

PLUM

XL
Series
Infusion Systems

For use with the following list numbers:

Plum XL	11555-04
LifeCare XL	11555-09, 11555-13, 11555-22, 11555-27, 11555-29, 11555-36, 11555-46, 11555-54, 11555-88
Plum XLM	11846-04
LifeCare XLM	11846-09, 11846-13, 11846-22, 11846-27, 11846-29, 11846-36, 11846-42, 11846-46, 11846-54, 11846-88
Plum XLM with DataPort	11859-04
LifeCare XLM with DataPort	11859-27, 11859-36, 11859-54

Technical Service Manual



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North Chicago, IL 60064
USA

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Change History

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	Updated Table 5-1		
	Included international DataPort content		
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	Included nurse call adapter information		

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Contents

Section 1

INTRODUCTION	1-1
1.1 SCOPE	1-1
1.1.1 GLOBAL PRODUCT CONFIGURATIONS	1-2
1.2 CONVENTIONS	1-4
1.3 ACRONYMS AND ABBREVIATIONS	1-4
1.4 USER QUALIFICATION	1-6
1.5 ARTIFACTS	1-6
1.6 INSTRUMENT INSTALLATION PROCEDURE	1-6
1.6.1 UNPACKING	1-6
1.6.2 INSPECTION	1-7
1.6.3 SELF TEST	1-7

Section 2

WARRANTY	2-1
--------------------	-----

Section 3

SYSTEM OPERATING MANUAL	3-1
-----------------------------------	-----

Section 4

THEORY OF OPERATION	4-1
4.1 GENERAL DESCRIPTION	4-1
4.2 ELECTRONICS OVERVIEW	4-2
4.2.1 POWER SUPPLY PWA	4-2
4.2.1.1 SWITCHER CIRCUITRY	4-2
4.2.1.2 VOLTAGE REGULATOR CIRCUITRY	4-3
4.2.1.3 BATTERY CHARGER CIRCUITRY	4-3
4.2.2 POWER SUPPLY PWA	4-4
4.2.2.1 SWITCHER CIRCUITRY	4-5
4.2.2.2 VOLTAGE REGULATOR CIRCUITRY	4-6
4.2.2.3 BATTERY CHARGER CIRCUITRY	4-6
4.2.3 MCU PWA	4-7
4.2.3.1 WATCHDOG CIRCUITRY	4-7
4.2.3.2 SERIAL COMMUNICATION CIRCUITRY	4-7
4.2.3.3 ALARM CIRCUITRY (XL)	4-7
4.2.3.4 ALARM CIRCUITRY (XLM)	4-8
4.2.3.5 ALARM POWER BACKUP CIRCUITRY	4-8
4.2.3.6 MOTOR DRIVER CIRCUITRY	4-8
4.2.3.7 PIN DETECTOR CIRCUITRY	4-9
4.2.3.8 UART (XLM WITH DATAPORT)	4-9
4.2.3.9 NURSE CALL ALARM (XLM WITH DATAPORT - NURSE CALL)	4-9
4.2.4 BUZZER BOARD PWA (XLM)	4-10
4.2.4.1 HIGH VOLUME AUDIBLE ALARM	4-10
4.2.4.2 LOCKOUT SWITCH	4-10
4.2.5 DISPLAY PWA	4-10
4.2.5.1 DISPLAY CIRCUITRY (XL)	4-10
4.2.5.2 DISPLAY CIRCUITRY (XLM)	4-11
4.2.5.3 EL PANEL DRIVER CIRCUITRY (XL)	4-11
4.2.5.4 LED BACKLIGHT PANEL AND DRIVER (XLM)	4-11
4.2.5.5 RUN INDICATOR CIRCUITRY	4-12

4.2.5.6	LINE POWER INDICATOR CIRCUITRY	4-12
4.2.5.7	CONTROL KNOB CIRCUITRY (XL)	4-12
4.2.5.8	CONTROL KNOB CIRCUITRY (XLM)	4-12
4.2.6	SENSOR PWA	4-12
4.2.6.1	PRESSURE AMPLIFIER/FILTER CIRCUITRY	4-13
4.2.6.2	AC (MAINS) AMPLIFIER CIRCUITRY	4-13
4.2.6.3	VOLTAGE REFERENCE CIRCUITRY	4-13
4.2.6.4	OPTO INTERRUPTER CIRCUITRY	4-13
4.2.6.5	EEPROM CIRCUITRY	4-13
4.2.7	BUBBLE SENSOR PWA AND PIN DETECTOR FLEX CIRCUITRY	4-14
4.2.7.1	TRANSMITTER CIRCUITRY	4-14
4.2.7.2	RECEIVER CIRCUITRY	4-14
4.2.7.3	PIN DETECTOR FLEX CIRCUITRY	4-15
4.3	MECHANICAL OVERVIEW	4-15
4.3.1	CASSETTE	4-15
4.3.2	MECHANISM ASSEMBLY	4-17
4.3.2.1	MOTOR AND VALVE ASSEMBLIES	4-18
4.3.2.2	PRIMARY/SECONDARY VALVE SUBSYSTEM	4-18
4.3.2.3	INLET/OUTLET VALVE SUBSYSTEM	4-19
4.3.2.4	PLUNGER DRIVE SUBSYSTEM	4-19

Section 5

MAINTENANCE AND SERVICE TESTS	5-1
5.1 ROUTINE MAINTENANCE	5-1
5.1.1 INSPECTING THE INFUSION SYSTEM	5-1
5.1.2 CLEANING THE INFUSION SYSTEM	5-2
5.1.3 SANITIZING THE INFUSION SYSTEM	5-3
5.2 PERFORMANCE VERIFICATION TEST	5-3
5.2.1 EQUIPMENT REQUIRED	5-3
5.2.2 ICONS AND ENGLISH LANGUAGE EQUIVALENTS	5-4
5.2.3 INSPECTION	5-4
5.2.4 INFUSION SYSTEM TEST SETUP	5-5
5.2.5 SELF TEST	5-5
5.2.6 KEYPAD AND CONTROL KNOB TEST	5-6
5.2.7 OPEN DOOR ALARM TEST	5-7
5.2.8 ALARM LOUDNESS TEST (XL)	5-7
5.2.9 ALARM LOUDNESS AND LOCK FUNCTION TESTS (XLM)	5-7
5.2.10 BATTERY LEGEND TEST	5-8
5.2.11 FREE FLOW TEST	5-8
5.2.12 DISTAL OCCLUSION TEST	5-8
5.2.13 PROXIMAL OCCLUSION TEST	5-10
5.2.14 DELIVERY ACCURACY TEST	5-10
5.2.15 EMPTY CONTAINER/AIR-IN-LINE ALARM TEST	5-11
5.2.16 ELECTRICAL SAFETY TEST	5-12
5.2.17 END OF PERFORMANCE VERIFICATION TEST	5-12
5.3 PERIODIC MAINTENANCE INSPECTION	5-12
5.4 BATTERY OPERATION OVERVIEW	5-12
5.4.1 BATTERY CHARGER CURRENT TEST (OPTIONAL)	5-13
5.5 DATAPORT CONNECTION AND GROUND CONTINUITY TEST (OPTIONAL)	5-15
5.6 NURSE CALL FUNCTION TEST (OPTIONAL)	5-16

Section 6

TRUBLESHOOTING	6-1
6.1 TECHNICAL ASSISTANCE.	6-1
6.2 ALARM MESSAGES AND ERROR CODES	6-1
6.2.1 OPERATIONAL ALARM MESSAGES	6-2
6.2.2 ERROR CODES REQUIRING TECHNICAL SERVICE.	6-6
6.2.3 SERVICE MODE	6-12
6.2.3.1 ALARM HISTORY.	6-12
6.2.3.2 SOFTWARE REVISION NUMBER	6-13
6.2.3.3 RUN TIME AND BATTERY RUN TIME	6-13
6.2.3.4 PARAMETER PROGRAMMING (XLM WITH DATAPORT)	6-13
6.3 TROUBLESHOOTING PROCEDURES.	6-15

Section 7

REPLACEABLE PARTS AND REPAIR.	7-1
7.1 REPLACEABLE PARTS	7-1
7.2 REPAIR PROCEDURES	7-3
7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS	7-3
7.2.2 REQUIRED TOOLS AND MATERIALS	7-3
7.2.3 SEPARATING THE FRONT ENCLOSURE ASSEMBLY, REAR ENCLOSURE ASSEMBLY, AND MAIN CHASSIS ASSEMBLY.	7-4
7.2.4 RUBBER FOOT PAD REPLACEMENT	7-5
7.2.5 BATTERY WITH WIRE HARNESS ASSEMBLY AND BATTERY DOOR COVER PAD REPLACEMENT.	7-6
7.2.6 FRONT ENCLOSURE ASSEMBLY, REAR ENCLOSURE ASSEMBLY, OR MAIN CHASSIS ASSEMBLY REPLACEMENT	7-7
7.2.7 FRONT ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT	7-8
7.2.7.1 DISPLAY PWA AND MCU/DISPLAY RIBBON CABLE REPLACEMENT	7-9
7.2.7.2 KEY INSERT REPLACEMENT	7-10
7.2.7.3 CONTROL KNOB, KNOB DETENT, WASHER, GASKET, SNAP RETAINER, AND DETENT RING REPLACEMENT	7-11
7.2.7.4 FRONT PANEL LABEL REPLACEMENT.	7-12
7.2.8 REAR ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT	7-12
7.2.8.1 FUSE REPLACEMENT	7-13
7.2.8.2 POWER SUPPLY PWA REPLACEMENT	7-15
7.2.8.3 AC (MAINS) POWER CORD, STRAIN RELIEF BUSHING, AND VELCRO RETAINER STRAP REPLACEMENT	7-17
7.2.8.4 AC (MAINS) POWER CORD REPLACEMENT.	7-18
7.2.8.5 DATAPORT/MCU CABLE ASSEMBLY REPLACEMENT (XLM WITH DATAPORT)	7-19
7.2.8.6 POLE CLAMP EXTRUSION, POLE CLAMP BACKING PLATE, AND ADHESIVE-BACKED CLIP INSULATOR REPLACEMENT	7-20
7.2.8.7 POLE CLAMP SHAFT/KNOB ASSEMBLY AND POLE CLAMP SHAFT TIP REPLACEMENT	7-21
7.2.8.8 BUZZER BOARD PWA REPLACEMENT.	7-21
7.2.9 MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT.	7-22
7.2.9.1 MECHANISM ASSEMBLY REPLACEMENT	7-22
7.2.9.2 MCU PWA AND SENSOR/MCU CABLE ASSEMBLY REPLACEMENT	7-24
7.2.9.3 CASSETTE DOOR AND MECHANISM SHIELD REPLACEMENT	7-25
7.2.9.4 OPENER HANDLE ASSEMBLY REPLACEMENT	7-29

Section 8

SPECIFICATIONS 8-1
 8.1 PLUM XL AND XLM 8-1
 8.2 LIFECARE XL AND XLM 8-2

Section 9

DRAWINGS 9-1

Section 10

INDEX 10-1

Figures

Figure 1-1 Plum XL Icon Based and English Language Front Panels 1-3
 Figure 1-2 Plum XLM Icon Based and English Language Front Panels 1-3
 Figure 1-3 Plum XL LCD Test Screens 1-8
 Figure 1-4 Plum XLM LCD Test Screens 1-8
 Figure 4-1 Major Elements of the Dual-Channel Cassette 4-16
 Figure 4-2 Fluid Path in the Cassette. 4-17
 Figure 4-3 Mechanism Valve Pins and Sensor Locations. 4-18
 Figure 5-1 Icons and English Language Equivalents 5-4
 Figure 5-2 Plum XL LCD Test Screens 5-6
 Figure 5-3 Plum XLM LCD Test Screens 5-6
 Figure 5-4 Distal Occlusion Test Setup 5-9
 Figure 5-5 Special Cassettes with Bubble Sensor Tips Removed 5-11
 Figure 5-6 Battery Charger Current Test Configuration 5-14
 Figure 5-7 DataPort Connector 5-16
 Figure 7-1 Front Enclosure, Main Chassis Assembly, and Rear Enclosure. 7-5
 Figure 7-2 Bottom View of Infusion System 7-6
 Figure 7-3 Display PWA and MCU/Display Ribbon Cable 7-8
 Figure 7-4 Control Knob, Knob Detent, Washer, Gasket, Snap Retainer, and Detent Ring Placement 7-9
 Figure 7-5 Rear Enclosure Assembly Components (115 VAC - Plum XL) 7-13
 Figure 7-6 Rear Enclosure Assembly Components (220 VAC - Plum XL) 7-14
 Figure 7-7 Rear Enclosure Assembly Components (115 VAC - Plum XLM) 7-16
 Figure 7-8 Rear Enclosure Assembly Components (220 VAC - Plum XLM) 7-17
 Figure 7-9 Exploded View of the Main Chassis Assembly 7-23
 Figure 7-10 Top View of the Main Chassis Assembly 7-25
 Figure 7-11 Mechanism Shield Replacement 7-26
 Figure 7-12 Cassette Door Replacement 7-27
 Figure 7-13 Cassette Door Replacement, Bottom View 7-29
 Figure 7-14 Opener Handle Assembly Replacement 7-30
 Figure 9-1 IPB for the Infusion System 9-5
 Figure 9-2 Front Enclosure, Rear Enclosure, and Main Chassis Assemblies 9-9
 Figure 9-3 Front Enclosure Assembly 9-11
 Figure 9-4 Rear Enclosure Assembly (XL - Domestic) 9-13
 Figure 9-5 Rear Enclosure Assembly (XL - International) 9-15
 Figure 9-6 Rear Enclosure Assembly (XLM - Domestic) 9-17
 Figure 9-7 Rear Enclosure Assembly (XLM - International). 9-19
 Figure 9-8 Rear Enclosure Assembly (XLM with DataPort - Domestic). 9-21
 Figure 9-9 Rear Enclosure Assembly (XLM with DataPort - International) 9-23

Figure 9-10	Chassis Assembly (XL)	9-25
Figure 9-11	Chassis Assembly (XLM)	9-27
Figure 9-12	Battery Replacement	9-29
Figure 9-13	Mechanical Assembly	9-31
Figure 9-14	Plum XL Block Diagram	9-35
Figure 9-15	MCU PWA Schematic (XL)	9-37
Figure 9-16	MCU PWA Schematic (XLM)	9-41
Figure 9-17	MCU PWA Schematic (XLM with DataPort)	9-45
Figure 9-18	Display PWA Schematic (XL)	9-63
Figure 9-19	Display PWA Schematic (XLM)	9-65
Figure 9-20	Bubble Sensor PWA Schematic	9-73
Figure 9-21	Sensor PWA Schematic	9-75
Figure 9-22	Pin Detector Flex Circuit Schematic	9-79
Figure 9-23	Power Supply PWA Schematic (XL - Domestic)	9-81
Figure 9-24	Power Supply PWA Schematic (XL - International)	9-85
Figure 9-25	Power Supply PWA Schematic (XLM - Domestic)	9-89
Figure 9-26	Power Supply PWA Schematic (XLM - International)	9-93
Figure 9-27	Power Supply PWA Schematic (XLM with DataPort)	9-101
Figure 9-28	Buzzer Board PWA Schematic	9-105

Tables

Table 1-1.	Global Product Configurations	1-2
Table 1-2.	Conventions	1-4
Table 4-1.	Battery Charge Current States	4-4
Table 5-1.	Cleaning Solutions	5-2
Table 5-2.	Battery Charger Current Test Parameters	5-14
Table 6-1.	Operational Alarm Messages and Corrective Actions	6-2
Table 6-2.	Error Codes Requiring Technical Service	6-6
Table 6-3.	Service Mode Control Knob Settings	6-12
Table 6-4.	Sub-modes of Parameter Programming	6-14
Table 6-5.	Communication Circuitry Selections	6-14
Table 6-6.	PVT Troubleshooting	6-15
Table 7-1.	Wire Color Coding	7-16
Table 9-1.	Drawings	9-1
Table 9-2.	IPB for the Infusion System	9-2

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Section 1

INTRODUCTION

The Plum XL™, XL Micro/Macro, and XL Micro/Macro with DataPort Infusion Systems are dual-line volumetric infusion systems designed to meet the growing demand for hospital-wide device standardization. The infusion system provides primary line, secondary line, and piggyback fluid delivery capabilities to furnish a wide range of general floor, critical care, and home care applications. Compatibility with LifeCare® 5000 PlumSet® administration sets and accessories make the infusion system convenient and cost-effective. The Plum XL Micro/Macro is herein referred to as XLM. The Plum XL Micro/Macro with DataPort is herein referred to as Plum XLM with DataPort.

Note: References to the Plum XL and XLM Infusion Systems apply to the LifeCare XL and XLM Infusion Systems as well.

Note: Unless otherwise stated, references to the Plum XLM include the Plum XLM with DataPort.

1.1 SCOPE

This manual is organized into 11 sections:

- Section 1 Introduction
- Section 2 Warranty
- Section 3 System Operating Manual
- Section 4 Theory of Operation
- Section 5 Maintenance and Service Tests
- Section 6 Troubleshooting
- Section 7 Replaceable Parts and Repair
- Section 8 Specifications
- Section 9 Drawings
- Section 10 Index
- Technical Service Bulletins



If a problem in infusion system operation cannot be resolved using the information in this manual, contact Abbott Laboratories (*see Section 6.1, Technical Assistance*). The *Plum XL System Operating Manual*, *Plum XL Micro/Macro System Operating Manual*, and *Plum XL Micro/Macro with DataPort System Operating Manual*, herein referred to as the system operating manual, contain specific instructions for operating the infusion system. Provision is made for inclusion of the system operating manual in *Section 3* of this manual.

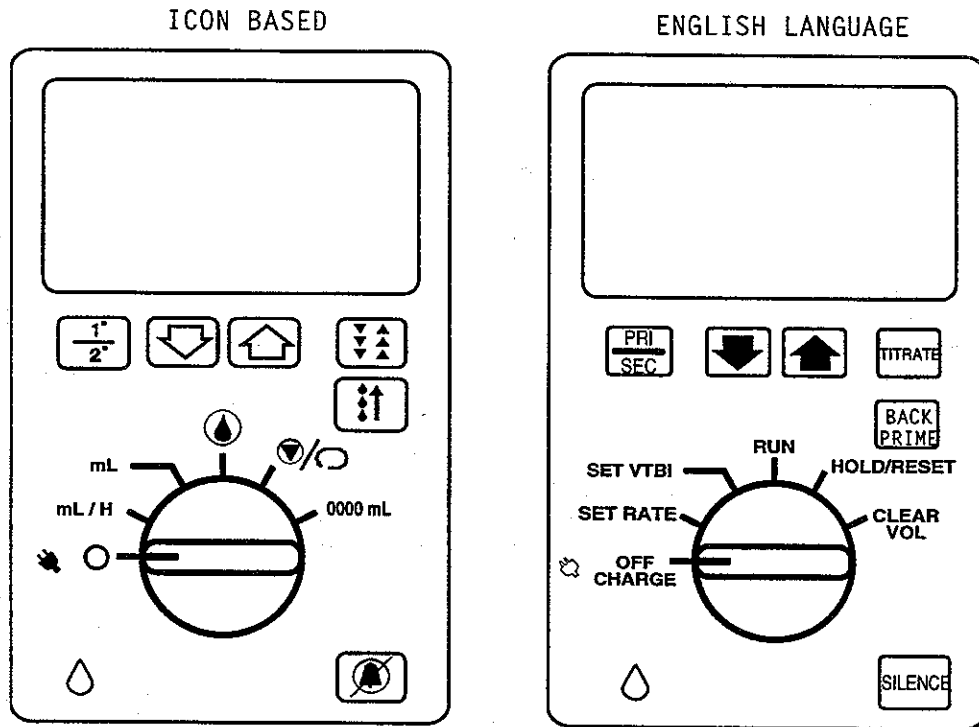
Note: Figures are rendered as graphic representations to approximate actual product; therefore, figures may not exactly reflect the product.

1.1.1

GLOBAL PRODUCT CONFIGURATIONS

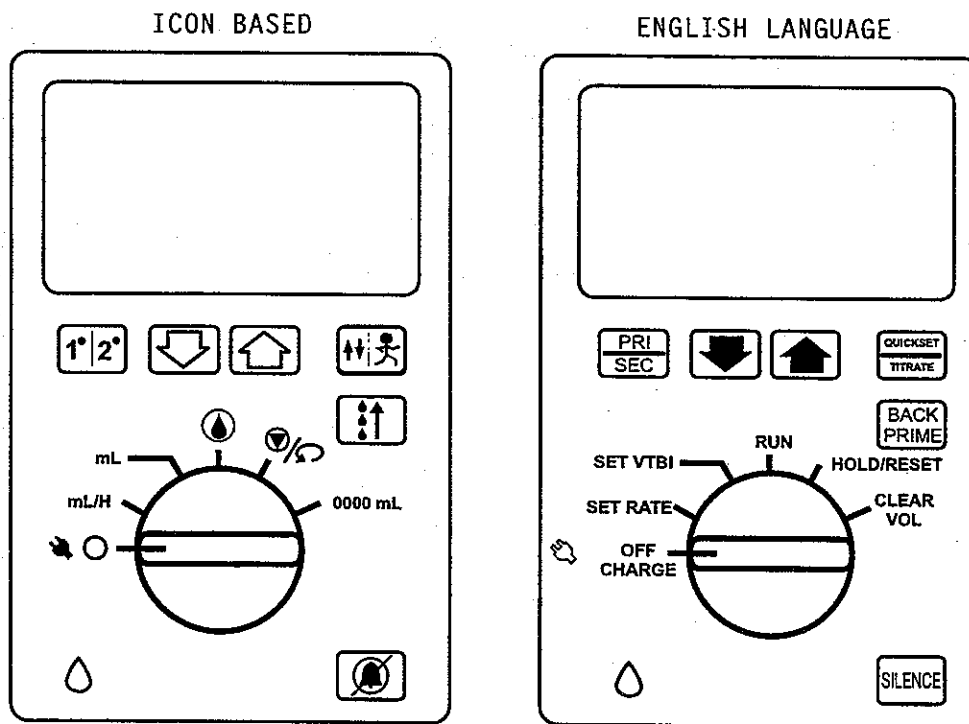
The design of the infusion system facilitates its operation in many countries with slight modification to the product. Three configurations presented in this manual are detailed in *Table 1-1, Global Product Configurations*. The front panels of the English language and icon based system are shown in *Figure 1-1, Plum XL Icon Based and English Language Front Panels* and *Figure 1-2, Plum XLM Icon Based and English Language Front Panels*.

Group Icon	List Number	Country	Power Supply	Rear Case	LCD
	11555-04 11846-04 11859-04	USA	100-130 VAC	Nondetachable AC (mains) power cord	English
	11555-13 11846-13	French Canadian	100-130 VAC	Nondetachable AC (mains) power cord	Icons
	11555-88 11846-88	Spanish (Latin America)			
	11555-27 11846-27 11859-27	Australia	210-260 VAC	Detachable AC (mains) power cord	English
	11555-54 11846-54 11859-54	UK			
	11555-09 11846-09	Spanish (Latin America)	210-260 VAC	Detachable AC (mains) power cord	Icons
	11555-22 11846-22	Spanish			
	11555-29 11846-29	French			
	11555-36 11846-36 11859-36	Europe			
	11846-42	Italy			
	11555-46 11846-46	Swedish			



96B03025

Figure 1-1. Plum XL Icon Based and English Language Front Panels



96B03026

Figure 1-2. Plum XLM Icon Based and English Language Front Panels

1.2 CONVENTIONS

The conventions listed in *Table 1-2, Conventions*, are used throughout this manual.

Convention	Application	Example
<i>Italic</i>	Reference to a section, figure, table, or publication	(see <i>Figure 5-4, Distal Occlusion Test Setup</i>)
[ALL CAPS]	In-text references to keys are described in all caps and enclosed in brackets	[TITRATE]
ALL CAPS	Screen displays	DOOR/CASSETTE
Bold	Emphasis	CAUTION: Use proper ESD grounding techniques when handling components.

Throughout this manual, warnings, cautions and notes are used to emphasize important information as follows:

WARNING

A WARNING CONTAINS SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING IS POTENTIALLY LIFE THREATENING.

CAUTION: A CAUTION usually appears in front of a procedure or statement. It contains information that could prevent irreversible equipment damage or failure.

Note: A note highlights information that helps explain a concept or a procedure.

1.3 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

- A Ampere
- AC Alternating current
- ACE Asynchronous communication element
- AC RMS Alternating current root mean square
- A/D Analog-to-digital
- CMOS Complementary metal-oxide semiconductor
- CPU Central processing unit

DC	Direct current
DMM	Digital multimeter
DPM	Digital pressure meter
ECG	Electrocardiograph
EEG	Electroencephalogram
EEPROM	Electrically erasable programmable read-only memory
EL	Electroluminescent
EMG	Electromyogram
EMI	Electromagnetic interference
ETO	Ethylene oxide
hr	Hour
Hz	Hertz
IC	Integrated circuit
IPB	Illustrated parts breakdown
IV	Intravenous
kHz	Kilohertz
KVO	Keep vein open
LCD	Liquid crystal display
LED	Light-emitting diode
mA	Milliamperes
MCU	Micro controller unit
MHz	Megahertz
ml	Milliliter
mV	Millivolt
PLL	Phase-lock loop
PVT	Performance verification test
PSI	Pounds per square inch
PWA	Printed wiring assembly
SPSTIN	Single-pole, single-throw in
UART	Universal Asynchronous Receiver/Transmitter
VCO	Voltage-controlled oscillator
VCC	Collector supply voltage
VDC	Volt DC
VDIG	Digital voltage
V_{pp}	Volts peak-to-peak
VTBI	Volume to be infused
μl	microliters
μs	microsecond

1.4

USER QUALIFICATION

The infusion system is for use at the direction or under the supervision of licensed physicians or by licensed or certified healthcare professionals who are trained in the use of the infusion system and the administration of parenteral fluids or drugs.

1.5

ARTIFACTS

Non hazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion devices. These potentials are well within accepted safety standards, but may create artifacts on voltage-sensing equipment such as ECG, EMG, and EEG machines. These artifacts vary at a rate that is associated with the infusion rate. If the monitoring machine is not operating correctly or has loose or defective connections to its sensing electrodes, these artifacts may be accentuated so as to simulate actual physiological signals. To determine if the abnormality in the monitoring equipment is caused by the infuser instead of some other source in the environment, set the infuser so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the infuser. Proper setup and maintenance of the monitoring equipment should eliminate the artifact. Refer to the appropriate monitoring system documentation for setup and maintenance instructions.

1.6

INSTRUMENT INSTALLATION PROCEDURE

CAUTION: Infusion system damage may occur unless proper care is exercised during unpacking and installation. The battery may not be fully charged upon receipt of the infusion system. Do not place the infusion system in service if it fails the self test.

CAUTION: Infusion system performance may be degraded by electromagnetic interference (EMI) from devices such as electrosurgical units, cellular phones, and two-way radios. Operation of the infusion system under such conditions should be avoided.

The infusion system installation procedure consists of unpacking, inspection, and self test.

Note: Do not place the infusion system in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infusion system to AC (mains) power for eight hours (*see Section 8, Specifications*).

1.6.1

UNPACKING

Inspect the infusion system shipping container as detailed in *Section 1.6.2, Inspection*. Use care when unpacking the infusion system. Retain the packing slip and save all packing materials in the event it is necessary to return the infusion system to the factory. Verify that the shipping container includes a copy of the system operating manual.

1.6.2**INSPECTION**

Inspect the infusion system packing container for shipping damage. Should any damage be found, contact the delivering carrier immediately.

CAUTION: Inspect the infusion system for damage. Should damage be found, contact Abbott Laboratories (*see Section 6.1, Technical Assistance*). Do not use the infusion system if it appears to be damaged.

Inspect the infusion system periodically for signs of defects such as worn accessories, broken connections, or damaged cable assemblies. Also inspect the infusion system after repair or during cleaning. Replace any damaged or defective external parts.

1.6.3**SELF TEST**

CAUTION: Conduct the self test before placing the infusion system in service. Do not place the infusion system in service if the self test fails.

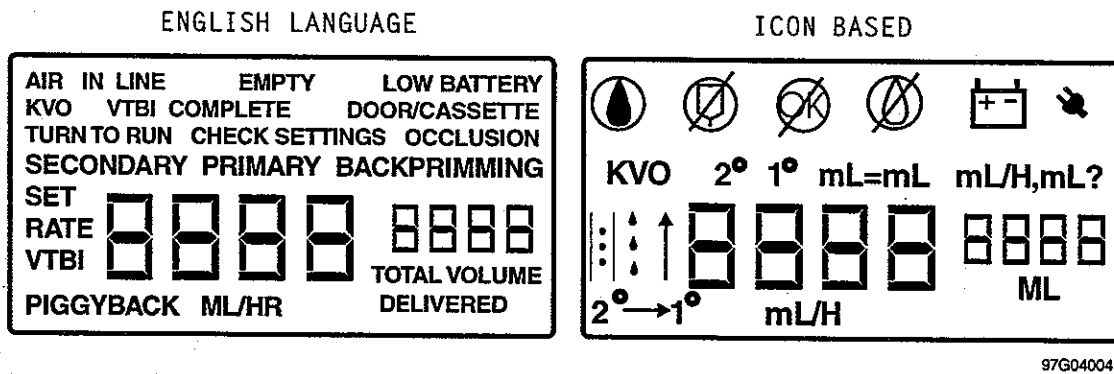
To perform the self test, refer to *Figure 1-3, Plum XL LCD Test Screens* and *Figure 1-4, Plum XLM LCD Test Screens*, and proceed as follows:

1. Connect the infusion system AC (mains) power cord to a grounded AC (mains) outlet and confirm the AC (mains) power icon (next to the OFF/CHARGE setting) illuminates.
2. Open the door assembly (cassette door) by lifting up on the cassette door handle.
3. Hold a primed cassette by its handle and insert the cassette into the cassette door guides. Do not force the cassette into position.
4. Close the cassette door handle to lock the cassette in place.
5. Turn the control knob to SET RATE to initiate the self test.
6. Verify the following screens display: the LCD test screen; four backward Cs (approximately two seconds); set rate screen.

Note: If the LCD test screen does not match *Figure 1-3* or *Figure 1-4* exactly, contact Abbott Laboratories.

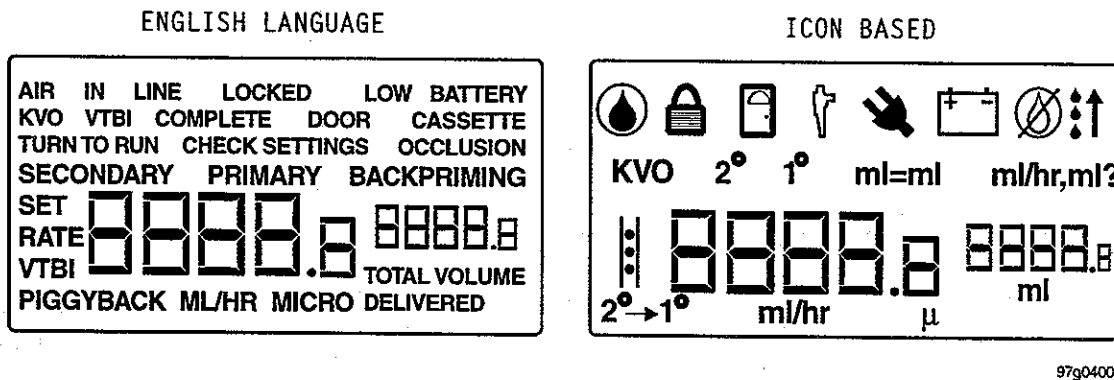
Note: If an alarm condition occurs during the self test, turn the control knob to OFF/CHARGE and repeat Step 5 and Step 6. If the alarm condition recurs, note the message and take corrective action (*see Section 6, Troubleshooting*). Repeat the self test. If the alarm condition recurs, remove the infusion system from service and contact Abbott Laboratories.

7. Disconnect the infusion system from AC (mains) power and confirm BATTERY displays on the LCD screen.
8. Turn the control knob to OFF/CHARGE and remove the administration set.
9. To allow the battery to charge fully, connect the infusion system to AC (mains) power for a minimum of eight hours with the control knob in the OFF/CHARGE position. Confirm the AC (Mains) power icon illuminates.



97G04004

Figure 1-3. Plum XL LCD Test Screens



97g04005

Figure 1-4. Plum XLM LCD Test Screens

Note: All LCD screens on international infusion systems are icon-based, with the exceptions of country codes 27 and 54.

Section 2

WARRANTY

Subject to the terms and conditions herein, Abbott Laboratories, herein referred to as Abbott, warrants that (a) the product shall conform to Abbott's standard specifications and be free from defects in material and workmanship under normal use and service for a period of one year after purchase, and (b) the replaceable battery shall be free from defects in material and workmanship under normal use and service for a period of 90 days after purchase. Abbott makes no other warranties, express or implied, as to merchantability, fitness for a particular purpose, or any other matter.

Purchaser's exclusive remedy shall be, at Abbott's option, the repair or replacement of the product. In no event shall Abbott's liability arising out of any cause whatsoever (whether such cause be based in contract, negligence, strict liability, other tort, or otherwise) exceed the price of such product, and in no event shall Abbott be liable for incidental, consequential, or special damages or losses or for lost business, revenues, or profits. Warranty product returned to Abbott must be properly packaged and sent freight prepaid.

The foregoing warranty shall be void in the event the product has been misused, damaged, altered, or used other than in accordance with product manuals so as, in Abbott's judgment, to affect its stability or reliability, or in the event the serial or lot number has been altered, effaced, or removed.

The foregoing warranty shall also be void in the event any person, including the Purchaser, performs or attempts to perform any major repair or other service on the product without having been trained by an authorized representative of Abbott and using Abbott documentation and approved spare parts. For purposes of the preceding sentence, "major repair or other service" means any repair or service other than the replacement of accessory items such as batteries, flow detectors, detachable AC power cords, and patient pendants.

In providing any parts for repair or service of the product, Abbott shall have no responsibility or liability for the actions or inactions of the person performing such repair or service, regardless of whether such person has been trained to perform such repair or service. It is understood and acknowledged that any person other than an Abbott representative performing repair or service is not an authorized agent of Abbott.

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Section 3

SYSTEM OPERATING MANUAL

A copy of the system operating manual is included with every infusion system. Insert a copy here for convenient reference. If a copy of the system operating manual is not available, contact Abbott Laboratories Technical Support Operations (*see Section 6.1, Technical Assistance*).

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Section 4

THEORY OF OPERATION

This section describes the infusion system theory of operation. Related drawings are provided in *Section 9, Drawings*. The theory of operation details the infusion system general description, electronics overview for both 115 VAC and 220 VAC systems, and mechanical overview of the system.

4.1

GENERAL DESCRIPTION

The infusion system includes the following features:

- Volume to be infused (VTBI) setting
- Safeguards to protect against overdelivery:
 - Motor speed is continuously monitored
 - Firmware senses malfunctions that could result in gravity flow
- Volume infused accumulation displays for primary and secondary solutions
- Flow rate selection from 1 to 999 ml/hr in 1 ml increments (XL)
- Flow rate selection from 0 to 99.9 ml in 0.1 ml/hr increments and 100 to 999 ml/hr in 1 ml increments (XLM)
- Battery operation
- Self test
- Simple setup (one hand cassette loading)
- Automatic memory retention of all previous therapy settings and fluid delivery data until cleared by user
- Alarms include the following:
 - OCCLUSION
 - AIR-IN-LINE
 - TURN TO RUN
 - LOW BATTERY
 - DOOR/CASSETTE (XL)
 - DOOR (XLM)
 - CASSETTE (XLM)
 - SET RATE
 - CHECK SETTINGS
 - VTBI COMPLETE
- Two-level adjustable alarm volume
- Remote monitoring with DataPort (XLM with DataPort)
- Nurse call alarm (XLM with DataPort - Nurse Call)

4.2

ELECTRONICS OVERVIEW

This section describes the function and electronic circuitry of each printed wiring assembly (PWA) in the infusion system: power supply PWA, micro controller unit (MCU) PWA, display PWA, buzzer board PWA, sensor PWA, and bubble sensor PWA. Schematic diagrams supporting the operation of infusion system PWAs are in *Section 9, Drawings*.

4.2.1

POWER SUPPLY PWA



The power supply PWA provides direct current (DC) power to system circuits and charges the battery (see *Figure 9-23, Power Supply PWA Schematic (XL - Domestic)*, *Figure 9-25, Power Supply PWA Schematic (XLM - Domestic)* or *Figure 9-27, Power Supply PWA Schematic (XLM with DataPort)*). The power supply PWA consists of switcher circuitry, voltage regulator circuitry, and battery charger circuitry. The following sections describe these circuits.

4.2.1.1

SWITCHER CIRCUITRY



The primary function of the switcher circuitry is to convert alternating current AC (mains) line power to an isolated +11 volts DC (VDC). Fuses F1 and F2, and variable resistor VR1 provide protection against AC (mains) line-high voltage spikes and excessive input power demands. Capacitors C1 and C2, transformer T1, and inductor L1 attenuate the conducted emissions. Bridge rectifier U1, resistor R1, and capacitor C3 provide the DC voltage required for switcher circuit. Diodes CR1 and CR2, R2, R3, CR4, C4, and C9 provide the supply voltage to the current mode-switcher controller integrated circuit (IC) U2. Transistor Q1, transformer T2, IC U2, and the associated passive components are enclosed in a shielded box to minimize radiated electromagnetic interference (EMI). U2 controls the duty cycle of Q1 through resistors R5 and R6. Resistor R9 provides current sensing. Resistor R8 and capacitor C7 filter the ramp voltage across R9 and feed it back to U2.

U2 configuration allows DC voltage at pin 9 (ERR+) to equal the peak voltage across resistor R9. DC voltage controls the delivered power through transformer T2 to regulate the output voltage. Voltage at U2-9 is limited to +1.25 VDC so that peak current through transistor Q1 is limited to approximately 2 amperes (A). This limit constitutes the output short protection.

Optocoupler U3 is part of the main regulation loop; it provides the UL-544 isolation barrier.

Resistor R61, diode CR5, and capacitor C6 provide protection from T2 windings short by applying the higher voltage across resistor R9 to the U2 inhibit input. C6 and the input impedance at U2-4 determine the low hiccup frequency in the event of a T2 winding short.

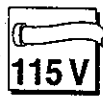
Diode CR3 and the clamp winding of transformer T2 provide intermediate energy transfer to capacitor C3 and limit the peak voltage across transistor Q1. At AC (mains) power-up, capacitor C12 provides delayed timing to permit the voltage potential at U2-14 (Vcc) to reach its minimum level.

Diode CR11 and capacitors C23 and C24 rectify the transformer T2 voltage to create the main DC voltage source (+BUSS) for the infusion system. Diode CR10, resistor R23, IC U4, and capacitor C19 constitute a secondary +12 VDC control loop for protection in case of primary loop failure. Diode CR12 and capacitor C25 create a feed-forward converted negative voltage across capacitor C25 to switch transistor Q9 on through resistor R57 and diode CR14. The Q9 output, housekeeping DC (HKDC), provides the necessary voltage to power both the main regulation loop and the charger circuitry. HKDC is at ground potential when AC (mains) is off and CR12 blocks unnecessary battery power drain. Resistors R58, R59, and R60; capacitors C30, C31, and C32; and IC U9 filter HKDC and create a stable +2.5 VDC reference voltage (F2.5V).

Resistors R21, R39, R44, and R45; capacitor C27; and components U8B and U3 constitute the main control loop. Transistor Q7, resistor R42, and diode CR9 eliminate latch-up at AC (mains) power-up by enabling voltage regulation only after +BUSS reaches +9 VDC.

4.2.1.2

VOLTAGE REGULATOR CIRCUITRY



The primary function of the voltage regulator circuitry is to provide constant DC level output. The motor voltage (VMOT) regulator circuitry (U8A, Q5, Q4, and associated passive components) provides a constant +9.35 VDC output when AC (mains) is on. Transistor Q2 remains forward-biased by HKDC through diode CR8 and resistors R11 and R12. While Q2 remains on, transistor Q3 is disabled to inhibit POWERHOLD and SPSTIN (single-pole, single-throw in) effect on the VMOT voltage regulator.

When AC (mains) is off, Q2 is disabled. If battery operation is required, Q4 is turned on momentarily by the SPSTIN signal and permanently by POWERHOLD. Since Q2 is off, Q4 switches the battery voltage through the VMOT circuitry to supply voltage to the necessary circuits, including the +5 VDC regulator U5. IC U5, the +5 VDC low-drop voltage regulator, powers most of the digital circuits in the infusion system.

4.2.1.3

BATTERY CHARGER CIRCUITRY



The primary function of the battery charger circuitry is to charge the battery. The main component of the battery charger circuitry is a constant current source comprised of transistors Q6 and Q8, IC U6B, resistor R33, and associated passive devices. Q6 is the current carrying device and R33 is the sense resistor. When AC (mains) is off, Q8 is off and Q6 is on.

The battery is charged by two current levels and trickle current (R20). Charge current control is achieved by controlling the voltage at U6-6 by the signals LOCHG (low charge), CHRГ_OFF (charge off), and BAT2 (battery 2). The BAT2 signal is active when a short is introduced at battery connector J26-3 and -4 (an active BAT2 signal implies battery type 2 is connected to connector J26). In this case, the charge current is lower since Q10 is on.

Table 4-1, *Battery Charge Current States*, lists the charge current state as a function of the control signals.

Note: Table 4-1 applies to all 115 VAC and 220 VAC infusion systems.

Table 4-1. Battery Charge Current States			
LOCHG Signal	CHRG_OFF Signal	J26-3 to J26-4	Approximate Current
Low	Low	Short	0.8 A
Low	Low	Open	1.2 A
High	Low	Short	0.16 A
High	Low	Open	0.25 A
Don't care	High	Don't care	Trickle = $(11-V_{bat})/475$

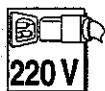
IC U7A also offers overpower protection for transistor Q6. When the voltage across Q6 generates more than +2.5 VDC at U7-4, the charge current switches to low.

The LOCHG_REQ (low charge request) signal alerts the MCU PWA of the battery voltage level. LOCHG_REQ is generated by ICs U6A, U7B, U7C, U7D, and associated passive components.

IC U6A, resistors R24 through R28, and capacitor C20 constitute a differential amplifier that monitors the battery voltage as the battery is being charged. The output of the differential amplifier is compared to a previously determined level by voltage comparator U7C. U7C generates the LOCHG_REQ signal. The voltage level depends on whether U7-13 or -1 is low or, alternately, whether battery one or battery two is connected.

4.2.2

POWER SUPPLY PWA



The power supply PWA consists of switcher circuitry, voltage regulator circuitry, and battery charger circuitry. Refer to *Figure 9-24, Power Supply PWA Schematic (XL - International)*, or *Figure 9-26, Power Supply PWA Schematic (XLM - International)*. The power supply PWA includes the following operational

modes:

- AC (mains) off. Infusion system is not connected to mains voltage and is not operating
- AC (mains) off, infusion system on. Infusion system is not connected to mains voltage and is operating
- AC (mains) on. Infusion system is connected to mains voltage and is not operating
- AC (mains) on, infusion system on. Infusion system is connected to mains voltage and is operating

4.2.2.1

SWITCHER CIRCUITRY



The switcher circuitry converts AC (mains) voltage to an isolated +11 VDC power through flyback topology.

Fuses F1 and F2, and variable resistors VR1 and VR2 provide protection against high-line voltage spikes and abnormally high input power demands. Capacitors C1, C2, C35, C36, C37, and C38, transformer T1, and inductor L1 are designed for attenuating the conducted emissions. IC U1, resistor R1, inductor L1, and capacitor C3 provide the DC voltage required for conversion by the switcher. Diodes CR1, CR2, CR4, and CR15; resistors R22, R68, R73, and R74; capacitors C4, C9, and C34; and transistors Q11 and Q12 provide the DC voltage for IC U2, the current mode switcher controller IC.

A UL-544 isolation barrier surrounds transistor Q1, transformer T2, IC U2, and associated passive components to minimize radiated EMI. Optocoupler U3 is part of the main regulation loop that provides the UL-544 isolation barrier.

IC U2 oscillates at approximately 40 kHz, a frequency dictated by the values of resistor R4 and capacitor C5. U2 controls the duty cycle of transistor switch Q1 through resistors R5 and R6, and diode CR16. Resistor R9 provides the current sense and resistor R8 and capacitor C7 filter the ramp voltage across R9 and feed it back to IC U2.

U2 configuration allows DC voltage at pin 9 (ERR+) to equal the peak voltage across resistor R9. This DC voltage controls the delivered power through transformer T2 to regulate the output voltage. Voltage at U2 pin 9 is limited to +1.25 VDC so that peak current through transistor Q1 is limited to 1.25 VDC divided by the value of resistor R9.

Resistors R61 and R72, diode CR5, and capacitor C6 provide transformer T2 winding short protection by applying the higher voltage across resistor R9 to the U2 inhibit input. C6 and the input impedance at U2-4 apply the low hiccup frequency to protect transistor Q1.

Diode CR3 and the clamp winding of transformer T2 provide intermediate energy transfer to capacitor C3 and limit the peak voltage across transistor Q1.

At AC (mains) power-up, capacitor C12 provides delayed timing to permit the voltage potential at U2-14 (Vcc) to reach its minimum level. Diode CR11, and capacitors C18, C23, and C24 rectify the transformer T2 voltage to create the main DC voltage source for the infusion system. Diode CR10, resistor R23, IC U4, and capacitor C19 constitute a secondary +12 VDC control loop for protection in case of primary loop failure. Diode CR12 and capacitor C25 create a feed-forward converted negative voltage across capacitor C25 to switch transistor Q9 on through resistor R57 and diode CR14. The Q9 output, housekeeping DC (HKDC), provides the necessary voltage to power both the main regulation loop and the charger circuitry. HKDC is at ground level when AC (mains) is off and diode CR14 inhibits unnecessary battery power drain. Resistors R58 through R60, capacitors C30 through C32, and IC U9 filter HKDC and create a stable +2.5 VDC reference voltage (F2.5V). Both HKDC and F2.5V are at ground level when AC (mains) is off.

IC U8B, with resistors R7, R21, R39, R43 through R45, capacitor C27, and IC U3 constitute the main loop control. Transistor Q7, resistor R42, and diode CR9 eliminate latch-up at AC (mains) power-up by enabling voltage regulation only after +BUSS reaches +9 VDC.

4.2.2.2**VOLTAGE REGULATOR CIRCUITRY**

VMOT voltage regulator circuitry (U8A, Q5, and Q4 and associated passive components) is at 9.35 VDC when AC (mains) is on.

Transistor Q2 remains forward-biased by HKDC through diode CR9 and resistors R11 and R12. While transistor Q2 remains on, transistor Q3 is disabled to inhibit POWERHOLD and SPSTIN from affecting the voltage regulator circuitry.

When AC (mains) is off, transistor Q2 is disabled. If battery operation is required, transistor Q4 is turned on momentarily by the SPSTIN signal and permanently by POWERHOLD through transistor Q3. Since Q2 is off, transistor Q4 switches the battery voltage through the VMOT circuitry to supply voltage to the necessary circuits, including the +5 VDC regulator U5. IC U5, the +5 VDC low-drop voltage regulator, powers most of the digital circuits in the infusion system.

4.2.2.3**BATTERY CHARGER CIRCUITRY**

The primary part of the battery charger is the constant current source, comprised of transistors Q6 and Q8, IC U6B, resistor R33, and associated passive devices. Transistor Q6 is the current-carrying device, and resistor R33 is the sense resistor. When AC (mains) is off, transistor Q8 is off and transistor Q6 is on.

The battery is charged by two current levels and trickle current (resistor R20). Current level is achieved by controlling the voltage at U6-6. IC U7A, transistor Q10, and resistors R31, R32, R34, R62, and R63 control the voltage at U6-6, and hence, the current level. The BAT2 signal is high (not logic level) when a short is introduced at the battery connector J26 pins 3 and 4, which implies that battery type 2 is connected to connector J26. In this case, the battery charge current is low since transistor Q10 is on.

IC U7A also serves as an overpower protection for transistor Q6. When the voltage across Q6 generates more than 2.5V at U7-4, the charge current switches to low.

The LOCHG_REQ signal alerts the MCU PWA of the battery voltage level; it is generated by U6A, U7B, U7C, U7D and associated passive components.

IC U6A, resistors R24 through R28, and capacitor C20 constitute a differential amplifier that reads the battery voltage as it is being charged. The output of the differential amplifier is compared to a previously determined level by U7C. U7C generates the LOCHG_REQ. The voltage level depends on whether U7-13 or U7-1 is low or, alternatively, whether battery type 1 or battery type 2 is connected.

4.2.3

MCU PWA

The MCU PWA contains micro controller U6 (see *Figure 9-15, MCU PWA Schematic (XL)*, *Figure 9-16, MCU PWA Schematic (XLM)*, or *Figure 9-17, MCU PWA Schematic (XLM with DataPort)*). The MCU PWA has five digital ports and one analog port. Each port is eight lines wide. The MCU PWA also includes the following circuitry:

- Watchdog
- Serial communication
- Alarm
- Alarm power backup
- Motor drivers
- Pin detector
- Universal Asynchronous Receiver/Transmitter (UART) (XLM with DataPort)

4.2.3.1

WATCHDOG CIRCUITRY

The watchdog circuitry continuously monitors the MCU PWA and contains IC U14. U14 is strobed by micro controller U16 at a predetermined minimum frequency; otherwise, the *RESET output becomes active. *RESET also becomes active if digital voltage (VDIG) is out of range. *RESET causes the MCU PWA to reset, blocks any signal to the motors, and turns the alarm on.

4.2.3.2

SERIAL COMMUNICATION CIRCUITRY

The serial communication circuitry interchanges data between the MCU PWA and either the liquid crystal display (LCD) screen or the electrically erasable programmable read-only memory (EEPROM).

Although data is transmitted to both the LCD screen and the EEPROM, the clock is diverted only to the selected receiver. If EE_CS is active, then *SCK appears as EE_CLK at IC U9C. If EE_CS is inactive, then *SCK is inverted to appear as LCD_CLK at IC U8B.

Data is read from either the LCD screen or the EEPROM. If EE_CS is active, then EE_DO appears as RXD at IC U7C. If EE_CS is inactive, then LCD_DO is inverted to appear as RXD at IC U7C.

4.2.3.3

ALARM CIRCUITRY (XL)

The alarm circuitry includes an oscillator circuit consisting of inverters U10C, U10B, and U10E. The oscillator circuit generates acoustic power at a predetermined frequency based on the BUZ1 self resonance. Normally, the BUZZER signal is low, U9-10 is high, and resistor network RN8-7 and RN8-8 disables the oscillator. The alarm can be activated by the BUZZER or *RESET signals becoming active and pulling RN8-7 down. When SW1 is set to LO, resistor R13 is electronically connected to the BUZ1-3 (buzzer drive) and the sound level decreases. U10D and U10F constitute a memory unit that disables the oscillator circuit when the U10F output is high.

At AC (mains) power-up, POWERHOLD becomes active and changes the U10D/U10F memory unit to enable the oscillator circuit. At a voluntary power-off, DIST_AIR_EN and PROX_AIR_EN become momentarily active. This momentary activation of DIST_AIR_EN and PROX_AIR_EN allows the memory unit to change to an oscillator-disabling state and the alarm does not sound. At a catastrophic failure, however, the memory unit remains enabled and the alarm sounds.

During a catastrophic failure, the alarm can be disabled by positioning the infusion system control knob to OFF/CHARGE.

4.2.3.4

ALARM CIRCUITRY (XLM)

The alarm circuitry includes an oscillator circuit consisting of inverters U10C, U10B, and U10E. The oscillator circuit generates acoustic power at a predetermined frequency based on the BUZ1 self resonance. Normally, the BUZZER signal is low, U9-10 is high, and resistor network RN8-7 and RN8-8 disables the oscillator. The alarm can be activated by the BUZZER or *RESET signals becoming active and pulling RN8-7 down. U10D and U10F constitute a memory unit that disables the oscillator circuit when the U10F output is high.

At AC (mains) power-up, POWERHOLD becomes active and changes the U10D/U10F memory unit to enable the oscillator circuit. At a voluntary power-off, DIST_AIR_EN and PROX_AIR_EN become momentarily active. This momentary activation of DIST_AIR_EN and PROX_AIR_EN allows the memory unit to change to an oscillator-disabling state and the alarm does not sound. At a catastrophic failure, however, the memory unit remains enabled and the alarm sounds.

During a catastrophic failure, the alarm can be disabled by positioning the infusion system control knob to OFF/CHARGE.

The alarm circuitry provides sound for low-level settings only. For high-level sound, see *Section 4.2.4, Buzzer Board PWA (XLM)*.

4.2.3.5

ALARM POWER BACKUP CIRCUITRY

The alarm power backup circuitry is provided through super capacitor C34. C34 offers power backup in the event of a catastrophic failure. Diodes CR15, CR19, and CR20 route the power for alarm driver U10 from VDIG or C34.

4.2.3.6

MOTOR DRIVER CIRCUITRY

The motor driver circuitry energizes the three stepper motors: plunger, input/output, and primary/secondary. The MCU PWA micro controller, U6, outputs MOTPHAS1 and MOTPHAS2 to inverters U9A and U9F which generate two additional signals: *MOTPHAS1 and *MOTPHAS2. These four signals are required to step the motors. Three motor enable signals manage the motor step width. The motor enable signals are: MOTPLN_EN (motor plunger enable), MOTIO_EN (motor input/output enable), and MOTPS_EN (motor primary/secondary enable). The four motor stepping signals activate ICs U2A, U3A, U3D, and U2D; or U2B, U3B, U3C, and U2C; or U5D, U5A, U4A, and U4D to switch the power metal-oxide semiconductor field-effect transistors (MOSFETs) Q1 through Q4, Q5 through Q8, or Q9 through Q12. When active, *RESET disables motor activity.

4.2.3.7**PIN DETECTOR CIRCUITRY**

The pin detector circuitry detects the primary and secondary valve pin motion. When PSV_EN is active, *PSV_EN becomes active and a constant current flows through light-emitting diode (LED) CR1 and LED CR2. CR1 and CR2 are located in the pin detector sensor assembly mounted on the bubble sensor PWA. If *P_S_EN is active, IC U11A is activated and U11B is de-activated, and vice versa. U11 serves as two hysteresis comparators and its output, PS_VALVE, is edge detected by the MCU PWA. The positive edges are detected by the MCU PWA INT1 input. The negative edges are detected by the MCU PWA PC3 input.

4.2.3.8**UART (XLM WITH DATAPORT)**

The UART used in the Plum XLM with DataPort infusion system is TL16C450 made by Texas Instruments. It is a complementary metal-oxide-semiconductor field-effect transistor (CMOS) version of an asynchronous communication element (ACE) typically functioning in a microcomputer system as a serial input/output interface.

The UART performs serial-to-parallel conversion on data received from the host computer and performs parallel-to-serial conversion on data received from the MCU. The MCU can read the status of the UART at any point in its operation. The status information includes the type of transfer operation in progress, the status of the operation, and any error conditions encountered.

The UART includes a programmable, on-board baud rate generator which is capable of dividing a reference clock input by divisors from 1 to (2¹⁶ - 1) and producing a 16 x clock to drive the internal transmitter logic. Provisions are also included to use this 16 x clock to drive the receiver logic. In the Plum XLM with DataPort infusion system, data is transmitted and received at 1,200 bits per second. The 16 x clock is running at 19,200Hz (16 x 1,200).

The UART includes a complete modem control capacity and a processor interrupt system that is software adjustable to user requirements minimize the computing required to handle the communication link. The software of the Plum XLM with DataPort infusion system programs the UART not to use its modem control capacity, but to interrupt the MCU when a byte of data is received from or transmitted to the host computer.

4.2.3.9**NURSE CALL ALARM (XLM WITH DATAPORT - NURSE CALL)**

During an alarm, an isolated contact closure is made by U22, a solid-state FET relay. The BUZZER signal from the microprocessor is filtered to maintain the contact closure between short beeps by the diode and RC network at the input to the driver U5.

The connection to the nurse call feature is made by an adapter that mates to the 15-pin serial port. The nurse call adapter connects to existing signalling equipment with a 1/4" phone plug.

4.2.4**BUZZER BOARD PWA (XLM)**

The buzzer board PWA is installed on the Plum XLM and XLM with DataPort (see *Figure 9-28, Buzzer Board PWA Schematic*). The buzzer board PWA includes the following circuitry:

- High volume audible alarm
- Lockout switch

4.2.4.1**HIGH VOLUME AUDIBLE ALARM**

In addition to the MCU PWA alarm circuitry, a loud piezo alarm buzzer is installed on the buzzer board PWA for high volume setting (see *Section 4.2.3.4, Alarm Circuitry (XLM)*). The high volume setting is selected by lever switch SW1. Switch SW1 is located on the buzzer board PWA, and during normal operation is accessible on the rear enclosure.

The BUZZER_HI signal connects to the central processing unit (CPU) port on the MCU PWA. The SPSTIN_BUZ signal connects to the SPSTIN (+BUSS) signal on the MCU PWA. SPSTIN_BUZ is the battery charging voltage. When an alarm occurs, the processor activates BUZZER_HI. When the switch SW1 is closed (high setting), the high volume piezo buzzer and the alarm circuitry on the MCU PWA activate. When switch SW1 is open (low setting), only the MCU PWA alarm circuitry activates.

4.2.4.2**LOCKOUT SWITCH**

The lockout switch SW2 is located on the buzzer board PWA and is accessible on the rear enclosure of the Plum XLM. The lockout switch is connected to the LOCKOUT1 signal on the display PWA, and to the LOCKOUT2 signal on the MCU PWA. LOCKOUT1 connects to the collector of Q7 on the display PWA. When lockout switch SW2 is closed, and Q7 saturates, LOCKOUT2 goes low and the LOCKED icon on the LCD illuminates.

4.2.5**DISPLAY PWA**

The display PWA receives serial data from the MCU PWA and displays it at the LCD (see *Figure 9-18, Display PWA Schematic (XL)*, or *Figure 9-19, Display PWA Schematic (XLM)*). The display PWA also includes most of the control knob functions required to operate the infusion system. The display PWA includes the following circuitry: display, electroluminescent (EL) panel driver (XL), LED backlight panel and driver (XLM), RUN indicator, line power indicator, and control knob.

4.2.5.1**DISPLAY CIRCUITRY (XL)**

ICs U2 and U3 are master- and slave-type serial input LCD drivers and are cascaded to form a 92-segment (4 back-plane by 23 fore-plane) driver. LCD panel U1 is designed to match the drivers and has 88 segments.

Display data is serially clocked into U2 at pin 21. The clocking signal, LCD CLK, is received at U2-23 and U3-22. The drive frequency is not synchronized to the data input and is dictated by resistor R7. To eliminate a false display during data updates, U2 and U3 are disabled by CR3, C14, R9, R8, and Q3.

4.2.5.2

DISPLAY CIRCUITRY (XLM)

IC U2 is the 128 segment LCD driver that can drive the four backplanes and 32 frontplanes. LCD panel U4 has 110 front panel segments multiplexed with the four backplanes.

Display data is clocked serially into U2 via DIN (pin 39) and DCLK (pin 38). The LCD drive frequency (approximately 100Hz) is set by R7 and is not synchronized to the data input into U2.

4.2.5.3

EL PANEL DRIVER CIRCUITRY (XL)

Transistor Q1 and transformer T1 windings 1-3 (primary) and 4-2 (feedback) constitute the main oscillator positive feedback. The T1 output winding (5, 8) provides a large-turn ratio (to T1 primary winding) to boost the output to 300 volts peak-to-peak (Vpp). The capacitance of EL panel EL1 and the inductance of the T1 output winding dictates the oscillation frequency of 300 hertz (Hz) to 500 Hz. As the capacitance of EL1 decreases because of aging, the frequency increases to maintain a constant brightness.

A control loop consisting of diode CR1; capacitors C13 and C10; resistors R13, R4, R3, and R6; IC U10B; and transistor Q2 maintains a constant output amplitude by rectifying the output and comparing it to the ELON signal.

4.2.5.4

LED BACKLIGHT PANEL AND DRIVER (XLM)

The display backlight panel is an array of 60 LEDs arranged as parallel elements of two series LEDs. The required drive voltage of the panel equals two LED voltage drops of approximately 4.2 VDC. The actual forward voltage changes with temperature and varies from panel to panel. Driving the panel with a constant current compensates for varying voltage requirements.

The XLM backlight panel requires approximately 200 mA for optimum brightness. The current is controlled utilizing a current mode switching technique enabling high efficiency operation with a wide power supply range of 7 to 11 volts. The signal VMOT is the supply voltage for the backlight constant current regulator.

Current through U5, LED panel, is regulated by Q3 operation until the voltage across current sensing resistors R14, R23, and R24 exceeds a reference voltage of approximately 96 mV. The voltage drop is filtered by R13 and C7 and then compared to the turn-off threshold determined by the voltage divider R11 and R12. Comparator U3, pin 1 drives low when the current through R14, R23, and R24 exceeds the turn-off threshold, discharging C4. U1 senses the quick discharge of C1 and then turns off Q1.

Q1 remains off while C4 charges via resistor R9. Q3 turns on when the the charge on C4 exceeds the input voltage high threshold of U3, pin 2.

4.2.5.5**RUN INDICATOR CIRCUITRY**

LED_{RUN}, when active, turns LED1 on. IC U10A (Q8 XLM) functions as a constant current source to LED1 by maintaining constant voltage across resistor R20. The voltage is approximately +3.33 VDC.

4.2.5.6**LINE POWER INDICATOR CIRCUITRY**

HKDC is active when the infusion system is operating on AC (mains), and turns on the line power indicator, LED2. HKDC brings transistor Q4 base voltage to VDIG + Vf through R15 (Vf equals forward voltage of diode CR1). This base voltage change causes Q4 to conduct and the current through LED2 equals approximately VDIG divided by the value of resistor R14.

4.2.5.7**CONTROL KNOB CIRCUITRY (XL)**

The control knob circuitry consists of transistor Q5; rotary switch Hall-effect sensors U11 through U15; reed switch S7; ICs U4, U5, and U7 through U9; and associated passive components. The control knob circuitry senses the control knob position and sends the position code to the MCU PWA. The HSENSEN signal, when active, switches transistor Q5 on and allows the output of rotary switch Hall-effect sensors U11 through U15 to be gated through ICs U4, U5, and U7 through U9. Resultant output conditions of rotary 0 (ROT0), ROT1, and ROT2 at ICs U9B, U7B, and U7A are sent to the MCU PWA as a three-bit code representing the control knob position. The S7 reed switch output, SPSTIN is transferred to the power supply PWA. If more or less than one Hall-effect sensor position signal is active, ROT0, ROT1, and ROT2 become active simultaneously to signify a failure. If the control knob is set to the OFF/CHARGE position, *SESTIN is enabled.

4.2.5.8**CONTROL KNOB CIRCUITRY (XLM)**

The control knob circuitry consists of transistor Q5; rotary switch Hall-effect sensors U11 through U15; reed switch S7; ICs U4, U5, U7, and U8; and associated passive components. The control knob circuitry senses the control knob position and sends the position code to the MCU PWA. The HSENSEN signal, when active, switches transistor Q5 on and allows the output of rotary switch Hall-effect sensors U11 through U15 to be gated through ICs U4, U5, U7, and U8. Resultant output conditions of rotary 0 (ROT0), ROT1, and ROT2 at ICs U7A, U7B, and U7D are sent to the MCU PWA as a three-bit code representing the control knob position. The S7 reed switch output, SPSTIN is transferred to the power supply PWA. If more or less than one Hall-effect sensor position signal is active, ROT0, ROT1, and ROT2 become active simultaneously to signify a failure. If the control knob is set to the OFF/CHARGE position, *SESTIN is enabled.

4.2.6**SENSOR PWA**

The sensor PWA consists of the following circuitry: pressure amplifier/filter, AC (mains) amplifier, voltage reference, opto interrupter, and EEPROM (see Figure 9-21, Sensor PWA Schematic).

4.2.6.1**PRESSURE AMPLIFIER/FILTER CIRCUITRY**

The pressure amplifier circuitry (IC U7, resistors R6 and R11 through R16, and capacitors C2 and C3) is a differential amplifier with an approximate gain of 600. Capacitors C2 and C3 are part of an automatic-zero system within U7. The combination of resistors R13 and R11 makes it possible for R12 (trimpot) to compensate for up to a 3 millivolt (mV) offset input from the strain gauge. In case of larger offsets, R13 must be removed from the sensor PWA. R12 is adjusted to approximately +0.7 VDC at distal pressure (DISTPRES) so that negative pressure spikes can be read by the MCU PWA.

The filter circuitry (resistors R1 and R3, capacitors C4 and C5, and IC U8A) constitutes a two-pole, 30-Hz Bessel active filter. The filter alternates the 500 Hz automatic-zero switching frequency of U7 and other noise.

4.2.6.2**AC (MAINS) AMPLIFIER CIRCUITRY**

The AC (mains) amplifier circuitry (IC U8A) processes negative spikes that may signify an occlusion on DISTPRES to a level manageable by the MCU PWA analog-to-digital (A/D) converter. The AC amplifier blocks slow pressure changes and amplifies the spikes to the required level. The AC amplifier also divides into the logarithmic compression circuit (resistor R7 and diodes CR1 and CR3), the bias/high-pass circuit (capacitor C8 and resistor R10), and the amplifier circuit (IC U8B, resistors R4 and R9, and capacitor C7). The logarithmic compression circuit limits the amplitude of the negative spikes at high back-pressure. The bias/high pass circuit blocks the slow pressure changes and biases the AC (mains) amplifier to +2.5 VDC.

4.2.6.3**VOLTAGE REFERENCE CIRCUITRY**

The voltage reference circuitry consists of ICs U1 and U6; transistor Q1; diodes CR2 and CR5; resistors R17 through R20, R22, and R23; and capacitors C9, C11, and C12. R22, C11, and C12 filter VMOT. R18 biases the reference U1. U6B buffers the +2.5 VDC REF. The +2.5 VDC REF is boosted by Q1, U6A, and associated components to generate the main +3.75 VDC reference 3V75REF. CR2 limits 3V75REF to VDIG level to protect the MCU PWA micro controller, U6. CR5 protects the base-emitter junction of Q1.

4.2.6.4**OPTO INTERRUPTER CIRCUITRY**

When PSENSEN is active, transistors Q2 and Q3 drive all LEDs in ICs U2, U3, and U4 with a constant current of approximately 22 milliamperes (mA). Resistor R24 limits the current.

4.2.6.5**EEPROM CIRCUITRY**

The EEPROM circuitry (IC U5) communicates serially with the MCU PWA. U5 receives commands and data through pin 3 as TXD. Stored data is transferred through pin 4 as EE_DO. When EE_CS is active at pin 1 and EE_CLK (pin 2) is in synchronization with TXD, U5 is enabled.

4.2.7**BUBBLE SENSOR PWA AND PIN DETECTOR FLEX CIRCUIT**

The bubble sensor PWA consists of the following circuitry: transmitter, receiver (which includes two channels, proximal and distal), and pin detector flex (see *Figure 9-20, Bubble Sensor PWA Schematic*, and *Figure 9-22, Pin Detector Flex Circuit Schematic*).

Note: Both proximal and distal sensors can transmit or receive.

4.2.7.1**TRANSMITTER CIRCUITRY**

The transmitter circuitry consists of a sweep oscillator, a voltage-controlled oscillator (VCO), and a driver.

The sweep oscillator (ICs U1A and portion of U2, capacitor C5, and resistor R15 through R18) oscillates at approximately 12 kHz with a 50 percent duty cycle. A complementary metal-oxide semiconductor (CMOS) gate within U2 is used for a quality rail-to-rail symmetrical signal for greater timing accuracy. The output of the sweep oscillator (C2) is between +2 VDC and +3 VDC. The C2 output is used to sweep the VCO at U2-9.

IC U2, capacitor C7, and resistor R21 constitute the VCO. U2 is originally a phase-lock loop (PLL) IC with the VCO portion sweeping output frequencies from 4 MHz to 6 MHz. The VCO center frequency is determined by R21 and C7. Activating either signal, PROX_AIR_EN or DIST_AIR_EN, enables the VCO.

The driver consists of a push-pull, emitter-follower complementary pair of transistors: Q4 and Q5. The driver supplies input to proximal sensor X1 and distal sensor X2.

4.2.7.2**RECEIVER CIRCUITRY**

The receiver consists of an amplifier, detector, and buffer.

The amplifier consists of transistors Q3, Q6, Q2, and associated passive components. The amplifier is biased by 2V5REF and is designed for wide power supply range. Q3 is biased by PROX_AIR_EN in order to receive from proximal sensor X1. Q6 is biased by DIST_AIR_EN to receive from distal sensor X2.

The detector is an emitter-follower transistor Q1. Q1 allows maximum input impedance. Capacitor C1 and resistor R4 constitute a time constant of 200 microseconds (ms). Since the time between peaks is approximately 40 ms, the output (*AIR_OPT) remains high with a pronounced sawtooth ripple.

The buffer (IC U1A and resistors R7 and R2) also amplifies the detected signal.

4.2.7.3**PIN DETECTOR FLEX CIRCUITRY**

The pin detector flex circuitry detects movement of the primary and secondary valve pins by optical transmitters CR1 and CR2, and optical receivers Q1 and Q2. Light interrupters are attached to the pins and as the pins move, the appropriate valve movement signals are transferred to the MCU PWA through the bubble sensor PWA.

4.3**MECHANICAL OVERVIEW**

The principal mechanical elements of the infusion system include the cassette and the mechanism assembly. When a cassette is locked into the operating position and the control knob is turned on, the infusion system performs a self test to verify the integrity of the internal systems. The operation of the mechanism assembly moves a plunger, causing a pumping action. A valve motor selects the primary or secondary valve, depending on the command. An additional valve motor alternately opens and closes an inlet valve and outlet valve to control fluid flow through the cassette pumping chamber.

The following sections detail the cassette and the mechanism assembly.

4.3.1**CASSETTE**

The cassette operates on a fluid displacement principle to volumetrically deliver fluid (see *Figure 4-1, Major Elements of the Dual-Channel Cassette*, and *Figure 4-2, Fluid Path in the Cassette*). Refer to the system operating manual for a description of the major cassette functions.

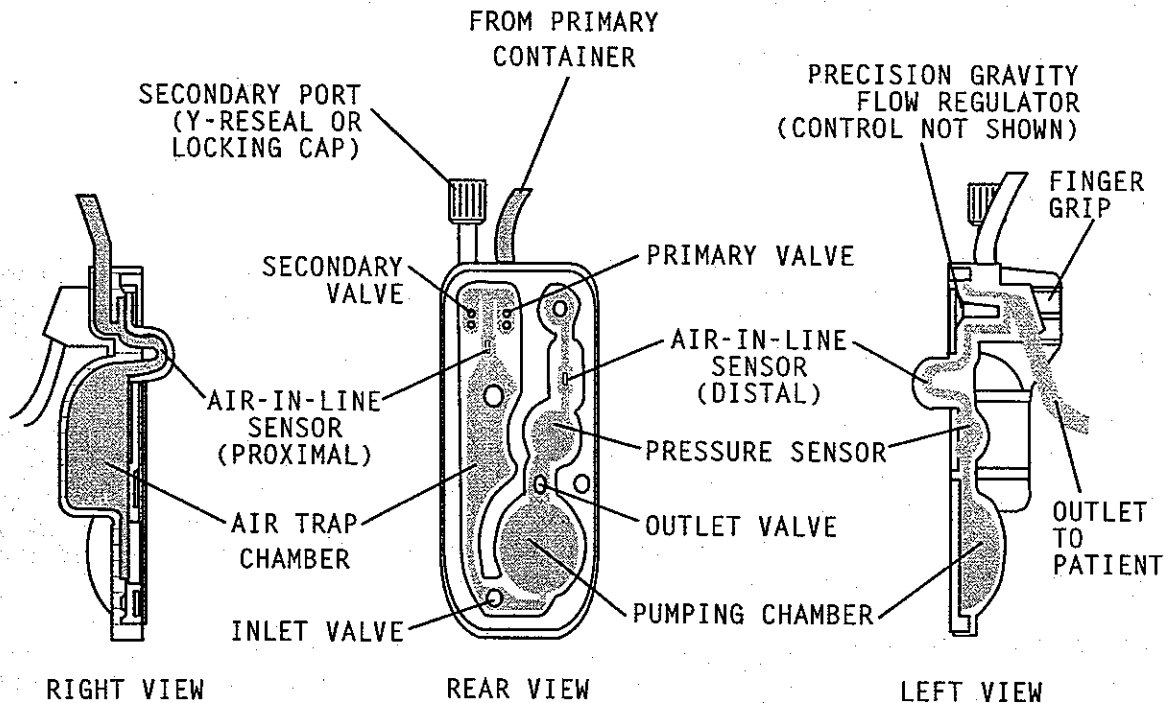
The pumping cycle begins when the outlet valve is opened and the inlet valve is closed. The plunger extends to deflect the cassette diaphragm and expel fluid. At the end of the pumping stroke, the outlet valve closes, the inlet opens, the appropriate primary or secondary valve opens, and the plunger retracts to allow fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed, the primary and secondary valves are closed, and the cycle is repeated.

The cassette contains two chambers: an upper air trap chamber and a pumping chamber. The two chambers are separated by an inlet valve (see *Figure 4-1 and Figure 4-2*) and operate together to detect air. The upper air-trap chamber receives fluid from the intravenous (IV) container through either the primary or secondary valve. The upper air-trap chamber collects air bubbles from the IV line and container to prevent them from entering the pumping chamber; the chamber can collect a substantial amount of air. The controller tracks the amount of air collected in the upper air-trap chamber. If a predetermined air collection threshold is exceeded, the controller starts an infusion system backprime and initiates a secondary display.

A proximal air-in-line sensor (bubble detector) is located between the primary/secondary valves and the upper air-trap chamber. The proximal air-in-line sensor detects air entering the upper air-trap chamber and initiates an audible alarm if the predetermined air collection threshold is exceeded. Similarly, a second air-in-line sensor located distal to the pumping chamber initiates an audible alarm if a predetermined amount of air is detected.

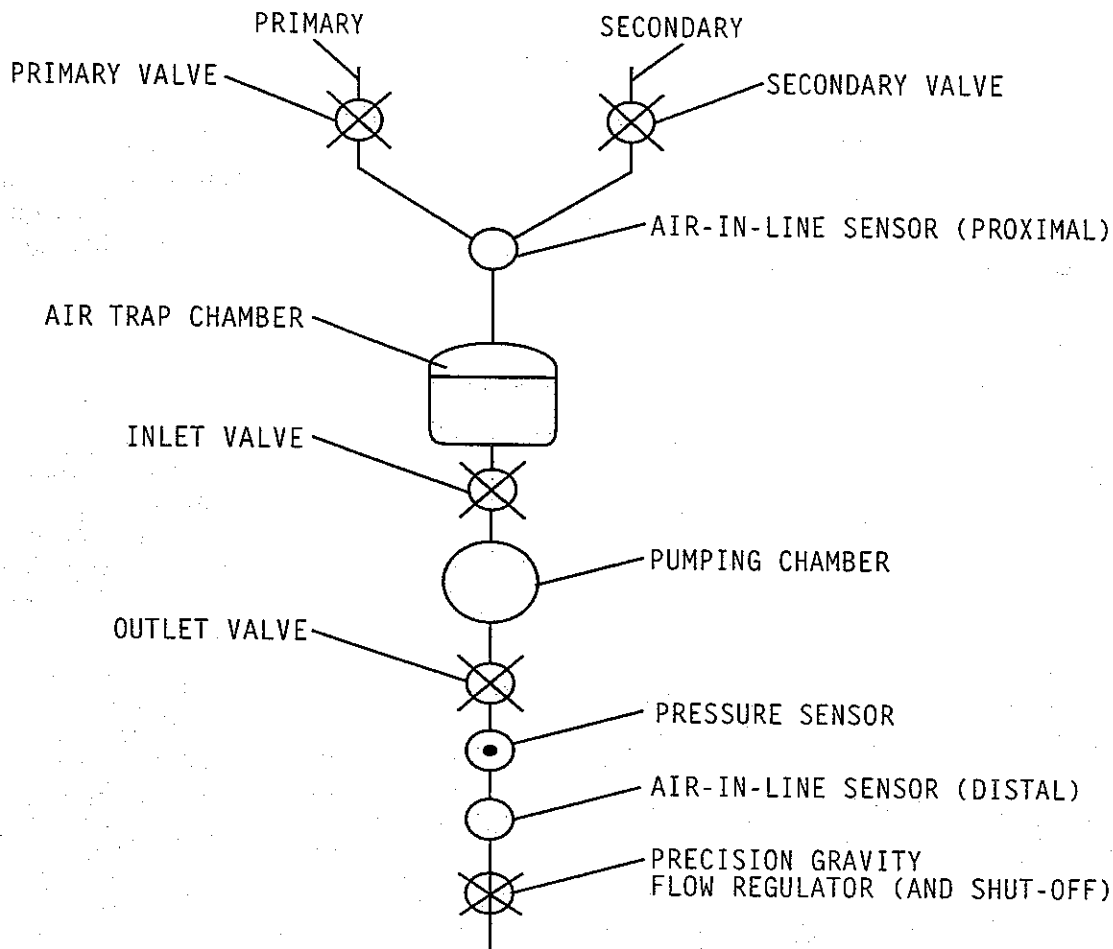
The pumping chamber receives fluid from the upper air-trap chamber through an inlet valve. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through an outlet valve. A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator is incorporated into the cassette distal end. This flow regulator is used to manually control flow when the cassette is not inserted in the pump. When the cassette is properly inserted into the infusion system and the infusion system door is closed, a mechanism opens the flow regulator to allow the infusion system to control fluid flow. When the infusion system door is opened, the same mechanism closes the flow regulator to disable fluid flow.



94F06014

Figure 4-1. Major Elements of the Dual-Channel Cassette



94B06002

Figure 4-2. Fluid Path in the Cassette

4.3.2

MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit consisting of the motor and valve assemblies, primary/secondary valve subsystem, inlet/outlet valve subsystem, plunger drive subsystem, air bubble (ultrasonic) sensor assemblies, cassette door, and pressure sensor assembly. The motor and valve assemblies, primary/secondary valve subsystem, inlet/outlet valve subsystem, and plunger drive subsystem are detailed in the following sections.

During infusion system operation, the mechanism assembly plunger motor drives a lead screw that is coupled to a nut in the plunger. The motor action and lead screw move the plunger forward to cause the delivery of approximately 0.33 ml of fluid per cycle. The plunger motion is synchronized to the valve motors to provide controlled fluid delivery.

4.3.2.1

MOTOR AND VALVE ASSEMBLIES

The mechanism assembly pumping action is controlled by three stepper motors. The first stepper motor, in conjunction with an associated valve assembly, activates the primary or secondary valve of the cassette, depending on the command. The second stepper motor alternately opens and closes the inlet and outlet valve to control fluid delivery through the cassette pumping chamber. A third stepper motor controls plunger movement.

4.3.2.2

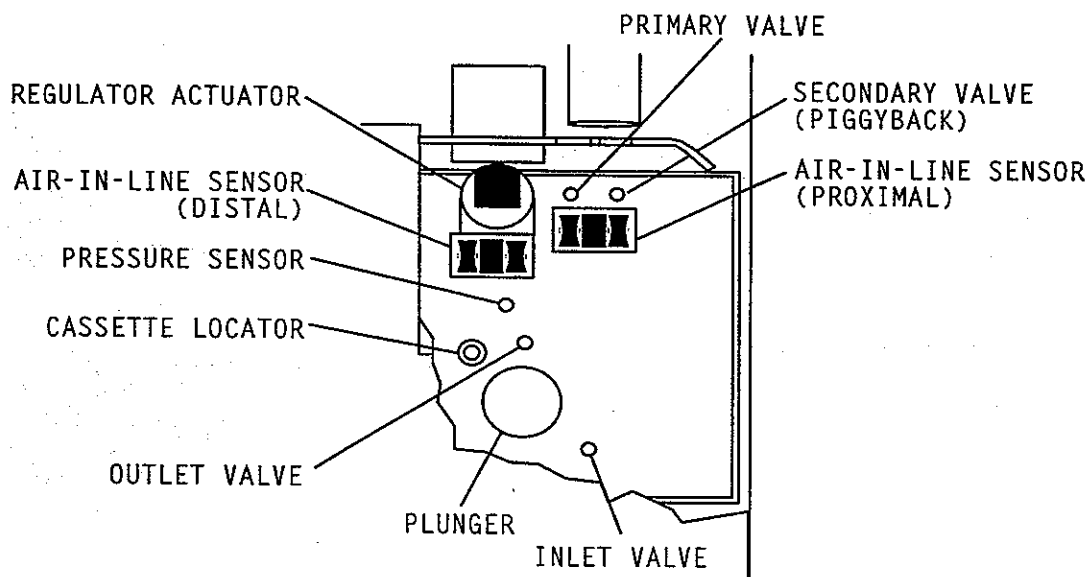
PRIMARY/SECONDARY VALVE SUBSYSTEM

The primary/secondary valve subsystem includes a motor designed to rotate a cam (see *Figure 4-3, Mechanism Valve Pins and Sensor Locations*). When the cam is positioned at the top dead center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the primary valve, while the secondary valve remains closed. Counterclockwise rotation opens the secondary valve, while the primary valve remains closed.

The primary/secondary valve subsystem consists of a stepper motor with attached cam and integral cam flag, primary and secondary rockers and valve pins, and a pin detector assembly. The cam flag passes through an interrupter module as it rotates with the cam. Valve home position is determined by this cam flag/interrupter module combination through predetermined factory calibration data. During operation, if the cam flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

The rocker is the connecting link between the cam and the valve pin.

The primary/secondary valve pins each have a series of interrupters that are optically detected by the pin detector assembly to assure proper valve pin movement.



94B06003

Figure 4-3. Mechanism Valve Pins and Sensor Locations

4.3.2.3**INLET/OUTLET VALVE SUBSYSTEM**

The inlet/outlet valve subsystem is similar in function and build to the primary/secondary valve subsystem, but it does not contain a series of interrupters or a pin detection assembly. Refer to *Section 4.3.2.2, Primary/Secondary Valve Subsystem*, for the inlet/outlet valve subsystem theory of operation.

4.3.2.4**PLUNGER DRIVE SUBSYSTEM**

The plunger drive subsystem includes a stepper motor. The stepper motor rotates approximately 1-2/3 revolutions per infusion system cycle to permit a 0.33 ml fluid displacement every infusion system cycle. The stepper motor then reverses and the plunger returns to home position. This cycle repeats for the duration of fluid administration. Excluding the stepper motor, the plunger drive subsystem includes the following components: ball thrust bearing, screw/coupler assembly, and plunger/support system.

The ball thrust bearing is positioned against the mechanism assembly chassis. As the plunger extends into the cassette diaphragm to displace fluid, the resulting load (due to pumping action and back pressure) is transferred axially through the ball thrust bearing to the mechanism assembly chassis.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter module. This screw/coupler flag/interrupter module combination is used in conjunction with predetermined factory calibration data to determine the plunger position.

During operation, if the screw/coupler flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

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Section 5

MAINTENANCE AND SERVICE TESTS

A complete maintenance program promotes infusion longevity and trouble-free instrument operation. Such a program should include routine maintenance, performance verification testing following any repair procedure, and periodic maintenance inspection.

5.1 ROUTINE MAINTENANCE

Routine maintenance consists of basic inspection and cleaning procedures. As a minimum requirement, inspect and clean the infusion pump after each use. In addition, establish a regular cleaning schedule for the infusion pump.

5.1.1 INSPECTING THE INFUSION SYSTEM

Inspect the infusion system periodically for signs of defects such as worn accessories or damaged cables. Also, inspect the infusion system after repair or during cleaning. Replace any damaged or defective external parts.

Inspect the following areas for missing or damaged parts:

- Labels
- AC (mains) power cord
- Velcro® retainer strap
- Rubber foot pads
- Door assembly (cassette door), shield, and handle
- Cassette guide spring and roller
- Valve pins, plunger, bubble detectors, and locator pin
- Front panel label
- All keypad switches
- Control knob and all external screws
- Pole clamp knob/shaft, extrusion, and tip insert
- Front and rear enclosures
- Battery access cover
- LCD screen
- DataPort connector (XLM with DataPort)

5.1.2

CLEANING THE INFUSION SYSTEM

Keeping the infusion system clean promotes system longevity and trouble-free instrument operation. Accumulation of dust or spilled fluids on the cassette door and housing can affect proper operation of the infusion system. Follow hospital protocol for establishing the infusion system cleaning schedule.

WARNING

DISCONNECT THE INFUSION SYSTEM FROM AC (MAINS) POWER PRIOR TO CLEANING. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN ELECTRICAL SHOCK.

CAUTION: Do not immerse the infusion system in liquids. Failure to comply may result in infusion system damage. Do not allow liquids to enter the infusion system electronics compartment.

CAUTION: Certain cleaning and sanitizing compounds may slowly degrade components made from some plastic materials. Using abrasive cleaners or cleaning solutions not recommended by Abbott Laboratories may result in product damage and potentially void the product warranty. Do not use compounds containing combinations of isopropyl alcohol and dimethyl benzyl ammonium chloride.

CAUTION: Do not spray cleaning solutions toward any openings in the infusion system.

Clean the exposed surfaces of the infusion system with a soft, lint-free cloth dampened with one of the cleaning solutions listed in *Table 5-1, Cleaning Solutions*, or a mild solution of soapy water. Remove soap residue with clear water. Do not use solvents that are harmful to plastic, such as isopropyl alcohol or acetone. Do not use abrasive cleaners.

CAUTION: To avoid infuser damage, cleaning solutions should be used only as directed in *Table 5-1*. The disinfecting properties of cleaning solutions vary; consult the manufacturer for specific information

Cleaning Solution	Manufacturer	Preparation
Coverage™ HBV	Steris Corporation, a division of Calgon Vestal Laboratories	Per manufacturer's recommendation
Formula C™	Diversey Corporation	Per manufacturer's recommendation
Household bleach	Various	Per hospital procedures; do not exceed one part bleach in ten parts water
Manu-Klenz®	Calgon Vestal Laboratories	Per manufacturer's recommendation
Sporicidin®	Sporicidin International	Per manufacturer's recommendation

Table 5-1. Cleaning Solutions		
Cleaning Solution	Manufacturer	Preparation
Super Edisonite®	S. M. Edison Chemical Co.	Per manufacturer's recommendation
Vesphene® Ilse	Calgon Vestal Laboratories	Per manufacturer's recommendation

5.1.3

SANITIZING THE INFUSION SYSTEM

Sanitize external surfaces of the infusion system using a cleaner listed in *Table 5-1, Cleaning Solutions*.

CAUTION: Do not sterilize the infusion system using heat, steam, ethylene oxide (ETO), or radiation. These methods may cause the infusion system to malfunction.

Note: Not all cleaning solutions are sanitizers. Check product labeling.

5.2

PERFORMANCE VERIFICATION TEST

The PVT is used for overall verification of infusion system performance and as a diagnostic tool during infusion system troubleshooting. The PVT consists of the tests in the subsequent sections. Conduct the PVT periodically per hospital procedures for compliance with accreditation requirements. If any malfunction is detected as a result of the PVT, refer to *Table 6-6, PVT Troubleshooting*.

Note: For effective and reliable product evaluation information, it is essential that the PVT be performed exactly as described in this manual.

5.2.1

EQUIPMENT REQUIRED

The PVT requires the following equipment (or equivalents):

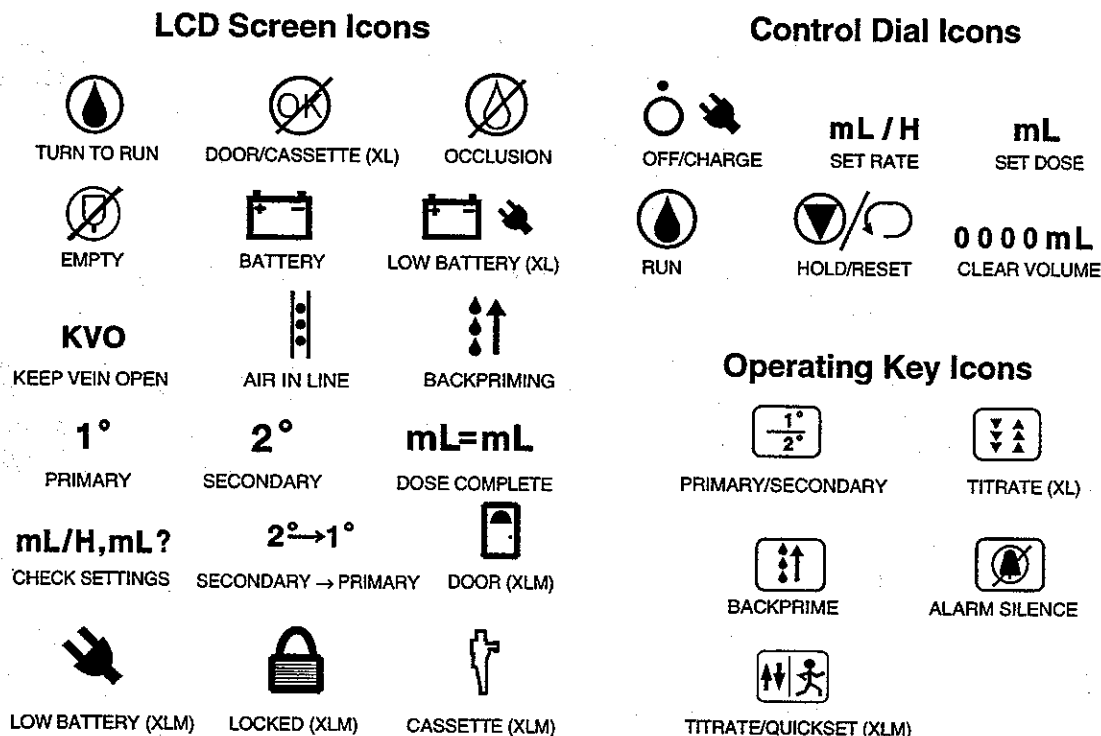
- Graduated cylinder, 25 ml, with 0.2 ml graduations (Type A)
- Sterile water or tap water in two IV bags/containers
- Pressure meter, Bio-Tek® DPM II
- Safety analyzer, Dynatech Nevada® 231D
- Three-way stopcock, List No. 3233-01 or 3232-01
- Reflux valve (optional)
- Special cassette with proximal bubble sensor tips removed
- Special cassette with distal bubble sensor tips removed
- IV set, List No. 6426-02
- IV set, List No. 3047-01
- IV set, List No. 11419 (or equivalent)

- IV set, List No. 11397 (or equivalent)
- Digital multimeter (DMM), Fluke® 8012A
- 21-gauge needle, List No. 4492, or 18-gauge blunt cannula
- Battery charger test box (optional)
- Computer with a terminal emulator (optional)
- RS-232 serial communication cable (optional)

5.2.2

ICONS AND ENGLISH LANGUAGE EQUIVALENTS

International infusion systems use icons in displays and labels. Refer to *Figure 5-1, Icons and English Language Equivalents*.



96B03022

Figure 5-1. Icons and English Language Equivalents

5.2.3

INSPECTION

Before starting the PVT tests, thoroughly inspect the infusion system as described in *Section 5.1.1, Inspecting the Infusion System*.

5.2.4**INFUSION SYSTEM TEST SETUP****WARNING**

A PATIENT SHOULD NEVER BE CONNECTED TO THE INFUSION SYSTEM DURING SYSTEM TESTING.

To set up the infusion system for the PVT, proceed as follows:

1. Confirm the infusion system and appropriate accessories are fully assembled.
2. Hang two sterile water containers at a height of 18 to 24 inches (46 to 60 cm) above the pumping chamber of the infusion system.
3. Connect the infusion system to AC (mains) power. Conduct all tests with the infusion system connected to AC (mains) power unless otherwise specified.
4. Verify the lockout switch is in the UNLOCKED (down) position (XLM only).

5.2.5**SELF TEST**

To perform the self test, refer to *Figure 5-2, Plum XL LCD Test Screens* and *Figure 5-3, Plum XLM LCD Test Screens*, then proceed as follows:

1. Connect the infusion system AC (mains) power cord to a grounded AC (mains) outlet and confirm the AC (mains) power icon (next to the OFF/CHARGE setting) illuminates.
2. Open the door assembly (cassette door) by lifting up on the cassette door handle.
3. Hold a primed cassette by its handle and insert the cassette into the cassette door guides. Do not force the cassette into position.
4. Close the cassette door handle to lock the cassette in place.
5. Turn the control knob to SET RATE to initiate the self test.
6. Verify the following screens display: the LCD test screen; four backward Cs (approximately two seconds); set rate screen.

Note: If the LCD test screen does not match *Figure 5-2* or *Figure 5-3* exactly, contact Abbott Laboratories.

Note: If an alarm condition occurs during the self test, turn the control knob to OFF/CHARGE and repeat Step 5 and Step 6. If the alarm condition recurs, note the message and take corrective action (*see Section 6, Troubleshooting*). Repeat the self test. If the alarm condition recurs, remove the infusion system from service and contact Abbott Laboratories.

7. Disconnect the infusion system from AC (mains) power and confirm BATTERY displays on the LCD screen.
8. Turn the control knob to OFF/CHARGE and remove the administration set.
9. To allow the battery to charge fully, connect the infusion system to AC (mains) power for a minimum of eight hours with the control knob in the OFF/CHARGE position. Confirm the AC (Mains) power icon illuminates.

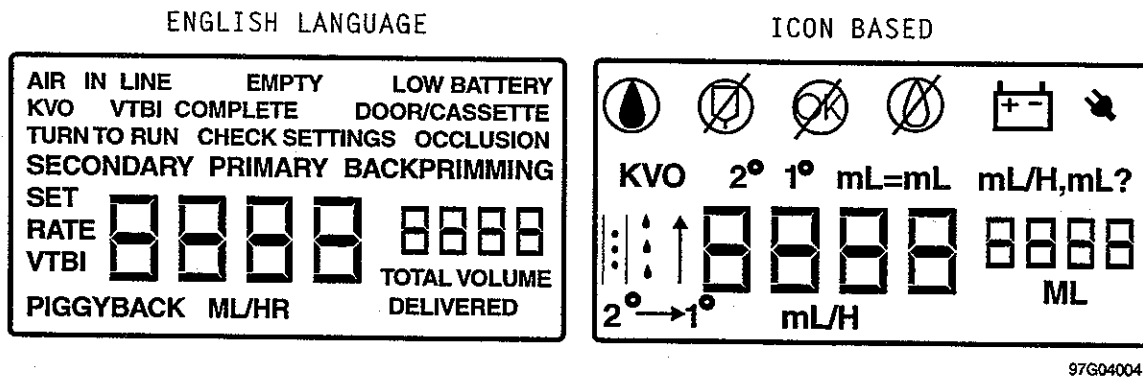


Figure 5-2. Plum XL LCD Test Screens

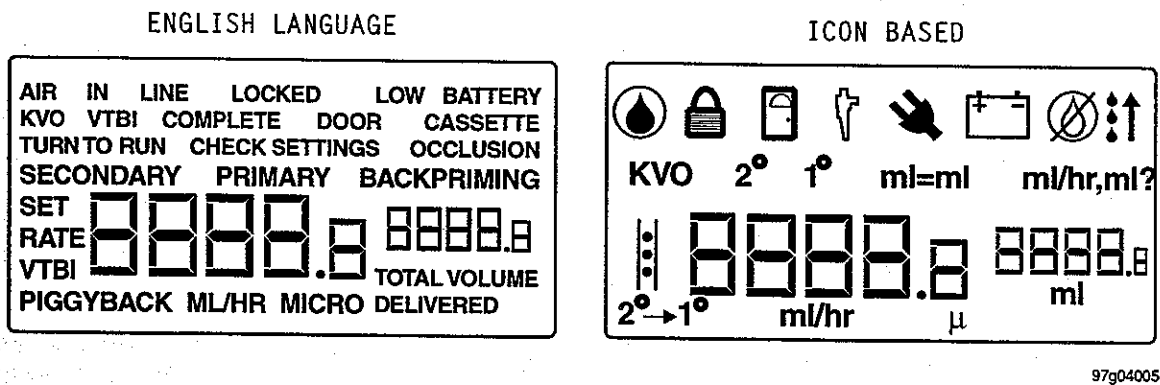


Figure 5-3. Plum XLM LCD Test Screens

Note: All LCD screens on international infusion systems are icon-based with the exceptions of country codes 27 and 54.

5.2.6

KEYPAD AND CONTROL KNOB TEST

To perform the keypad and control knob test, proceed as follows:

1. Turn the control knob to SET RATE. Press the following keys to verify that each key activates and the screen responds:
 - [PRI/SEC] toggles screen between PRIMARY and SECONDARY
 - [↑] raises value of delivery rate
 - [↓] lowers value of delivery rate
 - MICRO legend appears when the rate is lower than 100 ml/hr, and disappears when the rate is above 99.9 ml/hr (XLM)
2. Turn the control knob to SET VTBI. Press the following keys to verify that each key activates and the screen responds:
 - [↑] raises the value of volume delivered
 - [↓] lowers the value of volume delivered

3. Turn the control knob to RUN. Press and hold each key combination simultaneously to verify that each key combination activates and the screen responds:
 - [TITRATE/QUICKSET] and [↑] raises the value of the delivery rate
 - [TITRATE/QUICKSET] and [↓] lowers the value of the delivery rate
4. Turn the control knob to SET RATE. Press the [TITRATE/QUICKSET] key and observe a quick rate change occurs.
5. Turn the control knob to HOLD/RESET. Press and hold [BACK PRIME] to verify pumping occurs from the primary line up through the secondary inlet port.

5.2.7

OPEN DOOR ALARM TEST

To perform the open door alarm test, proceed as follows:

1. Close the clamp on the secondary line (to prevent fluid in containers from mixing).
2. Open the cassette door. Verify the DOOR/CASSETTE (XL) or DOOR (XLM) legend appears and an alarm sounds.
3. Press [SILENCE]. Verify the alarm mutes.
4. Close the cassette door and unclamp the secondary line.

5.2.8

ALARM LOUDNESS TEST (XL)

To perform the alarm loudness test, proceed as follows:

1. Turn the control knob to SET RATE and open the cassette door. Verify the DOOR/CASSETTE legend appears and an alarm sounds.
2. Toggle the audio switch (located on the infusion system bottom) between the high and low settings. Verify two alarm levels sound.
3. Press [SILENCE]. Verify the alarm mutes.
4. Close the cassette door.

5.2.9

ALARM LOUDNESS AND LOCK FUNCTION TESTS (XLM)

To perform the alarm loudness and lock function tests, proceed as follows:

1. Turn the control knob to SET RATE and open the cassette door. Verify the DOOR legend appears and an alarm sounds.
2. Toggle the audio switch (located on the rear panel) between the high and low settings. Verify two alarm levels sound.
3. Press [SILENCE]. Verify the alarm mutes.
4. Close the cassette door.
5. Turn the control knob to HOLD/RESET, then back to RUN.
6. Press the LOCK button (located on the rear panel). Verify LOCKED appears on the display.
7. Turn the control knob to any other position. Verify the infusion system stops pumping, an alarm sounds, and the display backlight and LOCKED flash.

8. Turn the control knob to RUN. Verify the infusion system starts to pump.
9. Press [SILENCE]. Verify that the alarm condition remains unchanged.
10. Press the LOCK button to clear the alarm condition.

5.2.10

BATTERY LEGEND TEST

To perform the battery legend test, proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Turn the control knob to SET RATE. Verify the line power indicator turns off and the BATTERY legend turns on within five seconds.
3. Reconnect the infusion system to AC (mains) power after the battery legend check.
4. Turn the control knob to OFF/CHARGE.

5.2.11

FREE FLOW TEST

To perform the free flow test, proceed as follows:

1. Insert a primed cassette into the infusion system.
2. Turn the control knob to SET RATE.
3. With the cassette door closed, check the distal end of tubing for fluid flow. Verify a minimal flow of fluid (a few drops maximum) occurs.
4. Open the cassette door and check the distal end of tubing for fluid flow. Verify a minimal flow of fluid (a few drops maximum) occurs.

Note: A small amount of fluid may be expelled from the cassette when opening or closing the door.

5. Close the cassette door and check the distal end of tubing for fluid flow. Verify a minimal flow of fluid (a few drops maximum) occurs.
6. Turn the control knob to OFF/CHARGE.

5.2.12

DISTAL OCCLUSION TEST

To perform the distal occlusion test, refer to *Figure 5-4, Distal Occlusion Test Setup*, and proceed as follows:

1. Connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-4*.

Note: A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.

Note: The height of the DPM must be 0 to 6 inches (0 to 15 cm) from the midline of the cassette.

2. Turn the control knob to SET RATE.
3. Set the rate to 40 ml/hr.

4. Turn the control knob to SET VTBI.
5. Set the volume to 100 ml.
6. Open the three-way stopcock to air.
7. Turn the control knob to RUN and allow the infusion system to stabilize for one minute. Verify all air is cleared from the tubing.
8. Set the three-way stopcock to measure pressure.
9. Verify the occlusion alarm occurs when DPM indicates 10.0 ± 1.8 psi (69.0 ± 12.4 kPa).
10. Turn the control knob to HOLD/RESET to clear the occlusion alarm. Open the three-way stopcock to air and disconnect the distal tubing.

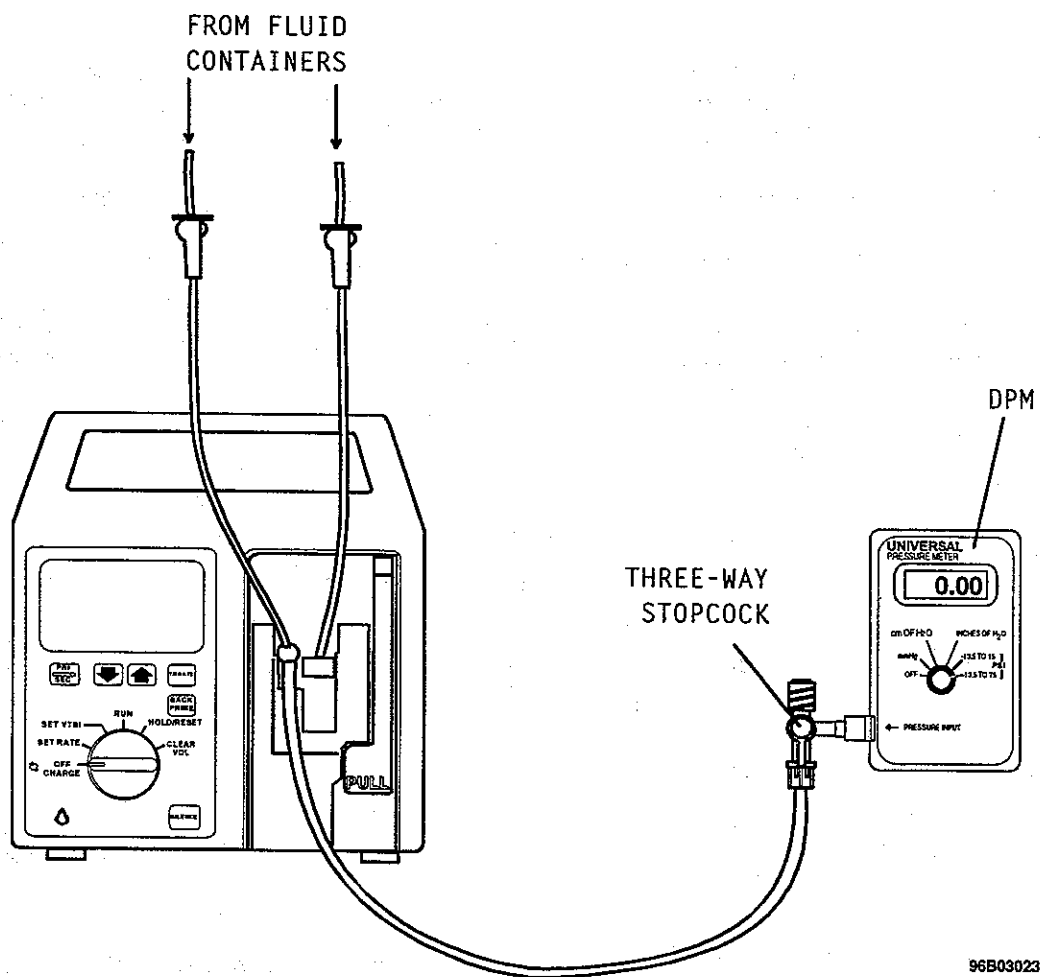


Figure 5-4. Distal Occlusion Test Setup

5.2.13**PROXIMAL OCCLUSION TEST**

To perform the proximal occlusion test, proceed as follows:

1. Turn the control knob to SET RATE. Set the rate to a value greater than 40 ml/hr.
2. Turn the control knob to RUN to start pumping fluid.
3. After several pumping cycles, clamp the tubing proximal to the cassette. After drops stop falling through the sight chamber, verify that an occlusion alarm occurs within three pumping cycles.
4. Press [SILENCE] and unclamp the proximal tubing.
5. Turn the control knob to OFF/CHARGE.

5.2.14**DELIVERY ACCURACY TEST**

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infusion system accuracy, return the infusion system to Abbott Laboratories Technical Support Operations.

CAUTION: Do not remove the protective cover from the butterfly needle.

To perform the delivery accuracy test, proceed as follows:

1. Attach an 18-gauge cannula, or a 21-gauge needle, to the distal end of the tubing. Verify the fluid container is 18 to 24 inches (46 to 60 cm) above the cassette pumping chamber. Verify all lines are unclamped.
2. Prime the tubing. Verify no air is in the tubing. Place cannula or needle in a 25 ml graduated cylinder.
3. Turn the control knob to SET RATE and set the primary rate to 400 ml/hr.
4. Press [PRI/SEC] to display SECONDARY and set the secondary rate to 400 ml/hr.
5. Turn the control knob to SET VTBI and press [PRI/SEC] to display PRIMARY.
6. Set the primary volume to 10 ml.
7. Press [PRI/SEC] to display SECONDARY and set the secondary volume to 10 ml.
8. Turn the control knob to CLEAR VOL to clear previous value. Verify four beeps sound.
9. Assure the graduated cylinder is dry.
10. Turn the control knob to RUN to start pumping fluid. Verify volume delivered is 20 ± 1 ml. Verify that after the VTBI is complete, the infusion system changes to KVO mode at a rate of 1 ml/hr.
11. Turn the control knob to OFF/CHARGE.
12. Clamp both lines. Remove the distal tubing. Remove the cassette from the infusion system.

5.2.15

EMPTY CONTAINER/AIR-IN-LINE ALARM TEST

To perform the empty container/air-in-line alarm test, proceed as follows:

1. Install the special cassette marked EMPTY in the infusion system. Confirm the special cassette proximal bubble sensor tips are removed (*Figure 5-5, Special Cassettes with Bubble Sensor Tips Removed*).
2. Turn the control knob to SET VTBI.
3. Set the volume to 100 ml.
4. Turn the control knob to RUN to start pumping. Verify that within three pumping cycles the audible alarm sounds and the AIR-IN-LINE and BACKPRIMING legends display.
5. Turn the control knob to HOLD/RESET.
6. Open the cassette door and remove the cassette.
7. Install the special cassette marked AIR in the infusion system. Confirm the special cassette distal bubble sensor tips are removed (*see Figure 5-5*).
8. Turn the control knob to RUN to start pumping. Verify that within three pumping cycles the alarm sounds and the AIR-IN-LINE legend displays.
9. Turn the control knob to HOLD/RESET.
10. Open the cassette door and remove the cassette.

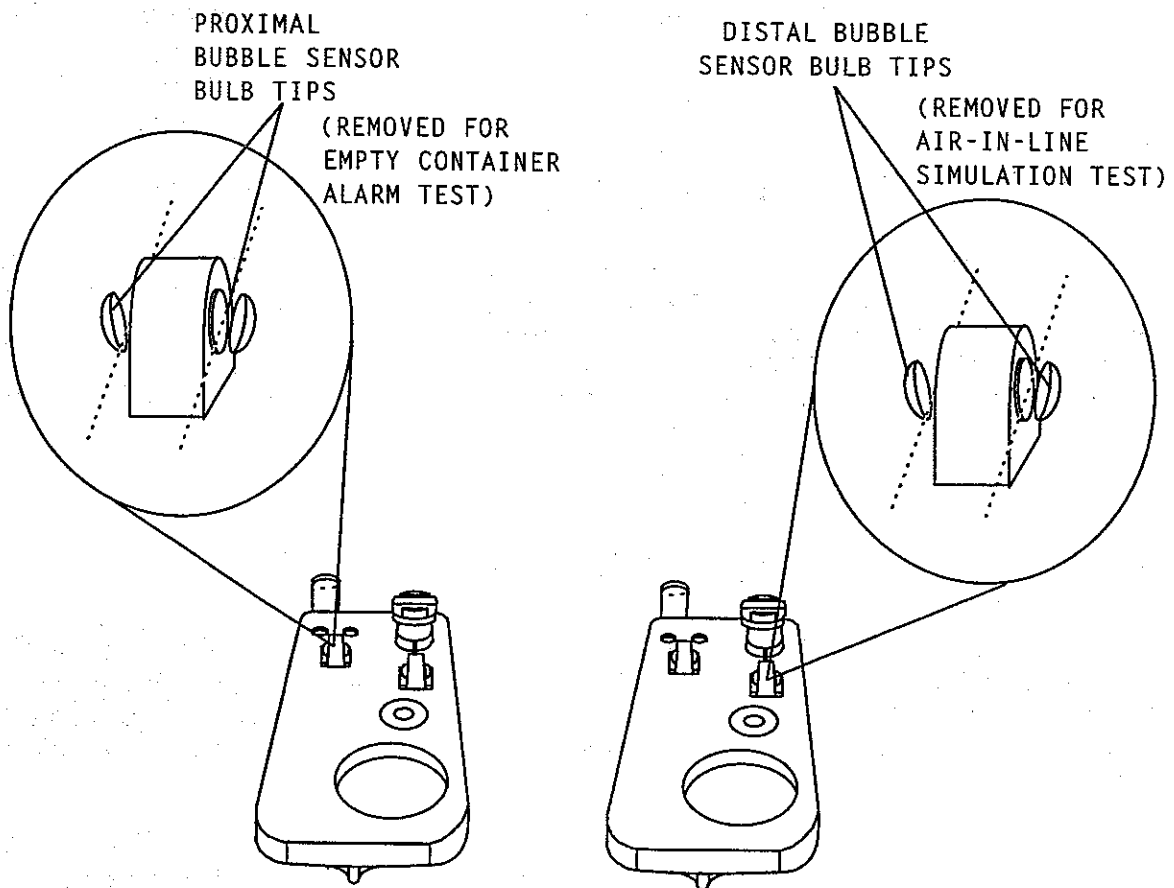


Figure 5-5. Special Cassettes with Bubble Sensor Tips Removed

9311H000

5.2.16

ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the infusion system AC (mains) power cord to a safety analyzer.
2. Connect the safety analyzer ground lead to the infusion system ground test-point screw located on the rear of the infusion system.
3. Check the leakage current with the safety analyzer. Leakage current must not exceed 100 microamperes (mA) (AC RMS).
4. Measure the resistance of the AC (mains) connector ground lug with the safety analyzer. Resistance should not exceed 0.1 Ω .

5.2.17

END OF PERFORMANCE VERIFICATION TEST

If all tests have been successful, proceed as follows:

1. Clear the dose history.
2. Reset the infusion system to the original configuration.
3. Return the infusion system to service.

Note: If any tests fail, refer to *Section 6, Troubleshooting*, or contact Abbott Laboratories Technical Support Operations.

5.3

PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommended that JCAHO and/or hospital protocol be followed for establishing an infusion pump periodic maintenance inspection schedule. Product specifications for this inspection are listed in *Section 8, Specifications*. To perform the periodic maintenance inspection, complete the performance verification test (see *Section 5.2, Performance Verification Test*).

5.4

BATTERY OPERATION OVERVIEW

The infusion system is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC (mains) power failure or inadvertent disconnection of the AC (mains) power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The infusion system should be connected to AC (mains) power whenever possible to allow the battery to remain fully charged. The infusion system line power indicator disappears and the BATTERY legend appears when the infusion system is operating on battery power.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. As a general rule, the more often the battery is discharged and recharged the sooner it will need replacement. The primary cause of damage is leaving the battery in a less than fully charged state for any period of time. Battery damage can occur in a matter of hours and cause a permanent loss of battery capacity. The amount of lost capacity depends on the degree of discharge, the storage temperature, and the length of time the battery was stored in a discharged state.

Note: A permanently damaged battery cannot be recharged to full capacity.

When the battery discharges below the acceptable level while the infusion system is operating, the alarm sounds and the LOW BATTERY message displays. Although it is not recommended to continue operating the infusion system on battery power at this point, the battery will continue providing power until discharged. At this point, the infusion system enters the battery discharged mode and operation ceases.

CAUTION: As soon as the LOW BATTERY alarm occurs, connect the infusion system to AC (mains) power.

Recharging occurs any time the infusion system is connected to AC (mains) power. It is recommended that the infusion system be connected to AC (mains) power whenever practicable to maximize available battery charge during transport or ambulation. The power switch does not have to be on for the battery to recharge. Recharging while the infusion system is operating is rate dependent.

Note: The infusion system should be operated on battery power for six continuous hours at least once every six months for optimum battery performance and life.

5.4.1

BATTERY CHARGER CURRENT TEST (OPTIONAL)

To perform the battery charger current test, refer to *Figure 5-6, Battery Charger Current Test Configuration*, then proceed as follows:

Note: Make certain the battery is in good condition and charged. If necessary, use a second battery for this test.

1. Disconnect the infusion system from AC (mains) power. Remove the battery access cover and disconnect the battery.
2. Connect the battery charger test circuit as illustrated in *Figure 5-6*. Make certain switch S1 is in the off position.
3. Connect the infusion system to AC (mains) power and allow 20 seconds for the current to stabilize. Read the current on the current meter.
4. Compare the measured current to the minimum and maximum values in *Table 5-2, Battery Charger Current Test Parameters*.

Note: If the reading is too low, the battery may be fully charged. Close switch S1; repeat Step 3 and verify per *Table 5-2*.

5. Disconnect the infusion system from AC (mains) power. Remove the battery charger test circuit. Reconnect the battery to the infusion system. Replace the battery access cover and secure.

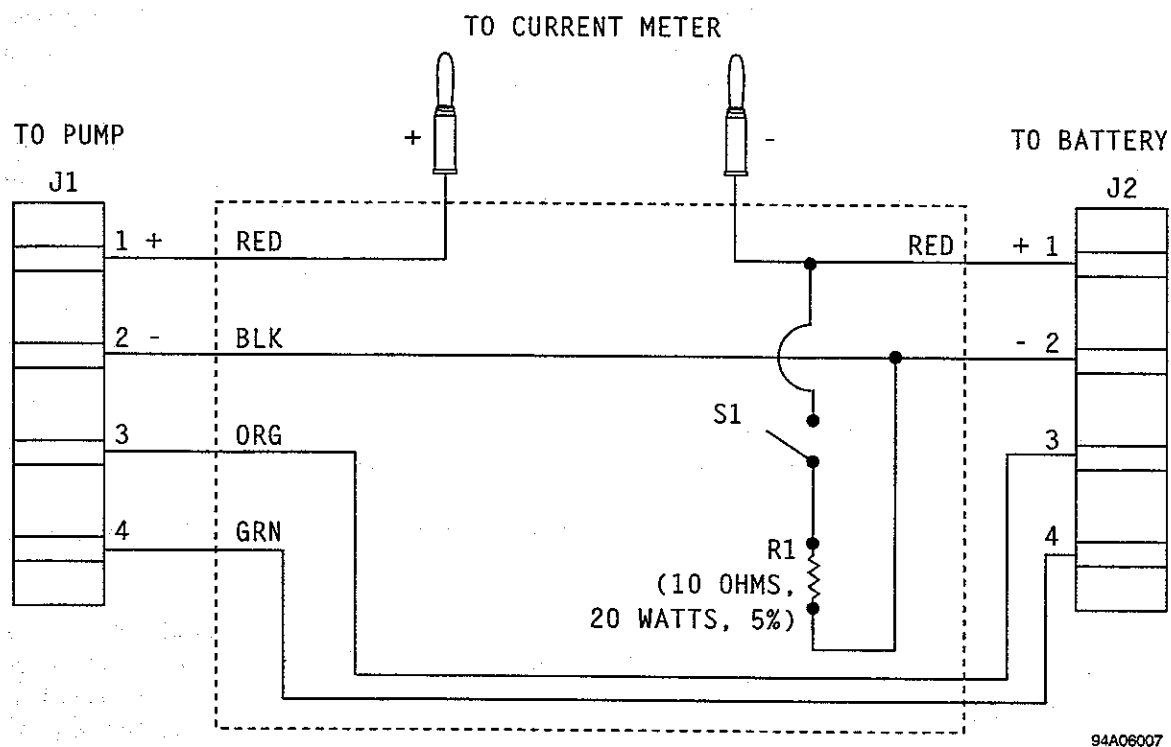


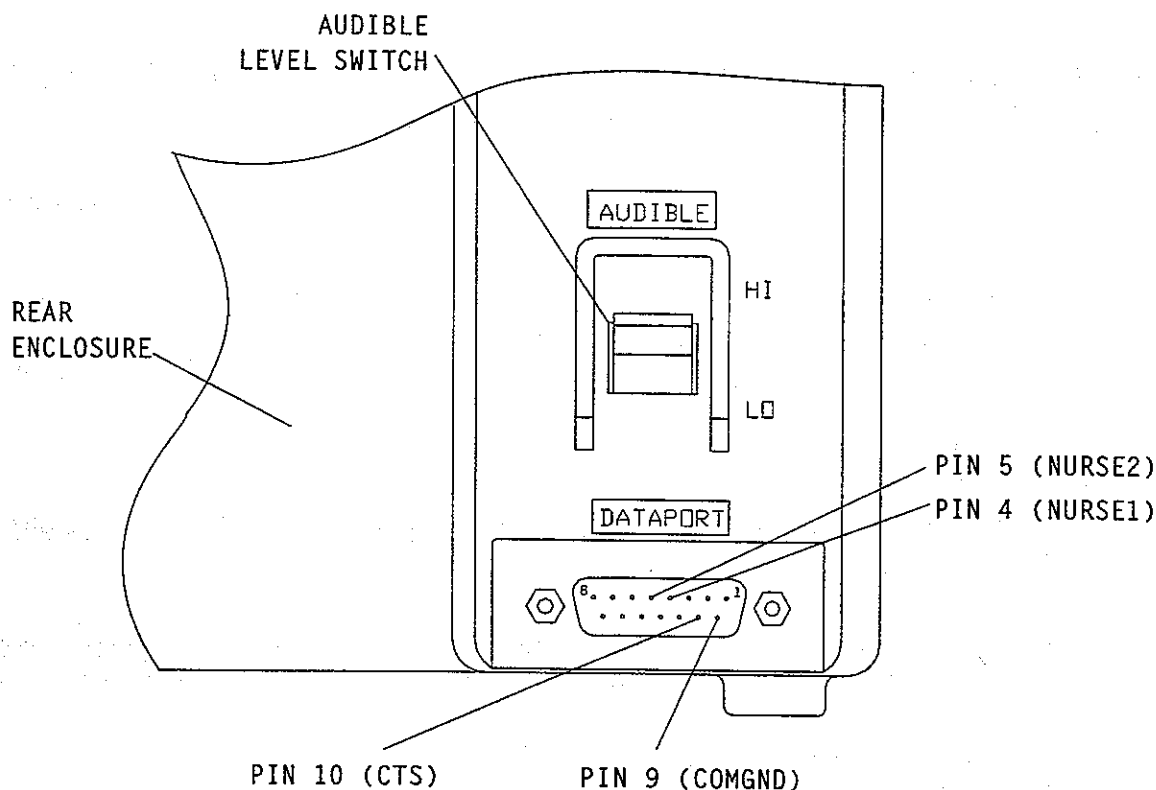
Figure 5-6. Battery Charger Current Test Configuration

Table 5-2. Battery Charger Current Test Parameters			
Battery Type	Jumper between Pins 3 and 4	Minimum Value	Maximum Value
1	No	1.0 Amps	1.4 Amps
2	Yes	0.64 Amps	0.92 Amps

5.5**DATAPORT CONNECTION AND GROUND CONTINUITY TEST (OPTIONAL)**

To perform the DataPort connection and continuity test, refer to *Figure 5-7, DataPort Connector*, then proceed as follows:

1. Confirm the infusion system and appropriate accessories are fully assembled.
 2. Measure the continuity with a DMM between the left lug of the DataPort connector and the ground test point on the lower left corner of the rear case. The resistance should not exceed 1 ohm.
 3. Connect the infusion system to AC (mains) power.
 4. Turn the control knob to the SET RATE position.
 5. Measure the voltage on the DataPort connector between pin 10 (CTS) and pin 9 (COMGND). Verify the voltage is 12.25 ± 0.25 VDC.
 6. Turn the control knob to the OFF position.
 7. Connect the infusion system to an available RS-232 serial port in the host computer.
 8. Set the terminal emulator in the host computer with the following parameters:
 - 1200 baud, 8 data bits, parity none, stop bits 1
 - Echo typed character locally
 9. Turn the control knob to the SET RATE position.
 10. Type in the following commands from the terminal emulator:
 T@0;I45A4<CR>
 where: <CR> = Carriage Return
- Note:** Commands are case sensitive.
11. Verify the response message is in the following format:
 FXX;YYYY;RZZZZ
 where: XX = Hard ID, YYYY = Soft ID, ZZZZ = CRC
 12. Turn the control knob to the OFF position.
 13. Disconnect the infusion system from the RS-232 cable DataPort Connector.



99G10001

Figure 5-7. DataPort Connector

5.6

NURSE CALL FUNCTION TEST (OPTIONAL)

To perform the nurse call function test, refer to *Figure 5-7, DataPort Connector*, then proceed as follows:

1. Confirm the infusion system and appropriate accessories are fully assembled.
2. Turn the control knob to the SET RATE position. Set the rate to a value greater than 40 ml/hr.
3. Turn the control knob to SET VTBI position. Set volume to 100ml.
4. Turn the control knob to RUN to start pumping fluid.
5. Measure the continuity between pin 4 and pin 5 with a DMM. Verify there is an open circuit between the two pins.
6. After several pumping cycles, clamp the tubing proximal to the cassette. After drops stop falling in the sight chamber, verify an occlusion alarm occurs within three pumping cycles.
7. Measure the continuity between pin 4 and pin 5 with the DMM. Verify there is a closed circuit between the two pins.
8. Press [SILENCE] and unclamp the proximal tubing.
9. Verify the continuity between pin 4 and pin 5 changes back to an open circuit once [SILENCE] is pressed.
10. Turn the control knob to OFF/CHARGE.

Section 6

TROUBLESHOOTING

This section contains information on obtaining technical assistance, alarm messages, and error codes for the infusion system.

6.1

TECHNICAL ASSISTANCE

For technical assistance, product return authorization, and to order parts, accessories, or manuals within the United States, contact Abbott Laboratories Technical Support Operations.

1-800-241-4002

For additional technical assistance, including Technical Service Bulletins, technical training, and product information, visit the website at:

www.abbotthpd.com/service

Send all authorized, prepaid returns within the United States to the following address:

Abbott Laboratories
Technical Support Operations
755 Jarvis Drive
Morgan Hill, California 95037

For technical assistance, product return authorization, and to order parts, accessories, or manuals from outside the United States, contact the nearest Abbott Laboratories sales office.

6.2

ALARM MESSAGES AND ERROR CODES

Under most alarm conditions, the infusion system ceases normal operation, generates an audible alarm, and displays an alarm message or error code on the LCD screen. There are two categories of alarm error codes: error codes that can be cleared by the operator and error codes that require qualified service personnel.

6.2.1

OPERATIONAL ALARM MESSAGES

Table 6-1, *Operational Alarm Messages and Corrective Actions*, lists infusion system error codes that can be cleared by the operator. Also listed in Table 6-1 are the alarm messages, descriptions, possible causes, and corrective actions.

Note: Operational alarm messages are displayed on the LCD screen. Associated error codes are displayed in the alarm history.




Table 6-1. Operational Alarm Messages and Corrective Actions				
Error Code	Alarm Message	Description	Possible Cause	Corrective Action
01-1	OCCLUSION 	Distal occlusion alarm	Distal pressure above 10 psi for five seconds	Unkink tubing or Check IV site or Replace administration set If condition recurs, contact Abbott Laboratories
01-2		Distal occlusion alarm	Distal pressure above 10 psi for two plunger strokes	
01-3		Distal occlusion alarm	Distal pressure above 13 psi	
01-4		Distal occlusion alarm	Excessive distal pressure during the valve leak test	
03-1		Proximal occlusion alarm	Clamp closed, tubing kinked, possible occluded tubing, or defective administration set Defective pressure circuit	
03-2		Proximal occlusion on secondary during backpriming		
06-1	AIR IN LINE BACKPRIMING 	Air detected in cassette Proximal air-in-line	1000 microliters (μ l) of air has entered the cassette since the last initialization	Backprime to expel air
07-1	AIR IN LINE 	Distal air-in-line	100 μ l bolus of air detected at distal sensor	Remove and reprime cassette
07-2		Distal air-in-line	260 μ l of air detected in the last 2.6 ml of fluid delivered	Remove and reprime cassette





Table 6-1. Operational Alarm Messages and Corrective Actions				
Error Code	Alarm Message	Description	Possible Cause	Corrective Action
08-1	AIR IN LINE BACKPRIMING 	Empty container alarm	500 µl of air detected entering the cassette in the last two intake strokes	Change container and backprime to expel air
10-1	CHECK SETTINGS ml/H=ml?	Check settings alarm	Rate and VTBI settings not correct	Turn control knob to SET RATE or SET VTBI to check settings or enter values
11-1	TURN TO RUN 	Turn to run alarm	Rotary control knob not in OFF/CHARGE or RUN positions, or no key is pressed for five minutes	Turn control knob to RUN, OFF/CHARGE, or HOLD/RESET position
12-1	VTBI COMPLETE ml=ml	Primary VTBI complete alarm	The VTBI for the primary channel has been delivered	Discontinue infusion or change container and program new VTBI setting
12-2		Secondary VTBI complete alarm	The VTBI for the secondary channel has been delivered	
13-1	CASSETTE DOOR/CASSETTE (XL only)  or 	Input/output valve leak test failure	Defective administration set. Cassette improperly loaded	Turn control knob to OFF/CHARGE position, open and close cassette door, then restart. If condition recurs, replace administration set
13-2		Primary/secondary valve leak test failure	OR Cassette improperly primed	
13-3			Valve leak test failure due to excessive signal noise	Fluid spillage around valve pins

Table 6-1. Operational Alarm Messages and Corrective Actions







Error Code	Alarm Message	Description	Possible Cause	Corrective Action
14-1	LOCKED 	Lock violation alarm	Control knob position changed while in LOCKED mode	Press LOCK button and reset settings
15-1	None. The device does not communicate to the host computer	UART test failure	The UART loop-back test during power-up failed	Replace the MCU PWA (see Section 7.2.9.2)
15-2	None. The device does not communicate to the host computer	Excessively frequent UART interrupts	The MCU does not have enough time to process the UART hardware due to UART hardware failure	Replace the MCU PWA (see Section 7.2.9.2)
15-3	None. The device does not communicate to the host computer	The UART receiver buffer has overflowed	The MCU does not have enough time to process the received data due to UART hardware failure.	Replace MCU PWA (see Section 7.2.9.2)
16-1	TURN TO RUN 	Control knob in between valid states for five minutes	Control knob not in OFF/CHARGE or RUN position	Turn control knob to RUN, OFF/CHARGE, or HOLD/RESET position
			Defective control knob assembly	Replace control knob assembly (see Section 7.2.7.3)
17-1	LOW BATTERY 	Low battery alarm	Low battery	Connect infusion system to AC (mains) power or turn control knob to HOLD/RESET, then to RUN position
17-2		Low battery re-alarms after 15 minutes	Low battery	Connect infusion system to AC (mains) power or turn control knob to HOLD/RESET, then to RUN position

Table 6-1. Operational Alarm Messages and Corrective Actions

Error Code	Alarm Message	Description	Possible Cause	Corrective Action
18-1	LOW BATTERY 	Discharged battery alarm	Fully discharged battery	Connect infusion system to AC (mains) power, turn control knob to OFF/CHARGE position or Replace battery
18-2	(Display blank)	Infusion system shutdown one minute after discharged battery alarm	Fully discharged battery	Connect infusion system to AC (mains) power, turn control knob to OFF/CHARGE position or Replace battery
19-1	DOOR DOOR/CASSETTE (XL only)  or 	Door open	Cassette door open	Turn infusion system control knob to OFF/CHARGE position or close cassette door
			Cassette not seated properly	Reseat cassette

6.2.2

ERROR CODES REQUIRING TECHNICAL SERVICE

Table 6-2, *Error Codes Requiring Technical Service*, lists infusion system error codes that require technical service. Also listed in Table 6-2 are the malfunction descriptions, possible causes, and corrective actions.

Note: The error code is displayed on the LCD screen; associated malfunction descriptions are not displayed. If reference to alarm history is required, refer to Section 6.2.3, *Service Mode*.

Table 6-2. Error Codes Requiring Technical Service			
Error Code	Malfunction Description	Possible Cause	Corrective Action
20-1	Stack overflow	MCU RAM error	Replace MCU PWA (see Section 7.2.9.2)
21-1	Critical data checksum failure at start up	MCU RAM error	Replace MCU PWA (see Section 7.2.9.2) If condition recurs, contact Abbott Laboratories
		Nonvolatile memory error	
21-2	Critical data checksum failure during operation	MCU RAM error	Replace MCU PWA (see Section 7.2.9.2)
21-3	Checksum of operational parameters failure at startup	MCU RAM error	
21-4	Checksum of operational parameters failure during operation	MCU RAM error	
29-1	ROM checksum failure at startup	MCU ROM error	
29-2	ROM checksum failure during operation	MCU ROM error	Replace MCU PWA (see Section 7.2.9.2)
29-3	ROM checksum test not being performed	MCU execution error	
34-1	EEPROM read/write test failure	Decode circuit failure	
		EEPROM chip failure	
35-1	Critical RAM values found incorrect	MCU RAM error	Replace MCU PWA (see Section 7.2.9.2) Replace display PWA (see Section 7.2.7.1)
41-1	Display (LCD) driver chip test failure	Decode circuit failure	
		Driver chip failure	

Table 6-2. Error Codes Requiring Technical Service			
Error Code	Malfunction Description	Possible Cause	Corrective Action
44-1 44-2	Audio BUZZER signal out of range	Audio buzzer or circuit failure	Replace MCU PWA (see Section 7.2.9.2)
		ADC on MCU chip not functioning properly or ADC reference voltage not correct	Check fuse F3 on power supply PWA; replace fuse if defective (see Section 7.2.8.1) If condition recurs, contact Abbott Laboratories
45-1	[PRI/SEC] key stuck in the on position	Switch S1 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)
45-2	[UP ARROW] key stuck in the on position	Switch S3 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)
45-3	[DOWN ARROW] key stuck in the on position	Switch S2 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)
45-4	[TITRATE] key stuck in the on position	Switch S4 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)
45-5	[BACKPRIME] key stuck in the on position	Switch S5 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction Description	Possible Cause	Corrective Action
45-6	[SILENCE] key stuck in the on position	Switch S6 on display PWA is shorted or stuck	Replace display PWA (see Section 7.2.7.1)
		Key insert in front panel is stuck	Replace key insert (see Section 7.2.7.2) Replace front enclosure assembly (see Section 7.2.6)
59-1	Valve motor moving at the wrong time	Position sensor failure	Replace mechanism assembly (see Section 7.2.9.1)
		Motor drive circuit failure	Replace MCU PWA (see Section 7.2.9.2)
60-1	Plunger motor position flag is stuck high during a re-synchronization	Position sensor failure	Replace mechanism assembly (see Section 7.2.9.1)
		Plunger motor not moving	Check connection at J7 on MCU PWA If condition recurs, contact Abbott Laboratories
60-2	Plunger motor position signal is a continuous low during a re-synchronization	Position sensor failure	Replace mechanism assembly (see Section 7.2.9.1)
		Enable circuit failed	Check connection at J7 on MCU PWA
		Plunger motor not moving	If condition recurs, contact Abbott Laboratories
61-1	Input/output motor position flag is a continuous high during a re-synchronization	Position sensor failure	Replace mechanism assembly (see Section 7.2.9.1)
		Input/output motor not moving	Check connection at J8 on MCU PWA If condition recurs, contact Abbott Laboratories
61-2	Input/output motor position signal is a continuous low during a re-synchronization	Position sensor failure	Replace mechanism assembly (see Section 7.2.9.1)
		Enable circuit failure	Check connection at J8 on MCU PWA
		Input/output motor not moving	If condition recurs, contact Abbott Laboratories

Table 6-2. Error Codes Requiring Technical Service			
Error Code	Malfunction Description	Possible Cause	Corrective Action
62-1	Primary/secondary motor position flag is a continuous high during a re-synchronization	Position sensor failure	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
		Primary/secondary motor not moving	Check connection at J9 on MCU PWA If condition recurs, contact Abbott Laboratories
62-2	Primary/secondary motor position signal is a continuous low during a re-synchronization	Position sensor failure	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
		Enable circuit failure	Check connection at J9 on MCU PWA If condition recurs, contact Abbott Laboratories
		Primary/secondary motor not moving	
63-1	Plunger motor phase loss	Plunger motor does not have enough torque	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
		Mechanical assembly failure	
64-1	Input/output motor phase loss	Input/output motor does not have enough torque	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
		Mechanical breakage in mechanism	
65-1	Primary/secondary motor phase loss	Primary/secondary motor does not have enough torque	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
		Mechanical breakage in mechanism	
71-1	Internal timers out of tolerance	Internal MCU PWA malfunction	Replace MCU PWA (<i>see Section 7.2.9.2</i>)

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction Description	Possible Cause	Corrective Action
73-1	+2.5-VDC ADC reference voltage out of tolerance	+2.5-VDC reference to ADC missing or bad	Check fuse F3 on power supply PWA; replace fuse if defective (<i>see Section 7.2.8.1</i>) If condition recurs, contact Abbott Laboratories
		+3.75-VDC reference to ADC missing or bad	Check fuse F3 on power supply PWA; replace fuse if defective (<i>see Section 7.2.8.1</i>) If condition recurs, contact Abbott Laboratories
		ADC failure	Replace MCU PWA (<i>see Section 7.2.9.2</i>)
73-2	+5-VDC ADC reference voltage out of tolerance	+2.5-VDC reference to ADC missing or bad	Check fuse F3 on power supply PWA; replace fuse if defective (<i>see Section 7.2.8.1</i>) If condition recurs, contact Abbott Laboratories
		+3.75-VDC reference to ADC missing or bad	Check fuse F3 on power supply PWA; replace fuse if defective (<i>see Section 7.2.8.1</i>) If condition recurs, contact Abbott Laboratories
		ADC converter failure	Replace MCU PWA (<i>see Section 7.2.9.2</i>)
74-1	Air sensor self test failure. Signal seen when sensors disabled	Air sensor or circuitry failure	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
74-4	Proximal air sensor signal is too high	Air sensor or circuitry failure	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)
74-5	Distal air sensor signal is too high	Air sensor or circuitry failure	Replace mechanism assembly (<i>see Section 7.2.9.1</i>)

Table 6-2. Error Codes Requiring Technical Service			
Error Code	Malfunction Description	Possible Cause	Corrective Action
81-1	Power supply PWA signals HKDC and DHKDC do not match	Power supply PWA failure	Replace power supply PWA (see Section 7.2.8.2)
		Failure in conditioning circuit on MCU PWA	Replace MCU PWA (see Section 7.2.9.2)
81-2	Power supply PWA signal HKDC is out of tolerance	Power supply PWA failure	Replace power supply PWA (see Section 7.2.8.2)
		Failure of conditioning circuit on MCU PWA	Replace MCU PWA (see Section 7.2.9.2)
81-3	Power supply PWA signal VMOT is out of tolerance when AC (mains) is applied	Power supply PWA failure	Replace power supply PWA (see Section 7.2.8.2)
81-4	Motor voltage drops too much when motor is energized	Power supply PWA failure	Replace power supply PWA (see Section 7.2.8.2) If condition recurs, contact Abbott Laboratories
		Motor drawing excessive current	
90-1	Calibration data in EEPROM checksum failure	EEPROM internal failure	Contact Abbott Laboratories
		EEPROM decode circuitry failure	
94-1	Control knob signal seen when disabled	Control knob circuitry failure	Replace display PWA (see Section 7.2.7.1)
94-2	Illegal control knob signal seen	Control knob circuitry failure	Replace display PWA (see Section 7.2.7.1)
94-4	Reed switch does not match control knob signal	Control knob circuitry failure	Replace display PWA (see Section 7.2.7.1)
		Reed switch failure	
95-1	Primary valve pin not moving	Pin detect circuitry failure	Replace mechanism assembly (see Section 7.2.9.1)
		Valve pin not present	
		Valve pin not moving	
95-2	Secondary valve pin not moving	Pin detect circuitry failure	Replace mechanism assembly (see Section 7.2.9.1)
		Valve pin not present	
		Valve pin not moving	

Table 6-2. Error Codes Requiring Technical Service

Error Code	Malfunction Description	Possible Cause	Corrective Action
96-1	UART test failure during operation	UART failure	Replace MCU PWA (see Section 7.2.9.2)
99-1 through 99-6	Failure of one of the internal software self-tests	MCU internal failure	Replace MCU PWA (see Section 7.2.9.2)

6.2.3**SERVICE MODE**

The service mode provides diagnostic and repair service information. On the Plum XL, the service mode is accessed by simultaneously pressing and holding the [TITRATE] and [SILENCE] keys while turning the control knob from the OFF/CHARGE position. On the Plum XLM, simultaneously press and hold the [TITRATE/QUICKSET] and [SILENCE] keys while turning the control knob from the OFF/CHARGE position. These keys must be pressed until the end of the self-test sequence, at which time normal infusion system operation is disabled and the service mode is accessed.

The following sections briefly describe the service mode-particular alarm history, software revision number, run-time, battery run-time and parameter programming functions. *Table 6-3, Service Mode Control Knob Settings*, lists the infusion system control knob settings used during the service mode and provides functional differences for each control knob setting.

Table 6-3. Service Mode Control Knob Settings

Control Knob Setting	Service Mode Information
SET RATE	Alarm history
SET VTBI	Software revision number
RUN	Run time and battery run time
HOLD/RESET (XLM with DataPort)	Parameter programming

6.2.3.1**ALARM HISTORY**

When the infusion system is in service mode and the control knob is turned to the SET RATE position, the alarm history can be viewed. In viewing the alarm history list, large digits indicate an alarm error number (Er01, Er02, Er03) and small digits indicate a four-digit alarm code. If there are no entries in the alarm history, the large digits indicate Er, and the small digits indicate ----.

The infusion system [↑] and [↓] keys are used to scroll through the alarm history. The first entry displayed is the most recent alarm. To view a previous alarm, press the [↑] key. The large numerals increment to indicate the order of alarms. Pressing the [↑] key has no effect when the end of the alarm history is reached. To review the entries, press the [↓] key.

When preventive maintenance is performed on the infusion system, it may be desirable to clear the alarm history. Clear the alarm history by simultaneously pressing and holding the [PRI/SEC] key and the [BACKPRIME] key for four seconds. The small digits flash and an audible tone sounds four times at a once-per-second rate. After four seconds, the alarm history list is cleared.

6.2.3.2

SOFTWARE REVISION NUMBER

When the infusion system is in service mode and the control knob is set to the SET VTBI position, the software revision number can be viewed.

The decimal point does not appear in the software revision number display, but is implied after the first digit. For example, if the display shows 105, the software revision number is 1.05. The software revision number may be necessary when contacting Abbott Laboratories.

6.2.3.3

RUN TIME AND BATTERY RUN TIME

When the infusion system is in service mode and the control knob is set to the RUN position, the run time and battery run time can be viewed.

In the run time and battery run time display, large digits indicate the total infusion system run time in tens of hours and the small digits indicate the battery run time in tens of hours. For example: if the large digits indicate 245 and the small digits indicate 79, the infusion system has been operated for a total of 2,450 hours and has also been operated on battery for 790 of those 2,450 hours.

When replacing the infusion system battery, it may be desirable to clear the battery run time. To clear the battery run time, simultaneously press and hold the [PRI/SEC] key and the [BACKPRIME] key for four seconds. The small digits flash and an audible tone sounds four times at a once-per-second rate. After four seconds, the battery run time is cleared. The total infusion system time cannot be cleared.

6.2.3.4

PARAMETER PROGRAMMING (XLM WITH DATAPORT)

When the infusion system is in service mode and the control knob is set to the HOLD/RESET position, three sub-modes can be viewed and changed. Each of these three sub-modes are used to change the value of an operational parameter of the infusion system as shown in *Table 6-4, Sub-modes of Parameter Programming*.

Sub-mode Name	Purpose	Sub-mode Index
Communication Selection	To select the communication with the host computer	1
Soft ID	To enter the soft ID of the infusion system	2
Channel Label	To enter the channel label of the infusion system	3

The first sub-mode (communication selection) is the default sub-mode of parameter programming. Subsequently pressing the [BACKPRIME] key will change it to the second sub-mode (soft ID), the third sub-mode (channel label), then to the first sub-mode. Within a sub-mode, the small digits indicate its index while the large digits indicate the current value of the parameter to be viewed and programmed.

6.2.3.4.1

Communication Selection

The value of the communication selection can be either 0 or 1. Value 0 means that the communication circuitry of the infusion system will be powered up when the device is operating on AC (mains) power, and will be powered down when the infusion system is operating on battery. Value 1 means the communication circuitry will be powered up regardless of the power supply type. *Table 6-5, Communication Circuitry Selections*, shows how the communication selection and the power supply determine the power of the communication circuitry.

Selection	AC Operation	Battery Operation
1	Power up communication circuitry	Power up communication circuitry
0	Power up communication circuitry	Power down communication circuitry

Note: Use the [↑] and [↓] keys to toggle the value between 0 and 1.

6.2.3.4.2

Soft ID

The large digits indicate the current value of the soft ID. The range is between 0 and 9999.

Use the [↑] and [↓] keys to change the value. The [↑] key increases the value up to, but does not exceed, 9999. The [↓] key decreases the value down to, but does not pass, 0.