

Infusion pumps

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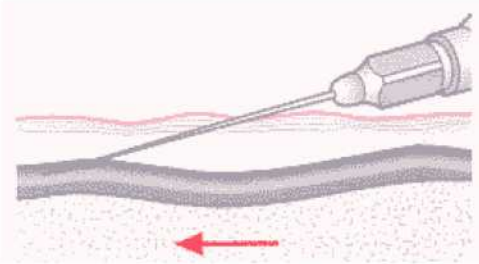
13.3.7 Maintain infusion pumps

Unit B 13.3 Maintaining General Bedside Nursing Equipment

Module 279 18 B Medical Instrumentation I

Function: infuse fluids

What is the function of an Infusion pump ?



An infusion pump infuses **fluids, medication** (antibiotics, pain medication) or **nutrients** into a patient's circulatory system. It is generally used **intravenously**, although arterial and subcutaneous infusions are occasionally used.

Why is it important ?

Infusion pumps can administer fluids in ways that would be impractically expensive or unreliable if performed manually by nursing staff. For example, they can administer as little as 0.1 mL per hour injections (too small for a drip), injections every minute, injections with repeated boluses, or fluids whose volumes vary by the time of day.



Use: the difference between drip chamber and infusion pump

A **drip chamber** is a device used to allow air to rise out from a fluid so that it is not passed downstream. These are commonly employed in delivery systems of intravenous therapy and act to prevent **air embolism**.

The use of a drip chamber allows an estimate of the rate at which fluid is administered. For a fluid of a given viscosity, drips from a hole of known size will be of nearly identical volume and the number of drips in a minute can be counted. The rate of flow is controlled by a **clamp** on the infusion tubing; this affects the resistance to flow.

However, other sources of resistance (such as whether the vein is kinked or compressed by the patients position) cannot be directly controlled and a change in position may change the rate of flow leading to inadvertently rapid or slow infusion.

Where this might be problematic an **infusion pump** can be used which gives a more accurate measurement of flow rate.



drip chamber



clamp



infusion pump

an infusion pump delivers a well-defined fluid volume

Use: general nursing, intensive care, surgery, recovery

The positive pressure generated by the various manufacturers' pumps can widely vary. All pumps should be able to overcome arterial pressures of a patient (**150-200 mmHg**). Most pumps have a pressure limit of **500 mmHg**. If the limit is reached, an **occlusion alarm** should sound. Pumps with lowered pressure limits are often labelled as **paediatric**.

On many pumps the output pressure also has a **low limit**. If the pressure in the fluid line is below the lower limit, an alarm should indicate a possible **loss of connection** to the patient or artery (an infiltration alarm, when the catheter is no longer in the blood vessel but infusing fluid into the surrounding tissue).

There are two basic classes of pumps:

- **Large volume pumps** can pump nutrient solutions large enough to feed a patient.
- **Small-volume pumps** infuse hormones, such as insulin, or other medicines, such as opiates.

Some infusion pumps are designed mainly for **stationary use** at a patient's bedside.

Others, called **ambulatory infusion pumps**, are designed to be portable or wearable.



wearable
injector

Construction: volume displacement pump

All fluid pumps work on one of three principles, **volume displacement**, **roller peristaltic** or **linear peristaltic**.

The **volume displacement pump** operates by filling a cavity (syringe) and then displacing a given volume of liquid. The positive displacement pump delivers a **constant volume** of liquid independent of the discharge pressure.



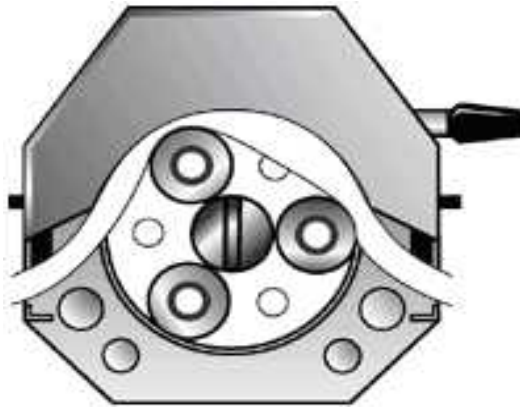
A volume displacement pump can require a dedicated (meaning: applicable to only one type of pump) IV (intravenous) administration set, available only from the manufacturer.



Small-volume pumps usually use a computer-controlled motor turning a screw that pushes the plunger on a syringe.

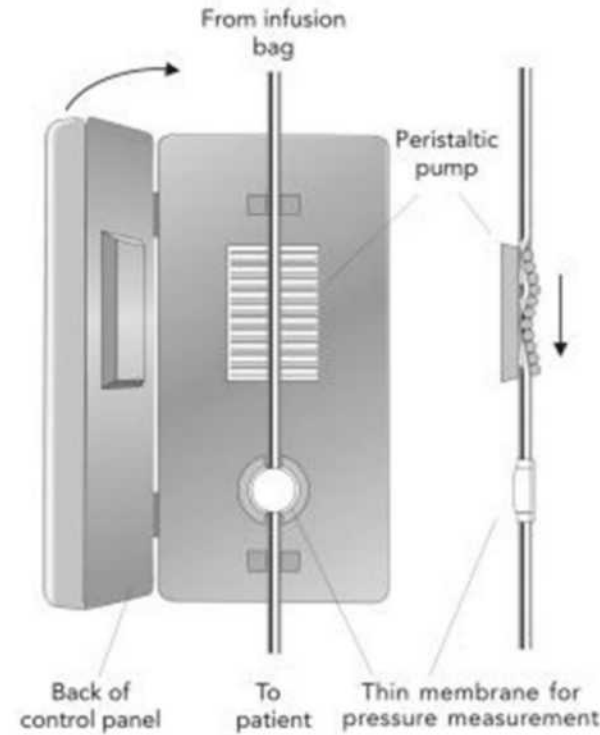
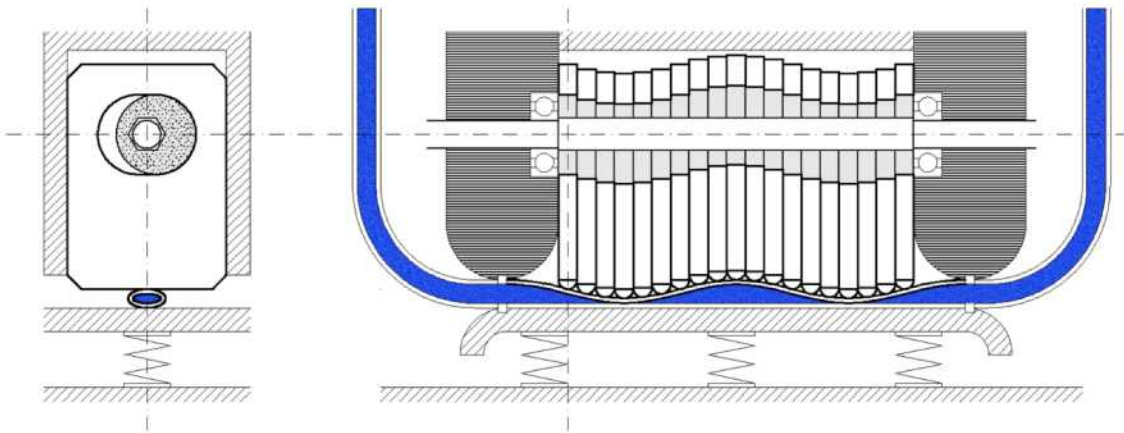
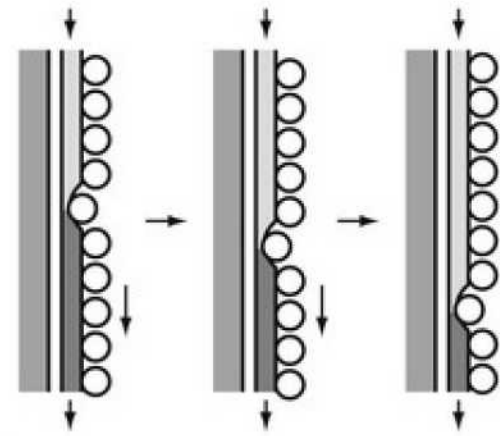
Construction: roller peristaltic pump

Large-volume pumps usually use some form of peristaltic pump. Classically, they use computer-controlled rollers compressing a silicone-rubber tube through which the medicine flows.

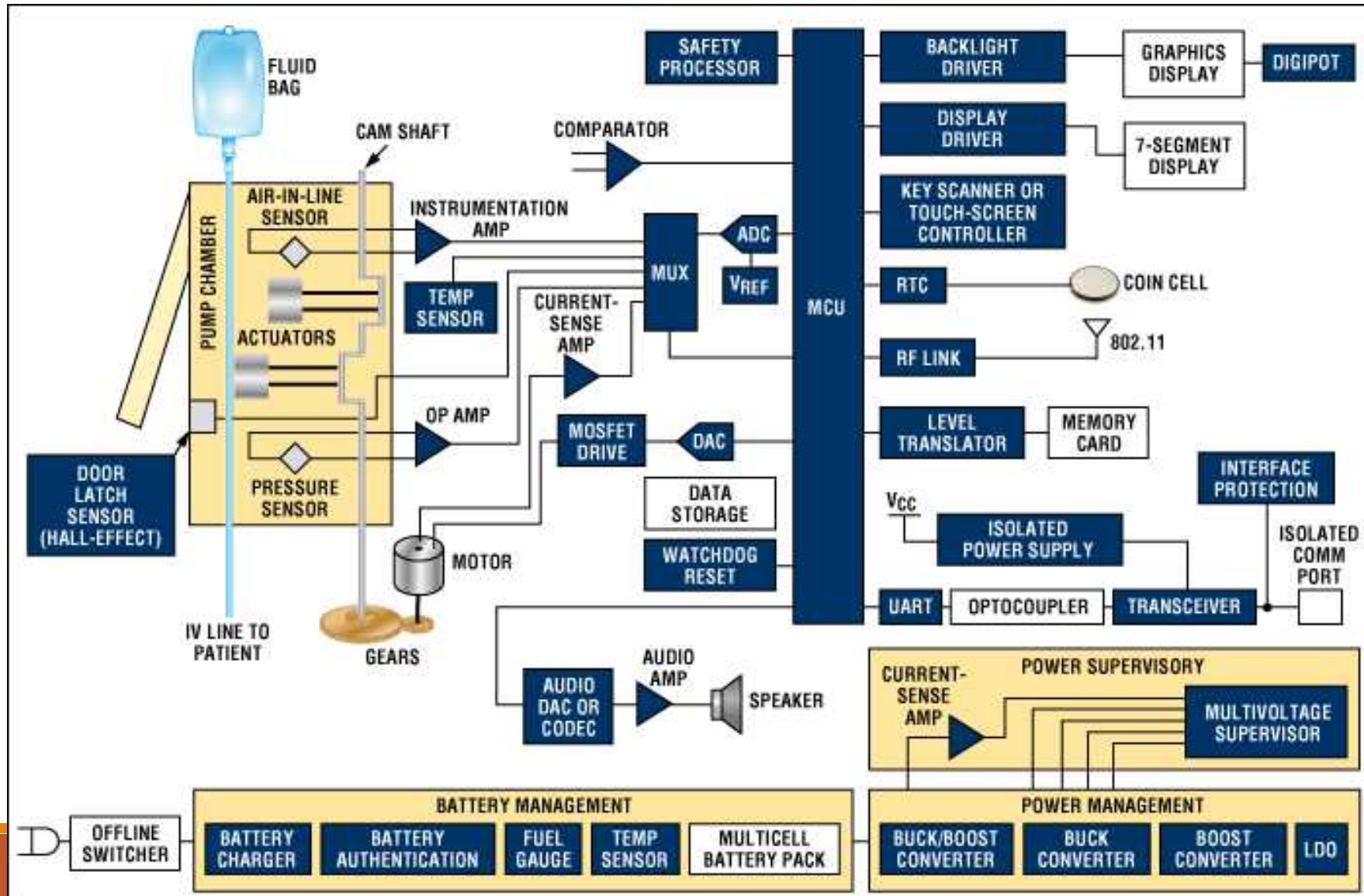


Construction: linear peristaltic pump

In the linear peristaltic pump the pump “milks” the fluid through the tubing of the IV line. This may require special, usually silastic, tubing. The basic operation is to occlude the pump with a roller, then advance the roller – or finger – forcing fluid through the tube. The tubing and fingers are typically linearly arranged. Since this tubing is a known diameter the volume infused by a peristaltic pump can be calculated as the area of the tubing times the distance that the fingers travel.



Construction: Functional Block Diagram



Trouble shooting

User error is common with pumps. While only the clinical staff should program the pump, **the technician must know the programming procedure** so they can troubleshoot or calibrate the units.

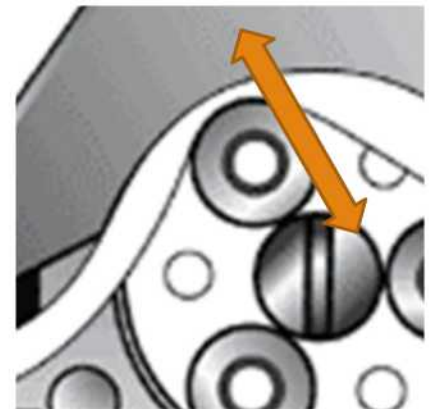
Some of the most common problems with syringe pumps are:

- the **clutch slipping** which causes under infusion of the drug,
- **broken latches** so the syringe does not fit securely onto the pump
- **bad batteries.**

User abuse is very common as the pumps are dropped on a regular basis.

With roller pumps, the **rollers** may need **adjustment**.

- If the roller is too close to the tube, it causes high friction, low flow rates and premature wear of the tube and motor.
- If the roller is too loose, there will be insufficient occlusion to move the required volume of liquid. Flow rates may drop as well, despite rapid motion of the rollers.



Safety and Testing considerations

Pumps should be **tested** for their delivered **volume with time, or flow rate**. This is easily accomplished with a graduated cylinder and a stop watch. If the flow rate is set to 10 millilitres per minute, then you should measure 10 millilitres in a minute (or 100 millilitres in 10 minutes) emptying into the graduated cylinder or measuring cup.

The **occlusion (or high pressure) limit** should be tested. The ideal test uses a **manometer**. However, an adequate test is to connect the pump to a tube strung up the wall. The pump should push water up the wall to the level of the pressure limit, then stop and sound an alarm. For example, if the pressure limit is set to 200 mmHg, then the column of water should ascend 260 cm (20 cm of Hg is equivalent in pressure to 260 cm of water). In the worst case, simply clamp off the tube and make sure the alarm sounds.

If the pump includes an **infiltration (low pressure) alarm**, then it can be tested by letting water from the pump exit the tubing from the pump at different heights. Typically the infiltration alarm will sound when the water exits the tubing a few centimetres above the pump. If the water must exit the pump at the level of the pump or below, then the alarm is not working.

If the pump has **batteries**, it is usually sufficient to simply test that the device runs on the batteries for a few minutes

Safety and Testing considerations

An **air filter** is an essential safety device in a pressure infuser, to keep air out of the patients' veins. The air filter is just a membrane that passes gas but not fluid or pathogens. When a large air bubble reaches it, it bleeds off.

Doctors estimate that 50 cm³ of air is enough to kill by filling the patient's heart.

Small bubbles in arteries can cause harm by closing of small arteries

Small bubbles in the veins pass through the heart and leave in the patients' lungs.

In summary, the infusion-related safety risks are:

- **uncontrolled flow** causing an overdose,
- **uncontrolled lack of flow**, causing an under-dose,
- **reverse flow**, which can siphon blood from a patient,
- **air in the line**, which can cause an air embolism.



END

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