

ASAE, 3-A and ISO STANDARDS FOR MILKING SYSTEMS.

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Presented at the 1992 Winter Meeting of the ASAE, Nashville, Tennessee

Major changes in ISO standards for the construction and performance of milking systems are reviewed. Recommendations are made to adopt, or adapt, the proposed new ISO standards as ASAE standards.

Milking machines, Standards, Performance guidelines.

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INTRODUCTION

1992 has been a vintage year for review of standards on the construction, performance and mechanical testing of milking systems. ASAE S518, Milking Machine Installations: Construction and Performance, was issued as a standard in January 1992 (1). This standard is likely to replace the performance specifications currently incorporated in 3-A Accepted Practices (2) as the key reference standard in the USA. A technical committee has been appointed to review the new ASAE standard and two related documents (3,4), in light of revised standards proposals from the International Standards Organization (ISO).

All three relevant ISO Standards (5,6,7) are being revised at present. The ISO Technical Committee 23/AHG MILK completed its review of the three standards for milking equipment in October, 1992. Major changes are proposed and similar changes may follow in other national standards. Representatives from the USA have played an important role in the ISO standards review. This input has been coordinated through the Equipment Manufacturers Institute. Copies of the proposed new standards will be circulated to member countries in January, 1993. The USA will be asked to vote on these standards as a member country of ISO TC/23.

As a guiding principle, such national and international standards and tests are useful only if they lead to improved milking, better physical, chemical or bacteriological quality of milk, or less mastitis. It is necessary to have a sense of proportion, and not useful to impose rigid limits, when there is no evidence that the effects implied in a particular standard are likely to give any practical benefit. To encourage innovation and new technology, standards should be written in the broadest performance terms possible. Innovation tends to be stifled by dimensional standards and rigid design criteria. Nevertheless dimensional guidelines, based on particular performance requirements, can be appended to a Standard so that users such as manufacturers, installers, and technicians do not have to estimate their own dimensional requirements based on the performance standards and the expected loads for individual milking systems.

These general principles have guided the revision of the ISO standards for milking systems to a remarkable degree. As a result, the proposed new ISO standards are a great improvement on the existing versions. Many of the new proposals can, and should, be incorporated into a revised set of ASAE standards.

ISO 3918 Terms and Definitions (5)

ISO is proposing terms and definitions that are simple, descriptive, precise and widely used internationally. All changes proposed by USA were accepted with only a few minor modifications. It now includes common US terms such as distribution tank, controller, stall cock, air vent, milk hose and milk:rest ratio.

Adoption of the new ISO terms and definitions as completely as possible by ASAE would facilitate common usage of terms internationally. Current US terminology is given in ASAE S 300.2 (3). Superficially, the new ISO and 1990 US definitions are similar, and about 30 terms are either identical or nearly so. However, there are inconsistencies and some of the differences are important. Examples of the inconsistencies include:

ISO 3918		ASAE S 300.2
unit	=	milking machine
air	=	vacuum
pulse	=	air

ISO 6690 Mechanical Tests (6)

The main change for both ISO and ASAE is the method for measurement of Effective Reserve and Manual Reserve. These terms are defined in ASAE S300.2 as follows.

Effective Reserve is defined as "the volume rate of air, admitted at or near the regulator location, that will cause the vacuum level to drop 2 kPa (0.6" Hg) below that existing when all milking units (with the liners stoppered) and all accessories are in operation".

Manual Reserve is defined as "the volume rate of air, admitted at or near the regulator location, that will cause the vacuum level to drop 2 kPa (0.6" Hg) below that existing when all milking units (with the liners stoppered) and all accessories, except the regulator, are in operation".

Thus, the two procedures are identical, except that the regulator is disconnected for the measurement of Manual Reserve. The relationship between the two measurements is:

$$\mathbf{Manual\ Reserve = Effective\ Reserve + Regulator\ Leakage}$$

The changes proposed by ISO are:

- 1) The operating vacuum level is defined as the mean vacuum level measured in or near the receiver when all units (with the liners stoppered) and accessories, including the regulator, are operating;
- 2) The air flowmeter should be connected at or near the receiver (rather than near the regulator) for the measurement of Effective Reserve and Manual Reserve. When these measurements are made at the receiver, they provide a more accurate indication of how much of the reserve pump capacity is really available to cope with contingencies during milking. They provide an overall measure of the regulator efficiency, the matching of the regulator to the vacuum pump, the position of the regulator within the installation, and the pressure drops in the airlines between the receiver and vacuum pump.

ISO 5707 Construction and Performance (7)

Significant changes from dimensional criteria in the existing Standard to performance requirements in the proposed Standard include the following.

Design of Milking Pipelines. The new performance requirement states "The internal diameter of the milkline shall be such that the vacuum drop in the milkline does not exceed 2 kPa (0.6" Hg) with all units operating at the designed milk and air flowrates." This proposal originated from a UW-Madison Milking Research Laboratory study and recommendations for sizing milklines to insure stratified flow during milking (8,9) The apparently contradictory requirements in the ISO Standard were resolved by specifying the common performance requirement, given above, and providing 2 informative annexes (one for sizing milklines without accounting for transient air admission, and the other with allowance for the transient air admitted during cup changing or liner slips). ASAE should be happy to accept this compromise.

Fluid flow in dual purpose milklines typically varies between "stratified flow" (when milk flows in the lower part of the milkline and air can flow in a clear, continuous path above the milk) and "slug flow" (when intermittent slugs of milk fill the entire cross-section of the milkline). Slug flow conditions almost always induce a transient drop in milkline vacuum greater than 2 kPa (0.6" Hg). Transient vacuum drops caused by slug flow are characterized by a rapid drop in milkline vacuum below the average stable level, and rapid recovery when the slug enters the receiver. Stratified flow is the preferred flow condition to maintain a reasonably stable vacuum supply to the cluster during milking. Nevertheless, transient vacuum drops associated with occasional slug flow conditions will have little or no effect on milking performance, mastitis, cell count or milk quality.

The key performance indicator of stratified flow is that any transient drop in milkline vacuum should not exceed 2 kPa (0.6" Hg) at the designed milk and air flowrates, including the transient air flows normally associated with cup changing and liner slips. ASAE recommendations for sizing milklines should be based on this performance guideline to insure that stratified flow is the normal flow condition for milking high-producing cows in parlors or stanchion barn installations, now and into the next decade. Guidelines for these herds cannot be logically based on the average of cows in today's herds. The more conservative approach is to base guidelines on the peak flowrates of the upper 25% of cows currently available, i.e., for cows with mean peak flowrates of 5.5 L/m (12 lb/m), according to Stewart et al (10).

Some examples of the maximum number of milking units per slope to ensure stratified flow for selected design criteria are given in Tables 1 to 3 (from 9). These Tables are derived by combining the criteria for stratified flow (from 8) together with predictions of the maximum expected milk flowrate (from 10).

Internal Diameter of Air Pipelines. The US proposals of Spencer and Mein (11) for sizing

the main air pipelines on the basis of a maximum acceptable vacuum drop were accepted. Thus, the length of line, the equivalent length of fittings, and the expected air flowrate are taken into account in choosing an appropriate line size. Furthermore, a preferred design guideline was added to the ISO Standard: "the air pipelines and system should be designed for a vacuum drop of not more than 2 kPa (0.6" Hg) between the vacuum pump and the receiver".

This design guideline has been used to derive Table 4 for ISO, and Table 5 (Spencer and Mein, unpublished). Either Table would be a suitable informative guideline to explain the performance specification in a revised ASAE Standard.

Flexible tubes. Apart from the long milk tube (milk hose), all dimensional requirements for flexible tubes have been deleted from the ISO Standard in favor of performance specifications for acceptable pulsation characteristics and for a maximum vacuum fluctuation (not more than 15 kPa cyclic fluctuation at the designed milk and air flowrates) in the liner beneath the teat. The principle embodied in this performance guideline is that clusters with low flow capacity (small diameter milk pathways and/or small claw bowls) might be suitable for milking low-producing, slower-milking cows in developing countries, but that higher capacity clusters are preferred for higher producing herds.

Cluster. The minimum claw volume of 80 ml was replaced by the performance specification given above for teat-end vacuum fluctuations.

Vacuum pump capacity and effective reserve

The new International Standards specify the minimum effective reserve rather than the pump capacity. ASAE should do the same. A specification for pump capacity is neither necessary nor desirable in a national standard. As long as the minimum effective reserve is specified, then a suitable vacuum pump can be selected with appropriate allowances for machine consumption, vacuum drop, altitude, leaks and wear.

A suitable basis for estimating the recommended capacity of new vacuum pumps to ensure the minimum Effective Reserve is given in Appendix 1 as:

New pump capacity = 1.33 x [2 scfm per unit plus minimum Effective Reserve]
plus extra air consumption of any special components.

The ISO standards committee has recommended a modest increase in both the base level and the incremental amount of Effective Reserve per unit. The proposed new formulas, in ASME units, are approximately:

For pipelines and weigh jar machines, with automatic shut-off valves in the claw:

$$7 + 1n \text{ scfm (where } n \text{ is the number of units) for up to 10 units,}$$
$$(200 + 30n \text{ L/m)}$$

$$18 + 0.3(n - 10) \text{ scfm free air for more than 10 units.}$$
$$(500 + 10(n-10) \text{ L/m)}$$

For installations without shut-off valves, the ISO proposal is to add 7 cfm (200L/m) to the base requirement:

$$\text{i.e. } 14 + 1n \text{ scfm for up to 10 units,}$$
$$(400 + 30n \text{ L/m)}$$

$$\text{or } 25 + 0.3(n - 10) \text{ scfm for more than 10 units.}$$
$$(700 + 10(n-10) \text{ L/m)}$$

It is likely that these ISO guidelines will be regarded as too low by most Americans, especially for small systems, unless claws with effective automatic shut-off valves are used. A common industry opinion is that current US guidelines for sizing vacuum pumps are too low for small systems, in the right range for systems with about 8-12 units, but they result in un-necessarily high reserve for larger systems.

The claims of quicker milking when small systems have more pump capacity may be due to excessive frictional losses in poorly plumbed systems. If so, then providing extra pump capacity may not be the most efficient solution. Perhaps small systems need the extra capacity mainly for cleaning. If so, then the current cleaning project at UW-Madison may result in revised guidelines for the vacuum pumping capacity required for air injection cleaning.

Possible new guidelines for the ASAE standard S 518, to replace current 3-A Accepted Practices are as follows.

- 1) The standard should specify the minimum Effective Reserve rather than the minimum pump capacity.
- 2) The minimum Effective Reserve should be 30 scfm for any milking system with 10 units or less, plus:
 - 1 scfm per unit above 10 and up to 20 units,
 - 0.5 scfm per unit above 20 units.

This proposal would meet the current industry concern that small systems seem to be under-pumped but large systems are over-pumped. It would produce figures that are higher than the current 3-A guidelines for systems up to 12 units, almost the same for 12 units, and then progressively lower pump capacities above 12 units.

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Table 1. Parlor, with units attached every 10 sec per slope

Peak flowrate	5.5 L/min/cow (12 lb/min)					
Steady air admission	10-20 L/min/unit (0.35-0.7 scfm)					
Transient air admission	100 L/min/slope (3.5 scfm)					
	<u>Number of units per slope</u>					
	<u>Slope</u>					
<u>Nominal Line Size</u>	<u>0.5%</u>	<u>0.8%</u>	<u>1.0%</u>	<u>1.2%</u>	<u>1.5%</u>	<u>2%</u>
48 mm (2 inch)	2	3	3	4	4	5
60 mm (2.5 inch)	4	5	6	7	8	10
73 mm (3 inch)	6	9	10	13	16	24
98 mm (4 inch)	21	(28)	(32)	(35)	(38)	(43)

Note: Figures in Tables 1 and 2 indicate an unlimited number of units for 96 mm (4") line above 0.8% slope. If more than 2 operators are attaching units on the same slope, the attachment rate may be quicker than 10 s per unit per slope. The figures in parentheses then apply.

Table 2. Parlor, with design conditions as for Table 1 except for transient air admission of 200 L/min/slope (7 scfm/slope).

	<u>Number of units per slope</u>					
	<u>Slope</u>					
<u>Nominal Line Size</u>	<u>0.5%</u>	<u>0.8%</u>	<u>1%</u>	<u>1.2%</u>	<u>1.5%</u>	<u>2%</u>
48 mm (2 inch)	1	1	2	2	3	3
60 mm (2.5 inch)	3	4	4	6	7	8
73 mm (3 inch)	4	7	8	10	12	17
98 mm (4 inch)	18	(26)	(31)	(33)	(36)	(40)

Table 3. Stanchion barn with units attached every 30 sec per slope

Peak flowrate	5.5 L/min/cow (12 lb/min)					
Steady air admission	10-20 L/min/unit (0.35-0.7 scfm)					
	<u>Number of units per slope</u>					
Transient air:	<u>100 L/min/slope (3.5 scfm)</u>			<u>200 L/min/slope (7 scfm)</u>		
	<u>Nominal Line size</u>					
<u>Slope</u>	<u>48mm 60mm 73mm</u>			<u>48mm 60mm 73mm</u>		
0.5 %	2	3	6	1	3	4
0.8 %	3	5	*	1	4	*
1.0 %	3	7	*	2	5	*

Note: * indicates no limit to the number of units.

Table 4. Recommended maximum air flowrate (liters/min free air) for a design limit of 2 kPa vacuum drop due to air flow in pipelines made of stainless steel or PVC.

Approx. length of straight pipeline (m)	Nominal pipeline diameter				
	38mm	50mm	63mm	75mm	100mm
	Equivalent length (m) added for 2 tanks and 6 elbows*				
	8 m	12 m	14 m	16 m	24 m
5 m	1000	2100	3550	5000	9300
10 m	770	1770	3100	4430	8500
15 m	650	1550	2800	4000	8000
20 m	550	1350	2550	3650	7500
30 m	-	1130	2200	3150	6750
40 m	-	940	1950	2750	6100

* This ready reckoner table includes an allowance for the equivalent length, expressed in meters of straight pipe, of one interceptor (or distribution tank), one sanitary trap and 6 elbows.

These calculations are based on a maximum vacuum drop of 2 kPa between the receiver and vacuum pump. The maximum air flowrate is normally from the vacuum regulator to the pump. Whenever additional air enters the milking clusters during milking, however, the maximum air flowrate is from the receiver to the vacuum pump.

Table 5. Recommended minimum pipe sizes (inches internal diameter) for the main airline of a milking system.

Vacuum pump capacity CFM-ASME	Approx. length of main airline (feet of straight pipe)				
	20	40	60	80	100
50	2	2	3	3	3
60	2	3	3	3	3
70	3	3	3	3	3
100	3	3	3	3	3
150	3	4	4	4	4
200	4	4	4	4	4
250	4	4	4	6	6
300	4	6	6	6	6
350	6	6	6	6	6
400	6	6	6	6	6

Notes: The main airline is defined as the pipeline between the vacuum pump and the sanitary trap near the receiver.

These calculations are based on a max. vacuum drop of 0.5 inches of mercury between the receiver and vacuum pump. The maximum air flowrate is normally from the vacuum regulator to the pump. Whenever additional air enters the milking clusters during milking, however, the maximum air flowrate is from the receiver to the vacuum pump.

This ready reckoner table includes an allowance for the equivalent length (feet of straight pipe) of one distribution tank, one sanitary trap and 4 elbows. If the system includes more than 4 elbows, then use the next pipe length column to the right for every 3 additional elbows.

APPENDIX 1. CALCULATING THE PUMP CAPACITY REQUIRED TO PROVIDE THE MINIMUM EFFECTIVE RESERVE

The following guideline for sizing new vacuum pumps is based on:

- 1) an assumed air consumption of 2 scfm free air per unit for pulsators, air vents and milk meters;
- 2) common or maximum allowances for regulator leakage, system leakage, and vacuum drop between the pump and receiver;
- 3) an additional 10% margin for new pumps to allow for some deterioration in pumping capacity during the working life of the pump;
- 4) additional allowances for air consumption of any particular components or fittings (e.g., air lubrication of some vacuum regulators).

Air consumption of units

Pulsator	1 scfm)	
Air vent	0.3-0.5scfm)	2 scfm per unit
Milk meter	0.3-0.5 scfm)	

Allowances for leakage, vacuum drop, and pump wear

Regulator leakage	(10% of pump capacity))	
)	
System leakage	(10% of pump capacity))	
)	= 33% extra
Vacuum drop in lines)	pump capacity
	(0.5" Hg = 3% of pump capacity))	
)	
Allowance for pump wear	(add 10% of pump capacity))	

New pump capacity = 1.33 x [2 scfm per unit plus minimum Effective Reserve]
plus extra air consumption of any special components.