa; PSI
40035	34	R/W	FLOAT	2	Maximum pressure setpoint for Pump B.	ATM; BAR; kPa; PSI
40037	36	R/W	FLOAT	2	Maximum pressure setpoint for Pump C.	ATM; BAR; kPa; PSI
40039	38	R/W	FLOAT	2	Maximum pressure setpoint for Pump D.	ATM; BAR; kPa; PSI
40041	40	R/W	FLOAT	2	Minimum pressure setpoint for Pump A.	ATM; BAR; kPa; PSI
40043	42	R/W	FLOAT	2	Minimum pressure setpoint for Pump B.	ATM; BAR; kPa; PSI
40045	44	R/W	FLOAT	2	Minimum pressure setpoint for Pump C.	ATM; BAR; kPa; PSI
40047	46	R/W	FLOAT	2	Minimum pressure setpoint for Pump D.	ATM; BAR; kPa; PSI
40049	48	R/W	FLOAT	2	Maximum flow rate setpoint for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40051	50	R/W	FLOAT	2	Maximum flow rate setpoint for Pump B.	mL/min; mL/hr; µL/min; µL/hr
40053	52	R/W	FLOAT	2	Maximum flow rate setpoint for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40055	54	R/W	FLOAT	2	Maximum flow rate setpoint for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40057	56	R/W	FLOAT	2	Minimum flow rate setpoint for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40059	58	R/W	FLOAT	2	Minimum flow rate setpoint for Pump B.	mL/min; mL/hr; µL/min; µL/hr
40061	60	R/W	FLOAT	2	Minimum flow rate setpoint for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40063	62	R/W	FLOAT	2	Minimum flow rate setpoint for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40065	64	R/W	FLOAT	2	Maximum flow limit in Constant Pressure Mode for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40067	66	R/W	FLOAT	2	Maximum flow limit in Constant Pressure Mode for Pump B.	mL/min; mL/hr; µL/min; µL/hr

Table 7-7 Holding Registers (Continued)						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40069	68	R/W	FLOAT	2	Maximum flow limit in Constant Pressure Mode for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40071	70	R/W	FLOAT	2	Maximum flow limit in Constant Pressure Mode for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40073	72	R	FLOAT	2	Actual pressure of Pump A.	ATM; BAR; kPa; PSI
40075	74	R	FLOAT	2	Actual flow rate of Pump A.	mL/min; mL/hr; µL/min; µL/hr
40077	76	R	FLOAT	2	Volume remaining in Pump A.	milliliters
40079	78	R	FLOAT	2	Actual pressure of Pump B.	ATM; BAR; kPa; PSI
40081	80	R	FLOAT	2	Actual flow rate of Pump B.	mL/min; mL/hr; µL/min; µL/hr
40083	82	R	FLOAT	2	Volume remaining in Pump B.	milliliters
40085	84	R	FLOAT	2	Actual pressure of Pump C.	ATM; BAR; kPa; PSI
40087	86	R	FLOAT	2	Actual flow rate of Pump C.	mL/min; mL/hr; µL/min; µL/hr
40089	88	R	FLOAT	2	Volume remaining in Pump C.	milliliters
40091	90	R	FLOAT	2	Actual pressure of Pump D.	ATM; BAR; kPa; PSI
40093	92	R	FLOAT	2	Actual flow rate of Pump D.	mL/min; mL/hr; µL/min; µL/hr
40095	94	R	FLOAT	2	Volume remaining in Pump D.	milliliters
40097	96	R	FLOAT	2	System flow rate of multi-pump pair AB.	mL/min; mL/hr; µL/min; µL/hr
40099	98	R	FLOAT	2	System pressure of multi-pump pair AB.	ATM; BAR; kPa; PSI
40101	100	R	FLOAT	2	Total volume delivered by multi-pump pair AB.	Liters
40103	102	R	FLOAT	2	System flow rate of multi-pump pair CD.	mL/min; mL/hr; µL/min; µL/hr
40105	104	R	FLOAT	2	System pressure of multi-pump pair CD.	ATM; BAR; kPa; PSI
40107	106	R	FLOAT	2	Total volume delivered by multi-pump pair CD.	Liters
40109	108	R	FLOAT	2	Analog voltage input on Analog Input 1 of the accessory connector.	Volts
40111	110	R	FLOAT	2	Analog voltage input on Analog Input 2 of the accessory connector.	Volts
40113	112	R	FLOAT	2	Analog voltage input on Analog Input 3 of the accessory connector.	Volts
40115	114	R	FLOAT	2	Analog voltage input on Analog Input 4 of the accessory connector.	Volts

Table 7-7 Holding Registers (Continued)						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40117	116	R/W	FLOAT	2	Volume at which Pump A will automatically switch to Refill Mode if AUTO REFILL A is ON.	milliliters
40119	118	R/W	FLOAT	2	Volume at which Pump B will automatically switch to Refill Mode if AUTO REFILL B is ON.	milliliters
40121	120	R/W	FLOAT	2	Volume at which Pump C will automatically switch to Refill Mode if AUTO REFILL C is ON.	milliliters
40123	122	R/W	FLOAT	2	Volume at which Pump D will automatically switch to Refill Mode if AUTO REFILL D is ON.	milliliters
40125	124	R/W	FLOAT	2	Volume that Pump A will be refill to if AUTO FILL TO A is ON.	milliliters
40127	126	R/W	FLOAT	2	Volume that Pump B will be refill to if AUTO FILL TO B is ON.	milliliters
40129	128	R/W	FLOAT	2	Volume that Pump C will be refill to if AUTO FILL TO C is ON.	milliliters
40131	130	R/W	FLOAT	2	Volume that Pump D will be refill to if AUTO FILL TO D is ON.	milliliters
40133	132	R/W	FLOAT	2	Percentage of total pump volume that the refilling pump of multi-pump pair AB will refill to.	%
40135	134	R/W	FLOAT	2	Percentage of total pump volume that the delivering pump of multi-pump pair AB will deliver to.	%
40137	136	R/W	FLOAT	2	Percentage of total pump volume that the refilling pump of multi-pump pair CD will refill to.	%
40139	138	R/W	FLOAT	2	Percentage of total pump volume that the delivering pump of multi-pump pair CD will deliver to.	%
40141	140	R/W	FLOAT	2	POOR FILL MARK A	% VALID ENTRYS:10,20,30,40,50,60, 70,80,90
40143	142	R/W	FLOAT	2	POOR FILL MARK B	% VALID ENTRYS:10,20,30,40,50,60, 70,80,90
40145	144	R/W	FLOAT	2	POOR FILL MARK C	% VALID ENTRYS:10,20,30,40,50,60, 70,80,90
40147	146	R/W	FLOAT	2	POOR FILL MARK D	% VALID ENTRYS:10,20,30,40,50,60, 70,80,90

Table 7-7 Holding Registers (Continued)						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40149	148	R/W	FLOAT	2	Volume being dispensed by Pump A in Dispense Mode.	milliliters
40151	150	R/W	FLOAT	2	Volume being dispensed by Pump B in Dispense Mode.	milliliters
40153	152	R/W	FLOAT	2	Volume being dispensed by Pump C in Dispense Mode.	milliliters
40155	154	R/W	FLOAT	2	Volume being dispensed by Pump D in Dispense Mode.	milliliters
40157	156	R/W	FLOAT	2	Full scale input range voltage for External mode.	Volts
40159	168	R/W	FLOAT	2	MIN MOD PRESS: Minimum modifier pump pressure	ATM; BAR; kPa; PSI
40161	160	R/W	FLOAT	2	Value of %B for Modifier Addition Mode.%C for Continuous Modifier Addition Mode.	%B FOR MODIFIER OR %C FOR CONTINUOUS MODIFIER
40201	200	R	FLOAT	2	Absolute maximum pressure for Pump A.	ATM; BAR; kPa; PSI
40203	202	R	FLOAT	2	Absolute maximum flow rate for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40205	204	R	FLOAT	2	Absolute maximum refill rate for Pump A.	mL/min; mL/hr; µL/min; µL/hr
40207	206	R	FLOAT	2	Maximum volume for Pump A.	milliliters
40209	208	R	FLOAT	2	Absolute maximum pressure for Pump B.	ATM; BAR; kPa; PSI
40211	210	R	FLOAT	2	Absolute maximum flow rate for Pump B.	mL/min; mL/hr; µL/min; µL/hr
40213	212	R	FLOAT	2	Absolute maximum refill rate for Pump B.	mL/min; mL/hr; µL/min; µL/hr
40215	214	R	FLOAT	2	Maximum volume for Pump B.	milliliters
40217	216	R	FLOAT	2	Absolute maximum pressure for Pump C.	ATM; BAR; kPa; PSI
40219	218	R	FLOAT	2	Absolute maximum flow rate for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40221	220	R	FLOAT	2	Absolute maximum refill rate for Pump C.	mL/min; mL/hr; µL/min; µL/hr
40223	222	R	FLOAT	2	Maximum volume for Pump C.	milliliters
40225	224	R	FLOAT	2	Absolute maximum pressure for Pump D.	ATM; BAR; kPa; PSI
40227	226	R	FLOAT	2	Absolute maximum flow rate for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40229	228	R	FLOAT	2	Absolute maximum refill rate for Pump D.	mL/min; mL/hr; µL/min; µL/hr
40231	230	R	FLOAT	2	Maximum volume for Pump D.	milliliters

Table 7-7 Holding Registers (Continued)						
Register	**Address**	**Read/ Write**	**Type**	**# Registers**	**Description**	**Units[a]**
40233	232	R	FLOAT	2	PUMP TYPE A	
40235	234	R	FLOAT	2	PUMP TYPE B	
40237	236	R	FLOAT	2	PUMP TYPE C	
40239	238	R	FLOAT	2	PUMP TYPE D	
40241	240	R	FLOAT	2	SOFTWARE MAJOR REV	
40243	242	R	FLOAT	2	SOFTWARE MINOR REV	
40245	244	R	FLOAT	2	SOFTWARE MICRO REV	

a. Pressure and flow rate based on user selected units

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Section 8 Serial Interface

8.1 Overview

The Teledyne ISCO SyriXus series syringe pumps can be remotely controlled by a computer through a built-in RS-232-C serial or USB interface. This function is supported by the Teledyne ISCO LabVIEW™ toolkit.

You can write your own custom program to control Teledyne ISCO syringe pumps using any suitable programming language, such as BASIC or C++. This section provides the syntax and responses for serial commands. Simplified examples of programs are also provided. It is possible for you to write custom programs capable of controlling up to seven controllers from a single computer, each with up to four connected pumps. Writing programs for serial control requires substantial knowledge of the software language used; consequently, **Teledyne ISCO does not provide support for developing your own programs because of the large range of possible programming languages.**

The toolkit contains a sample program capable of running one controller and one to three pumps. Its primary purpose is to provide an example to help the programmer start constructing custom programs for individual pump systems and applications. To modify the program in any way, you must have the complete LabVIEW Compiler, available from:

National Instruments Corporation
www.ni.com
Tel: (800) 531-5066
Fax: 512-683-8411
11500 N. Mopac Expwy
Austin, TX 78759-3504

This section of the manual provides detailed information about:

- Cable connections for serial control
- Setting up the controller(s) for serial control
- DASNET Protocol
- Serial Commands

8.2 Network Control and Communication

Network communications are always initiated by the network controller, which is typically a personal computer or laptop. Messages from the instruments are in response to messages from the network controller. All information on the network is transmitted as groups of ASCII characters called frames. The message frames contain the origin of the message, the destination of the message, and a checksum to verify the validity of the message.

Each SyriXus series controller is provided with a method of selecting unit identification numbers and a baud rate. For proper operation, each instrument must be set to a unique unit identification number (refer to Section 3.2.1 "Controller Models"). It is also important that each unit's baud rate is set to the same speed. The factory default setting is 9600 baud. Baud rates of 1200 and 19200 are typical. Other baud rates of 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 are supported by the SyriXus series pumps, but are not part of the Teledyne ISCO defined communications standard.

Electrical standards are RS-232-C; connector pin usage is outlined in Table 8-1 "External Control Connector Serial Pin Connections". Characters consist of 1 start bit, 8 data bits (low order first with 8th bit always set to zero), and 1 stop bit. There is no parity bit used. All characters will be printable ASCII characters. Control characters (0-1FH) are ignored except for carriage return (0DH).

The serial unit number and baud rate can be changed from the default values through the MENU key. Select SERIAL under the menu and adjust the values using the softkeys.

WARNING

Connecting devices to energized circuits may cause personal injury or property damage. Power must be removed from the pump before connecting external devices.

Table 8-1 External Control Connector Serial Pin Connections

Pin No.	Name	Function
1	CHASSIS GROUND	Used to connect to the shield of the interconnect cable.
2	RECEIVE	Serial interface data input. Standard RS-232-C signal levels.
3	TRANSMIT	Serial interface data output. Standard RS-232-C signal levels.
4	REQUEST TO SEND	RTS chain - RS-232-C input is buffered and connected to pin 21.
5	CLEAR TO SEND	CTS buffered RS-232-C output of pin 25 input.
6	+11 VDC	DATA SET READY is held on.
7	COMMON	Signal common for all signals.
8	+11 VDC	DATA CARRIER DETECT is held on.
9	+5 VDC	Test Voltage.
10	-11 VDC	Negative test voltage.
14	TRANSMIT CHAIN	Serial data from next unit.
16	RECEIVE CHAIN	Serial data to next unit.
21	RTS CHAIN	RTS buffered RS-232-C output of pin 4 input.
25	CTS CHAIN	CTS chain -RS-232-C input is buffered and connected to pin 5.
NOTE: Only pins 2, 3, and 7 are required for serial interface to one controller.		

8.3 USB Interface

The Teledyne ISCO SyriXus series syringe pump controller may include an optional USB interface. The USB connections are located on the pump controller rear panel labeled USB/Ethernet. The connector pin usage is outlined in Table 8-2 "USB Interface Pin Connections". Use optional cable (P/N 60-1244-487) to connect the USB to the 25 pin connector labeled USB/Ethernet. The drivers for the USB can be downloaded from http://www.isco.com/support/updates.asp.

WARNING

Connecting devices to energized circuits may cause personal injury or property damage. Power must be removed from the pump before connecting external devices.

NOTE

The cable (P/N 60-1244-487) will only work when attached to the optional USB/Ethernet connector on the back of the controller. Connecting this cable to any other connector on either the pump or controller will not work.

Table 8-2 USB Interface Pin Connections

Pin No.	Name
7	GND
11	Data -
12	Data +

8.4 Cabling for Serial Control

The serial connection feature allows the SyriXus series pumps to be controlled remotely from a personal computer through a common serial connector (RS-232-C). Almost all the pump commands available through the controller front panel can be handled by a user defined computer program to remotely control the pumps. Refer to Section 8.8 "Serial Commands for the SyriXus Series Pumps" for command syntax.

The cabling scheme for your system will depend on the number of instruments you need to control. When using serial control, the personal computer or laptop is always connected from the serial port to the serial port(s) of the SyriXus series controller(s) it is controlling. Each controller is connected to its pumps in the normal fashion, i.e. the pump control cables are attached to the pump 'A', 'B', 'C', and 'D' connectors on the rear panel of the pump controller. The cable you select to connect to your network will depend on the type of serial port your computer has and the number of controllers you wish to connect.

NOTE

Network communications are initiated by your computer.

8.4.1 One Controller

To connect one controller, use a null-modem cable (available from Teledyne ISCO, P/N 480-7996-00) to connect the 9-pin serial output port of your computer to the RS-232-C port on the rear of the SyriXus series controller, as shown in Figure 8-1. This cable may also be available from a computer parts store. If your computer does not offer a serial port, a USB to serial adapter may work, but Teledyne ISCO does not support or aid in the use or connection of these devices.

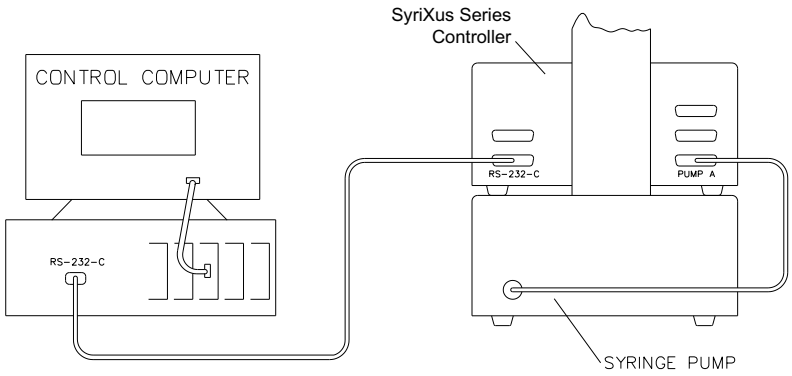


Figure 8-1 Serial network connection example - Single connection

With this configuration, your user-developed program would be able to provide:

- Constant Flow
- Constant Pressure
- Gradient

8.4.2 Two Controllers

To connect two controllers in a network, use a serial 'Y' cable (available from many computer parts stores) installed as shown in Figure 8-2.

NOTE

For the network to operate properly, all instruments connected to the network must be turned ON, even if they are not being used.

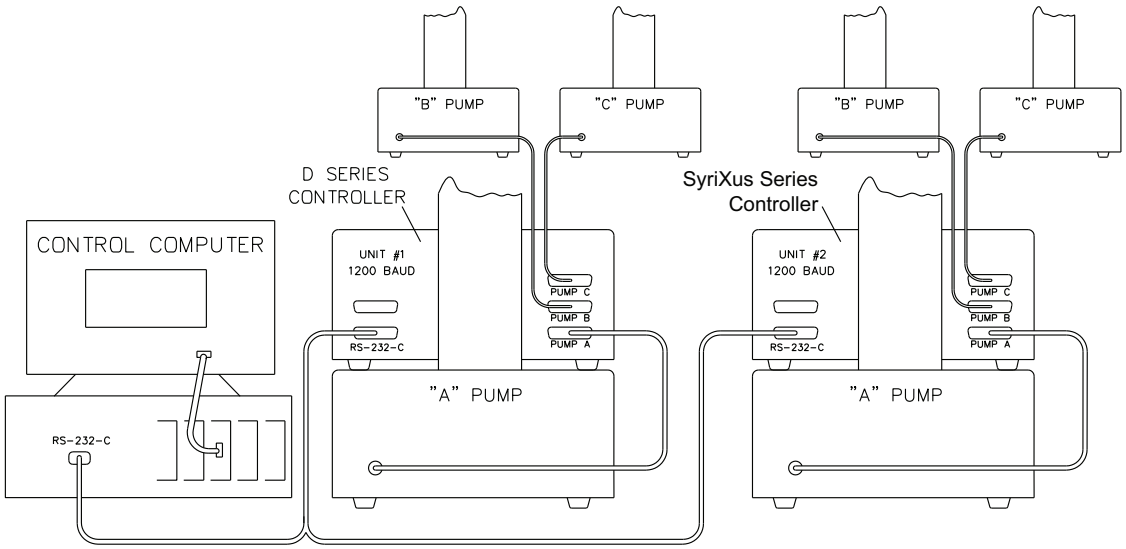


Figure 8-2 Serial network connection example - dual connection

Using this arrangement, the number of pumps that can be controlled by your program essentially doubles.

8.4.3 Three or More Controllers

This option was predominantly used by System Developers and Industrial Applications Implementers employing multiple banks of pumps for large scale installations. These developers have switched their communications schemes to one of the other interface options primarily because of the RS-232-C limitations of speed and cable lengths.

Although the functions still exist in the controller to allow the serial control of multiple controllers, Teledyne ISCO no longer offers the interconnection cables for three or more controllers and has discontinued the support of this function. Using this feature is no longer recommended for new development.

The necessary interconnection cables for this feature are no longer available; the user would be required to fabricate their own. When three or more controllers are to be managed by a user's program, one of the other communication protocols should be used.

Modern personal computer operating systems provide for multiple serial ports. If three or more controllers are to be controlled by a single computer, it is suggested that additional controllers be connected through other serial ports. The users software program could then open a communications channel with each serial port.

8.5 Serial Control Check List

In order to build and operate a custom program for Teledyne ISCO syringe pumps, you must have the following:

1. Sample program
2. LabView Compiler (optional - purchased separately)
3. Connection cable(s)
4. One (1) controller: cable 480-7996-00
5. Two (2) controllers: 'Y' cable from a computer parts store
6. Three (3) to seven (7) controllers: No longer supported
7. Source code (serial commands in your preferred computer language for DASNET conversion)
8. DASNET serial driver (for LabVIEW connection)

NOTE

Other programming languages capable of reading and writing ASCII codes through a serial port could be used instead. However, because of the wide range of operating systems and computer programming languages available, Teledyne ISCO cannot provide support or programming assistance for user developed control systems.

8.6 Controller Setup

Once the system is properly connected, turn the pump(s), controller(s) and computer ON. Then use the following procedure to place your controller(s) in serial control mode.

Press MENU > MORE (A) and select SERIAL (1). Factory controller default settings are baud rate 9600 and unit ID #6.

8.6.1 Restore Defaults (If Desired)

To restore defaults, press MENU, then SYSTEM RESET (5). **Resetting a system erases all programs and user settings stored in the controller.**

8.6.2 Change Defaults

1. Press MENU > MORE (A) > 1. Serial Option to enter the serial option setup screen.
2. Select the communication baud rate (between 300 and 115.2K) by pressing NEXT BAUD (A) until you reach the desired baud rate.

NOTE

All units in the network must be set to the SAME baud rate and be assigned a different unit.

3. Select an identification number for each controller (up to seven) by pressing NEXT ID # (B) until you reach the desired number.

NOTE

Multiple controllers in a network must each have a different ID number.

If several units are being configured, Teledyne ISCO suggests placing a label on the rear of each instrument listing the ID number and baud rate. This will help identify the controller in the future and prevent assigning the same ID number to two controllers or assigning an incorrect baud rate.

8.6.3 Verify Operation

To verify network operation, open a terminal emulator program on your computer, such as HyperTerminal™ (©Hilgraeve, Inc. Corp. 1287 N. Telegraph Rd. Monroe, Michigan 48162), and establish connection with the controller.

NOTE

If you will be using multiple controllers daisy-chained to a single serial port, you must connect and test each controller one at a time.

1. Press MENU > MORE (A) > MORE (A), and select DIAGNOSTIC MENU (2).
2. Select SERIAL TEST (6).

The SENT value displayed will increment indefinitely until you exit the test by pressing any key. This same value should appear on your computer screen. If it does not, verify that you are using the correct serial port on the computer, and that the communication cables are properly connected and in working order.

8.7 User-Written Software

When designing software to control the SyriXus series pumps, you must follow the DASNET communications protocol. This protocol allows a number of instruments to be controlled from a single RS-232-C serial port. Up to seven SyriXus series controllers may share a single serial data channel, with each controller only accepting commands that are meant for it. Refer to Section 8.4.3 "Three or More Controllers" for information about attaching multiple controllers. Each pump controller can then control up to four pumps each. Figure 8-1 shows a simple system where the personal computer or laptop is connected to the serial port on the rear panel of the pump controller (shown sitting on top of the pump module). The pump control cable is attached to the pump A connector on the rear panel of the controller.

8.7.1 DASNET

DASNET converts your direct serial commands into a form recognizable to Teledyne ISCO instruments. Using a computer language such as C or BASIC, serial commands can be entered, converted, and then sent to your instrument.

- "Example of BASIC Program to Demonstrate Conversion of Pump Commands to DASNET Frames" is an example BASIC language program which performs the required portion of the DASNET serial protocol.
- "Example of C Program Demonstrating Conversion of Pump Commands to DASNET Frames" is an example of a C language program which does the same.
- For a console C++ example, refer to "Example of C Program Demonstrating Conversion of Pump Commands to DASNET Frames".

8.7.2 Universal Driver from Teledyne ISCO

The Universal Driver from Teledyne ISCO is a serial software driver that can translate commands for a variety of compilers. When you are creating programs for SyriXus series syringe pumps, the driver converts serial commands to DASNET communications protocol, sends them to the serial port, and waits for a serial response.

Detailed information about the Universal Driver is available at www.teledyneisco.com in Technical Bulletin TB19 Universal Driver Software Tool. LabVIEW software operation is discussed in detail in Technical Bulletin TB06 Basic Operation of LabView Toolkit.

A copy of the driver can be downloaded from:

https://www.teledyneisco.com/pumps/pumps-software-and-firmware

Open the Software Utilities folder and select Universal D Series Pump driver to download the utility to a zip folder. Extract the sub-folder named 'Remote Pump'.

Example of BASIC Program to Demonstrate Conversion of Pump Commands to DASNET Frames

```
1 CLS : Z$ = "": PRINT "INPUT ALL ENTRIES IN CAPITAL LETTERS"
5 INPUT "INPUT UNIT ID >> ", UNITNUM'GET UNIT NUMBER
30 REM OPEN COM PORT SET FOR COM2 EDIT TO COM1 IF NEED
40 OPEN "COM2:1200,N,8,1,ASC" FOR RANDOM AS #2
50 PRINT : INPUT "ENTER STRING (HIT Q TO EXIT) >> ", I$'GET OUTPUT STRING FROM USER
65 IF I$ = "" THEN GOTO 50                    'IF BLANK INPUT THEN GO BACK
70 IF I$ = "Q" THEN GOTO 200                  'IF "Q" INPUT THEN QUIT
80 GOSUB 10000                                'CONVERT STRING TO DASNET FORMAT
90 GOSUB 20000                                'OUT DASNET STRING TO COM 2
120 PRINT "DASNET FORMATTED CMD >> "; O$      'OUTPUT FORMATTED CMD TO USER
124 PRINT : PRINT ">>>> PRESS CTRL-C IF NO RESPONSE FROM PUMP <<<<"
125 LINE INPUT #2, Z$                         'GET RESPONSE FROM PUMP 'CR' ENDS STRING
127 PRINT "DASNET RESPONSE >> "; Z$           'PRINT RESPONSE
128 Z$ = ""                                   'CLEAR BUFFER
130 GOTO 50                                   'GO BACK
200 CLOSE #2                                  'CLOSE COM2
210 SYSTEM                                    'END PROGRAM AND EXIT TO DOS

10000 REM this SUBROUTINE will convert a string (I$) into a string (O$)
10005 REM in DASNET protocol
10015 REM UNITNUM=UNIT NUMBER OF PUMP
10020 REM AFTER THE STRING IS SENT TO PUMP A CR IS REQUIRED TO TERMINATE MESSAGE
10030 REM VAR USED O$,I$,IL,Y$,LI,SUM,CSUM,UNITNUM
10100 O$ = CHR$(ASC("0") + UNITNUM)           'PUT UNIT ID FIRST IN OUTPUT STRING
10110 IL = LEN(I$)                            'GET LENGTH OF INPUT STRING
10115 REM IF INPUT IS JUST "R" ADD SPACE AND JMP BY # CHAR
10120 IF I$ = "R" THEN I$ = I$ + " ": GOTO 10180
10130 O$ = O$ + "R"                           'ADD "R" TO OUTPUT STRING
10140 Y$ = HEX$(IL)                           'GET # OF CHAR IN INPUT STRING IN HEX
10150 IF IL < 16 THEN Y$ = "00" + Y$          'PAD OUT # CHAR IN STRING IF NEED
10160 IF IL >= 16 THEN Y$ = "0" + Y$          'IF MORE THAN 16 THEN ONLY ONE PAD
10170 O$ = O$ + Y$                            'ADD # CHAR TO OUTPUT STRING
10180 O$ = O$ + I$                            'ADD INPUT STRING TO OUTPUT STRING
10190 IL = LEN(O$): SUM =                     'GET NEW LENGTH AND CLEAR SUM OUT
10200 FOR LI = 1 TO IL                        'TO ADD ALL ASCII FOR SUM
10210 SUM = SUM + ASC(MID$(O$, LI, 1))        'GET THE ASCII # OF (LI) ASCII CHAR
10220 NEXT LI
10230 REM THIS FINDS THE CHECKSUM
10235 REM THE # IS FIRST SUBTRACTED FROM 256
10236 REM THEN ANDED WITH 255 TO AND OFF EXTRA BITS
10240 CSUM = (256 - SUM) AND 255              'GET CHECK SUM
10245 IF CSUM < 16 THEN O$ = O$ + "0"         'PAD OUT CSUM IF NEED
10250 O$ = O$ + HEX$(CSUM)                    'PUT AT END OF OUTPUT STRING
10270 RETURN                                  'DONE RETURN

20000 REM THIS SUBROUTINE SENDS O$ TO THE COM PORT
20010 PRINT #2,                               'CR';     'SEND CR TO COM PORT
20020 PRINT #2, O$;                           'SEND O$ TO COM PORT
20030 PRINT #2, 'CR';                         'SEND CR TO COM PORT
20040 RETURN                                  'DONE
```

Note: Polling is part of the DASNET definition but is not required and is not shown in this example. If this program is run on a PC as is, the commands entered at the keypad will be output on serial port 2. This code was written in QBasic, version 4.5. QBasic is an integrated BASIC language interpreter created by Microsoft Corp, Redmond, WA, included in MSDOS version 5.0 and later, and in Windows 95, 98, NT 3.x and NT4. For later versions of Windows™, it can be downloaded from the Microsoft™ store.

Example of C Program Demonstrating Conversion of Pump Commands to DASNET Frames

```
#include<stdio.h>
#include<conio.h>
#include "b:comm.c"                                  /* edit to path needed */
                                                     /* a 'C' example of DASNET serial control */
int conv_das();
unsigned char in[256],out[256],buf[256];
char unitnum;
main()
{
unsigned port;
int speed;
  cputs("ENTER UNIT ID=");                           /* get parms */
  scanf("%d",&unitnum);
  cputs("ENTER COM PORT=");
  scanf("%d",&port);
  cputs("ENTER BAUD RATE=");
  scanf("%d",&speed);
  comm_open(port,speed);                             /* open comm port */
  in[0]=50;
  cputs("ALL ENTRIES IN CAPS\n\r");
while(1)
  cputs("\n\rENTER STRING(Q TO QUIT) >>>");
  cgets(in);
  if(in[2]=='Q') break;
  conv_das(&in[2],out);                              /* convert string */
  cputs("\nDASNET FORMATTED OUTPUT >>>");
  puts(out);                                         /* output converted string */
  comm_putc(0x0d);                                   /* send "CR" to serial port */
  dput(out);                                         /* output converted string to serial port */
  comm_putc(0x0d);                                   /* end with a "CR" */
  dgets(buf);                                        /* get response */
  cputs("\nDASNET RESPONSE >>>");
  puts(buf);                                         /* output response */
  comm_flush();                                      /* flush serial buffer to start again */
  }
comm_close();
}
                                                     /* dasnet conversion utility */
conv_das(char *in, char *out)
{
unsigned sum;
char *c_ptr;
c_ptr=out;                                           /* point to output */
*out++=unitnum+0x30;                                 /* put id first */
*out++='R';                                          /* add "R" to output */
if (!strcmp(in,"R"))                                 /* if just "R" add space to string */
  {
  *out++=' ';
  *out++=0x00;
  }
else                                                  /* add # char to string */
  sprintf(out,"%3.3X%s",strlen(in),in);
for (sum=0 ; *c_ptr; c_ptr++)                         /* add all chars together */
   sum+=*c_ptr;
sum=(0x100 - sum) & 0x0FF;                           /* get check sum */
sprintf(c_ptr,"%2.2X",sum);                          /* insert into string */
}
```

Example of Visual C++ Program Showing Conversion of Pump Commands to DASNET Frames

```
// visual C++ version 10.0
// Dasnet.cpp : Defines the entry point for the console application.
// A 'C, C++' example of DASNET serial control

#include "stdafx.h"
#include <windows.h>
#include<stdio.h>
#include<conio.h>
#include<string.h>

void commOpen(int port, long speed);
void conv_das(char *, char *);
void dgets(char *);
void dputs(char *);
void comm_putc(char);
int comm_getc(void);
BOOL GetCTS (void);


char unitnum;

HANDLE hCom;
DCB dcbSerialParams;

int _tmain(int argc, _TCHAR* argv[]) // console appication
{
      int commport;
      long speed;
      char in[512],out[512];

// printf("Starting Program");

printf("Enter Unit ID=");
scanf_s("%d",&unitnum);
printf("Enter Comm port=");
scanf_s("%d",&commport);
printf("Enter Baud Rate=");
scanf_s("%ld",&speed);
fflush(stdin);  //clear stdin buffer
commOpen(commport,speed);
while(1)
  {
  _cputs("\n\rString(Q TO Quit) >>>");
  gets_s(in,200);
  _strupr_s(in);  /*convert to upper case */
  if(in[0]=='Q') break;
  conv_das(in,out);
  _cputs("Dasnet Output >>>");
  puts(out);
  //printf("\nWriting to serial port");
  dputs(out);
  _strset_s(out,256,0);
  dgets(out);
  printf("Dasnet Response>>%s\n",out);
  }
```

Example of Visual C++ Program Showing Conversion of Pump Commands to DASNET Frames (Continued)

```
CloseHandle(hCom);
printf("Comm intr released\n");

}

void conv_das(char *in, char *out)
{
unsigned sum;
char *c_ptr;
c_ptr=out;
*out++=unitnum+0x30;  /* put id first */
*out++='R';

if (!strcmp(in,"R"))
  {
  *out++=' ';
  *out++=0x00;
  }

else
  sprintf_s(out,255,"%3.3X%s",strlen(in),in);

for (sum=0 ; *c_ptr; c_ptr++)
   sum+=*c_ptr;

sum=(0x100 - sum) & 0x0FF;        /* get check sum */
sprintf_s(c_ptr,255,"%2.2X",sum);
}

void dgets (char *buffer)
{
   char * ptr;
   DWORD dwBytesRead = 0;
   ptr = buffer;
   while (1)
   {
   char buf[2];
       /* get char if there                */
   if(!ReadFile(hCom, buf, 1, &dwBytesRead, NULL))
            {
            //error occurred. Report to user.
            }
     *buffer=buf[0];
     if (*buffer++ == 0x0d && ptr!=buffer || dwBytesRead==0)
      {
      *buffer = 0;
      break;
      }

   }
}
void dputs(char *out)
{
int n;
DWORD dwBytesRead = 0;
```

Example of Visual C++ Program Showing Conversion of Pump Commands to DASNET Frames (Continued)

```
int count=0;

n=strlen(out);
// start of packet
if(!WriteFile(hCom, "\r", 1, &dwBytesRead, NULL))
                {
                //error occurred. Report to user.
               }
// data
if(!WriteFile(hCom, out, n, &dwBytesRead, NULL))
                {
                //error occurred. Report to user.
                }
//end of packet
if(!WriteFile(hCom, "\r", 1, &dwBytesRead, NULL))
                {
                //error occurred. Report to user.
                }
}

void commOpen(int port, long speed)
{
TCHAR szComPort[20];

      if (port < 10)
        wsprintf(szComPort, _T("COM%d"), port);
      else
        wsprintf(szComPort, _T("\\\\.\\COM%d"),port);

       hCom = CreateFile(szComPort,
            GENERIC_READ|GENERIC_WRITE, // desired access should be read&write
            0,                  // COM port must be opened in non-sharing mode
            NULL,               // don't care about the security
            OPEN_EXISTING,      // IMPORTANT: must use OPEN_EXISTING for a COM port
            0,                  // usually overlapped but non-overlapped for existence test
            NULL);              // always NULL for a general purpose COM port

      if (INVALID_HANDLE_VALUE == hCom)
        {
            printf("\nComm %d port not available",port);
            //Sleep(2000);
            //exit(1);
            Sleep(1000);
            return;
        }
      else
      {
          printf("\nComm %d port available ",port);
          dcbSerialParams.DCBlength=sizeof(dcbSerialParams);

          if (!GetCommState(hCom, &dcbSerialParams))
                {
                //error getting state
                printf("Error getting Comm Port state");
```

Example of Visual C++ Program Showing Conversion of Pump Commands to DASNET Frames (Continued)

```
                Sleep(2000);
                exit(1);
                }
            switch(speed)
                {
                case 19200:
                    dcbSerialParams.BaudRate=CBR_19200;
                    break;
                case 38400:
                    dcbSerialParams.BaudRate=CBR_38400;
                    break;
                case 57600:
                    dcbSerialParams.BaudRate=CBR_57600;
                    break;
                case 115200:
                    dcbSerialParams.BaudRate=CBR_115200;
                    break;
                default:
                case 9600:
                    dcbSerialParams.BaudRate=CBR_9600;
                    break;
                }
            dcbSerialParams.ByteSize=8;
            dcbSerialParams.StopBits=ONESTOPBIT;
            dcbSerialParams.Parity=NOPARITY;
            if(!SetCommState(hCom, &dcbSerialParams))
                {
                //error setting serial port state
                printf("Setting Comm port state failed");
                Sleep(2000);
                exit(1);
                }
            //timeouts
            COMMTIMEOUTS timeouts={0};
            timeouts.ReadIntervalTimeout=100;
            timeouts.ReadTotalTimeoutConstant=100;
            timeouts.ReadTotalTimeoutMultiplier=100;
            //timeouts.WriteTotalTimeoutConstant=50;
            //timeouts.WriteTotalTimeoutMultiplier=10;
            if(!SetCommTimeouts(hCom, &timeouts))
                {
                //error occureed. Inform user
                printf("Setting Comm port timeouts failed");
                Sleep(2000);
                exit(1);
                }
            }
printf("\nComm intr installed");
}

int comm_getc ()
{
DWORD dwBytesRead = 0;
```

Example of Visual C++ Program Showing Conversion of Pump Commands to DASNET Frames (Continued)

```
char buf[2];
buf[0]=0;
        /* get char if there                */
   if(!ReadFile(hCom, buf, 1, &dwBytesRead, NULL))
            {
            //error occurred. Report to user.
            }
      return buf[0];
}
void comm_putc(char outchar)
{
DWORD dwBytesRead = 0;
char out[2];
out[0]=outchar;

if(!WriteFile(hCom, out, 1, &dwBytesRead, NULL))
                {
                //error occurred. Report to user.
                }

}
```

There are three types of operations within the network: network controller, master, and slave. A computer typically serves as the network controller. It supervises all data flow on the network. It also polls each unit which initiates data transfer and commands.

NOTE

The network controller (typically a personal computer or laptop) should not be confused with the pump controller. The network controller is used in addition to the pump controller.

The slave unit simply responds to commands accordingly. The SyriXus series pump controller functions as a slave unit. These functions may be combined in one unit (i.e., a computer can function as both a network controller and a master).

All data transfers are in a frame format. When the network controller polls an instrument, it will start to respond within 200 ms. If it does not reply, it will be polled again. If after three attempts at polling it does not reply, it will be dropped from the polling rotation. When the instrument does respond, the polling rotation does not advance until an error-free transfer has occurred.

The frame format for data transfers from the network controller is as follows:

destination\acknowledgement\message source\length\message\checksum\[CR]

- Destination - The 1-digit unit identification number of the instrument to receive the message.
- Acknowledgment - One character to indicate the success of the previous transmission. There are three possibilities: (1) E means error, resend the message immediately (E is sent by the network controller only. Other units signify errors by not replying; causing the controller to resend the message). (2) B means busy, resend message at next poll. (3) R signifies previous message was received.
- Message source - The unit ID of the unit that originated the message. If there is no message, this location is a space (20H).
- Length - The length of the message in 2-digit, hexadecimal format. Maximum length is 256, with 256 being represented by a 00. This field is eliminated if there are no messages.
- Message field - The area where the actual information is located. The maximum length is 256 characters long.
- Checksum - Also a 2-digit hexadecimal number. This number, when added to all the previous characters in the message (excluding control characters), will result in a sum. If there are no errors, the result of modulo 256 division of this sum should be 0.

Examples

Frame is R304STOPD1[CR] =

(R) (3) (0) (4) (S) (T) (O) (P)
52H + 33H + 30H + 34H + 53H + 54H + 4FH + 50H + D1H = 300H

300H MODULO 256 = 00

NOTE

All characters are converted to the ASCII equivalent and added, except for the checksum. The two characters of the checksum are converted to hexadecimal numbers and concatenated to form a single 2-digit number. This number is then converted to its ASCII equivalent and appended to the end of the message.

Hexadecimal Format Using MODULO

Step 1 **22FH = 52H + 33H + 30H + 34H + 53H + 54H +4FH + 50H**

Step 2

2FH = 22FH ⁄ 100H
Modulo

```
      2R2FH
100H ) 22FH
      −200H
       2FH
```

Step 3 **D1H = 100H − 2FH**

Step 4 Convert D1H to ASCII (Hex) and put at end of message.

Step 5 Put a “CR” (0DH) at the end of message for end of frame.

Decimal Format Using MODULO

Step 1 **559 = 82 + 51 + 48 + 52 + 83 + 84 + 79 + 80**

Step 2

47 = 559 ⁄ 256

Modulo

```
      2R47
256 ) 559
    −512
      47
```

Step 3 **209 = 256 − 47**

Step 4 Convert 209 to ASCII (Hex) and put at end of message.

Step 5 Put a “CR” (13) at the end of message for end of frame.

Hexadecimal Format Using NO MODULO

Step 1 **22FH = 52H + 33H + 30H + 34H + 53H + 54H + 4FH + 50H**

Step 2 **FED1H = 100H − 22FH**

Step 3 **D1H = FED1H & offH**

Step 4 Convert D1H = to ASCII (Hex) and put at end of message

Step 5 Put a “CR” (0DH) at the end of message for end of frame.

Decimal Format Using NO MODULO

Step 1 **559 = 82 + 51 + 48 + 52 + 83 + 84 + 79 + 80**

Step 2 **−303 = 256 − 559**

Step 3 **209 = 303 & 255**

Step 4 Convert 209 into ASCII (Hex) and put at end of message.

Step 5 Put a “CR” (13) at the end of message for end of frame. The carriage return “CR” signifies end of frame.

Acknowledgment Response from Pump Controller

The format for frames sent from the unit to the network controller is as follows:

acknowledgement\message destination\length\message\checksum\[CR]

All the parameters are as previously described except message destination. Message destination is the 1-digit identification number of the pump controller that the message is sent to.

An example of a typical data exchange is summarized below. For illustration, we will assume the network consists of a computer serving as a combination network controller and master. There will be one slave unit; a SyriXus model 260x pump. Details on the pump message format are in Section 8.8 "Serial Commands for the SyriXus Series Pumps". The computer will be unit #0, and the pump controller will be unit #6.

Network Controller and Master Unit #0

[CR]1R 5D[CR]

NOTE

A [CR] must start the network. The controller is checking for the presence of unit #1 but will get no response in 200 ms because there is no unit 1.

Network Controller and Master Unit #0

1R 5D[CR]
Still no response.

Network Controller and Master Unit #0

1R 5D[CR]
Still no response, so unit 1 will be dropped from the poll.

Network Controller and Master Unit #0

2R 5C[CR]
Checks for unit 2 but will get no response in 200 ms because there is no unit 2.

Network Controller and Master Unit #0

2R 5C[CR]
Still no response.

Network Controller and Master Unit #0

2R 5C[CR]
Still no response, so unit 2 will be dropped from the poll.

In this way units 3-5 will be checked and dropped from the poll.

Network Controller and Master Unit #0

6R 58[CR]
Check for presence of unit 6.

Unit 6

R 8E[CR]
Unit 6 responds.

Network Controller and Master Unit #0

7R 57[CR]
Since unit 7 does not exist, it will be dropped from the polling scheme.

Network Controller and Master Unit #0

6R008IDENTIFY84[CR]

The master verifies the fact that unit 6 is a Model ___D. Refer to Table 3-2 "D Series Controller to SyriXus Series Pump" for the model name returned for each of the SyriXus series pump models.

In this example, the master and the network controller are a single unit. If they were separate units, the master would send the inquiry to the network controller; then the network controller would send the message to the slave unit the next time it is polled. The slave would respond with the message to the network controller. The next time the master is polled, the message would be relayed.

The same sequence would occur with all messages. Since the master and the network controller are combined in this example, the relaying of messages is not necessary.

Unit 6

R027SERIES=1240-02__, Model ___D PUMP, REV __XX[CR]
The pump responds with identity and software revision letter. (In this example 02__ would be 021; Model ___D would be 260D; REV __ signifies the software revision, XX would be replaced by the correct checksum, which is B4.)

Network Controller and Master Unit #1

6R006REMOTE16[CR]
This places the pump in the Remote Mode.

Unit 6

R 8E[CR]
The pump acknowledges that it accepted the command.

Network Controller and Master Unit #1

6R00ACONST FLOWF8[CR]
This puts the pump into Constant Flow Rate Mode.

Unit 6

R 8E[CR]
The pump verifies that it received the message.

Network Controller and Master Unit #1

6R009FLOW=1.00AB[CR]
This sets the pump's flow rate to 1.00 mL per minute.

Unit 6

R 8E[CR]
The pump verifies that it received the message.

Network Controller and Master Unit #1

6R 58[CR]
Polls the pump.

Unit 1

R 8E[CR]
Pump responds.

Network Controller and Master Unit #1

6R003RUNF0[CR]
The pump is started.

Unit 1

R 8E[CR]
The pump responds.

The system is now running and the network controller continues the polling scheme. If the controller gives an improper command, the units will respond with a problem message indicating the type of error.

The format of the message is given in Section 8.8 "Serial Commands for the SyriXus Series Pumps" and specifies the commands used for this instrument.

It is important to follow this format. Spaces are ignored anywhere within the message field. Commands must be in uppercase letters. The network definition allows multiple commands in a message field when delimited by semicolons, but the SyriXus series controller is limited to single commands. It will respond with a PROBLEM=INVALID COMMAND message.

8.8 Serial Commands for the SyriXus Series Pumps

Table 8-3 "Serial Commands" is a list of the serial commands recognized by the pump. These commands are the message part of the DASNET protocol. The operand always follows the equals sign. The REMOTE command must be sent once, before any command that changes the operation of the pump will be accepted.

NOTE

When setting a value, the serial command will always be followed by an equal sign.

Table 8-3 Serial Commands

Command (Refer to *NOTE 1* & *NOTE 2*.)	Description
%B=#	Enter # for percentage of modifier.
ALOG1	Status of the analog voltage input on pin 21, P6.
ALOG2	Status of the analog voltage input on analog input 3 of the accessory connector.
ALOG3	Status of the analog voltage input on analog input 2 of the accessory connector.
ALOG4	Status of the analog voltage on analog input 1 of the accessory connector.
ALOG5	Status of the analog voltage input for Press 'D'.
ALOG6	Status of the analog voltage on analog input 4 of the accessory connector.
CLEAR	Stops all motors, sets flow rate and pressure setpoints to zero.
CONTIN CONST FLOW CONTIN CONST FLOWCD	Puts pump in continuous flow under Constant Flow Mode.
CONTIN CONST PRESS CONTIN CONST PRESSCD	Puts pump in continuous flow under Constant Pressure Mode.
CONTIN MODIFIER	Put pump in continuous Modifier Addition Mode.
CONST FLOW CONST FLOWB CONST FLOWC CONST FLOWD	Put pump in Constant Flow Mode.
CONST PRESS CONST PRESSB CONST PRESSC CONST PRESSD	Put pump in Constant Pressure Mode.
DELIVER DELIVERCD	Set the dual-pump mode to deliver fluid when running.
DIGITAL	Returns the status (High or Low) of the digital outputs. Format is digital = xxxxxxxx, where 'x' is either 'H' or 'L'. The status order returned corresponds with the outputs 1—8. "X"= no change.

Table 8-3 Serial Commands (Continued)	
Command (Refer to *NOTE 1* & *NOTE 2*.)	**Description**
DIGITAL = xxxxxxxx 1 ——— 8	Sets the digital output either High or Low, where 'x' is either 'H' or 'L'. The order corresponds with the outputs 1-8.
DIG CONTROL	Returns the status of the digital output control bits as either REMOTE (R) or INTERNAL (I). The return message format is DIG CONTROL=xxxxxx, where 'x' is either 'R' or 'I'. "R" indicates the corresponding bit is controlled remotely; and 'I' indicates the corresponding bit is controlled internally by pump software. The status order returned corresponds with the outputs 1-8.
DIG CONTROL = command 1 ——— 8	Sets the digital output control bits to either internal or remote, where 'x' is either 'R' for REMOTE or 'I' for INTERNAL CONTROL. 'R' indicates the corresponding bit will be controlled remotely (through the serial port). 'I' indicates the corresponding bit will be controlled internally by pump software. The order corresponds with the outputs 1-8.
DISPENSEA DISPENSEB DISPENSEC DISPENSED	Returns the dispense volume for Dispense Mode.
DISPENSEA=# DISPENSEB=# DISPENSEC=# DISPENSED=#	Sets the dispense volume for Dispense Mode. Format is XXX.XXX mL. Leading and trailing zeros are not required. Can only be changed when pump is stopped.
FLOW FLOWCD	Returns the delivering pump's flow rate in Continuous Pumping mode and Modifier Addition Mode. In INDEPENDENT Mode FLOW returns the pump A flow rate and FLOWCD returns the pump C flow rate.
FLOWA FLOWB FLOWC FLOWD	Returns the actual flow rate of the pump.
FLOW=# FLOWB=# FLOWC=# FLOWD=#	Returns the actual flow rate of the pump Enter # for a flow rate setpoint (Constant Flow Mode). Format is XXX.XXXXXXX mL/min. Only 5 figures are significant. Leading and trailing zeros are not required.
G GG G& G&2	Gets pump information. 'G' and 'GG' commands return a text string that contains current pressure, analog input, and digital input information. 'G&' is the Get All command. This returns the same information as 'G,' plus flow rates, units, operation status, and more. For four pump operation use the 'G&2' command. Refer to Section 8.8.1 "Get Status Command" for a complete description of this serial command.

Table 8-3 Serial Commands (Continued)	
Command (Refer to *NOTE 1* & *NOTE 2*.)	**Description**
IDENTIFY	Pump responds 'SERIES=1240-0___, MODEL ____D PUMP; REV__.' For each pump, REV__ is the internal pump program software revision. (For example, if the controller was attached to two 100DMs, the message would read 'SERIES=1240-024, MODEL 100DM PUMP; SERIES=1240-024, MODEL 100DM; REV__.') The series number is the original catalog number for the pump type. It may not match the production series number on the pump serial label. SERIES=1240-024, MODEL 100DM PUMP SERIES=1240-027, MODEL 100DX PUMP SERIES=1240-021, MODEL 260D PUMP SERIES=1240-025, MODEL 500D PUMP SERIES=1240-103, MODEL 500HPx PUMP SERIES=1240-052, MODEL 1000D PUMP SERIES=1240-063, MODEL 65D PUMP SERIES=1240-096, MODEL 65DM PUMP SERIES=1240-819, MODEL 30D PUMP
INDEPENDENT INDEPENDENTCD	Put pumps in Independent Mode.
IPUMPA=1, IPUMPA=0 IPUMPB=1, IPUMPB=0 IPUMPC=1, IPUMPC=0 IPUMPD=1, IPUMPD=0	Turns the pressure integral control On and Off for the pump indicated. 1 = ON 0 = OFF
LGE,F:XX,A:0X	Action to perform when gradient program reaches the end. The pump needs to be in local mode only. File # F: 01-99 Action A: 00=Hold final value 01=Stop after final step 02=Return to initial value and hold 03=Return to initial value and repeat program
LGGO	Start Gradient Command. This starts a gradient program (same as the 'RUN' key). This command will check to see if there is a gradient running and respond with 'RUNNING' if there is. The pump needs to be in local mode only.
LGSL,F:xx	Select Gradient File Command. This selects a gradient file to be run. This command will reset the controller to the saved file gradient type. If the selected gradient file does not exist, the controller will respond with 'PROBLEM=INVALID OPERAND.' The pump needs to be in local mode only.
LGST	Stop Gradient Command. This stops a gradient program. The pump needs to be in local mode only.
LGDL,F:xx,S:xx	Gradient Step Download command. This downloads a step from the pump to the PC. This command will respond with 'PROBLEM=INVALID OPERAND' if the file or step does not exist. The controller will respond with step information if the command is valid. Refer to Section 8.8.2 "Gradient Download Command" for complete information on Gradient step download commands. The pump needs to be in local mode only.
LGUL,F:xx,S:xx	Gradient Step Upload command. This transfers a step from the PC to the controller. Refer to Section 8.8.3 "Gradient Upload Commands" for complete information on Gradient step download commands. The pump needs to be in local mode only.

Table 8-3 Serial Commands (Continued)	
Command (Refer to *NOTE 1* & *NOTE 2*.)	**Description**
LIMITS LIMITSB LIMITSC LIMITSD	Returns the pressure and flow rate limits.
LOCAL	Returns the instrument to local control. Front panel control is enabled and all motors are stopped (if control was previously remote).
MAXFLOWA=# MAXFLOWB=# MAXFLOWC=# MAXFLOWD=#	Enter # to designate the maximum flow rate setpoint.
MAXFLOWA MAXFLOWB MAXFLOWC MAXFLOWD	Returns the maximum flow rate setpoint.
MAXPRESSA=# MAXPRESSB=# MAXPRESSC=# MAXPRESSD=#	Enter # to designate the maximum pressure setpoint.
MAXPRESSA MAXPRESSB MAXPRESSC MAXPRESSD	Returns the maximum pressure setpoint.
MFLOWA=# MFLOWB=# MFLOWC=# MFLOWD=#	Enter # to designate the maximum flow limit in Constant Pressure Mode.
MFLOWA MFLOWB MFLOWC MFLOWD	Returns the maximum flow limit setpoint.
MINFLOWA=# MINFLOWB=# MINFLOWC=# MINFLOWD=#	Enter # to designate the minimum flow rate setpoint.
MINFLOWA MINFLOWB MINFLOWC MINFLOWD	Returns the minimum flow rate setpoint.
MINPRESSA=# MINPRESSB=# MINPRESSC=# MINPRESSD=#	Returns the minimum pressure setpoint.
MINPRESSA MINPRESSB MINPRESSC MINPRESSD	Returns the minimum pressure setpoint.

Table 8-3 Serial Commands (Continued)	
Command (Refer to *NOTE 1* & *NOTE 2*.)	**Description**
MODE	MODE A P, B P, C P, D P A, B, C, D refer to the pump connection. P- Constant Pressure F- Constant Flow R- Refill PG- Pressure Gradient F1- Flow Gradient 1 Pump F2- Concentrated Gradient 2 Pump CF- Continuous Constant Flow CP- Continuous Constant Pressure MO- Modifier Mode 2 Pump MM- Modifier Mode 3 Pump
MODIFIER	Put pumps in Modifier Addition Mode.
PRESS=# PRESSB=# PRESSC=# PRESSD=#	Enter # to designate pressure setpoint (Constant Pressure Mode).
PRESS PRESSCD	Returns the delivering pump pressure in continuous pumping mode and Modifier Addition Mode. In INDEPENDENT Mode PRESS returns the pump A pressure and PRESSCD returns the pump C pressure.
PRESSA PRESSB PRESSC PRESSD	Returns the actual pressure of the pump.
PRESSCNTRLDIFF1	Sets the pressure control input to Analog input 1, with a pressure range of 50 psi.
PRESSCNTRLDIFF1=XXXXX	Sets the pressure control input to Analog input 1 and sets the pressure range. The range is 1 to 5000. the units are psi, with a value of 5000 representing 5000 psi at 5 volts.
PRESSCNTRLDIFF2	Sets the pressure control input to Analog input 2, with a pressure range of 500 psi at 5 volts.
PRESSCNTRLDIFF3	Sets the pressure control input to Analog input 2, with a pressure range of 5000 psi at 5 volts.
PRESSCNTRLNORM	Sets the pressure control input to the standard input.
PRESSDIFF=XXXXX	Differential pressure setpoint. (PSI*10) 0 to 50,000 maximum (0 to 5000 psi)
PRESSDIFF	Reads the differential pressure value. (PSI*10) The transducer can also be read via the ‘ALOGx’ serial commands.
RANGEA RANGEB RANGEC RANGED	Provides scaling information for the system parameters. Refer to Section 8.8.4 "Range Command" for more information about this serial command.
RAPIDA RAPIDB RAPIDC RAPIDD	Activates the automatic rapid pressurization cycle (Constant Flow Mode only).
RECEIVE RECEIVECD	Set the dual-pump mode to receive fluid when running.
REFILL REFILLB REFILLC REFILLD	Move cylinder to bottom at preset refill rate.

Table 8-3 Serial Commands (Continued)

Command (Refer to *NOTE 1* & *NOTE 2*.)	Description	
REFILL=# REFILLB=# REFILLC=# REFILLD=#	Enter # to designate refill rate.	
REMOTE	Disables controller front panel control and enables all serial commands. Stops all motors (if control was previously local).	
RLIMITA RLIMITB RLIMITC RLIMITD	Returns the refill flow rate limit.	
RSVP RSVPB RSVPC RSVPD	Pump responds with 'READY' message.	
RUN RUNB RUNC RUND RUNALL	Same as front panel. Initiates pumping.	
SETFLOWA SETFLOWB SETFLOWC SETFLOWD	Returns the flow rate setpoint.	
SETPRESSA SETPRESSB SETPRESSC SETPRESSD	Returns the pressure setpoint.	
STATUSA STATUSB STATUSC STATUSD	Returns with status of pump. May be any combination of responses listed below.	
	STATUS= STOP RUN REFILL HOLD EQUIL. LOCAL REMOTE EXTERNAL	PROBLEM= OVER PRESSURE UNDER PRESSURE CYLINDER FULL CYLINDER EMPTY MOTOR FAILURE
STOP STOPB STOPC STOPD STOPALL	Same as front panel with the exception that pump remains under remote serial control.	
UNITSA=	Enter the desired flow or pressure units after the equal sign. Acceptable values are: ATM, BAR, KPA, PSI, ML/MIN, ML/HR, UL/MIN, UL/HR. (Sets all pumps.)	
VOLA VOLB VOLC VOLD	Return the volume remaining in cylinder in mL. Format is 'XXX.XXXX' mL.	
VOLTOT VOLTOTCD	Returns the total volume delivered when using continuous flow or modifier.	
VOL RESET VOL RESETCD	Will reset the volume total to zero.	

Table 8-3 Serial Commands (Continued)	
Command (Refer to *NOTE 1* & *NOTE 2*.)	**Description**
ZEROA ZEROB ZEROC ZEROD	'Zeros' the pressure sensor offset.
ZERODIFF1 ZERODIFF2 ZERODIFF3	'Zeros' the pressure sensor offset for the respective analog input.
NOTE 1 The analog input range is -1.5 to 11.6 volts. There is NO conversion of the returned number. The number returned (0 to 65535 decimal) will have an offset of 7500 added to the number (7500 = 0 volts) and a scale of 5000 for every 1 volt, for example: $\frac{\text{number} - 7500}{5000} = \text{volts}$ $\frac{(32500 - 7500)}{5000} = 5 \text{ volts}$	
NOTE 2 The only pump B commands accepted in continuous pumping mode or Modifier Addition Mode are: %B, FLOWB, LIMITSB, PRESSB, REFILLB, REFILLB=, STATUSB, VOLB.	

8.8.1 Get Status Command

The 'G' and 'G&' serial commands retrieve information from the pump controller. Each command returns a text string which can be read as shown in Figure 8-3 and Figure 8-5.

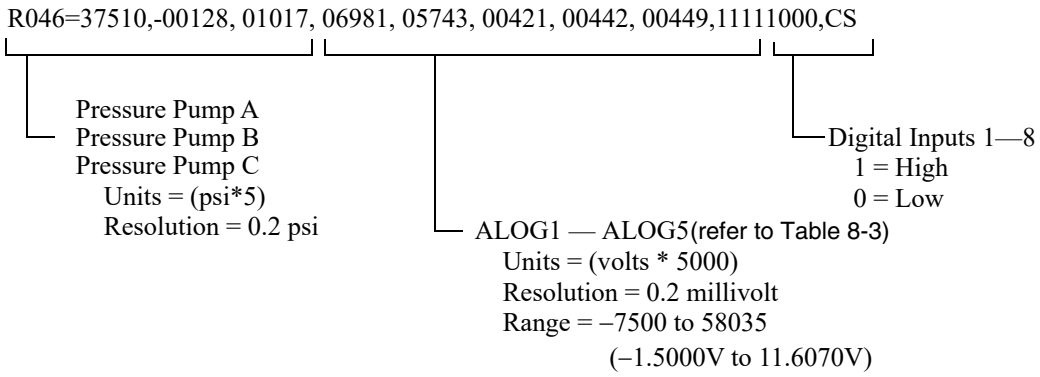


Figure 8-3 Get status string 'G' command

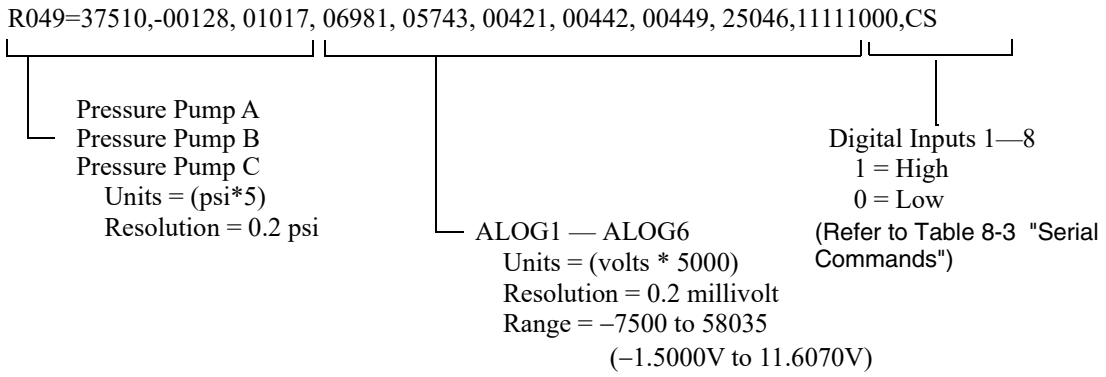


Figure 8-4 Get status string 'GG' command

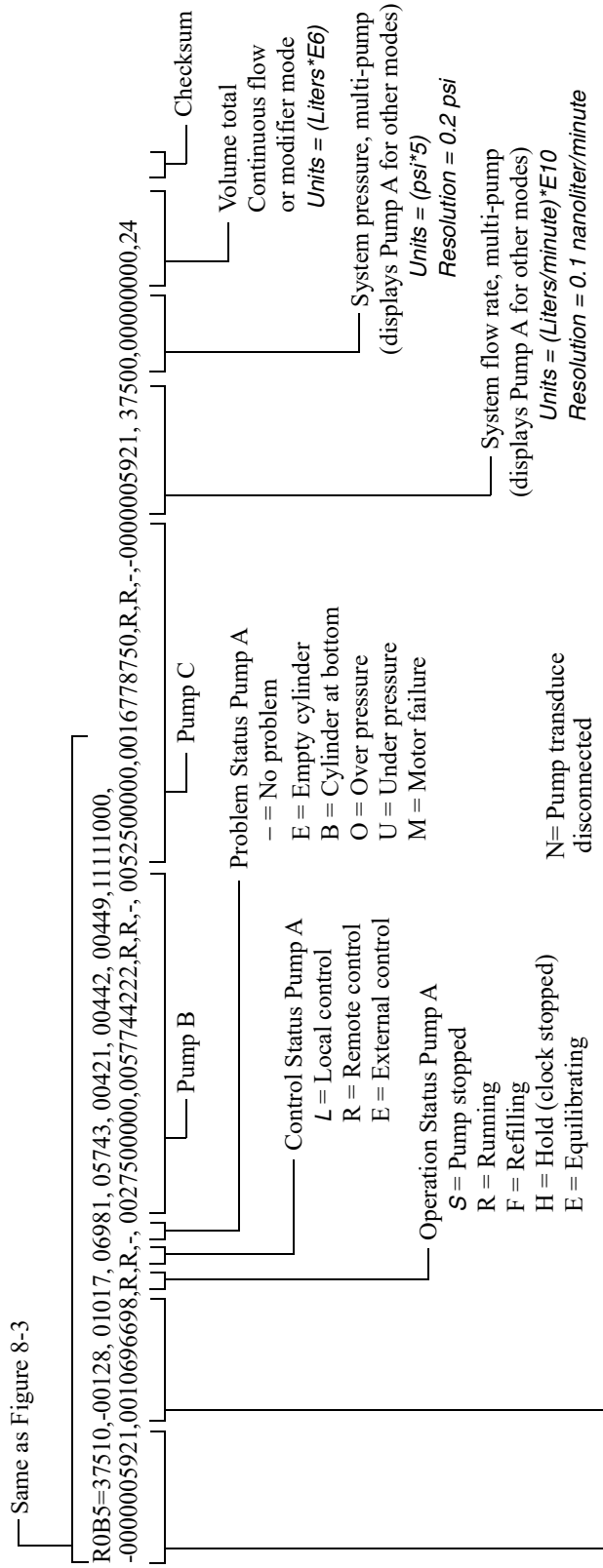


Figure 8-5 Get all status string 'G&' command

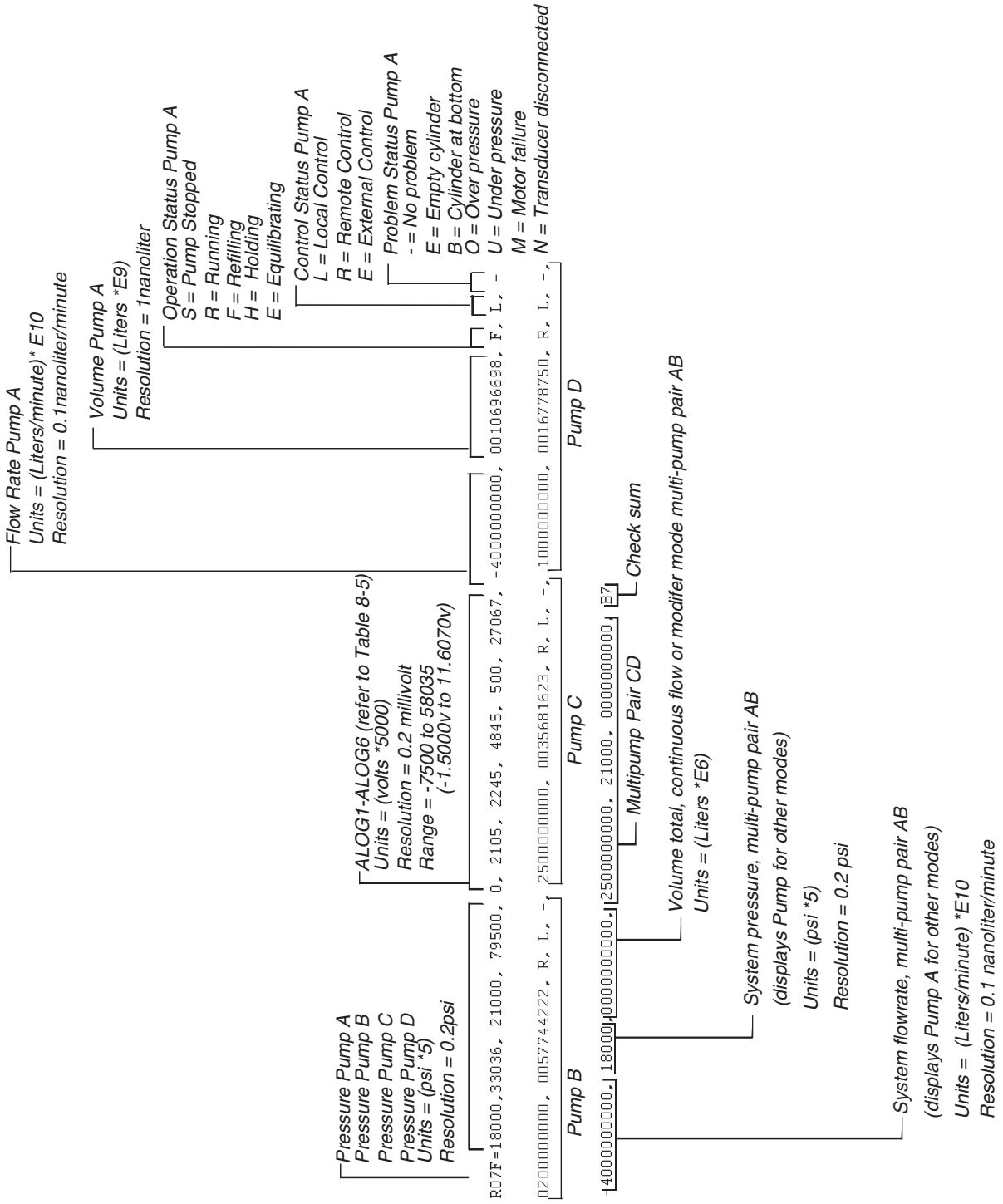


Figure 8-6 Get all status strings from four pump operation 'G&2' command

8.8.2 Gradient Download Command

This command downloads a step from the SyriXus series pump to the PC. This command will respond with 'PROBLEM=INVALID COMMAND' if the file or step does not exist. If the file and step is valid, the controller will respond as shown in Figure 8-7 and Figure 8-8.

8.8.3 Gradient Upload Commands

These commands upload a step from the PC to the SyriXus series pump. This command will respond with 'PROBLEM=INVALID COMMAND' if the file or step does not exist. If the file and step is valid, the controller will respond as shown in Figure 8-9 and Figure 8-10. Figure 8-11 shows an example of a pressure programming upload command.

NOTE

Gradient upload commands must follow the format shown in the figures below. Where necessary, leading and trailing zeros must be included so that the numerical values are represented properly. Also note that the single-pump gradient commands include spaces in the command string.

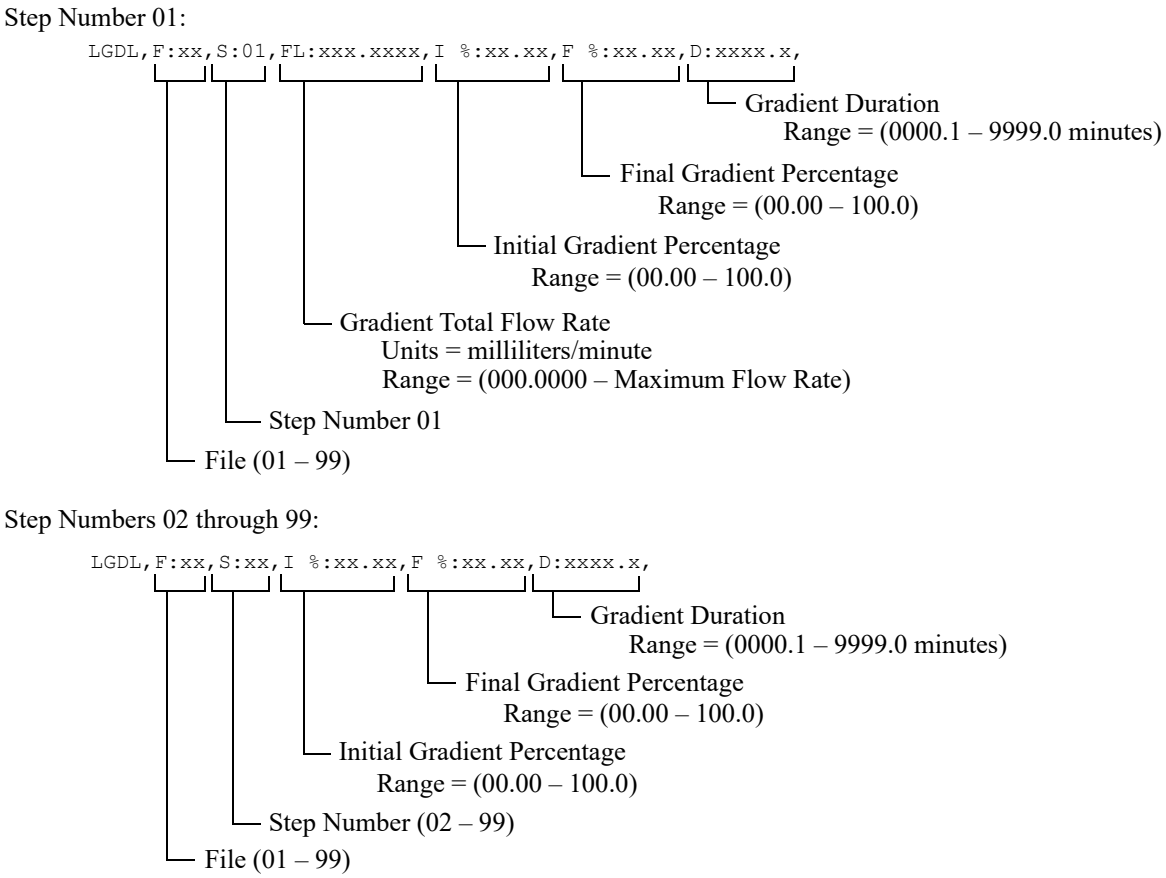


Figure 8-7 Gradient download commands - single-pump flow gradient

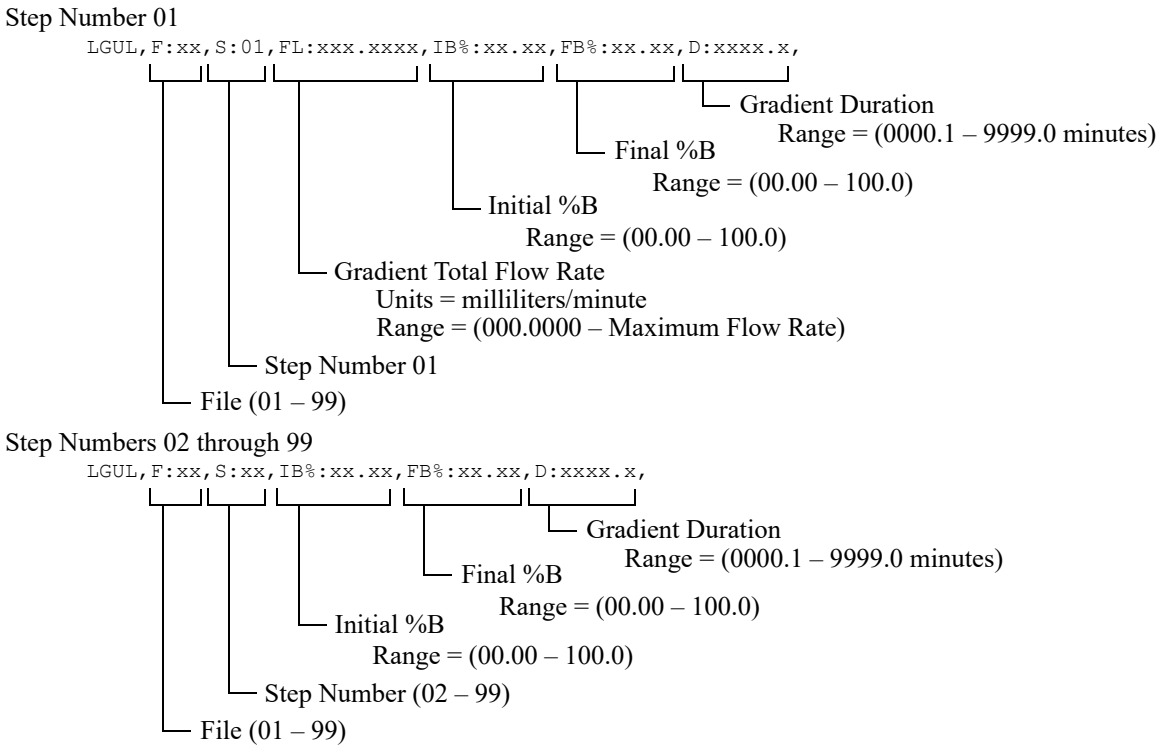
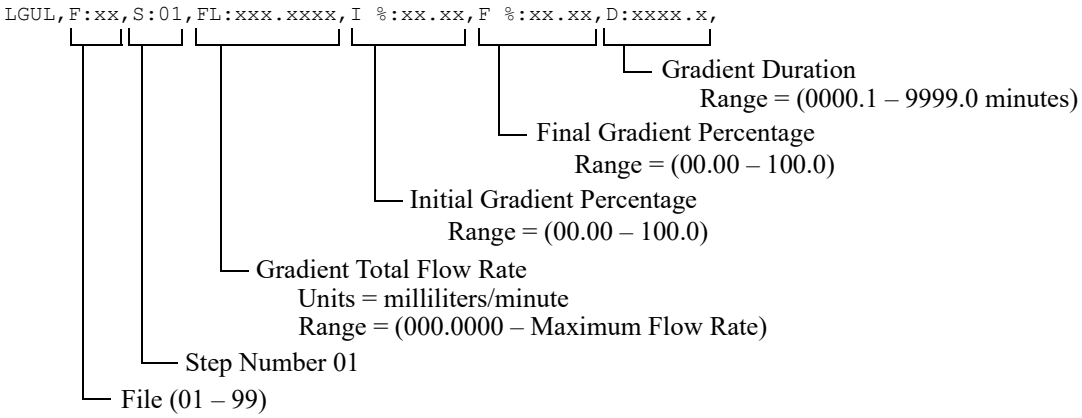


Figure 8-8 Gradient download commands - two-pump flow gradient

Step Number 01:



Step Numbers 02 through 99:

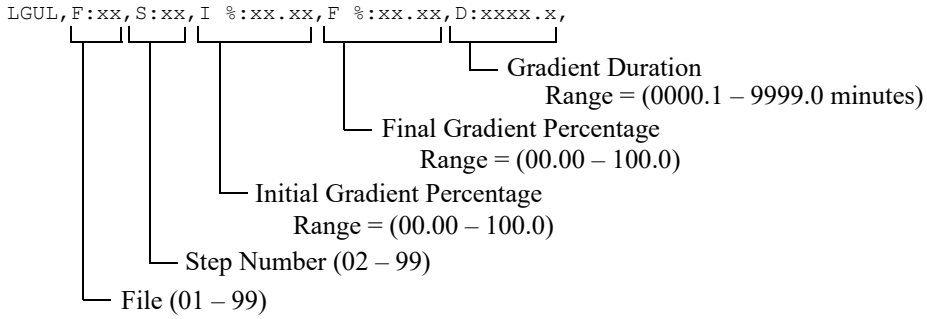


Figure 8-9 Gradient upload commands - single-pump flow gradient

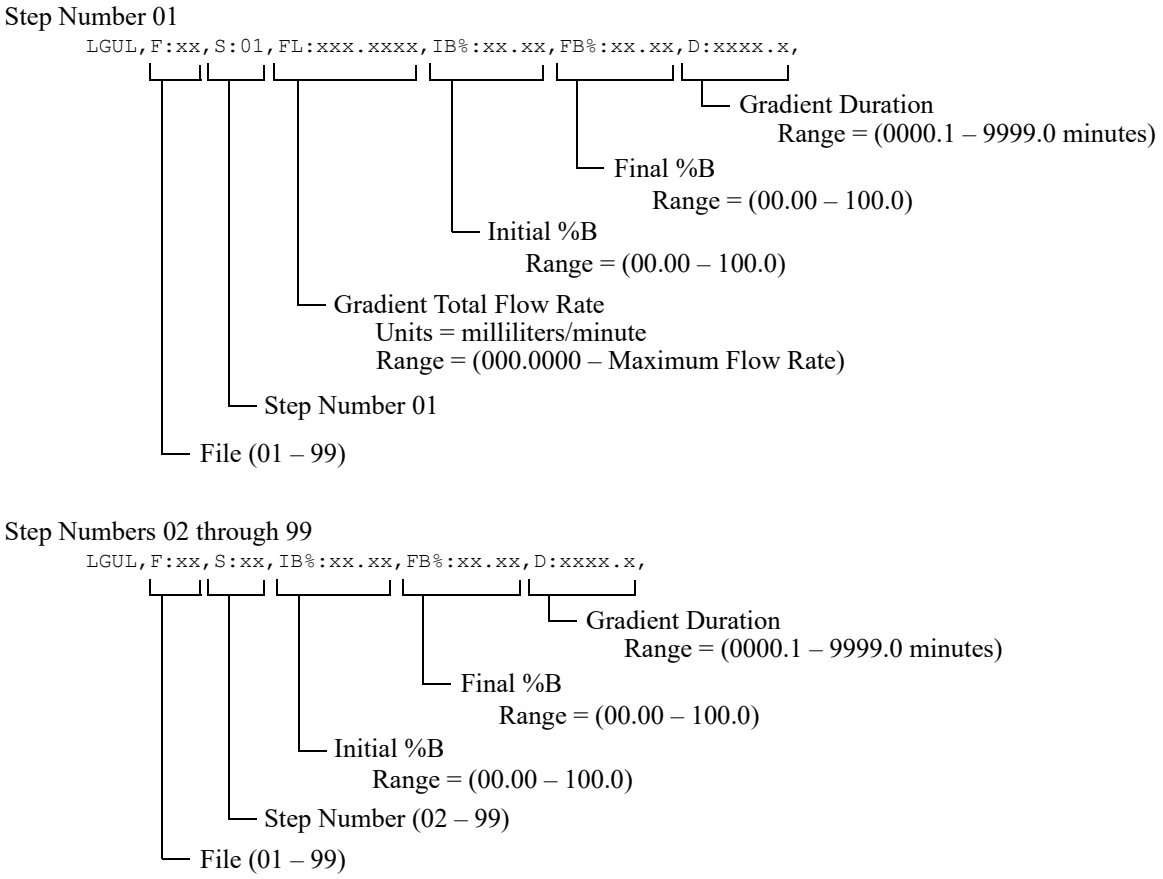


Figure 8-10 Gradient upload commands - two-pump flow gradient

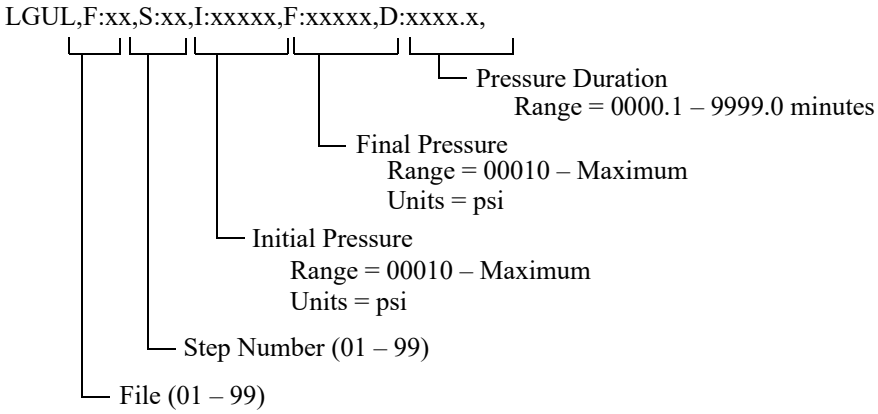


Figure 8-11 Upload commands - single-pump pressure programming

8.8.4 Range Command

The RANGE command provides scaling information for the system parameters. For example,

6R006RANGEA34

may return a string similar to the one shown in Figure 8-12.

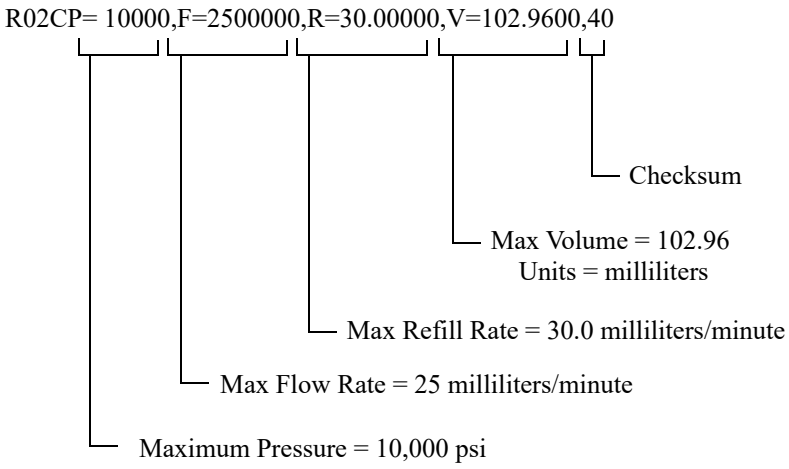


Figure 8-12 Range serial commands

8.8.5 Error Messages

If an error occurs in a message, one of the following responses will be sent. The format of an error message is 'PROBLEM=_____.' Refer to Table 8-4 "Error Messages".

Table 8-4 Error Messages

Error	Description
PROBLEM=LOCAL MODE	The pump was sent a command before being placed in remote mode. Refer to Section 8.8 "Serial Commands for the SyriXus Series Pumps".
PROBLEM=INVALID COMMAND	The command sent was not recognized by the pump.
PROBLEM=INVALID OPERAND	The operand (character(s) following the = sign) is missing or is incorrect; *e.g.*, the number was too large.
PROBLEM=PUMP RUNNING	The command sent is only valid when the pump is stopped.
PROBLEM=OVERPRESSURE PROBLEM=UNDERPRESSURE	Sent in response to a high or low pressure limit condition.
PROBLEM=CYLINDER EMPTY	Sent when the pump cylinder is empty.
PROBLEM=CYLINDER FULL	Sent when the pump cylinder is full.
PROBLEM=NO PUMP	Sent when the pump is not present
PROBLEM=WRONG PUMP MODE	Sent when the pump is in the incorrect mode for the command.

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Section 9 Pump Maintenance, Troubleshooting, and Servicing

9.1 Replacement Parts

Replacement parts are available for some of the SyriXus series pump models (excluding models that are certified). Most components for the HLf (Hazardous Location) pump models, for example, are not available for end user repairs to comply with their certification requirements. These units would need to be returned to the factory for repair.

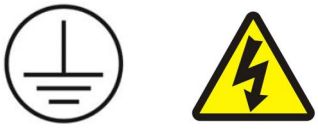
Replacement Parts Lists are available at www.teledyneisco.com. These lists will identify the part numbers for replacement components available for customer repairs. Some commonly replaced parts can be ordered directly from our online store. Other components will require calling our customer service department to assist in selecting the right parts and guidance on installation.

NOTE

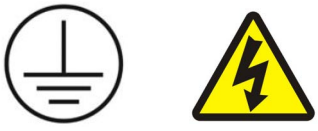
For replacement part numbers and parts ordering, use the Teledyne ISCO Online Store located at https://store.teledyneisco.com/.

RISK OF ELECTRIC SHOCK - DISCONNECT THE ELECTRIC POWER BEFORE SERVICING. ONLY TRAINED SERVICE PERSONNEL MAY REMOVE THE CASE TOP.

RISQUE DE CHOC ÉLECTRIQUE. COUPER L´ALIMENTATION AVANT LA RÉPARATION. L´USAGER NE DOIT PAS DÉMONTER L´INSTRUMENT OU DÉRANGER LE MÉCANISME DEDANS. ADRESSER LA REPARATION SEULEMENT AUX TECHNICIENS COMPÉTENTS.



Electrical Hazard! Earth ground bonding conductor. Do not remove or disconnect.



Mise à la terre. Ne pas enlever ni déconnecter.

DANGER

LINE VOLTAGE IS PRESENT INSIDE THIS UNIT AT ALL TIMES, REGARDLESS OF SWITCH SETTINGS. IF INTERNAL ADJUSTMENTS OR REPAIRS ARE NECESSARY, THE LINE CORDS MUST BE DISCONNECTED TO REMOVE POSSIBLE SHOCK HAZARD BEFORE OPENING THE INSTRUMENT CASE.

9.2 Introduction

This section contains maintenance and repair procedures which you can do yourself or have done by a service technician on-site.

To view the schematic drawings referred to in this section, first find the serial number for your unit. Contact the Teledyne ISCO Customer Service Department and request a copy of the schematic for your unit. You will need to provide the serial number so that the correct schematic can be retrieved.

9.3 Technical Customer Service Department

If you have a question about a procedure, need parts information, or need assistance, call or email the Teledyne ISCO Customer Service department. In your message, be sure to include all the details about your instrument and the nature of the error.

Call the Service Department before returning the unit for factory repair. Often a problem can be solved in the field with just a little extra help.

Contact Information:

Teledyne ISCO
Customer Service Dept.
4700 Superior Street
Lincoln, NE 68504-1398 USA

Email: IscoService@teledyne.com

Phone:	General	(800) 228-4373
	Toll Free	(800) 775-2965
	Outside USA, Canada, and Mexico	(402) 464-0231

How to Ship Returns

In the rare event that an instrument must be returned for maintenance, the following measures must be taken to ensure a proper return:

- Teledyne ISCO Technical Service (Section 9.3 "Technical Customer Service Department") must be contacted prior to shipment to obtain a clean return form. Provide the serial number of the unit when contacting Technical Service.
- The applicable safety data sheet (SDS) paperwork of the last substance ran must be received by Technical Service.
- The syringe pump must be shipped with the cylinders removed from the pumps and any residue completely rinsed with methanol or water.
- Wrap the unit in heavy paper or a plastic bag. If the original box is not available, put the wrapped unit in a strong cardboard box at least six inches longer in each basic dimension than the unit.
- Fill the box equally around the unit with resilient packing material.
- Seal it with strapping tape and ship it to the address on the warranty. The warranty at the end of the manual also describes the conditions under which Teledyne ISCO will pay surface shipping costs.

NOTICE

- Do not return the pump without contacting the Teledyne ISCO Technical Customer Service Department (Section 9.3 "Technical Customer Service Department").
- Do not return the pump without first providing written guarantee that it has been decontaminated of hazardous or potentially lethal materials.

Teledyne ISCO reserves the right to refuse shipment if no decontamination assurance has been provided prior to shipment. Failure to decontaminate a pump may result in legal action taken by state or federal authorities.

NOTE

It is very important that the shipment be well-packed and fully insured. Damage claims must be settled between you and the carrier. This can delay repair and return of the unit to you.

9.4 General Cleaning

For general cleaning of the instrument's front panel or enclosure, use a mild detergent in water or isopropyl alcohol on a sponge which is mostly squeezed out.

9.5 Resetting the System

This action **completely deletes** user programmed settings, erasing all programs and returning the controller to factory default settings. Record your program settings and parameters before performing a reset operation. If ZERO PRESS has been employed, all corrected offsets will be lost.

9.5.1 Basic Reset

To perform a **basic reset**, press MENU > SYSTEM RESET (5) > CONTINUE (A).

9.5.2 Hard Reset

To perform a **hard reset**:

1. Turn the controller switch to STANDBY.
2. Press and hold CLEAR ENTRY.
3. While still holding CLEAR ENTRY, turn the controller switch to ON. Continue holding down CLEAR ENTRY for one second.
4. Release the CLEAR ENTRY key and turn the controller switch back to STANDBY.
5. Turn the controller switch back to ON, and perform the **Basic Reset**, as described above.

9.6 Diagnostic Menu

The syringe pump controller can run a number of system tests that are initialized using the keypad.

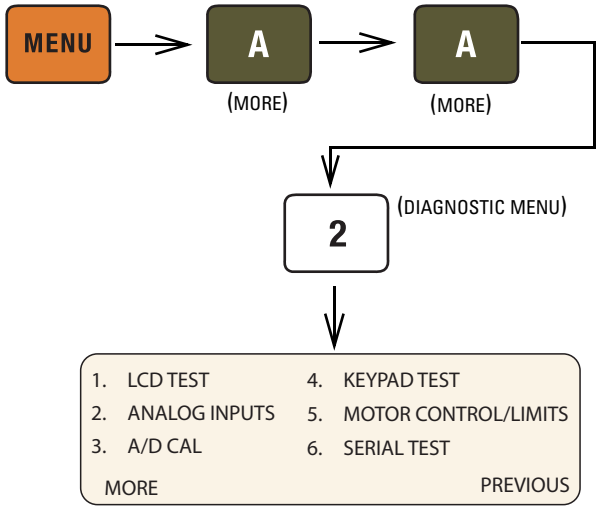


Figure 9-1 Accessing the diagnostic menu

9.6.1 LCD TEST

Cycles all segments of the display through all displayed characters. To stop the test, press any key.

9.6.2 ANALOG INPUTS

Displays the values of all analog inputs in volts. In the left column, with all connected pumps at zero pressure, the pressure readings should be near zero. Readings for pumps not connected are meaningless.

After the initial reading, pressurize the pump and then observe the test screen once more to verify that the value for that pump has increased.

The right column represents the four analog input terminals on the rear panel of the controller. For any terminal shorted to ground, the value should read a steady zero.

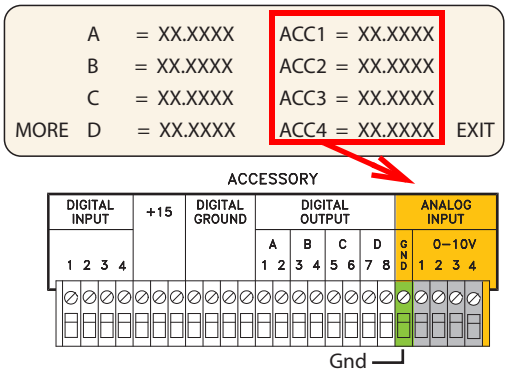


Figure 9-2 Analog input diagnostic screen

Press EXIT (D) to return to the diagnostic menu.

9.6.3 KEYPAD TEST

The screen will briefly display the name of each key pressed. Press EXIT (D) to return to the diagnostic menu.

9.6.4 MOTOR CONTROL/LIMITS

Tests the digital position controls.

From the Limits menu, you can set minimum and maximum flow rate limits and pressure limits, as well as the maximum flow rate in Constant Pressure Mode. High and low limits cannot exceed pump specifications.

The pump stays within these limits by means of a flag that moves up and down with the ball nut assembly, and two optical sensors at the top and bottom of the tower side plate as shown in Figure 9-3.

When a sensor is interrupted, it has a logic 1; when it is uninterrupted, it has a logic 0. Therefore:

- Upper limit 0, Lower limit 1
- Upper limit 1, Lower limit 0
- Upper limit 0, Lower limit 0 = Cylinder is partially full
- Upper limit 1, Lower limit 1= Illegal state

An illegal state can indicate failure of one or both sensors. The controller display will toggle immediately between CYLINDER FULL and CYLINDER EMPTY when you press REFILL or RUN (the pump will not run).

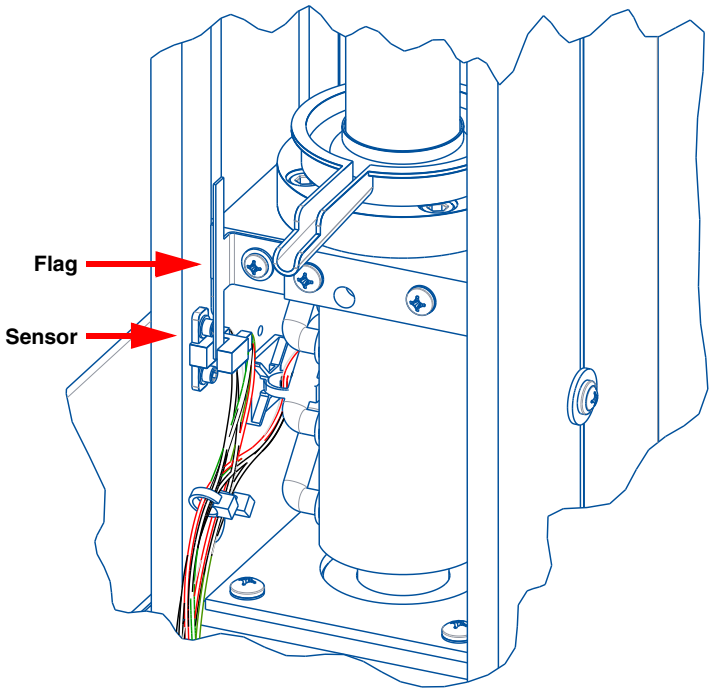
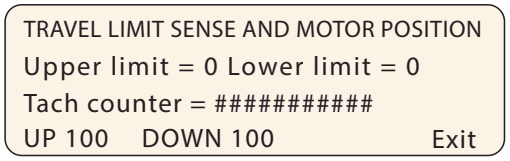


Figure 9-3 Optical sensor, interrupted by flag (bottom sensor shown, rear tower cover plate removed)

Select the pump to be tested (A, B, or C).



Press UP 100 (A) or DOWN 100 (B) to move the piston up or down 100 counts. The tach counter value will increase or decrease by 100 counts, accordingly. When the ball nut assembly reaches the top or bottom of the tower, the corresponding limit will change from 0 to 1. If the cylinder was refilled using the REFILL button, it may require multiple presses of the 'UP 100' softkey before the 'Lower limit' indicator changes to 0. When the Lower limit indicator is 1, pressing the DOWN 100 softkey will have no effect. Similarly, when the Upper limit is 1, pressing the Up 100 softkey (B) will have no effect.

If the rear tower cover plate is removed to expose the sensors, as shown above in Figure 9-3, you can simply interrupt the sensors with a slip of paper, rather than using the flag.

If either sensor fails, the sensor harness must be replaced.

Press EXIT (D) to return to the diagnostic menu.

9.6.5 SERIAL TEST

Tests the serial channel.

First, confirm operation of the **internal port**. On the RS-232-C port on the rear of the controller, short pins **2 and 3** and then run the test. The screen should display:

```
Rec: ****** Serial Test #### *****
Sent: ****** Serial Test #### *****

Press any key to exit
```

The four digits in the REC line should match the four digits in the SENT line, with a very slight delay.

If the unit passes the internal port test, next perform the I/O test. Use a null-modem cable (available from Teledyne ISCO, P/N 480-7996-00 or most computer parts stores) to connect the 9-pin serial output port of a computer to the 25-pin serial RS-232-C port, as shown in Figure 9-4.

NOTE

Avoid using a USB converter cable; test results have shown this not to be dependable.

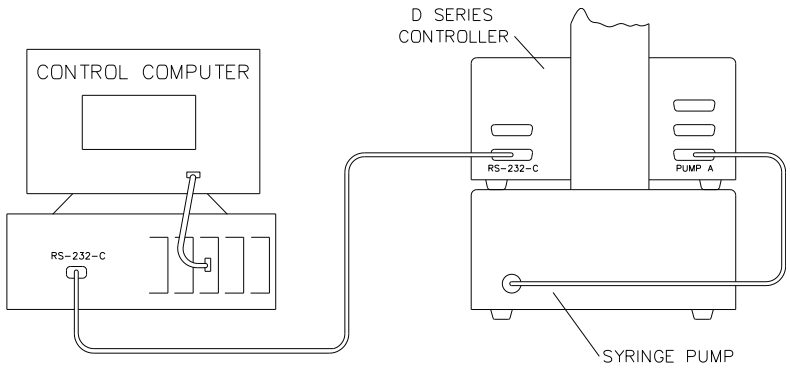


Figure 9-4 Serial connection to a computer

Open a terminal emulator program such as HyperTerminal™ (©Hilgraeve, Inc. Corp. 1287 N. Telegraph Rd. Monroe, Michigan 48162). The factory default port settings are:

- BPS - 9600. Baud rate should match controller setting (refer to Section 8.2 "Network Control and Communication")
- Data bits - 8
- Parity - None
- Stop bits - 1
- Flow control - None

Run the test again. The screen should display:

```
Rec: [whatever is typed from PC]
Sent: ****** Serial Test #### *****

Press any key to exit
```

Anything typed on the computer keyboard should appear in the top line on the controller display. The computer should continually display the serial test shown in the second line of the controller display.

9.7 Removing the Case Top

For some maintenance procedures, the case top of the controller or the pump may need to be removed. Because interior access is easier with the controller, this method of troubleshooting should be used whenever possible.

RISK OF ELECTRIC SHOCK - DISCONNECT THE ELECTRIC POWER BEFORE SERVICING. ONLY TRAINED SERVICE PERSONNEL MAY REMOVE THE CASE TOP.

RISQUE DE CHOC ÉLECTRIQUE. COUPER L´ALIMENTATION AVANT LA RÉPARATION. L´USAGER NE DOIT PAS DÉMONTER L´INSTRUMENT OU DÉRANGER LE MÉCANISME DEDANS. ADRESSER LA REPARATION SEULEMENT AUX TECHNICIENS COMPÉTENTS.

9.7.1 Controller Case Top Removal

Troubleshooting for a number of issues can be done on the controller main circuit board. Remove the four screws holding the case top in place (two screws on each side). Lift the cover straight up and off.

Figure 9-5 Controller case top screws (2 of 4 shown) - TBD

9.7.2 Pump Case Top Removal

Some maintenance and troubleshooting procedures require accessing the pump module interior. Remove the six screws holding the case top in place (three screws on each side). Lift the cover straight up and off.

Figure 9-6 Pump case top screws (3 of 6 shown) - TBD

9.8 Test Points

The following sections contain tables listing the most commonly used test points and their voltages. Refer to the controller schematic and the pump schematic (available at www.teledyneisco.com).

RISK OF ELECTRIC SHOCK - DISCONNECT THE ELECTRIC POWER BEFORE SERVICING. ONLY TRAINED SERVICE PERSONNEL MAY REMOVE THE CASE TOP.

RISQUE DE CHOC ÉLECTRIQUE. COUPER L´ALIMENTATION AVANT LA RÉPARATION. L´USAGER NE DOIT PAS DÉMONTER L´INSTRUMENT OU DÉRANGER LE MÉCANISME DEDANS. ADRESSER LA REPARATION SEULEMENT AUX TECHNICIENS COMPÉTENTS.

9.8.1 Power Supply (A1)

Output voltages of the power supply can be verified. The voltages in the pump unit, between circuit common (TP106) and the fuses or at the test points should be:

F104	+22 VDC to +31 VDC
F103	+8.1 VDC to +13 VDC
F102	–22 VDC to –31 VDC
TP111	+15 VDC ± 0.6 VDC
TP110	–15 VDC ± 0.6 VDC
TP109	+5 VDC ± 0.3 VDC

The voltage between motor common (TP101) and +VM (TP105) should be +60 to +90 V.

9.8.2 Controller

The voltages in the controller unit between circuit common (TP16, TP5, TP6) and the test points should be:

TP32	+5 VDC ± 0.002 VDC
TP12	+8.1 VDC to +13 VDC
TP43	–15 VDC ± 0.6 VDC
TP44	+15 VDC ± 0.6 VDC
TP20	+3.3 VDC ± 0.0 VDC
TP9	+2.5 VDC ± 0.0 VDC
TP7	+1.5 VDC ± 0.0 VDC

NOTE

These voltages are displayed during the Analog Input routine in the Diagnostics section of the firmware (Section 9.6.2 "ANALOG INPUTS").

9.9 Lubrication

The pump is a precision engineered instrument that must be lubricated every two years or every 6,000 strokes (whichever comes first) to ensure proper service life. The pump has an easy-to-access lube wheel that keeps the main gears lubricated during operation. Refer to Figure 9-7, configuration 1 or 2, depending on your pump motor type. Use Never-Seez® and DUOLEC® 1608 lubricants.

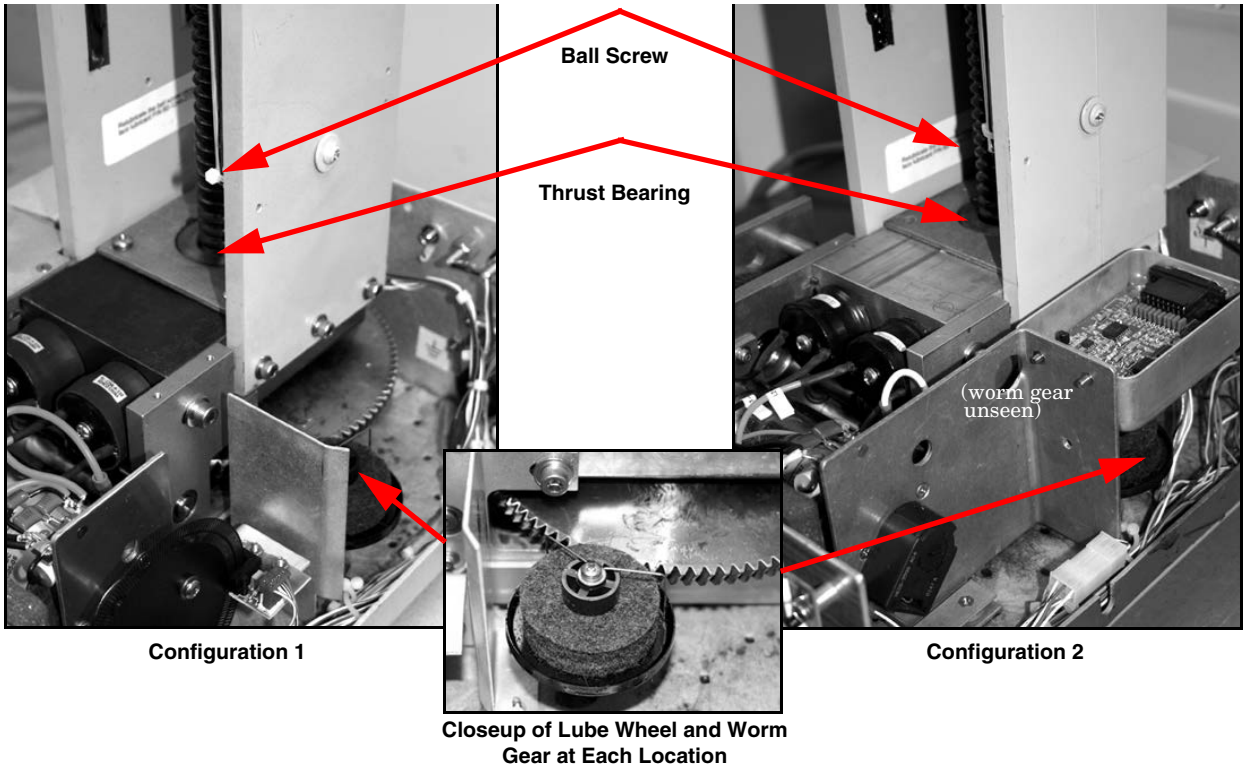


Figure 9-7 Gear train lubrication and motor drive service

Worm / Worm Gear

The worm and worm gear are lubricated by a lubrication wheel. Apply DUOLEC 1608 directly to the felt part of the wheel until it is saturated. The wheel may also be directly lubricated by trickling oil into the wheel while the pump is running.

WARNING

Risk of injury! Keep fingers and objects away from the moving components

NOTE

Use only DUOLEC 1608 lubrication on the worm and worm gear. Do not substitute.

9.9.1 Ball Nut

The ball screw, which drives the ball nut, must be kept lubricated with Never-seez.

1. Remove the case top, as detailed in Section 9.7 "Removing the Case Top", and front cover to gain access to all parts requiring lubrication.
2. To lubricate the ball nut, run the pump until the ball nut reaches its maximum height.
3. Apply two beads of lubricant, on opposite sides of the ball screw, down its entire length.

The precision thrust bearing at the base of the ball screw (refer to Figure 9-7) is factory lubricated and should not need re-greasing.

9.10 Seal Cleaning and Replacement

Before cleaning or replacing the piston or wiper seals, the cylinder must first be emptied.

Caution

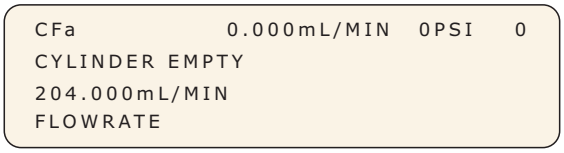
Handle with care. Never let surfaces of seals, piston, or cylinder come into contact with abrasives or fingernails.

Tools Required

- 1/4” and 1/8” Allen wrenches
- #2 Phillips screwdriver
- Wrench set from maintenance kit
- Never-Seez® lubricant from accessory package

Procedure

1. Run the pump until empty.



2. Disconnect the power cord and pressure transducer cables, and plumbing connections from the pump. Wrap the transducer cable around the cylinder cap. On SyriXus pumps with an external transducer, the transducer cable can be disconnected from the transducer instead.
3. Using a 1/8” Allen wrench, loosen the lock screw located on the front of the cylinder mounting block about two turns. Do not completely remove the lock screw.

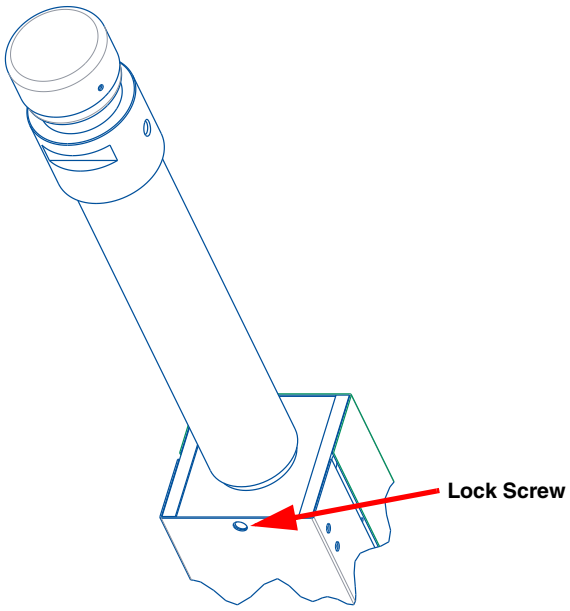


Figure 9-8 Cylinder lock screw

4. Unscrew the cylinder using either a strap wrench or the clamp and wrench in the Teledyne ISCO wrench package (P/N 60-1247-101) to not mar the cylinder’s outer surface.
5. Once the cylinder has been unscrewed, lift it straight up and off the piston and the push tube.

Caution

Do not tilt the cylinder while removing it. Seal damage can result.

9.10.1 Piston Seal (Excludes 30D)

Sometimes dirt or other solids on the seal can cause leakage. Removing and cleaning the seal may stop the leak and a new seal may not have to be used. However, if you remove and inspect the seal and it does not have any obvious crease or you did not find any foreign material on the seal, then the seal must be replaced. Check the wear ring. Refer to Section 9.11 "Wear Ring Cleaning and Replacement".

NOTE

DO NOT use abrasives while cleaning the piston and piston seal area. Scratches caused by the use of such abrasives will cause leaking. If either the cylinder or seal has been scratched, it must be replaced to maintain flow rate specifications.

NOTE

If your pump uses polyethylene piston seals, be sure to follow Section 9.10.2 "Piston Seal Break-In (Aqueous Seals Only)" for this type of seal.

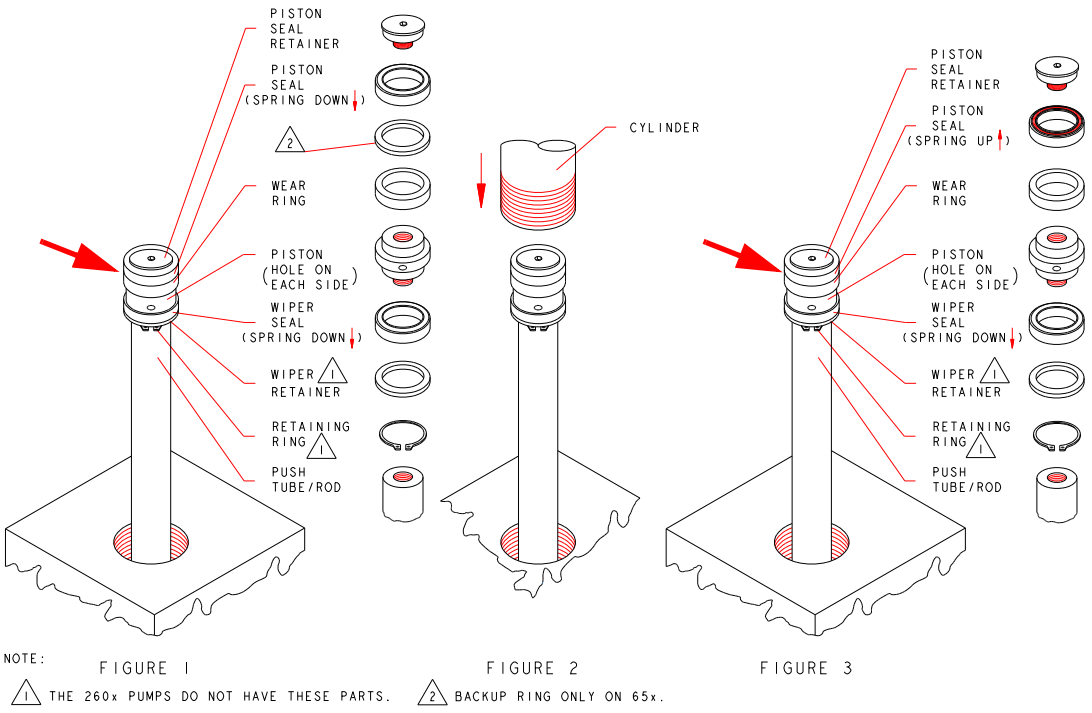
Accessing the Piston Seal

1. Unscrew the piston seal retainer (Figure 9-9) from the piston and remove the seal from it. Notice that the spring embedded in the seal is facing up or is on the top side of the seal.
2. Clean both the piston seal retainer and the cylinder thoroughly. Use a clean microfiber cloth when cleaning the piston and cylinder parts. Do not touch the seal surfaces with anything metal. Ultrasonic cleaning in a suitable solvent and air drying is strongly preferred. Make sure all parts which come in contact with the seal are free of dirt and other solids.
3. Once the seal and cylinder surfaces have been cleaned, rinse both parts with isopropyl alcohol.

9.10.2 Piston Seal Break-In (Aqueous Seals Only)

The break-in procedure is intended only for the UHMWPE (aqueous) piston seal to prevent the spring from bowing out of shape.

1. Assemble the piston assembly per Figure 9-9 (1). Be sure to install the top seal on the piston with the spring facing down.
2. Slide the cylinder over the piston assembly, per Figure 9-9 (2), and allow it to sit for 15 minutes. This “breaks in” the seal for the steps that follow.
3. Remove the cylinder.
4. Reassemble the top seal with the spring facing up, per Figure 9-9 (3).
5. Install the cylinder over the piston assembly again and screw onto the mounting block.
6. Leak test the pump.



Model 1000x - Contact Teledyne ISCO Technical Service for additional instructions with these seals

Figure 9-9 Break-in procedure for aqueous seals

9.10.3 All Other Piston Seals

1. Access the piston seal as previously described.
2. Orient a new seal so that the spring in the seal is facing up.
3. Slide the seal onto the piston.
4. Replace the piston seal retainer.

9.10.4 Wiper Seal

Although the wiper seal does not normally have to be changed, periodic cleaning is advisable.

Removal and Cleaning

1. Remove the cylinder as described previously.
2. Locate the piston (Figure 9-9).
3. With the exception of the 500x, which has wrench flats, use a spanner wrench with an 1/8” pin of appropriate size or the proper tool from the ISCO wrench package (P/N 60-1247-101) in the round hole on the side of the piston.

   Teledyne ISCO includes piston wrench tools in the wrench packages for all SyriXus series pumps.
4. Use the tool to twist the piston loose, then unscrew it by hand.
5. Remove the retaining ring (500x only) and wiper retainer, then lift off the wiper seal. Being careful not to scratch any sealing surfaces, gently break free any solids from the seal and piston. Rinse all the solids away with distilled water.

Reinstalling the Wiper

1. Install the piston seal onto the retainer with the spring oriented towards the retainer.
2. Install the wiper seal onto the piston base with the spring facing down.

NOTE

In the Model 1000x pump, which has a wash gland option, the wiper seal is installed with the spring facing **up**.

3. Thread the piston base onto the push tube.
4. Install the piston seal retainer onto the piston base.
5. Replace the cylinder over the piston and push tube assembly and screw it into the cylinder mounting block. The cylinder should be screwed into the cylinder mounting block until the cylinder bottoms firmly against the stop ring in the cylinder mounting block (the cylinder will no longer turn). **Do not overtighten**.
6. Unscrew the cylinder until the inlet and outlet ports are lined up as you had them before. Do not unscrew the cylinder more than one full turn from the stop position.
7. Lock the cylinder by tightening the locking screw on the front of the cylinder mounting block to 30 in-lbs (3.4 N-m). Reinstall covers.

9.11 Wear Ring Cleaning and Replacement

Although the wear ring does not routinely need to be replaced, occasionally it becomes worn or damaged, depending on how the pump has been used. Teledyne ISCO recommends that when replacing the seal or cleaning the piston, check the wear ring for any signs of deterioration.

1. Follow the instructions in Section 9.10 "Seal Cleaning and Replacement", to access the cylinder.
2. Remove the piston seal retainer and slide off the seal. The wear ring should then slide easily up and off the piston.

WARNING

Do not use metal tools on the seals, near ring piston or cylinder bore (including micrometers or calipers).

The wear ring prevents the piston from direct metal-to-metal contact with the cylinder wall, and should, therefore, extend at least 0.010" beyond the circumference of the piston flange. Check the bottom of the wear ring, which rests on the piston flange, for extrusion or any unevenness. If there is an indentation (of 0.0010" or more) marking the outline of the piston flange on the wear ring, then you should replace the wear ring. However, if the surface is smooth, the wear ring does not need replacing.

9.12 Flushing the Cylinder

After cylinder/seal maintenance or during modifier (liquid solvent) change, the pump cylinder should be flushed to remove possible residue.

The way in which the cylinder is flushed will depend on your pumping system and whether you are pumping a liquefied gas such as CO_2 (refer to Section 9.12.1 "Gas Solvent Changeover") or a liquid modifier such as methanol (refer to Section 9.12.2 "Liquid Solvent Changeover and Flushing").

WARNING

When changing from one working fluid to another, ensure that the two working fluids are not chemically reactive with each other which could create a potentially hazardous situation.

9.12.1 Gas Solvent Changeover

This procedure is used when changing from one gaseous solvent to another.

1. Close the valve on the fluid supply tank so that no solvent is supplied to the system.
2. Turn the controller ON.
3. Run the pump until the cylinder is empty. It may be necessary to turn OFF auto-refill (Section 3.4.3 "Refill") so that the pump stops when the cylinder is empty. If there was any pressure in the system, wait until all the pressure bleeds off.
4. Change the solvent tank.
5. Close the pump outlet valve.
6. Open the valve on the tank to repressurize the system.
7. Cycle the pump between REFILL and RUN a few times, opening and closing the appropriate valves at the proper time to purge any remaining gas from the pump. Use about 10 - 20 mL per stroke to purge.

9.12.2 Liquid Solvent Changeover and Flushing

This procedure is typically used for modifier systems when changing from one liquid solvent to another.

NOTE

If high ionic strength aqueous reagent solutions are allowed to remain in the pump, solid residues may be formed, which will scratch the seals and the polished inner surface of the cylinder of the pump. These scratches allow leakage, which compromises performance.

To Clean the Cylinder

1. Press CONST FLOW > RUN. You will be asked to designate which pump if more than one is present.
2. Press a softkey to run the desired pump.
3. Run the pump until the message “CYLINDER EMPTY” is displayed. It may be necessary to turn OFF auto-refill (Section 3.4.3 "Refill") so that the pump stops when the cylinder is empty.
4. Place the pump inlet line in a flask containing a compatible solvent or a detergent solution.
5. Press REFILL. You will be asked to designate the pump to refill if more than one is present. Press a softkey to refill the pump.
6. Fill the pump and repeat this procedure several times. Place the pump inlet line in a flask containing distilled water or appropriate solvent. Fill the pump and then run it until empty. several times to flush out any solvent or detergent solution.
7. Run the pump until the message “CYLINDER EMPTY” is displayed. You are now ready to fill the pump with new liquid solvent.

NOTE

Do not leave buffer solutions which contain dissolved salts or corrosive buffers in the cylinder overnight or for long periods of time. The pump should be stored with methanol or isopropanol (at least partially fill the cylinder with either solvent and then run the pump until the message “CYLINDER EMPTY” is displayed) when it is not being used.

9.13 Overpressure Conditions

The operator can set the maximum pressure limit on the pump controller (refer to Section 3.8.7 "LIMITS"). The pump can be set to stop running if an overpressure condition occurs.

A shear key is located in the worm gear assembly of the pump. Should the maximum pressure circuit fail and excessive pressures (pressures that exceed maximum pressure limits) persist in the operation of this pump, the torque limiting shear key may become damaged. The shear key will yield at pressures slightly above maximum pressure, to protect the pump from permanent damage.

In the event of a shear key failure, the pump will sound as though it is running, but the piston will not move up the cylinder. When this occurs, the pump motor will not stop automatically.

WARNING

Damage to the pressure transducer and push tube could be possible if the key failed due to extreme overpressure.

WARNING

The shear key is NOT a safety feature! It provides a measure of protection against damage to the equipment. Avoid overpressure situations by properly installing and programming the pumping system. In applications where overpressure conditions are possible, install an appropriate pressure relief safety device in your apparatus.

9.13.1 Shear Key

The replacement shear key part number for all SyriXus pumps is 60-1243-607

1. Place the pump on its side and remove the four panhead screws that attach the access plate to the case bottom, as shown in Figure 9-10.
2. Remove the cotter pin that passes through the castle nut and ball screw.
3. Use a 3/4" wrench to remove the castle nut shown below.
4. Remove the spacer.
5. The two broken halves of the shear key should be protruding from the brass worm gear and the ball screw.

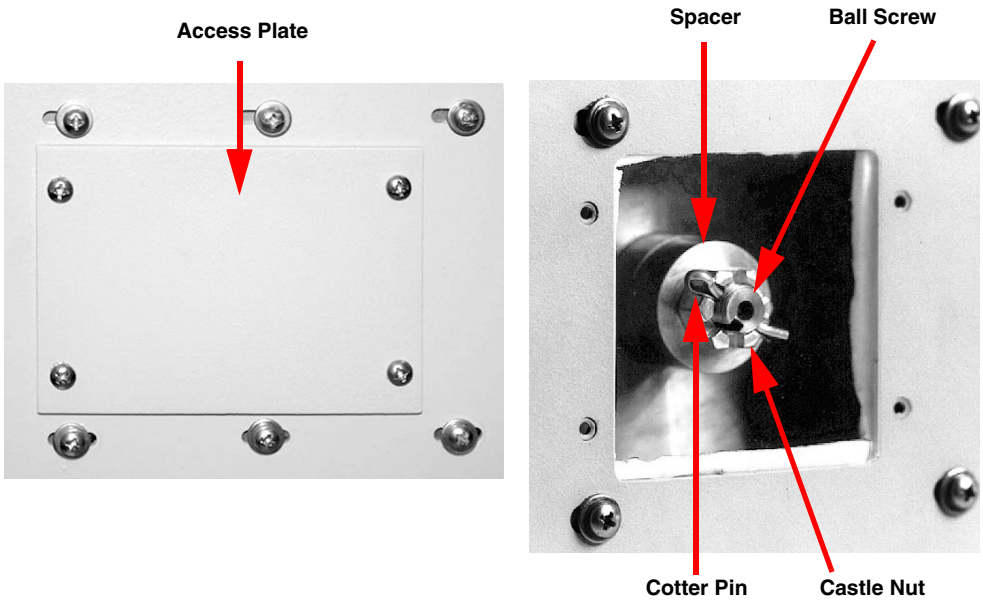


Figure 9-10 Accessing the shear key

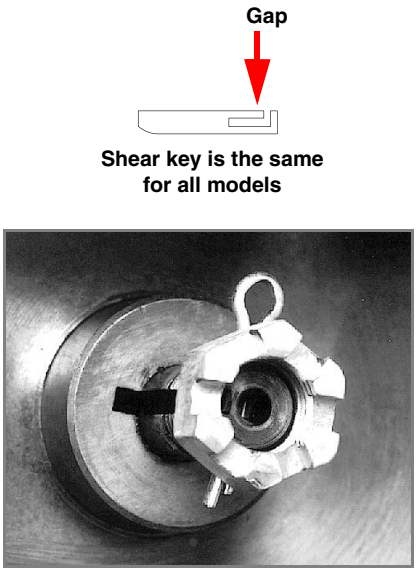


Figure 9-11 Shear key replacement

9.13.2 Replacement Using an Allen Wrench

An Allen wrench can be used to aid replacement of the shear key.

NOTE

It may be easier to use a flat blade screwdriver in the shear key gap to pull the centermost half out first. Take care not to push the other half into the worm gear.

1. Locate the hole at the bottom of the ball screw and insert an Allen wrench ball to rotate the ball screw so that the slot on the screw and the tool are lined up, then lock with locking pin.
2. Rotate the ball screw until the broken halves of shear key are realigned (Figure 9-11).
3. Remove the broken shear key halves by gripping them with pliers or vise grips and pulling them out.

NOTE

Use care not to push the pieces into the gear, making them more difficult to remove.

4. Insert the new shear key into the slot with the gap facing away from the shaft, as shown in Figure 9-11. Push the shear key about half-way into the worm gear. Do not push it all the way in.
5. Proceed to the final steps in Section 9.13.4 "Completion of Shear Key Replacement".

9.13.3 Replacement Without Installation Tool

1. Follow steps 1. through 5. in Section 9.13.1 "Shear Key".
2. Insert the cotter pin into the ball screw, and screw the castle nut onto ball screw, with the slot on castle nut outward, as shown in Figure 9-11.
3. Use a 3/4" wrench on the castle nut and rotate the ball screw clockwise until the broken halves of the shear key are realigned (Figure 9-11).

Caution

Never use tools on the ball screw. Doing so will render it inoperable and beyond repair.

4. Remove the castle nut and cotter pin.
5. Remove the broken shear key halves by gripping them with pliers or vise grips and pulling them out.

NOTE

Use care not to push the pieces into the gear, making them more difficult to remove.

6. Insert the new shear key into the slot with the gap facing away from the shaft, as shown in Figure 9-11. Push the shear key approximately half way into the worm gear. Do not push it all the way in.

9.13.4 Completion of Shear Key Replacement

1. Slide the spacer onto the ball screw. The spacer will push the shear key into proper position. Install the castle nut on the ball screw. If the shear has been installed as described above, the spacer will position it properly as the castle nut is tightened.
2. Install the castle nut with the slots facing away from the spacer. Hand tighten the castle nut.
3. Torque the castle nut to **250 in-lbs (28 N-m)** only once. Do not repeat this torque.
4. Loosen the nut until the nut can be turned by hand. Tighten the nut to finger tight.
5. Torque the castle nut to **100 in-lbs (11.3 N-m)**. Do not repeat this torque.
6. Insert the cotter pin through the castle nut and ball screw. If the holes do not line up, **loosen** the castle nut slightly until any set of holes allow the cotter pin to be inserted.

Caution

Do not loosen the nut more than 30° beyond the torqued position to align the holes.

7. Reinstall the access cover.

9.14 Motor Brushes

If the pump does not run properly, one possible cause is worn brushes.

Inspect the motor brushes every two years of operation, or every 6,000 piston strokes, whichever comes first. Both brushes wear at approximately the same rate; therefore, only the top brush, which is more easily accessible, need be inspected.

RISK OF ELECTRIC SHOCK - DISCONNECT THE ELECTRIC POWER BEFORE SERVICING. ONLY TRAINED SERVICE PERSONNEL MAY REMOVE THE CASE TOP.

RISQUE DE CHOC ÉLECTRIQUE. COUPER L´ALIMENTATION AVANT LA RÉPARATION. L´USAGER NE DOIT PAS DÉMONTER L´INSTRUMENT OU DÉRANGER LE MÉCANISME DEDANS. ADRESSER LA REPARATION SEULEMENT AUX TECHNICIENS COMPÉTENTS.

The bottom brush is accessed by removing a cover on the bottom of the pump and extracting the brush through the uncovered opening.

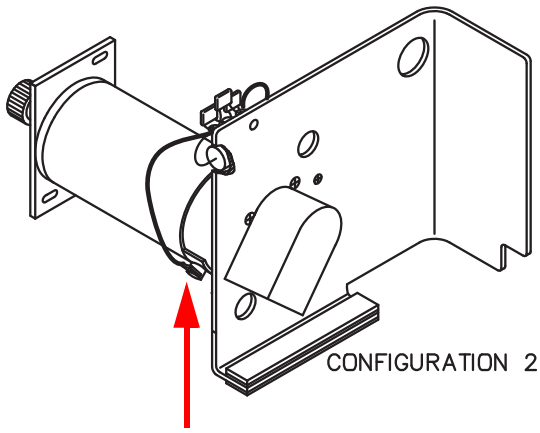


Figure 9-12 SyriXus series motor brush replacement

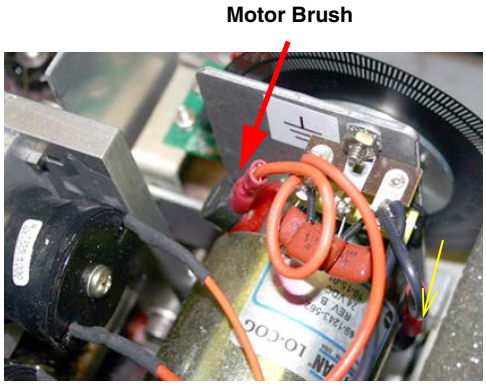


Figure 9-13 Location of motor brushes

A new brush is 1.1 cm long. Brushes should be replaced before they wear to less than 0.4 cm long.

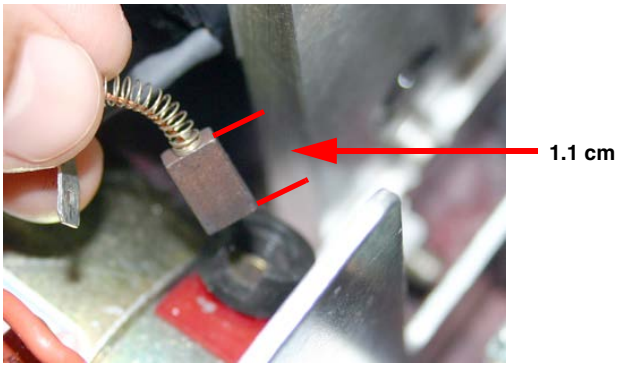


Figure 9-14 Length of a new motor brush (1.1 cm)

1. Unscrew the brush retainer from the motor using a straight edge screwdriver.
2. Pull the brush out of the slot and measure its length. If it is nearing 0.4 cm, replace both brushes.

NOTE

Alternatively, the entire motor can be replaced instead. For longer-lived optimal performance, replace the motor when the brushes wear down.

9.14.1 Motor Brush Disassembly

1. Remove the wire lead by pulling on the spade connector.
2. Unscrew the brush retainer from the motor using a straight edge screwdriver.
3. Pull the old brush out of the slot.
4. Connect the new brush to the wire lead.
5. Insert the new brush into the slot (needle nose pliers recommended).
6. Push the spring down into the slot in the motor. You may need to use the edge of the screwdriver to gently press the metal tabs (Figure 9-15) on the spring down into the slot. Ensure that the tabs on the sides of the brush go into the slot. Reinstall the brush retainer, tightening it with the screwdriver (do not overtighten).

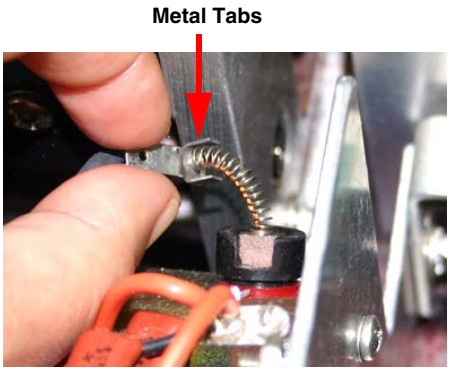


Figure 9-15 Inserting new motor brush

9.15 Calibrations

It should not be necessary to readjust the instrument unless repairs have been made on the electronic circuitry or the controller cable length has been changed.

9.15.1 Pressure Transducer Calibration

NOTE

Please contact the Customer Service Department using the information in 9.3 "Technical Customer Service Department", if your pressure transducer requires recalibration.

9.15.2 A/D Circuit Adjustment

This adjustment is done in the controller unit.

1. With the controller operating and pumps not running, press MENU, MORE, MORE, 2, 3, to display the A/D Calibration screen.
2. Adjust R109 (REF) to obtain a voltage of 2.5000 VDC ± 0.0001 at TP18 (REF) with respect to TP28 (A GND).
3. Connect a jumper between TP25 (ANLG2) and TP28 (A GND).
4. Connect a jumper between TP21 (ANLG1) and TP18 (REF).
5. Adjust R86 (GAIN) until the GAIN display reads 2.5000 ± 0.0001.
6. Adjust R10 (OFFSET) until the OFFSET display reads 0.0000 ±0.0001.
7. Repeat steps 5 and 6 until both readings are within ± 0.0001.
8. Remove the jumpers.

9.15.3 Limit Sensor Adjustment

In the event that the limit sensors must be replaced on the pump, use the following procedure:

1. Disconnect the instrument from mains power.
2. Disconnect the pressure transducer cable from the pump, and remove the tubing from the inlet and outlet ports.
3. Loosen the four cover screws and remove the front and rear tower cover from the pump.
4. The cylinder must be unscrewed several turns to avoid accidentally bottoming the piston out during calibration of the limit sensor. Therefore, loosen the cylinder lock screw approximately two full turns, using a 1/8” hex key. Do not remove the set screw. The lock screw is located in the front side of the cylinder mounting block and is a 1/4-20 setscrew.

5. The limit sensor assembly includes two limit sensors, the wire harness and connector, and a conduit which protects the wires running between the sensors as shown in Figure 9-16.

   Depending upon when your pump was manufactured, the protective conduit may be directly fastened to the pump or retained with mounting tabs and cable ties.

   If the conduit is fastened directly to the case, then it must be removed and the plastic mounting tabs included with the limit sensor assembly package should be installed using the existing screws and screw holes.

To Install the Mounting Tabs

   a. Remove the screws and the conduit.

   b. Then use the same screws and holes to install the mounts. Be sure the tab portion of the mount is facing away from the sensors, as shown in Figure 9-17, (the screw aperture is closest to the sensors).

   If your pump already has the plastic tabs installed, cut and discard the plastic cable ties which run through the tabs and hold the conduit.

6. Remove the four screws holding the limit sensors, and unplug the cable from the power circuit board. The replacement limit sensor assembly includes both the upper and lower sensor and the plug.

NOTE

There are several additional cable ties along the path from the limit sensors to the power board. Two are reusable twist ties and (usually three) others need to be cut to free the limit sensor wires. These cable ties must be replaced to prevent the wires from entangling with the worm gear.

7. Install the new limit sensor harness; and secure the protective conduit by running the cable ties through the mounts and tightening. Then cut the excess cable tie and discard.

NOTE

Be sure the circuit board connector is mated pin-for-pin with the jack.

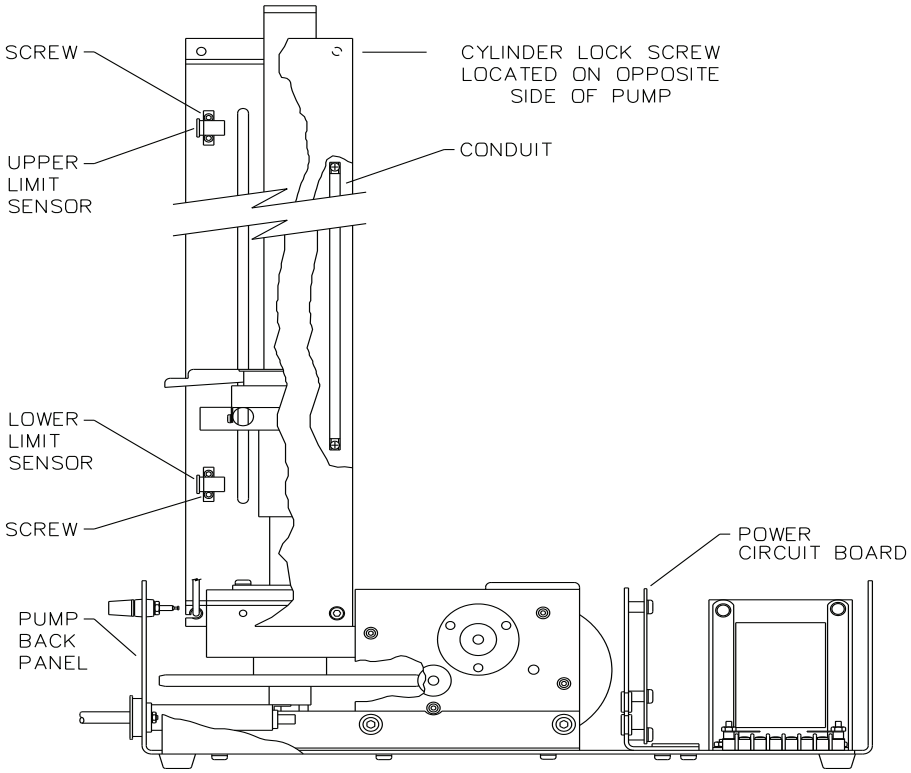


Figure 9-16 Limit sensor replacement

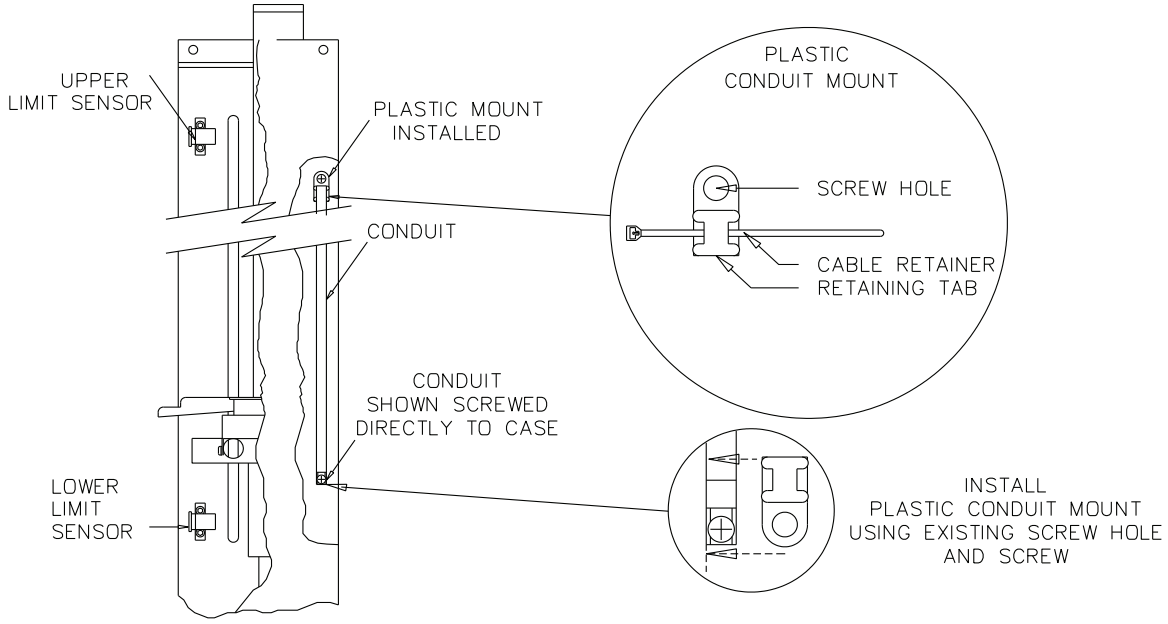


Figure 9-17 Installing the plastic mounts

8. Ensure that the cylinder is unscrewed several turns. If you need to use a wrench, we recommend a strap wrench or wrenches in the Teledyne ISCO wrench package (P/N 60-1247-101) which will not mar the cylinder's outer surface.
9. Center the pump bottom limit sensor with respect to the mounting screws and tighten them.
10. Raise the top limit sensor to the extent of the slots and tighten the upper screw.

NOTE

Install only the top screw in the top sensor and align the bottom slot in the top sensor with the screw hole, at this time. When the pump is run until the cylinder is empty, the sensor flag on the ball screw will obstruct access to the bottom screw on the upper sensor. The bottom screw will be installed after the calibration is completed and the ball screw is lowered.

11. Now the new limit sensors MUST be calibrated, as explained in 9.15.4 "Limit Sensor Calibration".

9.15.4 Limit Sensor Calibration

Once the new limit sensor assembly is installed, the sensors must be calibrated. Before calibrating the limit sensors, be sure the cylinder is unscrewed several turns. Follow steps 8-10 in the previous section (Section 9.15.3 "Limit Sensor Adjustment"). Use the following procedure to calibrate the limit sensors:

1. Connect the pressure cable and power cord and turn the controller ON.
2. Press REFILL and enter the maximum rate.
3. Press STOP when the interrupter flag is approximately 1/4" from the full (lower) sensor.
4. Press 'A' (FLOW RATE), and use the number key to set 10 (mL/min). Press the ENTER key.
5. Press REFILL. After the lower limit sensor is interrupted, the motor will stop.
6. Press CONST FLOW.
7. Press 'A' (FLOW RATE) and select MAX.
8. Press RUN.

NOTE

Watch carefully and ensure that the sensor flag goes into the top sensor without contacting the sensor. If the flag collides with the top sensor, the sensor may be damaged and require replacement.

9. Press STOP when the volume counter in the upper right-hand corner of the LCD reads 005.00 mL or less.
10. Press 'A' (FLOW RATE) and enter 5 mL/min.
11. Press RUN.
12. Press STOP when the counter reads 000.30 or less.
13. Press 'A' (FLOW RATE) and enter 1 mL/min.
14. Press RUN.
15. When the counter counts from 000.01 to 000.00, press STOP.
16. Lower the upper limit sensor to the point where the flag just interrupts the sensor. ('CYLINDER EMPTY' will flash on the screen.)
17. Tighten the top upper limit mounting screw.
18. Turn the controller to STANDBY and disconnect the pressure cable.
19. Screw the cylinder into the cylinder mounting block until the cylinder bottoms firmly against the stop ring in the cylinder mounting block (the cylinder will no longer turn). **Do not overtighten.**
20. Unscrew the cylinder a minimum of a half turn, then line up the inlet and outlet ports as you had them before. Do not unscrew the cylinder more than one full turn from the stop position.
21. Lock the cylinder by tightening the locking screw.
22. Connect the pressure cable and power cord and turn the controller ON.
23. Press REFILL. Wait until you have access to the second upper limit sensor mounting screw slot. Insert the sensor mounting screw and tighten it.
24. Install the covers.

9.15.5 Electric Valve Motor Calibration

If a motor is replaced on the electric valve assembly, it must be calibrated before use, in order to obtain optimum closure force. Remove the top covers from both the controller and the electric valve assembly.

WARNING

The instrument must be powered on during this procedure; use extreme caution while servicing.

1. Note the voltage value written on the side of the newly installed motor.

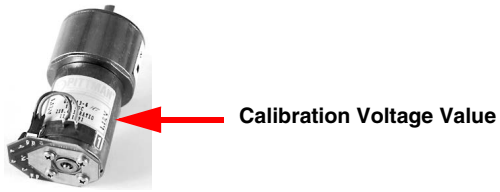


Figure 9-18 Electric valve motor voltage

2. Inside the controller, attach the leads of a voltmeter across resistor R204 on the electric valve interface board.
3. Press ACC CTRL (ACC CTRL) > PRGM GRAD (PRGM GRAD).
4. Press the number key that corresponds with the new motor. This opens the valve.
5. Press the corresponding number key again to close the valve; the motor will continue to apply torque to the valve for approximately 30 seconds.
6. On the electric valve assembly CBA, adjust the corresponding potentiometer to the voltage printed on the side of the motor (refer to Figure 9-19).

NOTE

This procedure must be done during the 30 seconds that the motor is applying torque and the valve is in its closed position. The valve may have to be opened and closed more than once to complete this procedure.

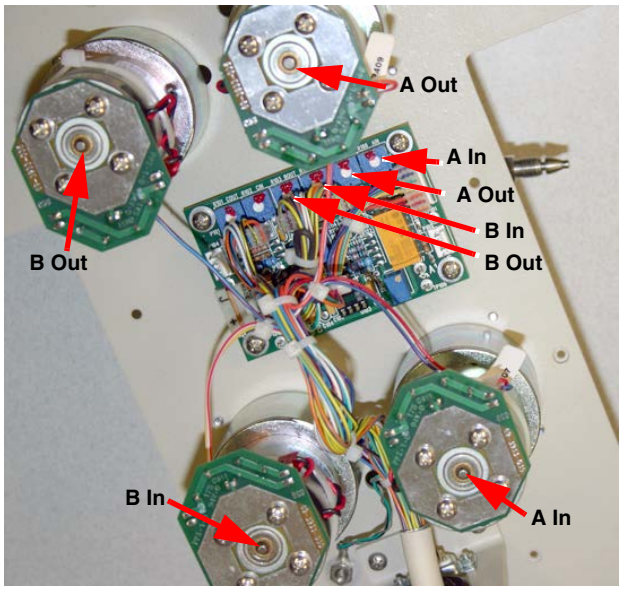


Figure 9-19 Electric valve motor adjustment

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SyriXus Series Pumps Installation and Operation Guide

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Radio Interference Statement - FCC

This equipment has been tested and found to comply with the limits for a class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

Radio Interference Statement - Canada

This ISM apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Ce générateur de fréquence radio ISM respecte toutes les exigences du Règlement sur le materiel brouilleur du Canada.