

Understanding Your Test Results

The Infutest 2000 measures Instantaneous Flow, Average Flow, and Infused Volume. **Of these, Average Flow and Infused Volume are the most important because it is these measures which the pump manufacturers use in specifying the accuracy of their products.** At this time, manufacturers do not specify pump performance in terms of instantaneous flow. However, Infutest's ability to measure instantaneous flow (and Infutest's FLOW graph display) can be useful in comparing the **quality** of fluid delivery of pumps of differing makes and models.

The Infutest measures instantaneous flow by observing the volume delivered from a pump over relatively *short* time intervals. These time intervals nominally range from 4 to 20 seconds, the exact interval depending on the rate. **The majority of medical infusion devices do not produce "steady flow" when the volume delivered is measured over such short time intervals.** This fact has been previously described in the scientific literature. For example, refer to the test results and graphs in:

- Stull et al. "Flow rate variability from electronic infusion devices", *Crit. Care Medicine*, vol.16, pp. 888-891, 1988.
- Farrington "Flow rate variability from selected syringe and mobile infusion pumps", *Drug Intelligence and Clin. Pharm.*, Vol. 22, pp. 687-690, Sept. 1988.
- Leff et al. "Accuracy, continuity, and pattern of flow from five macrorate infusion devices", *Am. J. Hosp. Pharm.*, vol. 45, pp. 361-5, Feb. 1988.
- Auty, B. "Equipment for intravenous infusion - some aspects of performance", *Agressologie*, vol. 29, 12: 824-828, 1988.
- Tam, Y. "Automated performance checking of infusion equipment", *Clin. Phys. and Physiol. Meas.*, vol.10, pp. 311-318, 1989.

Infutest's Average Flow is a cumulative measurement of the total volume delivered from the pump divided by the total time taken to deliver it. All medical infusion devices will produce a stable Average Flow reading (i.e. a horizontal line on Infutest's AVG. graph) if given enough time. Infutest's instantaneous flow reading and FLOW graph, however, will be highly dependent on the **functional type, manufacturer and model** of pump being tested.

SYRINGE pumps (e.g. AutoSyringe AS20S, Bard 150 XL, MedFusion 2001) can exhibit a "startup characteristic" in which flow is initially low, and then gradually increases to the set rate as slack in the lead screw mechanism is taken up. Syringe pumps can also produce erratic flow if the syringe has been re-used so often that its internal lubricant has worn off. Such anomalies can be avoided, however, by installing a new syringe and allowing the pump to run for several minutes before testing.

LINEAR PERISTALTIC pumps (e.g. Baxter 6200, Sigma 6000) tend to be more erratic in their instantaneous flow at lower rates - you will normally see large peaks and valleys in Infutest's FLOW graph when testing many linear peristaltic pumps at rates **below 50 ml/hr**. Such instantaneous variations are related to the design and precision of the finger mechanism which squeezes the tubing, and to the quality and compliance of the tubing section being squeezed.

The opposite is true of many **CASSETTE** pumps (e.g. IMED 960, IVAC MedSystem 3, McGaw Horizon, Siemens MiniMed III). These pumps often produce more erratic instantaneous flow at higher rates as the pump compensates between delivering the required volume and refilling its cassette on alternating cycles. Infutest's FLOW graph will normally show large peaks and valleys when testing many cassette pumps at rates **over 500 ml/hr**. Depending on the cassette pump, large dips in the FLOW graph may appear at periodic intervals.

Caution should be exercised when testing some cassette pumps. When set to high delivery rates, such pumps can produce brief bursts of flow which are beyond Infutest's ability to measure (peak flow exceeding 1700 ml/hr). In this case, Infutest will appear to "lock up", failing to begin a measurement or halting a measurement in progress. **For example, the IMED model 960 pump should not be tested at rates over 700 ml/hr.** If set to 800 ml/hr, the IMED 960 will produce a very high flow (exceeding 1800 ml/hr) immediately following the cassette refill cycle.

ENTERAL FEEDING and **TPN** pumps (e.g. Abbott Provider, Sherwood Kangaroo 324), inventoried by many **Home Care** providers, can produce the most non-steady flow of the devices mentioned so far. Such pumps often deliver fluid by alternately turning on and

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Series C & Series D

off the motor of a rotary peristaltic mechanism. Since the motor runs at one speed, the duration of the motor's "on-cycle" and the interval between on-cycles determines the flow rate. The bolus delivered in each on-cycle may range from 0.2 ml to 2 ml, with the zero-flow interval between bolus deliveries ranging from a few seconds to **several minutes**. Infutest's status indicator will show "VPF" when testing such devices, and the FLOW graph may show large, periodic rises and falls at rates over 100 ml/hr.

Because of these differences in short-term delivery characteristics, pump manufacturers choose to specify the accuracy of their products based on **Average Flow**, or the total volume delivered in a test divided by the total time. For most pumps operating at 50 to 500 ml/hr, Infutest's AVG. graph will stabilize to a straight, horizontal line after running the Single Rate Test for 5 to 10 minutes. At this point, most of the pumps described above will have produced a stable enough reading to verify the pump's accuracy. Note this limit on the minimum test time is due to the quality and design of the **pump being tested**, not the Infutest.

You should find a "flow accuracy" or volumetric test procedure in the Service Manuals of the infusion devices you will be testing. These procedures will define the manufacturers' recommendations for pump settings, minimum test time and/or collected volume. The pump Service Manuals will include specifications for device performance or an acceptance range based on the volumetric test results. Always refer to the manufacturer's procedures and recommendations before using Infutest to test your pumps.