Negative Pressure Generated, by Roller Pumpheads

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Although commonly used roller pumps are sometimes referred to as "steady flow pumps," they produce flows and pressures which are variable with respect to time. It is the intent of this report to show that, under certain conditions, the output pressure of such pumps is negative during part of the pumping cycle, and that measures can be instituted to reduce (bring more positive), or eliminate, negative pressure. The presence of negative pressure always poses the hazard of an air leak *into* the system. Negative pressure, particularly between bubble trap and patient, should always be avoided. If no practical way to avoid negative pressure can be found, extreme caution should be exercised to avoid any leaks in this part of the system.

Figure 1 depicts the test setup:

Water was pumped from reservoir R through a Med-Science Electronics single roller pump fitted with 1/2 inch I.D. x 1/8 inch precision wall silicone rubber pump head tubing S, past a pressure port (luer fitting on 1/2 x 1/2 inch connector) Pp, to which was connected a strain gage transducer T. The fluid then passed thru a 1/2 inch flow probe F, six feet of Tygon 3/8 inch ID x 3/32 inch wall tubing L, a 1/4 inch ID x 1/16 inch wall x 12 inch long inflow cannula IC, and into a standpipe SP. The standpipe provided approximately 70 mm. Hg. constant pressure.

Results: Test 1

1. Pump head inserted "loosely" (less than the maximum amount of tubing inserted into the supporting rings).
2. Pump head tubing extending 1 ft. outside of the supporting rings on the inlet and the outlet.

Mean Flow (l/min)	Pressure (mm Hg)	
	Max.	Min.
2	250	20
3	300	20
4	360	-20
5.6	370	60

Test 2:
Conditions same as test 1 except that the pump head tubing is inserted "tight" (maximum amount of tubing inserted into the supporting rings).

Mean Flow (l/min)	Pressure (mm Hg)	
	Max.	Min.
1.9	260	-10
3.2	300	-5
4.0	380	-50
5.0	400	-30
6.0	440	-30

Test 3:
Conditions same as test 2 except that S = 3 inches of tubing extending outside of supporting rings on the high pressure (outlet) side.

Mean Flow (l/min)	Pressure (mm Hg) Max.	Min.
2.0	290	-20
2.9	295	0
4.1	405	-100
5.0	470	-70
5.8	520	-50

Essentially similar tests were performed on a Pemco double roller pump with essentially the same results: negative pressure greater than 100 mm. Hg. with the pump tubing inserted tightly against the outside supporting ring and no negative pressure with the pump tubing inserted loosely.

Discussion:

The "pressure" of a fluid moving in a conduit is a complex combination of the applied pressure and the velocity and acceleration of the fluid particles. In the case of distendible tubing (used in roller pumps) the physical characteristics of the tubing walls can also exert a significant effect. The negative pressure measured in these experiments is probably generated when the entire pump head tubing goes from low to high pressure as the roller finishes one cycle and begins the next. By inserting the pump head tubing loosely and/or leaving a length of the much more distendible silicone rubber tubing on the high pressure side the effect was reduced in our test setup. Other configurations may be quite different and the pressure in each individual system must be measured to determine if negative pressure is present. This can be done on a system while in use but extreme caution must be exercised to insure that air does not enter as a result of the measurement procedure!

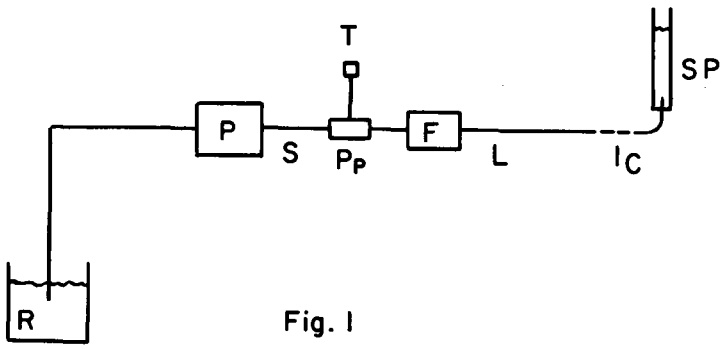


Fig. I

R = reservoir

P = pump (Med-Science Elect. single roller)

S = Silicone rubber pump lead (1/2 ID x 1/8" precision wall)

P_P = Pressure port (Luer fitting on 1/2 x 1/2 plastic connector)

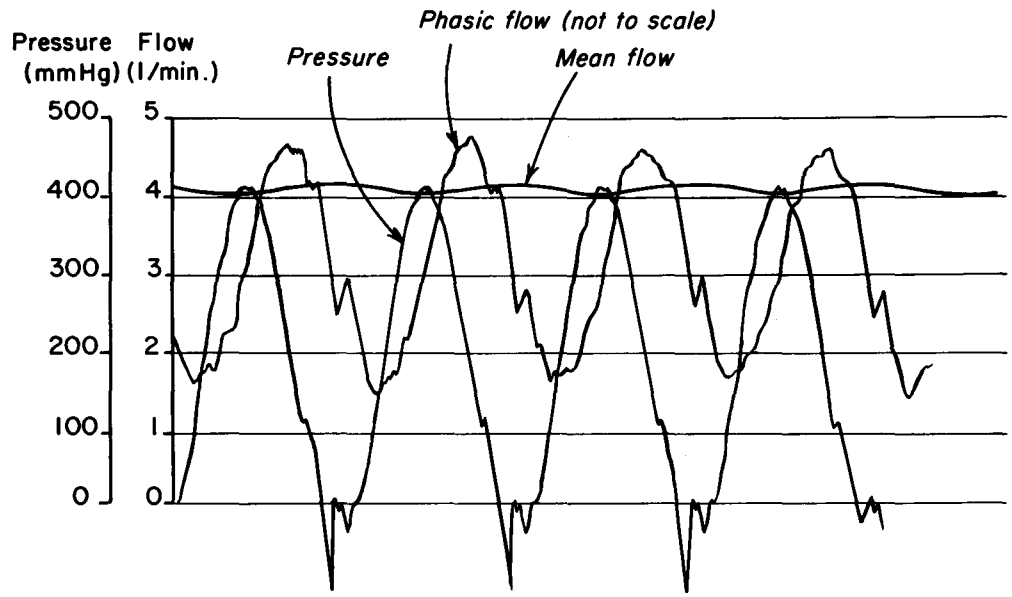
T = Transducer (Statham P 23 Db)

F = Flow probe (Micron 1/2")

L = Arterial line (3/8 ID x 3/32 wall x 6' Tygon)

IC = Inflow cannula (1/4 ID x 1/16 wall x 6" long Tygon)

SP = Standpipe (provides ≈ 100 mm Hg. pressure at any flow 0 - 8 l/min)



SUMMARY

1. Commonly used roller pumps can produce negative pressure during part of the pumping cycle.
2. Judicious placement of tubing into the pump can reduce or eliminate negative pressure.
3. Determinants of pressure are complex. Measurement is the only practical way to determine instantaneous pressure. Extreme caution is necessary.