

End of artificial teat used to simulate on-and-off flow of cow's teat under pulsated vacuum.

Vacuum and flow characteristics of milking machine claws

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Research literature relating mastitis to the milking machine is abundant but not always conclusive. Certain characteristics of the milking system, including pulsation rate, pulsation ratio, cluster weight, and vacuum levels, have been studied. Their effect on milking rate is well established, but it has been more difficult to establish a relation to milking speed between conditions inside the inflation and subsequent udder infection.

What several workers have demonstrated is that the effect of irregular vacuum fluctuations, combined with cyclic vacuum fluctuations, can cause increased udder infections. It has been shown that variation in milk flow between teats in the same claws as well as between claws is associated with vacuum fluctuations. Since milk impacted on the teat end may carry organisms, milking equipment should be designed to minimize these fluctuations to reduce the cross

flows that cause teat end impacts.

Trials were conducted to study the milk flow and vacuum stability of several milking machine claws currently in use. Since the trend is toward using larger volume claws, the relationship of claw volume to these characteristics was considered important.

Materials and methods

Claws from several U.S. manufacturers were tested, their internal volumes ranging from 30 to 360 ml. To eliminate the variability of milk flows from cows, it was necessary to use mechanical teats and a metering device that could supply predetermined flow rates of water to the teat cups. A bucket milking system was used.

Flow rates were determined by measuring three one-minute flows at each of the three selected conditions of the trials. The same shells and DeLaval 01 liners were

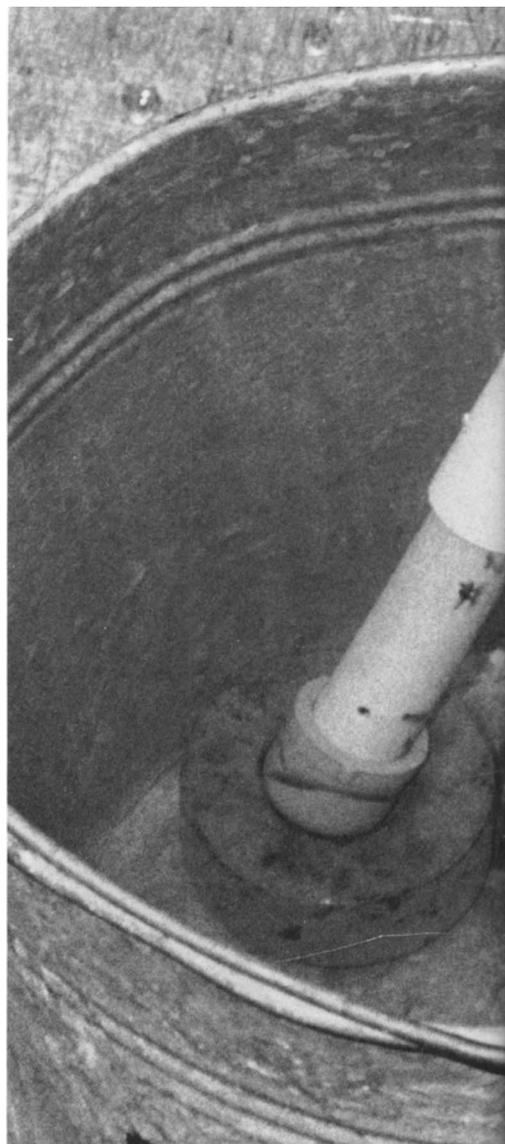
used throughout the trials. Vacuum at the bucket was held constant at 15 inches of mercury.

The pulsators used were DeLaval 2x2 alternating and DeLaval 4x0 simultaneous. The pulsation ratio was 50:50 for each pulsator and the pulsation rate was 50 cfm for each. Vacuum and degree of vacuum were measured with a bellows-type Detco vacuum recorder.

Series 1

Five claws with internal volume ranging from 30 to 360 ml were tested using 2 × 2 (alternating) pulsation. The tests were run at five separate flow rates designated as very fast (VF), fast (F), medium (M), slow (S), and very slow (VS) ranging from approximately 6 to 21 pounds per minute. (See table.)

There were significant or highly significant differences in projected milking



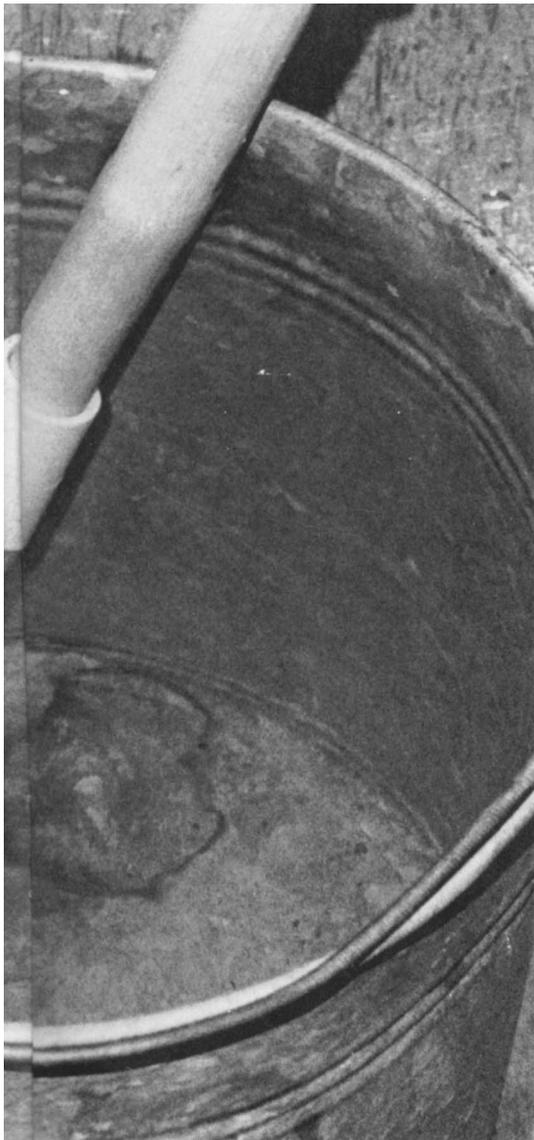
Milking rates from 6 to 23 pounds per minute were able PVC pipe. Hole size was varied according to

speed between claws when 11 pounds per minute or greater flow rates were used. At the very fast rate, the fastest claw could handle 21.6 pounds per minute whereas the slowest claw averaged 20.5 pounds per minute.

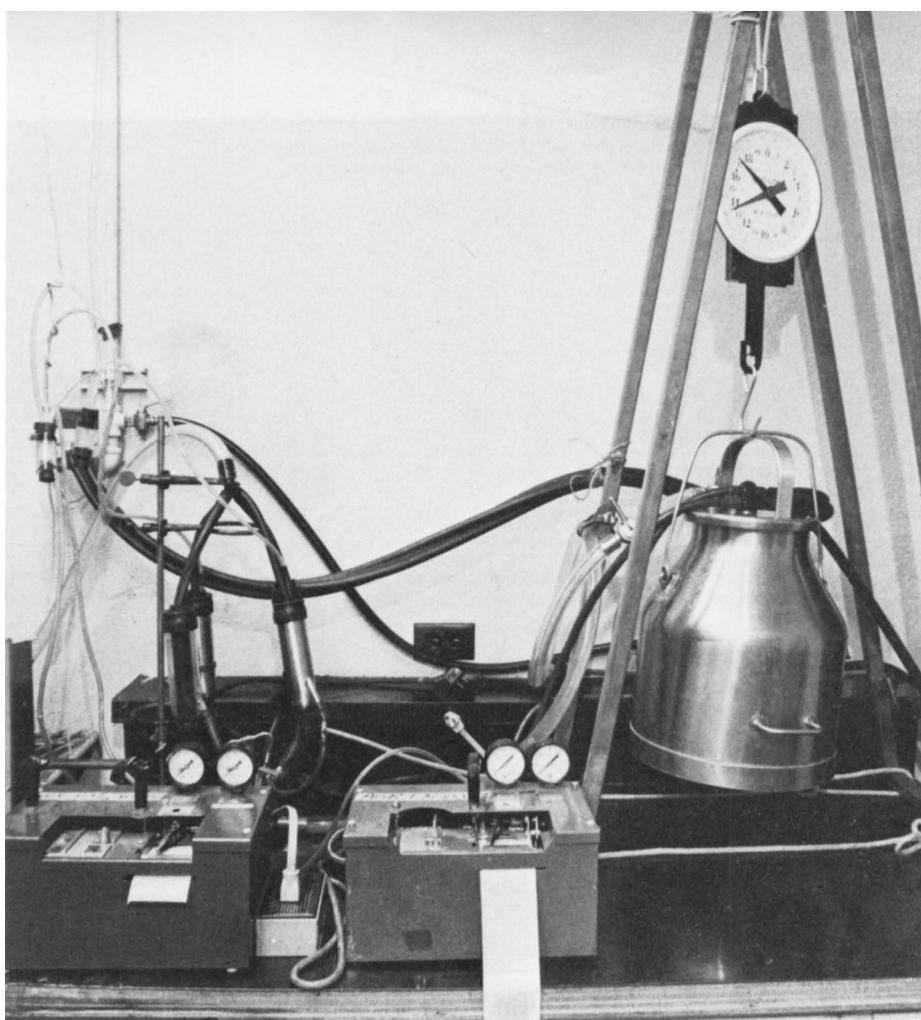
When ranked according to flow characteristics, the claws held the same relative position at the three highest flow rates (VF, F, M), but these positions were not related to claw volume. The larger claw did not necessarily accommodate greater volumes of liquid.

To determine the potential for cross-flow in the claw due to alternate pulsation, the maximum cyclic difference in vacuum in each claw was measured, using side-to-side pulsation. Significant differences among claws were found at the VF and VS rates only. These differences again were not directly related to claw volume.

With the alternate pulsators there was



simulated by drawing water through interchangeable desired milking rate.



Equipment used to record milking rates and vacuum levels. One recorder charted vacuum at right front and rear teat while the other recorded pulsator action and vacuum at the claw outlet.

a highly significant increase in vacuum variation between claws increasing flow rate. Claw type did not influence vacuum differences across the claw which ranged from .27 to .80 inches of mercury as flow rates increased from VS to VF.

The differences were quite small. It is suspected that instrumentation more sensitive than the Detco recorder would have given greater response differences. As measured there was a threefold increase in vacuum fluctuation within each claw type as flow rate increased from 6 to 20 pounds per minute.

Teat cup vacuum level varied with the rate of flow, averaging 9.3, 10.0, 11.0, 12.2, and 13.0 inches of mercury from very fast to very slow flow rates. Significant vacuum fluctuation differences within each flow rate category and between claw types were noted, except for the very slowest flow rates (fig. 1).

The degree of fluctuation found in the teat cup was significantly different between claw types at the VF and M flow rate only. The 350 ml claw had the smallest and the 30 ml claw had the greatest vacuum fluctuation. Fluctuation was not related to claw volume in the other three claw types.

Vacuum fluctuations in teat cups were not a function of claw type. They did

vary with flow rates 1.19, 1.01, 0.93, 0.73, and 0.87 inches of mercury, yielding values of rate decreasing from VF to VS.

Series 2

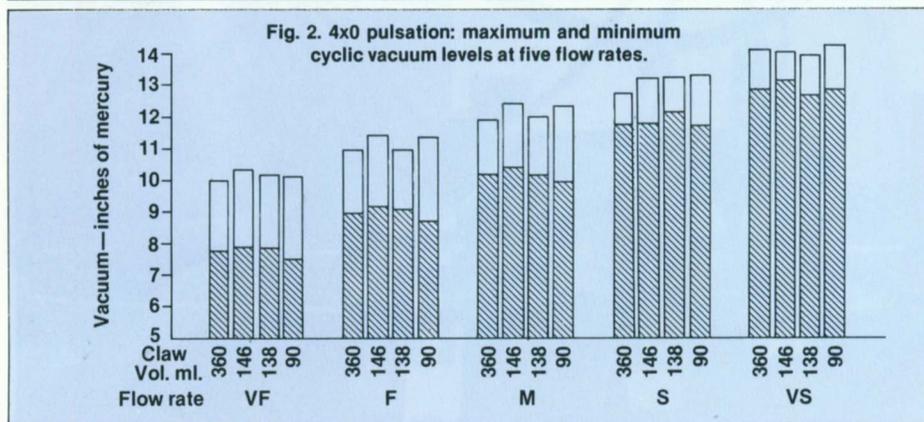
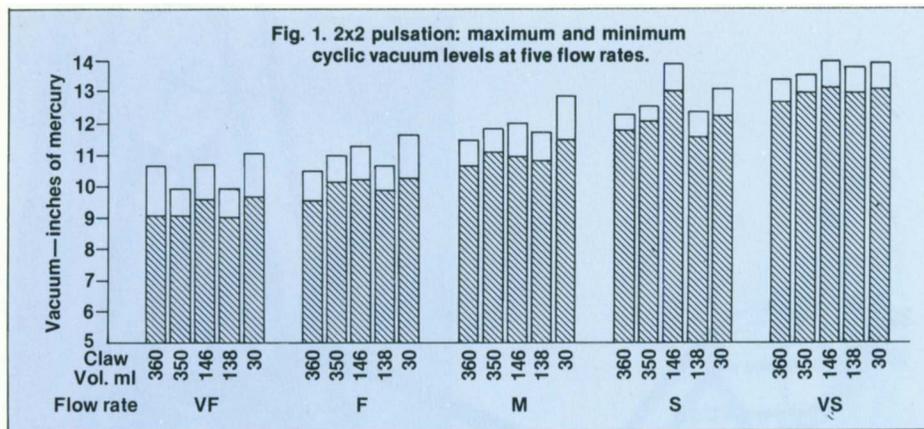
Four claws were tested in this series using simultaneous (4 x 0) pulsation. Internal claw volume ranged from 90 ml to 360 ml.

There were significant differences in the flow rates between claws, except at VS and VF rates. As with alternate pulsators, each claw type was not influenced by flow rate. The flow volumes were directly related to claw volume only in the two largest claws (fig. 2).

Minimum vacuums were 7.8, 9.0, 10.2, 11.8, and 12.8 from flow rates of VF to VS respectively. Vacuum differences between claws were significant only at the VF rate. Vacuum fluctuation was significantly different between claws at the M and F rates only.

When ranked in order of amount of fluctuation, the smallest claw showed the greatest fluctuation at all four rates, whereas the largest claw had the least or next to least at the highest four flow rates.

As in Series 1, differences in vacuum fluctuation between flow rates were highly significant. Fluctuations from VF to VS, respectively, were 2.35, 2.20, 1.95, 1.25, and 1.18. At the three highest rates, these values



flow rates and slower than alternating pulsation at lower flow rates. This interaction may help explain part of the conflicting results reported in the literature concerning the comparative efficiency of the two types of pulsations.

There was a threefold increase in side-to-side vacuum fluctuation with 2x2 pulsation as milking speed increased from 6 up to 20 pounds per minute. Differences in side-to-side fluctuation between claws were significant at only the fastest and slowest flow rates.

Vacuum fluctuation increased with flow rate. Fluctuation was approximately twice as great at 21 to 23 pounds per minute as at 5 to 6 pounds per minute and was twice as great with 4x0 as with 2x2 pulsation at the higher milking rates.

With 2x2 pulsation, minimum cyclic vacuum decreased from 13 to 9 inches of mercury as flow rate was increased, whereas it decreased from 13 to 8 inches of mercury with 4x0 pulsation.

It is concluded that other than the smallest volume claws the claws tested were not consistently different from one another in their "milking" characteristics based on claw volume. With minimum cyclic vacuum in the range of 8 or 9 inches of mercury at the fastest flow (21 pounds per minute) and 10 to 11 inches of mercury at 15 pounds per minute, it appears that vacuum available for teat end massage may not be adequate at milking speeds of 15 pounds per minute and above.

Tests were not made at pulsation ratios other than 50:50 or with standardized air inlets or with various amounts of lift or with various sizes of long milk tube. But because these variables are commonplace, it would seem advisable to compile tables of equipment specifications that will best meet the conditions to be found on individual dairies.

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are approximately twice those found with 2x2 pulsation.

Series 3

In this series were compared three claws with alternating (2x2) and simultaneous (4x0) pulsation.

There were highly significant differences in milking speed between pulsator types (see table), between claws, and for interaction between flow rates and pulsators. There was a difference of approximately 2 pounds per minute in favor of the 4x0 pulsation at the VF rate compared with a difference of .70 pounds per minute favoring the 2x2 pulsation at the VS rate.

This interaction is opposite from that expected since simultaneous (4x0) pulsation tends to flood claws, short milk tubes, and liners, causing greater vacuum fluctuations.

Milking speed differences among claws were highly significant, except at the VS rate, but differences were small, amounting to .75 pounds per minute over the four flow rates where significance was present.

Cyclic vacuum fluctuation was significantly greater for 4x0 pulsation at all flow rates. Differences between pulsator types were 1.16, 1.18, .93, .33, and .45 inches of mercury from VF to VS, respectively.

Minimum cyclic vacuum was lower at all flow rates with 4x0 than with 2x2 pulsation, whereas maximum levels were higher

with 4x0 pulsation, thus accounting for the greater fluctuation with 4x0 pulsation.

Significant differences in fluctuation between claws were found only at the F rate.

Summary

These trials were conducted primarily to determine the effect of claw volume on milking speed and teat end vacuum. Several claws ranging in size from 30 to 360 ml internal volume were tested using alternate or simultaneous pulsation, and significant differences in milking speed between claws were found at approximately 9 pounds per minute and above.

A significant interaction between flow rate and pulsation type was found. Simultaneous pulsation "milked" faster at higher

Analysis of Variance and Means - 2 x 2 and 4 x 0 Pulsation										
Factor	Flow rate	Claw vol. (ml)			Puls. type		Claw	Puls.	Interaction	
		360	146	138	2 x 2	4 x 0				
Milking speed (lbs/min.)	VF	22.40	21.97	21.67	21.02	23.00	**	**	C x P	—
	F	19.30	19.00	18.40	18.17	19.58	**	**	C x P	—
	M	15.10	14.90	14.30	14.87	14.66	**	**	C x P	—
	S	10.60	10.20	10.00	10.87	9.62	**	**	C x P	—
	VS	5.59	5.72	5.80	6.05	5.35	—	**	C x P	—
	\bar{x}	14.6	14.35	14.03	14.20	14.44			FR x P	**
Vacuum fluctuation	VF	1.90	1.75	1.60	1.22	2.38	—	**	C x P	*
	F	1.48	1.68	1.23	0.87	2.05	**	**	C x P	—
	M	1.28	1.50	1.33	0.90	1.83	—	**	C x P	—
	S	0.83	1.20	0.93	0.82	1.15	—	*	C x P	—
	VS	0.93	0.78	1.03	0.68	1.13	—	**	C x P	—
		\bar{x}	1.28	1.38	1.22	0.90	1.71			

*Significance at .05 **Significance at .01 —No significant difference