



Technical Manual

CADD-Micro[®]

Model 5900

Ambulatory Infusion Pump

For detailed instructions, specifications, warnings, warranties, and additional information on operating CADD® pumps, please refer to the *Operator's Manual* supplied with the product. If you have additional comments or questions concerning the operation of CADD pumps, please call this number: **800-426-2448**. Our staff is available to help you twenty-four hours a day with the programming and operation of the CADD pump infusion systems. Ask for Clinical Services.

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1 Introduction

The Technical Manual is intended to provide a basic, but limited, understanding of the mechanical and electrical operation of SIMS Deltec, Inc. CADD-Micro® Computerized Ambulatory Drug Delivery (CADD®) pump to persons familiar with such computerized devices. The *CADD-Micro Operator's Manual* should be used in conjunction with this publication for complete information.

This manual also outlines cleaning and functional testing procedures that can be performed on the CADD-Micro pump.

IMPORTANT NOTICE:

CADD-Micro pump operations and safety features are based on a microcomputer design. Inadequate servicing or tampering with the safety features of the pump may seriously affect performance and safety.

For that reason, ALL SERVICING AND REPAIR OF THE CADD-Micro® PUMP MUST BE PERFORMED BY SIMS DELTEC, INC. OR ITS AUTHORIZED AGENTS.

The manufacturer's warranty agreement shall become null and void if

- the pump is not used in accordance with the *Operator's Manuals* and *Instructions for Use* for the pump accessories; or,
- the pump is serviced by persons other than SIMS Deltec, Inc. or those authorized by SIMS Deltec, Inc.

Limited Warranty

The limited warranty associated with the CADD-Micro pump can be found in the product literature supplied with the product when originally purchased, which is incorporated herein by reference. SIMS DELTEC, INC. SPECIFICALLY DISCLAIMS ANY OTHER WARRANTY, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR USE. SIMS Deltec, Inc. further disclaims responsibility for the suitability of

the system for a particular medical treatment or for any medical complications resulting from the use of the system. The manufacturer shall not be responsible for any incidental damages or consequential damages to property, loss of profits, or loss of use caused by any defect or malfunction of the system.

If you wish to receive additional information about the extent of the warranty on this product, please contact your Deltec representative or call Clinical Services at 1-800-426-2448.

All recommendations, information, and literature supplied by SIMS Deltec, Inc. with respect to the CADD product line are believed to be accurate and reliable, but do not constitute warranties. No agent, representative, or employee of SIMS Deltec, Inc. has authority to bind SIMS Deltec, Inc. to any representation or warranty, expressed or implied.

Exposing CADD Pumps to Radiation and Magnetic Fields

CAUTION:

The pump SHOULD NOT BE DIRECTLY IRRADIATED by therapeutic levels of ionizing radiation because of the risk of permanent damage to the pump's electronic circuitry. The best procedure to follow is to remove the pump from the patient during therapeutic radiation sessions or diagnostic levels of radiographic and fluoroscopic radiation. If the pump must remain in the vicinity during a diagnostic or therapy session, it should be shielded, and its ability to function properly should be confirmed following treatment.

Magnetic fields produced by magnetic resonance imaging (MRI) equipment will adversely affect the operation of the pump. Remove the pump from the patient during MRI procedures and keep it at a safe distance from magnetic energy.

2 CADD-Micro® Pump Model 5900 Series

Delivery Modes

The CADD-Micro Model 5900 pump may be used to provide a continuous rate of infusion, demand doses, and up to 24 timed, automatic doses, each with its own delivery rate. The CADD-Micro pump offers the capability for intravenous, intra-arterial, subcutaneous, intraperitoneal, and epidural microinfusions. It functions with a “real-time” clock, enabling the pump to deliver a dose at a particular time of day, or a number of doses throughout the day for prescriptions which require multiple infusion rates. (See Figure 1.)

Figure 2 shows a diagram of the CADD-Micro pump.

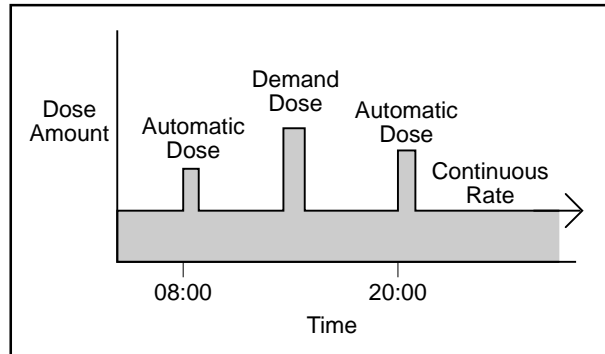


Figure 1. CADD-Micro Model 5900 series pump sample delivery profile.

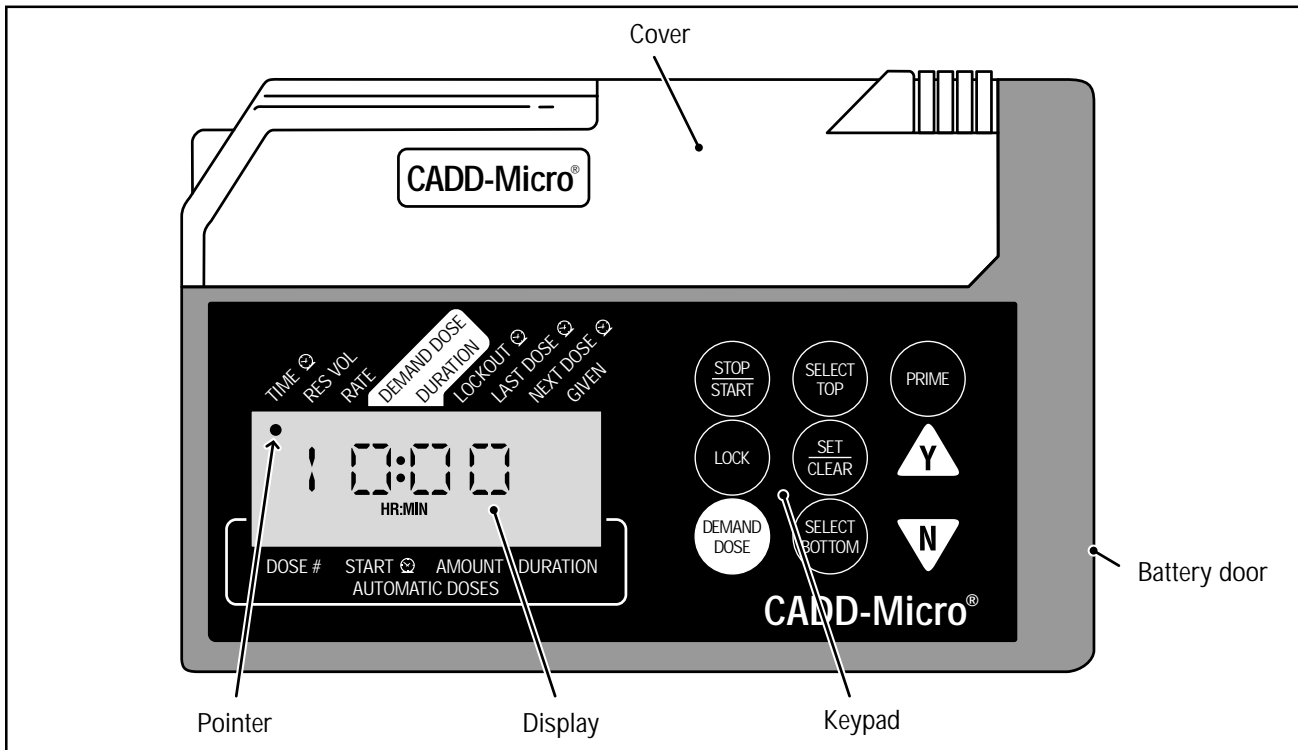


Figure 2. Front view of the CADD-Micro pump.

Technical Specifications (Nominal)

Maximum Infusion Rate: 26 ml/hr (sum of 2 ml/hr continuous RATE, 12 ml/hr automatic dose, and 12 ml/hr demand dose).

Continuous Programming Modes

RATE: 0.000, or 0.020 to 2.000 ml/hr in 0.002 ml/hr increments

Demand Dose Modes

Demand Dose Amount (DEMAND DOSE): 0.000, or 0.020 to 1.000 ml in 0.002 ml increments.

Demand Dose DURATION: FAST, :05 to :15 in 1-minute increments, and :15 to 24:00 hr:min in 5-minute increments.

Lock Out Time (LOCKOUT ☹): :00 to 1:00 hr:min in 1-minute increments and 1:00 to 23:55 hr:min in 5-minute increments.

“FAST” Duration: Dose is delivered over a whole number of minutes at a maximum rate of 12 ml/hr (0.2 ml/min).

Automatic Dose Modes

Automatic Dose Number (DOSE #): NONE, 1 through 24.

Automatic Dose Start Time (START ☹): —:—, 00:00 to 23:55 hr:min in 5-minute increments.

Automatic Dose AMOUNT: 0.000, or 0.020 to 1.000 ml in 0.002 ml increments and 1.000 to 10.000 ml in 0.010 ml increments.

Automatic Dose DURATION: FAST, :05 to :15 minutes in 1-minute increments and :15 to 24:00 hr:min in 5-minute increments.

General Record-keeping Modes

Time of Day (☹): 00:00 to 23:59 hr:min in 1-minute increments.

Reservoir Volume (RES VOL): 0.000 to 10.500 ml in 0.100 ml increments.

Volume Given (GIVEN): 0.000 to 19.998 ml, in 0.002 ml increments.

Next Dose Time (NEXT DOSE ☹): —:—, 00:00 to 23:59 hr:min in 1-minute increments.

Demand Dose Counter: 0 to 9999.

Pump Characteristics

Volumetric Resolution: 0.002 ml per interval at rates < 0.12 ml/hr; 0.004 ml per interval at rates ≥ 0.12 ml/hr and < 1.44 ml/hr; 0.008 ml per interval at rates ≥ 1.44 ml/hr.

Delivery Interval: Dependent upon rate.

Delivery Accuracy: ± 3%, nominal when delivering 1 ml at room temperature with no back pressure.

Dimensions

Size: 2.3 cm x 7.6 cm x 11.9 cm (0.9 in x 3.0 in x 4.7 in)

Weight: 255 grams (9 ounces) including battery and empty reservoir.

Alarms

- Pump in Stop mode.
- Low reservoir-residual volume.
- Reservoir-residual volume at 0.000 ml.
- Low battery warning.
- Battery depleted.
- Hardware and software fault detection.
- High delivery pressure (8 ± 4 psi).
- Conflicting program values.
- Reservoir cover removed.
- Dose started.
- Dose locked out.
- Next dose locked out.
- One or more automatic doses locked out.
- Dose in progress.
- Cancel demand dose.
- Dose added.
- Dose removed.
- Number of doses programmed.
- Remove all doses.
- Change time of day.
- No rate or doses programmed.
- Cancel next automatic dose.
- Number of doses given.
- Reservoir cover off.
- Reservoir cover on.
- Key stuck.

Power

Power Sources: 9-volt alkaline or lithium battery (use DURACELL® MN 1604 or EVEREADY® #522, for example; or ULTRALIFE® Lithium U9VL).

The External Power Source (EPS) system is NOT to be used to power the pump.

Reservoir Capacity

10-ml Micro Medication Reservoir.

Environmental Requirements

Operating Temperature Range: +2°C to 40°C (35°F to 104°F).

Storage Temperature Range: -40°C to 70°C (-40°F to 158°F).

Humidity Range: 10% to 90% relative humidity noncondensing.

3 Batteries

Battery Compatibility

Recommended Batteries

Nine-volt alkaline or lithium batteries are recommended for use with the CADD-Micro pump. Carbon-zinc, mercury, zinc-air, or rechargeable nickel-cadmium 9-volt batteries should not be used. The EPS system is NOT to be used with the CADD-Micro pump.

Battery Life

CADD pumps have been designed to provide optimal battery life. The expected battery life in the Deltec CADD-Micro infusion pump depends on the following factors:

- Programmed delivery rate.
- Operating temperatures.
- Battery type and brand.
- Battery age.

DURACELL Alkaline Battery Life

Table 1 may be used to predict typical alkaline battery life when an alkaline battery is used in the CADD-Micro pump. As expected, battery life decreases as the delivery rate increases. These tables are based on laboratory tests using fresh DURACELL alkaline batteries in CADD-Micro pumps while the pumps were operating at room temperature.

Actual battery life may be significantly shorter, depending on the operating temperature and the storage conditions of the battery.

Battery life is shortened significantly at very low operating temperatures. For example, at 0°C (32°F), an alkaline battery will yield approximately 30% of its normal capacity.

Alkaline batteries do not need to be stored in a refrigerator. After four years of storage at 21°C (70°F), an alkaline battery retains approximately 86% of its original capacity. Battery life will be shorter if the battery is stored above room temperature. An alkaline battery stored at 43°C (110°F) will be down to approximately 80% of its capacity within one year.

Recommended storage conditions are 10°C to 25°C (50°F to 77°F) with no more than 65% relative humidity noncondensing.

Table 1. Typical battery life for alkaline-type batteries used with the CADD-Micro pump.[†]

Delivery Rate	Alkaline Battery Life	Total Volume Delivered (per Battery)
10 ml/day	7-9 days	70-90 ml

[†] This table is based on laboratory tests conducted at room temperature using fresh DURACELL alkaline batteries. Actual battery life will vary, depending on the brand of battery, battery shelf life, and temperature conditions.

ULTRALIFE Lithium Battery Life

Table 2 may be used to predict typical lithium battery life when a lithium battery is used in the CADD-Micro pump. As expected, battery life decreases as the delivery rate increases. These tables are based on laboratory tests using fresh ULTRALIFE lithium batteries in CADD-Micro pumps while the pumps were operating at room temperature.

Actual battery life may be significantly shorter, depending on the operating temperature and the storage conditions of the battery. Lithium battery life is dependent upon the temperature and relative humidity of storage. Recommended storage conditions are less than 20°C (68°F) with a desiccant to ensure less than 10% relative humidity.

Table 2. Typical battery life for ULTRALIFE lithium-type batteries used with the CADD-Micro pump.[†]

Delivery Rate	Lithium Battery Life	Total Volume Delivered (per Battery)
10 ml/day	16 days	170 ml

[†] This table is based on laboratory tests conducted at room temperature using fresh ULTRALIFE lithium batteries. Actual battery life depends upon the brand of battery selected, the particular battery selected, battery shelf life, and temperature conditions. Deltec's testing indicates a large variability in battery life.

4 Construction

The housing has been designed to be water resistant. The battery compartment is not water resistant.

NOTE:

CADD ambulatory infusion pumps are water resistant, but are not waterproof.

The battery compartment is accessed through a removable door in the back housing. Within the battery compartment is space for the battery and the two battery contacts.

The Micro Medication Reservoir (syringe) is attached to the top of the pump, underneath the reservoir cover. To install the reservoir, rotate the drive nut so its left edge lines up with the corresponding graduation on the pump. Place the reservoir onto the pump making sure the plunger rod end is seated firmly around the drive nut, and the reservoir heel is engaged in its slot. Snap the reservoir in place. Slide the reservoir cover completely onto the pump. (See Figure 3.)

NOTE:

The Micro Medication Reservoir is intended for single use only.

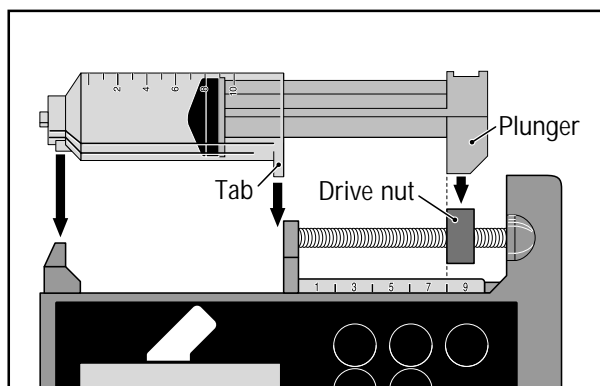


Figure 3. Attaching the Micro Medication Reservoir to the CADD-Micro pump.

The keyboard, located on the front housing is composed of nine membrane switches and is sealed against moisture. All of the keys contain domes to provide a tactile feel when the key is pressed. The keyboard keys are sensed by the pump's microprocessor.

The custom Liquid Crystal Display (LCD), also located on the front housing, shows the pump status and parameter settings. The annunciators to be displayed are selected by the pump's microprocessor, according to status conditions and keyboard entries.

The CADD-Micro Model 5900 pump incorporates labels along the top and bottom of the LCD, which correspond to functions that are programmed into the pump or calculated by the pump. A dot, or pointer, in the LCD indicates which of the 13 functions you are viewing or programming.

The microprocessor and other circuitry which control the pump are located on two printed circuit boards. The microprocessor board contains the Central Processing Unit (CPU) and its associated circuitry. The LCD board contains the Liquid Crystal Display with its associated circuitry, the motor driver circuitry, and other miscellaneous circuitry. Both printed circuit boards are coated with a transparent moisture-barrier material.

The CADD-Micro Model 5900 pumping mechanism subassembly contains the motor, gear train, lead screw, drive nut, sensing disk, infrared light source, and infrared detector. Via the motor driver circuitry, the pump's microprocessor controls motor rotation.

All connections between the printed circuit boards are soldered to maintain reliability. The two printed circuit boards are connected by a ribbon connector which is soldered at both ends. The keyboard is connected to the LCD board via a flex circuit tail which is soldered to the LCD board. Discrete soldered wires connect the pumping mechanism, motor, and sensors to the printed circuit boards.

5 Theory of Operation

Keyboard Circuitry

CADD pumps are controlled by a microprocessor. The actions of the microprocessor are controlled by a program, which is contained in the EPROM.

Commands are issued to the microprocessor from the user via the nine keys on the keyboard. These keys are connected in a four by four matrix. The X and Y lines of the matrix are continuously scanned by the keyboard encoder. When one of the four X lines is connected to one of the four Y lines by pressing a key, a keyboard interrupt message is sent to the microprocessor by the keyboard encoder. In response, the microprocessor reads the four-bit code corresponding to the key pressed from the keyboard encoder. A unique code corresponds to each key. Even if more than one key is pressed simultaneously, the code for only one of the keys is presented to the microprocessor.

Data Memory EEPROM

The settings of the pump's delivery and record-keeping parameters are stored by the microprocessor in an Electrically Erasable Programmable Read Only Memory (EEPROM). Whenever the microprocessor uses data from the EEPROM, the data is checked for validity.

Time Base Circuitry

The microprocessor crystal frequency is 1.2283 MHz. The microprocessor divides this clock by four, resulting in a data bus frequency of 307.2 kHz. For increased safety, the pump has a dual time base with two crystals that are checked at power-up and every few minutes.

LCD Display Circuitry

The high-impedance, low-power, special drive signals for the liquid crystal display are provided by the LCD-driver. Each annunciator and each numeric segment is driven by a

separate connection to the LCD-driver. When an annunciator or numeric segment AC signal is 180° out of phase with the display back-plane, the associated area on the LCD will be dark. Each numeric character on the LCD is formed from darkening combinations of seven segments for each of the four numeric characters. Each annunciator is, in effect, a single segment which has been printed on the LCD to form an entire word or phrase, such as LOW BAT. The display driver resides on the data bus and command and data signals are sent to it in parallel. Once the location and character to be displayed has been sent to the LCD-driver by the microprocessor, the LCD-driver automatically displays the character until the microprocessor issues new commands to change the display.

Programmable Array Logic Circuitry

A Programmable Array Logic (PAL) device contains memory decoding and alarm control logic. A separate device generates the audible alarm tones and warble signal. A separate, dedicated control circuit is used to generate the necessary low battery alarm and microprocessor reset control signals.

Safety Timeout Circuitry

In the CADD-Micro pump, failure of the microprocessor to periodically reset the watchdog timer circuit results in automatic disabling of the motor and enabling of the alarm. The watchdog timer circuit will then repeatedly attempt to reset the microprocessor. The motor will continue to be disabled and the alarm enabled until proper operation of the microprocessor is detected.

Motor Driver Circuitry

The motor driver circuit is composed of a one-shot, power FETs, and various passive components. When the microprocessor issues a signal from an output port-bit, the motor receives power and begins to rotate. When the infrared detector has signaled the microprocessor that the motor has rotated, the microprocessor terminates a signal and the output of the one-shot goes low, taking power from the motor

and then applying an electrical brake to the motor which stops its rotation very accurately. An independent input from the microprocessor watchdog timer circuit can disable the motor if a microprocessor failure is detected.

The motor hardware time-out circuit will stop the motor if it remains enabled for more than approximately 2.5 seconds. An independent time-out circuit watching the microprocessor will also stop the motor after a maximum of 2.25 seconds if the microprocessor is not functioning properly.

Rotation of the motor is sensed by the microprocessor via an infrared-sensitive photo detector. An infrared light source is mounted so that its light beam illuminates the infrared detector. A disk with a series of slots around its perimeter is mounted concentrically to the camshaft and rotates with it between the infrared light source and detector. When the flag interrupts the light beam, the output of the detector is sensed by the microprocessor via an input port bit. Power to the infrared LED light source is controlled by the motor driver circuit and is off when the motor is not running to conserve battery life.

In the microprocessor software, multiple checks are made on motion of the camshaft. When the motor is commanded to start, the infrared sensor must show that a specific amount of rotational movement has occurred within 500 milliseconds and that the motor has stopped. One revolution of the motor is divided into twenty pump segments. A software algorithm allows verification of the proper number of pump segments (twenty) for each revolution of the motor. In addition, no camshaft rotation can take place when the motor has not been commanded to run.

Power Circuitry

Power for the pump is normally supplied by a 9-volt alkaline battery or a 9-volt lithium battery. These types of batteries have a fairly low internal resistance over their discharge range, which will keep power supply noise low. Other types of batteries, such as carbon-zinc, exhibit high internal resistance, especially near depletion. A voltage drop across the internal resistance occurs when current is drawn by the

motor during pump activations. This current is demanded in short pulses when the motor is first turned on and generates large spikes in the battery voltage. This noise can cause the low battery detection circuit to shut down the pump.

The motor driver circuit power is taken directly from the battery, but the microprocessor and its associated circuitry requires closely regulated and filtered 5-volt power which is supplied from the micropower voltage regulator. This regulator will supply 5-volt power until its input voltage is approximately 5.8 volts. After that point, the output of the regulator will follow the input voltage down.

Low Voltage Detection Circuitry

Low voltage detection is performed with a combination of software controlled measurements and hardware set points. The software has the ability to measure the battery voltage via an analog-to-digital converter on board the microprocessor. (See Table 3.)

When the battery voltage reaches between 6.4 and 7.2 volts, the software will flash the LOW BAT annunciator on the LCD at a rate of 1 second on and 1 second off, and an audible alarm will be activated every five minutes. This

Table 3. CADD-Micro pump LOW BAT conditions.

Voltage Trip Point	CADD Pump Status
> 7.2 V	No alarm
6.4–7.2 V*	Transition to low battery condition; indicator blinks; 3 beeps every 5 min [†]
5.9–6.7 V*	Transition to low battery condition; indicator appears on LCD; continuous alarm ^{††}

*The trip-point differential is between 0.15 and 0.50 volts.

[†] The pump emits 3 beeps every 5 minutes, and the LOW BAT indicator blinks on the pump's display, indicating that the battery power is low; but the pump is operable.

^{††} The pump emits a continuous, variable-tone alarm, and LOW BAT remains on the display but does not blink; the battery power is too low to operate the pump; and the pump operation has stopped.

will continue until the battery voltage reaches between 5.9 and 6.7 volts. At this point the software will activate a continuous LOW BAT annunciator and an audible alarm, and will enter a shutdown mode in which pumping is disabled. The specified ranges of these two voltage thresholds appear to overlap. In reality, however, these thresholds do not overlap since both thresholds use the same measurement circuit. A shift in voltage of one threshold due to component value variations will result in a similar magnitude shift in the other threshold.

In addition to the software shutdown, a hardware shutdown will occur as the battery voltage reaches approximately 5.6 volts. As the battery voltage continues to decrease, the shutdown sequence is not outwardly apparent. The sequence provides for safe hardware shutdown when the battery voltage is no longer high enough to reliably support microprocessor operation.

Pumping Mechanism

The pumping mechanism is a syringe drive-type mechanism. Pumping occurs when the motor rotates the lead screw which in turn advances the drive nut. The Micro Medication Reservoir (syringe) rod is driven by the advancing drive nut. The amount of fluid delivered is controlled by a sensing disk, infrared light source, infrared detector, and software. (See Figure 4.)

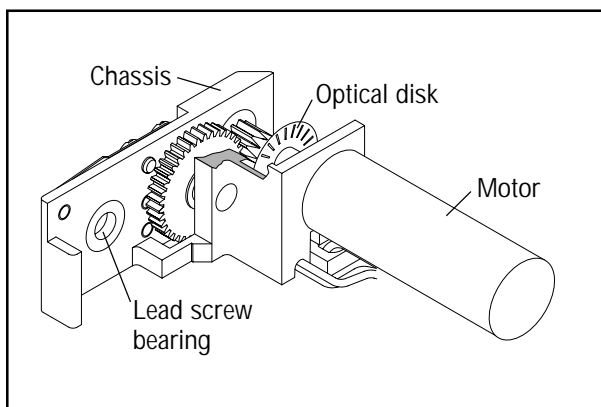


Figure 4. A simulated pumping mechanism in a CADD-Micro pump.

Pumping Characteristics

If the fluid path to the patient becomes blocked, the reservoir and tubing will expand as pumping occurs. This expansion generates an axial force on the lead screw which in turn applies a force to a switch. When the pressure in the reservoir reaches 55 ± 28 kPa (0.55 ± 0.28 bar, 8 ± 4 psi), the occlusion detector switch closes, whereupon the microprocessor stops the pump mechanism and issues visual and audible alarms. The maximum pressure that can be developed is 83 kPa (0.83 bar, 12 psi).

To deliver the amount of drug specified by the parameter settings, the pump's microprocessor causes the pump mechanism to deliver 0.002, 0.004, or 0.008 ml fluid "pulses" timed according to the desired rate. An increase in the delivery rate causes a decrease in the interval between motor activations. The amount delivered per motor activation for different rates is as follows:

EFFECTIVE RATE	AMOUNT
< 0.12 ml/hr	0.002 ml
$\geq 0.12 < 1.44$ ml/hr	0.004 ml
≥ 1.44 ml/hr	0.008 ml

Thus to deliver 1.5 ml/hr, for example, the microprocessor solves these equations:

Mechanism activations per 1 hour

$$\begin{aligned}
 &= 1.5 \text{ ml per 1 hour} / 0.008 \text{ ml per activation} \\
 &= 1.5 / 0.008 \\
 &= 187.5
 \end{aligned}$$

Time (seconds) between activations

$$\begin{aligned}
 &= 3600 \text{ sec per 1 hour} / \text{number of activations per hour} \\
 &= 3600 / 187.5 \\
 &= 19.2
 \end{aligned}$$

The microprocessor uses its timer circuits to accurately time the 19.2 seconds (in this example) between mechanism activations. The time base accuracy is ultimately determined by the 1.288 MHz quartz crystal oscillator.

6 Safety Features and Fault Detection

Hardware Safety Features

Key hardware safety features include a watchdog timer circuit, motor driver and motor watchdog circuits, and a voltage detector circuit. Each safety circuit performs a unique function to insure the over-all safety of the device. (See Figure 5.)

Watchdog Timer Circuit

The microprocessor must send an appropriate signal to the watchdog circuit at least once every 2 seconds. If the microprocessor does not send the signal, the watchdog circuit will time out and shut down the pump.

The watchdog circuit is a CMOS one-shot. It is configured to operate in the “retriggerable” mode. If the one-shot times out, the Q and not-Q lines change state. The Q line, going low, will put the microprocessor into reset. The not-Q line, going high, will force the audible alarm on. Once the one-shot times out, there is no way for the one-shot to be retriggered without removing and reinserting the battery.

Motor Driver/Motor Watchdog Circuit

The motor control circuitry is designed to prevent the pumping mechanism from running continuously. Under normal conditions the microprocessor turns on the motor by triggering a one-shot which in turn applies power to the motor. This one-shot has a 4.7 second time out. If, for some reason, the pump controller did not shut the motor off after 4.7 seconds the one-shot would time out and shut off the motor.

The motor control circuit also incorporates additional circuitry which continuously monitors the voltage being applied to the motor. If under any circumstance voltage is applied to the motor for more than 7 seconds, this circuit will automatically cut power to the motor. In this case, the motor will be disabled in a manner different from the method in which the one-shot turns off the motor.

A means has been provided for the microprocessor to sense the voltage applied to the motor. (See “Software Safety Features” on page 12 of this manual.)

Voltage Detector Circuit

The low voltage detection circuitry works in two stages. First, when the battery voltage begins to get low, a signal is sent to the microprocessor. Second, the microprocessor then sounds a periodic alarm and flashes the LOW BAT annunciator on the LCD display.

When the battery voltage drops to the point at which reliable operation of the pump controller can no longer be guaranteed, the following action will take place: the motor circuit is disabled by a method independent from all others; the microprocessor is forced into reset; and a continuous audible alarm and the LOW BAT annunciator are turned on. Once the pump controller goes into low battery shutdown, only replacing the old battery with a fresh one will clear the condition.

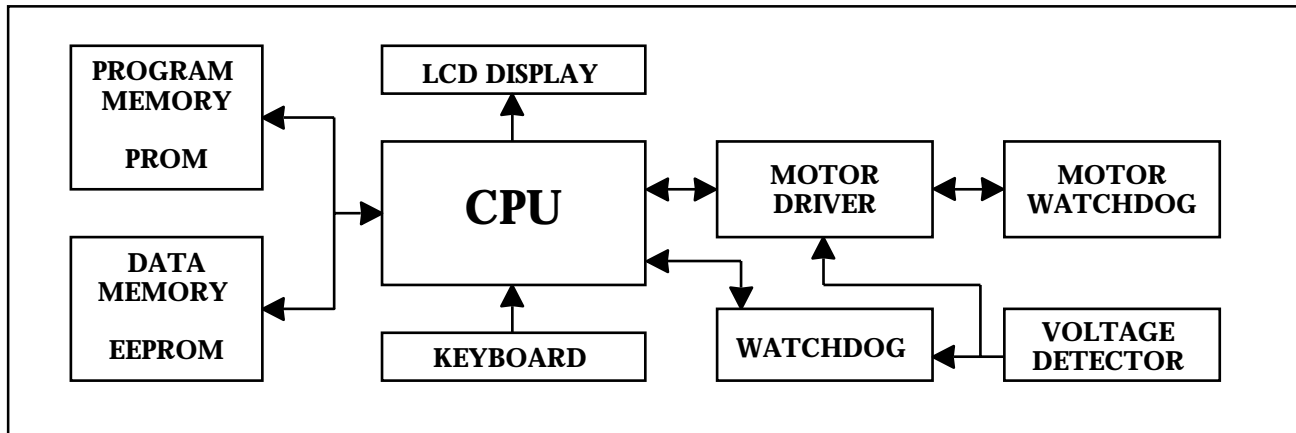


Figure 5. CADD-Micro pump hardware block diagram.

Software Safety Features

Hardware-Related Software Safety Features

Program Memory (PROM) Check

At power up, and at regular intervals thereafter, the program memory is tested by the software. The content of the memory is added and then compared against a checksum. If they do not match, the software will turn on a continuous, audible alarm and stop all drug delivery.

Data Memory (EEPROM) Check

At power up, the data memory is tested by the software. The content of the memory is checked, address by address, for the proper data. If any bad data is found, the software automatically reprograms the data memory to the default (safe) settings and stops all drug delivery. The user is then shown the new data and, at the same time, a series of audible alarms will sound.

Working Memory (RAM) Check

At power up, the random access memory is checked. A special bit pattern is written to and read from each address in the RAM. If any bad data is found, the software will turn on a continuous, audible alarm and stop all drug delivery.

Motor Circuit Check

At power up and every second thereafter, the motor circuit is checked to ensure no power is being applied to the motor; except, of course, when the motor is actually on. If the software

detects power being applied to the motor, it will sound a constant audible alarm and will no longer attempt to deliver medication.

During every pump activation, the software checks to see whether the motor completes one activation. If the motor fails to turn, or fails to complete a cycle, the software will turn on a continuous, audible alarm, and the pump controller will no longer attempt to deliver the medication.

Keyboard Encoder Check

Every time the software receives data from the keyboard encoder, it is checked. If the data is not within the correct range, a constant audible alarm is turned on, and the pump controller will no longer attempt to deliver drug.

Data Handling Software Safety Features

Data Stored in RAM

All data that is stored in RAM and used in some way to control the delivery of drug is stored redundantly or with a checksum. Before the data is used, its validity is checked. If a mismatch or checksum error is found, a continuous audible alarm is turned on and the pump controller will no longer attempt to deliver the medication.

Data Stored in EEPROM

All data stored in EEPROM is checked before it is used. If the data is found to be bad (improper checksum) a continuous audible alarm is turned on and the pump controller will no longer attempt to deliver the medication.

Data Used in Calculations

When a calculation is made which is used in determining how much drug to deliver a check is made on the result of the calculation. If the result is not within proper limits, a continuous audible alarm is turned on and the pump controller will no longer attempt to deliver the medication.

Timer Data Registers

The data stored in the timer control register is checked every second for accuracy. If the data is not correct a continuous audible alarm is turned on and the pump controller will no longer attempt to deliver the medication.

Interrupt Service Routines

The software is organized around three interrupt service routines. When the battery is

inserted, the power-up module initializes the pump and performs safety checks, after which it waits for a timer or keyboard interrupt. A keyboard interrupt occurs whenever a key is pressed, and the service routine responds according to the pressed key. A timer interrupt occurs every second, and the service routine maintains all time-dependent functions. (See Figure 6.)

The software routines are functionally grouped into software modules. In addition to the modules that service the interrupts, there are also modules that contain routines to control the LCD, pump motor, EEPROM, and delivery rate calculations. (See Figure 7.)

KEYBOARD INTERRUPT SERVICE MODULE	POWER UP MODULE	TIMER INTERRUPT SERVICE MODULE
Service keyboard input as appropriate for keys pressed and current pump status.	Initialize system. Perform safety checks. Wait for timer or keyboard interrupt.	Perform periodic safety checks. Maintain pump interval timing. Maintain time-dependent alarms. Maintain flashing annunciators.

Figure 6. Interrupt service routines.

<table border="1"> <thead> <tr> <th data-bbox="191 1348 613 1415">DISPLAY ROUTINES</th> </tr> </thead> <tbody> <tr> <td data-bbox="191 1415 613 1608">Handles various methods of displaying and toggling LCD segments.</td> </tr> </tbody> </table>	DISPLAY ROUTINES	Handles various methods of displaying and toggling LCD segments.	<table border="1"> <thead> <tr> <th data-bbox="623 1348 1045 1415">MATH ROUTINES</th> </tr> </thead> <tbody> <tr> <td data-bbox="623 1415 1045 1608">Contains arithmetic routines. Divide. BCD to binary.</td> </tr> </tbody> </table>	MATH ROUTINES	Contains arithmetic routines. Divide. BCD to binary.	<table border="1"> <thead> <tr> <th data-bbox="1055 1348 1476 1415">CALCULATION ROUTINES</th> </tr> </thead> <tbody> <tr> <td data-bbox="1055 1415 1476 1608">Contains routines to calculate pump parameters. Pumping interval. Bolus amounts.</td> </tr> </tbody> </table>	CALCULATION ROUTINES	Contains routines to calculate pump parameters. Pumping interval. Bolus amounts.
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MISCELLANEOUS ROUTINES								
Routines to do various tasks: walking digits, on/off, display, beep, and limit check.								

Figure 7. CADD-Micro software routines.

Hardware and Software Fault Detection

Overview

If a CADD pump displays an error code, a hardware or software fault has been detected by the microprocessor, and the pump should be returned for servicing.

When hardware or software faults are detected by the microprocessor, the pump operation stops, and a continuous, audible alarm will be activated. An error message will be displayed. On the next power up, an error code will again be displayed with the software level. The pump will be in Lock Level 2. All of the programmed functions will have default values. (See the pump's *Operator's Manual* for specific defaults.)

Order of Error Code Events

1. There is a continuous, two tone audible alarm and the display will read EEEE.
2. To silence the error code alarm, remove the battery.

3. At the next power-up and each subsequent power-up thereafter (until the pump is serviced), the microprocessor will write a software revision, plus an error code in the EEPROM. Four characters will appear on the LCD; the first character indicates the software revision number, the second character "E" represents an error has occurred, and the remaining two characters indicate the error code number. (See Figure 8.) These four characters will remain in memory and will appear on the LCD upon each power-up until another fault occurs. (See "Testing Procedures" in this manual for detailed instructions regarding the power-up check.) The CADD-Micro pump records the last three internal faults detected by the microprocessor.

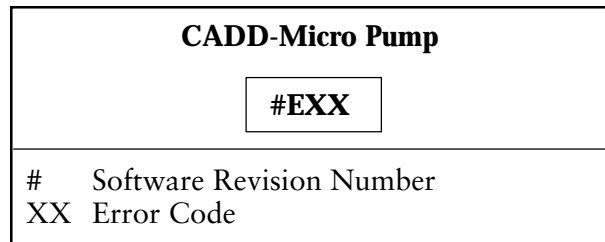


Figure 8. Error code display.

Error Codes

The error codes and their meanings follow:

- | | | | |
|----|--|----|--|
| 01 | Microprocessor failure. | 32 | Power-up ROM error. |
| 02 | Event data error. | 33 | Data error. |
| 03 | Internal microprocessor “watchdog” timing out. | 34 | Reservoir cover data is corrupted. |
| 04 | Clock monitor circuit is reset. | 35 | EEPROM checksum error. |
| 05 | Run mode sequence is not followed exactly. | 36 | Motor run sequence is out of order. |
| 06 | Run mode status data is corrupted. | 37 | Motor run sequence is out of order. |
| 07 | Delivery variable has an invalid value. | 38 | Delivery software data is corrupted. |
| 08 | Invalid values were used in calculations. | 39 | Delivery software data is corrupted. |
| 09 | Dose delivery data is corrupted. | 40 | Delivery rate data is invalid. |
| 10 | Results from delivery calculations are out of range. | 41 | Encoder error. |
| 11 | Dose delivery data is corrupted. | 42 | Software sequence error when pumping fluid. |
| 12 | Invalid Keyboard data. | 43 | Pumping software data corrupted. |
| 13 | Invalid Keyboard data on the DEMAND DOSE, STOP/START and PRIME keys. | 44 | Pumping software data corrupted. |
| 14 | Voltage reference is too low. | 45 | Pumping software data error. |
| 15 | Voltage reference is too high. | 46 | Pumping software data corrupted. |
| 16 | Real time clock RAM is corrupted. | 47 | Motor latch-up circuit error. |
| 17 | Power-up time-base error. | 48 | Motor latch-up capacitor error. |
| 18 | Watchdog circuit test failed on power-up. | 49 | Motor latch-up circuit error. |
| 19 | CONFIG register of the microprocessor is out of range. | 50 | Driver motor reset improperly. |
| 20 | Watchdog indicates a low voltage on the WDO line. | 51 | Watchdog reset fails motor disable. |
| 21 | Self test sequence error. | 52 | Driver motor activated improperly. |
| 22 | Self test sequence error. | 53 | Driver motor activated improperly. |
| 23 | Invalid op-code has been executed. | 54 | Motor is not active when expected. |
| 24 | Unassigned interrupt is functional. | 55 | Encoder disk is not rotating in the expected amount of time. |
| 25 | Microprocessor is “lost.” | 56 | Motor latch-up circuit failure. |
| 26 | Clock sequence error. | 57 | Motor latch-up capacitor failure. |
| 27 | Clock is out of specification. | 58 | Motor latch-up capacitor failure. |
| 28 | ROM data is corrupted. | 59 | Motor software data is corrupted. |
| 29 | Microprocessor stack data overflow. | 60 | Scheduling software tasks data is corrupted. |
| 30 | Data for the five minute testing sequence is corrupted. | 61 | Incorrect sequence has occurred when starting a demand dose. |
| 31 | CPU error. | 62 | Incorrect sequence has occurred when going into Run mode. |
| | | 63 | Watchdog reset did not occur. |
| | | 64 | Bad data in ROM table. |
| | | 65 | Incorrect value in software function. |

7 Cleaning and Inspection Procedures

In the event your institution, hospital, or other health care facility decides it would be appropriate to establish a maintenance program for any CADD pump product, procedures contained in this section may be considered for inclusion in such a program. Please note that the following information is not meant to be inclusive of all items which should be included in your program. The suggested procedures are only provided as a reference for your use.

NOTE:

Persons performing the following tests and procedures should be familiar with Deltec CADD pumps. Please read the *Operator's Manual* supplied with the pumps before proceeding.

WARNING:

CADD pumps are sealed units. A broken or damaged seal will, therefore, be considered conclusive evidence that the pump has been misused and/or altered, which voids any and all warranties. All service and repair of CADD pumps must be performed by SIMS Deltec, Inc. or its authorized agents.

Cleaning

The CADD-Micro pump housing may be cleaned with a soft damp cloth. Do not use abrasive cleaners or immerse the pump in cleaning fluid or water. The pump may be cleaned with one of the following solutions:

- Soap solution.
- Ethyl alcohol (70%).
- Chlorhexidine (70%) in alcohol.
- Isopropyl alcohol.
- Sodium hypochlorite (household bleach 5.25%) 1:10 dilution.

The leadscrew may be cleaned as required with an aerosol lint and dust remover. If necessary, the leadscrew may require additional cleaning with isopropyl alcohol using a lint free cloth. The leadscrew is self-lubricating.

CAUTION:

Do not lubricate the leadscrew or the plastic drive nut. Battery life and delivery accuracy may be affected if the leadscrew or the drive nut is tampered with.

Visual Inspection

- Visually inspect the pump for any damage to the LCD, keyboard, and housing. Check the lead screw and drive nut for any damage.
- Check the battery door for proper operation. It should not be broken.
- Examine the battery compartment for damage. If the battery contacts appear corroded, clean them with a cotton swab and isopropyl alcohol. If the battery contacts appear to be bent or pushed in, straightening may be possible with a small screwdriver or other suitable tool. Care must be taken so as not to damage the pump housing or to incur further damage to the contacts.

Mechanical Inspection

- Press each key on the keyboard. Each key should have a distinctive dome feeling. The keys should not feel flat.
- Attach the battery door. The battery door should fit snugly in place when it is closed on the pump with a battery inserted. (The battery door may fit loosely when no battery is installed.)
- Attach a Micro Medication Reservoir to the drive nut and pump. Check for a snap when the reservoir engages onto the pump. Slide the reservoir cover onto the pump and check the display for the message "COVER ON." If the cover does not slide on completely, the reservoir may not be placed properly.

8 Testing Procedures

Functional Testing

NOTE:

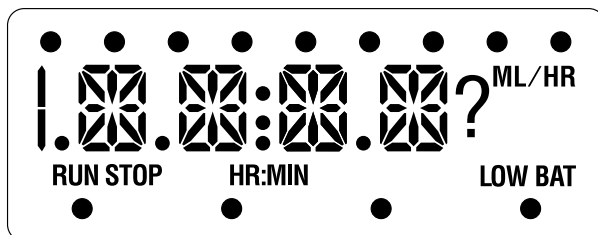
Deltec does not recommend specific time intervals for maintenance of CADD pumps. The selection of maintenance time intervals remains the responsibility of the health care provider.

Power-up Check:

- Make sure the reservoir cover is in place. Insert a battery in the pump and observe the LCD during power up. All of the characters on the LCD will be displayed. Then one or four characters will appear. If four characters appear, the first character indicates the software revision number, the second character “E” represents an error has occurred, and the remaining two characters indicate the error code number. The pump has experienced an electrical or mechanical fault and should be returned for service. (An explanation of the error codes can be found on page 15 of this manual.) If one digit appears, this is the software revision. The pump has powered up normally. The pump should sequentially display all of the programmed values and beep six times. Each annunciator should operate properly for each setting. Continue with the LCD check.

LCD Check:

- Remove and re-insert the battery. In approximately 5 seconds the display will flash all of the characters on the LCD. Check that each segment of the LCD appears on the display.



- Place the pump in Lock Level 0 (LL0). With the pump in the RES VOL mode, scroll to

0.600 ml. Press the SET/CLEAR key. Press the SELECT TOP key seven times or until the RES VOL mode is visible, then observe the display. The stop annunciator should be flashing, along with steady RES VOL and ml annunciators.

Motor and Gear Train Check:

- Press and hold the PRIME key until four P's (PPPP?) appear on the display. Release the PRIME key. Now press and continue to hold the Y key. The pump should begin to prime. While priming the pump, listen to the motor for excessive noise or grinding sounds. Count the number of pump activations. The pump should prime 30 times and then stop. With the pump in the RES VOL mode the display should show a RES VOL of 0.300 ml.

RES VOL Alarm Check:

- Prime the pump again. After 30 activations, the pump should stop and alarm by sounding two beeps every second. The pump should also return to the RES VOL mode and show 0.000 ml flashing on the display. Now press the SET/CLEAR key. The alarm should be silenced, and the display should again show a RES VOL of 0.600 ml.

Starting/Stopping the Pump:

- Check the STOP/START key by pressing and holding it until the letters R-U-N appear on the display and you hear a beep. The current lock level will appear and the pump will display all of its programmed values in sequence. When it is finished, “RUN” will flash in the lower left corner of the display. The STOP annunciator should no longer be present. Now press and hold the STOP/START key. The letters S-T-O-P should appear one by one and you should hear a beep. STOP should flash on the lower left corner of the display and the current time of day should appear.

NOTE:

A “NO RATE OR DOSES PROGRAMMED” message may appear, indicating that the pump will not allow you to change to the Run mode if a continuous rate, demand dose, or automatic dose has not been entered. If this alarm occurs, enter a RATE of 0.100 ml, then repeat the above test.

Demand Dose Key Check:

- Check the Demand Dose key operation by programming the pump with the following values:

Lock Level	LL0
RES VOL	0.600 ml
RATE	0.000 ml/hr
DEMAND DOSE	0.080 ml
DURATION	FAST
LOCKOUT ☹	:05 hr:min
GIVEN	0.000 ml (Press SET/CLEAR)
Demand Dose Counter *	0
Automatic Doses **	NONE

* To set the Demand Dose Counter to zero, press the SELECT/TOP key to move the pointer to GIVEN. The volume of the medication given will appear. Press the Y key. The number of demand doses that have been delivered will appear followed by the message "DEMAND DOSES GIVEN." Then another message "CLEAR DOSE COUNTER?" will follow. Press Y to clear the dose counter.
** If DOSE # shows "1" instead of "NONE," clear the automatic doses by setting the START ☹ to dashes.(—:—).

- Press and hold the STOP/START key until the letters R-U-N appear on the display and you hear a beep. The current lock level will appear and the pump will display all of its programmed values in sequence. When it is finished, "RUN" will flash in the lower left corner of the display.
- Now press the DEMAND DOSE, then the Y key, and note the time. The pump should beep once and begin to deliver. Count the number of activations. The pump should make 10 activations. After 10 activations, press the SELECT TOP key until the RES VOL mode is visible. The display should show a RES VOL of 0.520 ml. Press the DEMAND DOSE and Y key two more times within the next 5 minutes. A message should appear stating "DOSE LOCKED OUT" (The pump should not deliver.) Place the pump in the Stop mode.

Medication Given and Demand Dose Counter Check:

- Press the SELECT TOP key to advance the display to the GIVEN screen. The display should now show 0.080 ml. Press the Y key.

The display should show 1 demand dose given. Clear the demand dose.

Automatic Dose Check:

- Check the Automatic Dose operation by programming the pump to the following values:

Lock Level	LL0
RES VOL	0.200 ml
RATE	0.000 ml/hr
DEMAND DOSE	0.000 ml
LOCKOUT ☹	:00 hr:min
GIVEN	0.000 ml (Press SET/CLEAR)
Automatic Doses	1
Dose #	1
Automatic Dose Start	00:10 hr:min
Automatic Dose Amount	0.050 ml
Automatic Dose Duration	:05 MIN
Time of day	00:05

- Press and hold the STOP/START key until the letters R-U-N appear on the display and you hear a beep. The current lock level will appear and the pump will display all of its programmed values in sequence. When it is finished, "RUN" will flash in the lower left corner of the display.
- Press the SELECT BOTTOM key. Dose number "1" should appear on the display. Press the SELECT TOP key. The current clock time setting should be displayed. When the pump's clock time is 00:10, automatic dose #1 should begin. A pointer should flash above the automatic dose AMOUNT label. After 5 minutes, when the pump's clock time is 00:15, pumping should stop, and the flashing pointer should disappear. Press the SELECT TOP key to advance to the RES VOL mode. The display should show a RES VOL of 0.150 ml. Press the SELECT TOP key to advance to the GIVEN mode. The display should show a GIVEN value of 0.050 ml. Stop the pump.

Activation Timing Check:

- Check the activation timing by programming the pump with the following values:

Lock Level	LL0
RES VOL	0.100 ml
RATE	2.000 ml/hr
DEMAND DOSE	0.000 ml
LOCKOUT ☹	:00 hr:min
GIVEN	0.000 ml (Press SET/CLEAR)
Automatic Doses	NONE

- Press and hold the STOP/START key until the letters R-U-N appear on the display and you hear a beep. Start a timer when you hear the beep. The current lock level will appear and the pump will display all of its programmed values in sequence. When it is finished, “RUN” will flash in the lower left corner of the display.
- Count the activations. One activation should occur every 14 seconds. Approximately 3 minutes and 30 seconds (3:30) and 13 activations after hearing the beep in the Run mode, the RES VOL alarm will occur. The display should show a RES VOL of 0.000 ml and GIVEN value of 0.100 ml.

Pump Safety Check (PSC)

The CADD-Micro pump is self-tested on power up and every five minutes thereafter.

Occlusion Pressure-Switch Test

- Remove the reservoir cover and reservoir from the pump. Grasp the gray drive nut on the lead screw and pull towards the lead screw black seal. The pump should alarm and the message “***HIGH PRESSURE OR SYRINGE EMPTY***” should appear on the display. Release the drive nut. The alarm should be silenced, and the message should not appear on the display.

Occlusion Pressure Range Tests**Occlusion Pressure Range Test I****Description:**

A micro extension set is attached to the CADD-Micro pump with a filled reservoir. The needle is occluded by inserting into an eraser. When the pump is primed, pressure will be generated, causing the message “*** HIGH PRESSURE OR SYRINGE EMPTY***” to appear and the alarm to sound.

Equipment needed:

- CADD-Micro pump.
- 10-ml Micro Medication Reservoir.
- Micro infusion set with needle (MiniMed® Sof-set™, Model No. MMT-111 or equivalent).
- Pencil eraser.

Procedure:

1. Insert a battery and wait for the pump to power up.
2. Attach a Micro Medication Reservoir (syringe) filled with distilled water to the pump.
3. Attach a micro infusion set with needle to the reservoir. Prime the air from the system.
4. Insert the infusion set needle into the eraser.
5. Prime the CADD-Micro pump and count the number of activations that occur before the high pressure alarm sounds.
6. The pump should alarm between 13 and 25 activations.

Occlusion Pressure Range Test II**Description:**

An adjustable metered pressure source is connected to the reservoir. The pressure is slowly increased until the high pressure alarm sounds.

Equipment needed:

- Pressure gauge, 30 psi \pm 1 psi.
- CADD-Micro pump.
- 10-ml Micro Medication Reservoir.
- Micro infusion set with needle (MiniMed Sof-set, Model No. MMT-111 or equivalent).
- Y-site with luer.

Procedure:

1. Insert a battery and wait for the pump to power up.
2. Attach a Micro Medication Reservoir (syringe) filled with distilled water to the pump.
3. Attach a micro infusion set with needle to the reservoir. Prime the system.
4. Insert the needle into the Y-site. Prime the Y-site tubing. Attach the Y-site to the apparatus as shown in Figure 10.

5. Program the pump to the following parameters:

Lock Level	LL0
RES VOL	10.000 ml
RATE	0.000 ml/hr
DEMAND DOSE	1.000 ml
DURATION	00:10 hr:min
LOCKOUT ☹	:00 hr:min
GIVEN	0.000 ml (Press SET/CLEAR)

Automatic Doses NONE

6. Start the pump. Press the Demand Dose key then the Y key. The high pressure alarm should sound between 4 and 12 psi (8 ± 4 psi). If the alarm does not activate, it may be due to the size of the air space between the needle and the pressure gauge. Reduce the air gap by replacing the air with water. Repeat step 6.

NOTE:

As an alternative to using a micro infusion set and Y-site, an extension set with a female luer may be used.

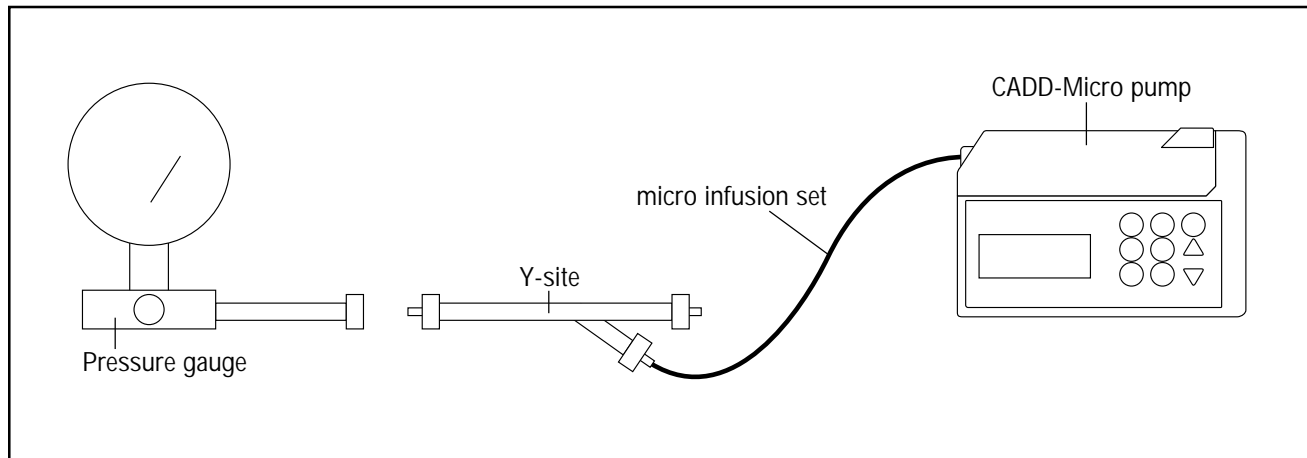


Figure 10. Occlusion test set-up for CADD-Micro pump.

Gravimetric Accuracy Testing

Description:

A Micro Medication Reservoir is partially filled with water. The reservoir is then attached to the pump and the entire pump and reservoir are weighed. Then the pump is set to deliver a certain amount of water. The pump is weighed again. The amount of water delivered is compared to the amount that the pump should have delivered.

Nominal system accuracy is given in the technical specifications section. That is, under the test conditions described below, the accuracy of the pump and reservoir will be nominal with a 90% confidence level. The nominal conditions are as follows: degassed distilled water at $25 \pm 5^\circ\text{C}$ without back pressure.

Equipment needed:

- 10-ml Micro Medication Reservoir (new reservoir)
- 300 g capacity balance accurate to 0.01 g.
- 10 ml of room temperature degassed distilled water.
- Micro infusion set with needle (MiniMed Sof-set, Model No. MMT-111 or equivalent).

Procedure:

1. Fill the empty Micro Medication Reservoir (syringe) with 9 ml of room temperature distilled water.
2. Remove any air from the reservoir.
3. Attach the reservoir to the pump. Attach the micro infusion set with needle to the reservoir. Prime the pump. Wait two minutes for stabilization. Weigh the entire pump including reservoir and micro infusion set and record the weight. This is the **predelivery weight**. (This weight includes the reservoir, pump, infusion set, and the weight of the water.)
4. Program the pump to the following values:

Lock Level	LL0
RES VOL	8.000 ml
RATE	0.000 ml/hr
DEMAND DOSE	0.000 ml
LOCKOUT ☹	:00 hr:min

GIVEN	0.000 ml (Press SET/CLEAR)
Automatic Doses	1
Dose #	1
Automatic Dose Start	00:10 hr:min
Automatic Dose Amount	8.000 ml
Automatic Dose Duration	FAST
Time of day	00:05

NOTE:

The intended delivery volume is 8.000 ml, RES VOL. (1 ml of water at 20°C weighs 1 gram.)

5. Start the pump and allow it to deliver the RES VOL amount of 8.000 ml. Delivery will begin when the pump's real time is 00:10 hr:min. Deliver the water into a convenient container and discard when completed. At the end of delivery, approximately 38 minutes later, the pump should alarm and the display will show a RES VOL at 0.000 ml.
6. Again, weigh the entire pump and reservoir. This is the **postdelivery weight**.
7. Calculate the difference in weight between the predelivery weight and the postdelivery weight. This is the **weight of the amount delivered**.
8. Find the difference between the volume of the amount delivered and the intended delivery volume. This is the **inaccuracy volume**.
9. Divide the inaccuracy volume by the intended delivery volume and multiply by 100. This is the **accuracy error percentage**. (See Table 4.)
10. If the accuracy error percentage is greater than 3%, repeat the test with a new reservoir. If the pump fails a second time, the pump should be returned for service.

An example of accuracy testing calculations is shown on page 22.

Table 4. Percentage calculation for the CADD-Micro pump.

Pre-Delivery Weight	Post-Delivery Weight	Weight of Amount Delivered	Intended Delivery Volume	Inaccuracy Volume	Accuracy Error	Accuracy Error Percentage
225.73 g	217.92 g	7.81 g = 7.81 ml	8.000 ml	-0.19 ml	-0.19 ml ÷ 8.000 ml = -0.024	-0.024 x 100 = -2.4%

EXAMPLE:

$$\begin{array}{r} \text{Predelivery Weight} \quad 225.73 \text{ g} \\ \text{Postdelivery Weight} \quad - 217.92 \text{ g} \\ \hline \end{array}$$

$$\begin{array}{r} \text{Weight of the Amount} \quad = \quad \mathbf{7.81 \text{ g}} \\ \text{Delivered} \quad \quad \quad \quad = \quad \mathbf{7.81 \text{ ml}} \end{array}$$

$$\begin{array}{r} \text{Volume of the Amount Delivered} \quad 7.81 \text{ ml} \\ \text{Intended Delivery Volume} \quad \quad - \quad 8.000 \text{ ml} \\ \hline \end{array}$$

$$\text{Inaccuracy Volume} \quad = \quad \mathbf{-0.19 \text{ ml}}$$

$$\begin{array}{r} \text{Inaccuracy Volume} \quad \quad \quad -0.19 \text{ ml} \\ \text{Intended Delivery Volume} \quad \div \quad 8.000 \text{ ml} \\ \hline \end{array}$$

$$\text{Accuracy Error} \quad = \quad \mathbf{-0.024}$$

$$\begin{array}{r} \text{Accuracy Error} \quad \quad \quad -0.024 \\ \quad \quad \quad \quad \quad \quad \quad \times 100.00 \\ \hline \end{array}$$

$$\text{Accuracy Error Percentage} \quad = \quad \mathbf{-2.4\%}$$

Deltec

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