Operating Manual for the BSP-99M Multi-Speed Syringe Pump

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1. APPLICATION
The Model BSP-99M has many uses in Medicine, Research and Industry. It was specifically
designed to introduce a fluid at an exact reproducible flow rate from a readily available syringe.
Two procedures are in current practice, a) adding the fluid into the patient/system (ICN,
Radiology, etc.) and b) adding the fluid into a Y tubing for dilution (Obstetrics, Dialysis,
Industrial process, etc.).

2. SAFETY
An accurate method of adding liquids (medication, drugs, hormones, electrolytes, anti-
coagulants, etc.) which allows the user to administer the dosage at the exact flow rate.
Eliminated are clogged valves and erroneously calibrated drip intervals. At a glance, one can
easily determine the amount of fluid infused. The pump comes into contact with a sterile
syringe, never the fluid, and when properly filled cannot introduce air into the patient.

3. FLOW RATES
The Model BSP-99M can accommodate from a 50cc syringe to a microliter syringe, both in
plastic and in glass. The Model BSP-99M has a built in flow chart, calibrated for the Multifit
brand syringe, with 99 equally spaced speeds from:

- 1.45 to 143. cc/hr........................................... with 50cc syringe
- 0.95 to 94. cc/hr........................................... with 30cc syringe
- 0.71 to 70. cc/hr........................................... with 20cc syringe
- 0.40 to 39. cc/hr........................................... with 10cc syringe
- 0.25 to 25. cc/hr........................................... with 5cc syringe

To determine flow rates with other syringes, a calibration sheet is included at the end of this
manual.
4. SET-UP PROCEDURES & SYRINGE INFORMATION

4.1 Syringe placement
Care should be exercised that the hub of the syringe barrel is positioned adjacent to the syringe clamp when loading the infusion pump. If a gap exists between the hub and the clamp, accurate flow rates cannot be assured, as the entire syringe (both barrel and plunger) may move forward. A visual check by observing the plunger move in relation to the barrel by turning the front knob of the pump is advised.

4.2 Glass syringes
An extra precaution is needed when using glass syringes with a ground glass plunger. These syringes exhibit almost no sliding friction and thus can cause an uncontrolled infusion in the following two ways:

The weight of the plunger may be sufficient to push the fluid out of the syringe if the syringe is held with the plunger above.

The weight of the fluid in the tubing may be sufficient to siphon the fluid out of the syringe if the catheter infusion site is below the syringe elevation. To test for these two conditions, it is suggested that the syringe be interconnected to the tubing and held vertically at the height of the pump. If no motion occurs, the syringe can then be placed in the pump.

4.3 The following can be practiced to reduce the danger of an uncontrolled infusion:
Lower the relative height of the infusion pump in relation to the infusion site. With the pump below the infusion site, the instrument will pump the fluid to the higher elevation.

Use a smaller bore catheter which will reduce the weight of the fluid in the tubing and impart some friction upon the flowing fluid.
Position the pump so that the syringe is vertical (plunger below) and the weight of the syringe plunger will be acting against the weight of the fluid.

Use a syringe with a rubber seal on the plunger (o-ring or plastic syringe).

4.4 Small syringes
Syringes of less than 5ml in capacity can be held more securely in the syringe clamp by fabricating a simple adapter. A piece of wood, 1" diameter, approximately 1 1/4" long, with a hole drilled in the center, will accommodate the syringe. A lip, to prevent the adapter from sliding in the clamp, can be formed by a round head screw inserted parallel to the axis, near the edge. (print available upon request).

Care should be exercised in preventing fluids from dripping into the pump and the electrical switches. If leaking occurs, the pump can be tipped at a slight angle so that the fluid will flow to the rear of the pump (away from the electrical switches). The pump can also be set-up with the rear of the motor housing on the table and the syringe in a vertical position. Excess fluid will drip on the covered motor housing with out causing a problem.

If liquids do enter the instrument, the pump can be drained by storing it in the vertical position.

4.5 Flow Rate Check
Prior to using a syringe pump, it is a good idea to index the Rate Selector switch to 00 and place ones fingers on the front knob to feel if the pump motor is pulsing. No pulses should occur. If pulses are felt the Rate Selector switch has dirt or liquid in it and should be cleaned. A second check can be made by indexing the switch setting to 50. The front knob should rotate at 1 revolution per minute (same as the second hand on a clock).
5. OPERATING INSTRUCTIONS

Move slide to rear (towards motor section) by squeezing the jaws to release the grip.

Select syringe size (example 50cc) and fill with appropriate fluid.

Insert syringe by lifting clamp cover and placing into clamp. Now slide can be moved toward the end of the syringe. Fine adjustments may be made by turning the knob so that the slide makes contact with the rear of the syringe. Hold the pump in the upright position and rotate the front knob to purge air from the syringe.

Locate desired flow rate on movable chart.

Read two digit number on left of chart (i.e. 26).

Set that same number on the digital switch.

Attach tubing to the syringe.

Press on/off switch to start measurement.

If desired, change rate of infusion while pump is in operation.

6. SPECIFICATIONS

6.1 Accuracy

Overall accuracy within 2%, repeatability within ½%. Calibrated 115 volts A.C. Less than 1% change in flow rate with a 15 volt difference.
6.2 Pressure limits
Accurate flow up to 5 psi or 270 mm/hg with a 50-60cc syringe; 7 psi or 400 mm/hg with a 30-35cc syringe; 10 psi or 500 mm/hg with a 20cc syringe, 20 psi or 1000 mm/hg with a 10cc syringe.

6.3 Electrical
3 wire grounded plug, 15 watts @ 115 volts 50-60 hertz. Less than 25 micro amperes current leakage.

6.4 Available Accessories
Micro-Syringe Adapter

6.5 Physical
Weight - 7 ½ pounds, Size - 6" H x 6" W x 10" L

7. TECHNICAL SPECIFICATIONS
The BSP-99M pump pushes a syringe by imparting linear motion through the rotation of a stainless steel lead screw. The relationship of rotary speed to linear travel is 1.00 revolution = 0.07692 inches = 0.19538 cm.

The motor is a stepper type, and each step is 0.09375° or 3840 steps equal one revolution. Thus each step transmits a linear travel of 0.00002003 inches or 0.00005088 cm.

The BSP-99M has a rate selector switch with 99 distinct speeds, each 1% apart. The pump is calibrated so that at rate switch setting of ‘50’, the motor will rotate at 1.00 RPM. Thus to attain 3840 steps in one minute, the electronic circuit must have an output of 64 PPS (pulses per second) when the rate selector switch is at ‘50’.
When the rate selector switch is at the following settings, the corresponding motor speeds and the circuit pulse rates are:

<table>
<thead>
<tr>
<th>SWITCH</th>
<th>MOTOR</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>0.020</td>
<td>0.128</td>
</tr>
<tr>
<td>10</td>
<td>0.200</td>
<td>12.800</td>
</tr>
<tr>
<td>20</td>
<td>0.400</td>
<td>25.600</td>
</tr>
<tr>
<td>50</td>
<td>1.000</td>
<td>64.000</td>
</tr>
<tr>
<td>90</td>
<td>1.800</td>
<td>115.200</td>
</tr>
<tr>
<td>99</td>
<td>1.980</td>
<td>126.720</td>
</tr>
</tbody>
</table>

The variable speed pump at its lowest setting 00.1 has a motor speed of 0.002 RPM. Thus it can be shown that if the rate selector switch is set at 1.6, the flow rate will be 1.04 ul/mn with a 1 ml Hamilton syringe.

8. ENGINEERING

All critical parts are fabricated from stainless steel, and the bronze bearings are lubricated for life; thus a minimum of maintenance is required. A lead screw, which is directly coupled to a stepper motor, eliminates the need for expensive gear trains, or inaccurate friction drives. The BSP-99M motor is precisely controlled by a highly reliable electronic circuit and is compensated for voltage variations and back pressure surges. A clutch built into the instrument is designed to prevent the motor from burning out.

9. SYRINGE EMPTY SHUT-OFF SWITCH

This feature uses a micro switch that opens the electrical circuit when the slide assembly passes a trip point. This trip point is adjustable so that the pump can accommodate various sizes and brands of syringes. The motor will cease operation and the lighted power switch will disconnect, thus providing a visual indication that the infusion is complete.
Adjusting the trip point of the switch is simple. To the left of the front knob is the slotted head of the adjustment screw. With a coin, key or screwdriver, the screw can be turned.

Insert an empty syringe with the plunger at the 0 ml mark. Move the slide assembly to the rear of the plunger. With the pump speed at 00, turn the adjustment screw counter clockwise until the power light goes out. If it is desirable to completely empty the syringe, rotate the adjustment screw clockwise until the syringe plunger is at the 0 ml mark and the power switches off. Each ½ turn of the adjustment screw, 1800, will allow the plunger to push .025 inches further.

10. SYRINGE EMPTY ALARM
At rear of the pump are a speaker and two switches. The left switch adjusts the volume of the sound (loud is approximately 70db at 8”) (soft is approximately 40bd at 8”). The right switch adjusts the frequency of the beeps (fast is 2 beeps per second) (slow is 1 beep per 7 seconds). The user can adjust each switch to satisfy the individual requirements of each application.

To the left of the front knob, is the head of the screw that is used for adjusting the trip point of the SPDT shut-off switch.

Set-up procedure for the different syringe sizes can be accomplished by the following:

Using an empty syringe set at 2 ml, place it in the syringe clamp.

Move the slide assembly to the rear of the syringe plunger, then turn the front knob until the plunger is at the 1ml mark of the syringe barrel.

Turn the rate switch of the pump to 00 and flip ON the power switch.
With a key or a screwdriver, turn the adjustment screw clockwise a number of turns to assure that the trip switch is beyond the stop position.

Next put the frequency switch in the fast position and slowly turn the adjustment screw counter clockwise until the beeping starts.

The alarm is now set to trigger at the 1ml mark for this size syringe. The electrical wiring of the pump will disconnect the infusion motor when the beeping starts. If it is more convenient to use the alarm as a warning (low flow rate applications) that the syringe is almost empty, a technician can move one wire by the following:

Remove 2 screws from the motor cover and slide the door up.

At the upper corner is a terminal block. The top wire is (purple) is connected to the alarm. By removing this wire, the alarm will not beep.

The center wire (red) is +12vdc. Do not remove.

The bottom wire (black) is connected to the motor. When the black wire is on the lowest tab, its electrical path is routed through the SPDT shut-off switch.

When the black wire is moved to the center position (tab provided for) the motor will operate when the alarm is beeping.

To eliminate the alarm and shut-off switch from use in the pump, turn the adjustment screw clockwise 5 or 10 turns.
11. MAINTENANCE

11.1 Cleaning
Use water and detergent and/or alcohol. White housing is an ABS plastic and blue chassis is aluminum coated with vinyl paint.

11.2 Lubrication
A drop of oil on the bearings, and Vaseline or silicon spray on the lead screw is recommended annually.

11.3 Flow Rate Check
With the digital switch set on 50, the front knob should turn at 1 RPM. For the BSP-99M the speed is one-tenth as fast. Formula for any setting is: 3000 - NR on digital switch = seconds per revolution. With the digital switch set at 00, no rotation should occur. (By lightly holding the front knob, one can feel if the motor is pulsing. See problem B).

12. PROBLEMS

12.1 Front knob does not rotate
Remove from rear of white housing, 2 screws, lift sliding door, remove spacer and motor. Pry up motor connector (test point 9), and remove connector to left of motor (test point 8).

Check continuity of hospital grade plug, DPST switch, and wiring with ohmmeter between plug and test point 8.

Check transformer fuse continuity with ohmmeter between red and yellow wire at test 8.

With connector at test point 8 re-inserted and pump plugged into 115v AC, use a 12v DC meter to check output from the stepper motor driver. Digital switch should be at a low number.
The 12v meter will indicate the pulses at test point 9 when the +V is connected to the red terminal (female at the V end) and the -V is connected to any of the other four terminals.

Check the motor coils with an ohmmeter to determine if any are open circuits. Substitute another motor in the circuit to check if the motor is the cause of the problem.

If item a) or d) is the problem, repair as necessary. DPST power switch can be forced up with a thin screwdriver. If item b) or c) is the problem, pump must be disassembled as explained in section B.

12.2 Instrument Pulses at 00
Digital switch must be cleaned and to do so pump must disassembled. Remove the left screw in the motor chamber. With the pump on the bench, front knob to the left, hold the blue chassis from moving and slide the white pump section approximately 1/8” to the left. This releases a catch. The white pump section can now be rotated clockwise (as viewed from the right side of the pump, axis at the rear). Then by pulling the white section toward oneself, the pump separates. If some difficulty is encountered, a spacer (screwdriver) can be used to distort the plastic away from the metal frame. The chassis cover can be lifted off, and the digital switch can be removed. To clean, soak the switch in warm water or in an ultrasonic cleaner. Switch should be thoroughly dry prior to assembly. If a new section of switch is required, a jumper wire will have to be re-soldered to connect the #9 contacts.

12.3 Syringe is not emptying
Check if IV tubing is kinked or syringe is bound.

Check pressure capability of the A-1008 slide assembly by either using a pressure gauge or by sealing a 50ml syringe with 50ml of air, and running the pump until the air inside is compressed to 36ml. If slide is not capable of pushing syringe, both the lead screw and the slide should be inspected for wear, and one should be replaced.
12.4 No output pulse from circuit board

Circuit board can be checked without removing board from chassis.

Transformer output prior to bridge rectifier (1), is 14 to 18v AC. After the rectifier it should be a minimum of 13.5v DC.

Voltage after regulator (3) should be 12v DC.

Voltage is changed to pulses with a 555 timer (4). Needed to obtain the correct frequency is 3.1uf capacitance. Frequency can be adjusted through a potentiometer approximately 8%.

With the motor in the circuit, and the digital switch set at 90 (purple wire jumped to yellow wire, do not by-pass 2000 ohm resistor), the pulse rate at test point 2 is 115.2 pulses per second.

Pulses from the 555 timer sequence the stepper motor driver (5).

Check if at setting 90 the pulse rate is 90 times the pulse rate when the digital switch is set at 01. If not, the 2N3646 transistor and the 1N4001 diode are not functioning and should be replaced.

If any component is not responding to check, P.C. board can be removed and faulty part should be replaced. Adjustment of potentiometer can be accomplished by drilling a small hole in aluminum chassis.

13. CALIBRATION OF FLOW RATES

The following is a list of cross-sectional areas of various syringes from different manufacturers. These sizes have some importance when using a syringe type pump, because the accuracy of the flow rate is determined by the cubic centimeters of fluid per unit length of syringe.

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th>MULTIFIT Cross-Section</th>
<th>STYLEX Cross-Section</th>
<th>MONOJECT Cross-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cc</td>
<td>0.176 sq cm</td>
<td>1 cc - 0.716 sq cm</td>
<td>1 cc - 0.173 sq cm</td>
</tr>
<tr>
<td>2 cc</td>
<td>0.626 sq cm</td>
<td>2 cc - 1.212 sq cm</td>
<td>3 cc - 0.622 sq cm</td>
</tr>
<tr>
<td>5 cc</td>
<td>1.084 sq cm</td>
<td>5 cc - 2.018 sq cm</td>
<td>6 cc - 1.263 sq cm</td>
</tr>
<tr>
<td>10 cc</td>
<td>1.692 sq cm</td>
<td>10 cc - 2.888 sq cm</td>
<td>12 cc - 1.977 sq cm</td>
</tr>
<tr>
<td>20 cc</td>
<td>3.017 sq cm</td>
<td>20 cc - 3.987 sq cm</td>
<td>20 cc - 3.308 sq cm</td>
</tr>
<tr>
<td>30 cc</td>
<td>4.047 sq cm</td>
<td>30 cc - 6.413 sq cm</td>
<td>35 cc - 4.474 sq cm</td>
</tr>
<tr>
<td>50 cc</td>
<td>6.173 sq cm</td>
<td>50 cc - 6.413 sq cm</td>
<td>60 cc - 5.545 sq cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th>PLASTIPAK Cross-Section</th>
<th>TERUMO Cross-Section</th>
<th>BURRON Cross-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cc</td>
<td>0.173 sq cm</td>
<td>1 cc - 0.175 sq cm</td>
<td>1 cc - 0.184 sq cm</td>
</tr>
<tr>
<td>2.5 cc</td>
<td>0.578 sq cm</td>
<td>2.5 cc - 0.640 sq cm</td>
<td>3 cc - 0.712 sq cm</td>
</tr>
<tr>
<td>5 cc</td>
<td>1.129 sq cm</td>
<td>5 cc - 1.947 sq cm</td>
<td>5 cc - 1.197 sq cm</td>
</tr>
<tr>
<td>10 cc</td>
<td>1.635 sq cm</td>
<td>10 cc - 4.174 sq cm</td>
<td>10 cc - 1.840 sq cm</td>
</tr>
<tr>
<td>20 cc</td>
<td>2.850 sq cm</td>
<td>20 cc - 6.673 sq cm</td>
<td>20 cc - 3.247 sq cm</td>
</tr>
<tr>
<td>30 cc</td>
<td>3.662 sq cm</td>
<td>30 cc - 6.673 sq cm</td>
<td>30 cc - 4.831 sq cm</td>
</tr>
<tr>
<td>50 cc</td>
<td>5.556 sq cm</td>
<td>60 cc - 7.159 sq cm</td>
<td>60 cc - 7.159 sq cm</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Syringe Size</th>
<th>HAMILTON Cross Section</th>
<th>UNIMETRICS Cross-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 cc</td>
<td>0.008 sq cm</td>
<td>0.05 cc - 0.008 sq cm</td>
</tr>
<tr>
<td>.10 cc</td>
<td>0.017 sq cm</td>
<td>.10 cc - 0.017 sq cm</td>
</tr>
<tr>
<td>.25 cc</td>
<td>0.042 sq cm</td>
<td>.25 cc - 0.042 sq cm</td>
</tr>
<tr>
<td>.50 cc</td>
<td>0.083 sq cm</td>
<td>.50 cc - 0.083 sq cm</td>
</tr>
<tr>
<td>1 cc</td>
<td>0.167 sq cm</td>
<td>1 cc - 0.167 sq cm</td>
</tr>
<tr>
<td>2.5 cc</td>
<td>0.417 sq cm</td>
<td></td>
</tr>
<tr>
<td>5 cc</td>
<td>0.833 sq cm</td>
<td></td>
</tr>
<tr>
<td>10 cc</td>
<td>1.667 sq cm</td>
<td></td>
</tr>
</tbody>
</table>

MULTIFIT is the trademark of Becton, Dickinson & Co., Rutherford, NJ
STYLEX is the trademark of Pharmaseal Laboratories, Glendale, CA
MONOJECT is the trademark of Sherwood Medical Industries, St. Louis, MO
PLASTIPAK is the trademark of Becton, Dickinson & Co., Rutherford, NJ
TERUMO is the trademark of Terumo Corporation, Piscataway, NJ
BURRON is the trademark of Burron Medical Products, Inc., Bethlehem, PA
HAMILTON is the trademark of Hamilton Company, Reno, NV
UNIMETRICS is the trademark of Unimetrics Corporation, Anaheim, CA
### MODEL BSP-99M SYRINGE PUMP CALIBRATION SHEET FOR BD MULTIFIT SYRINGES

<table>
<thead>
<tr>
<th>SIZE</th>
<th>MULTIFIT</th>
<th>STYLEX</th>
<th>MONOJECT</th>
<th>PLASTIPAK</th>
<th>TERUM</th>
<th>BURRON</th>
<th>HAMILTON</th>
<th>UNIMETRICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1cc</td>
<td>1.00</td>
<td>?</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>1.05</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>2-3cc</td>
<td>1.00</td>
<td>1.14</td>
<td>0.99</td>
<td>0.92</td>
<td>1.02</td>
<td>1.14</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>5-6cc</td>
<td>1.00</td>
<td>1.12</td>
<td>1.16</td>
<td>1.04</td>
<td></td>
<td>1.10</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>10-12cc</td>
<td>1.00</td>
<td>1.19</td>
<td>1.17</td>
<td>0.97</td>
<td>1.15</td>
<td>1.09</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td>20cc</td>
<td>1.00</td>
<td>0.96</td>
<td>1.10</td>
<td>0.95</td>
<td></td>
<td>1.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-35cc</td>
<td>1.00</td>
<td>0.99</td>
<td>1.11</td>
<td>0.91</td>
<td>1.03</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-60cc</td>
<td>1.00</td>
<td>1.04</td>
<td>0.90</td>
<td>0.90</td>
<td>1.08</td>
<td>1.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### EXAMPLES:

The flow rate for the BSP-99M Pump can be calculated from:

\[
\text{flow rates in cc/hr} = 0.23446 \, \text{cm/hr} \times \text{number of rate selector switch} \times \text{syringe cross-section in sq.cm.}
\]

The Model BSP Pump is calibrated for Multifit Syringes. Assuming a flow rate of 50 cc/hr is desired with a 50 cc Multifit Syringe. The built-in flow rate chart will list 34 - 49.2 cc/hr & 35 - 50.7 cc/hr. If a 50cc Plastipak Syringe is substituted, the flow rate at 35 will be 50.7 cc/hr \times 0.90 = 45.6 cc/hr. To attain the correct flow divide 35 by 0.90 to obtain a flow rate setting of 39. The actual flow rate with the 50cc Plastipak Syringe will be 50.8 cc/hr.

*While it is our intent to precisely determine each syringe size, BRAINTREE SCIENTIFIC, INC. cannot be responsible for the accuracy of the enclosed information.*

SYRINGE PUMPS FOR MEDICINE, RESEARCH AND INDUSTRY