Milking Machine Installations—Construction and Performance

STANDARD

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Milking Machine Installations—Construction and Performance

Proposed by the Milking Machine Manufacturers Council of the Equipment Manufacturers Institute; developed by ASAE IET 441 Milk Handling Equipment Committee; approved by the Electrical and Electronic Systems Division Standards Committee; adopted by ASAE January 1992; revised March 1994, July 1996.

1 Purpose and scope

1.1 This Standard specifies the minimum dimensional requirements for the satisfactory functioning of milking machines, including the minimum performance requirements for milking and cleaning. It also specifies requirements for construction and installation.

1.2 This Standard applies to machines intended for milking cows or water buffaloes. The qualitative requirements also apply to machines for milking sheep and goats.

1.3 This Standard is not expected to apply in every respect to installations with special design features which are (or may be) available; for example:

- bucket milkers;
- small mobile installations with an individual vacuum pump for each unit;
- independent air and milk transport milking machines;
- single-pipe pipeline milking installations;
- milking installations with double vacuum systems;
- milk extraction without pulsation;
- systems with compressed air pulsation or other special pulsation characteristics.

1.4 This Standard does not address the relevant safety (mechanical and electrical) or hygiene requirements.

1.5 This revision is based upon ISO/DIS 5707-1995, Milking Machine Installations—Construction and Performance, which was finalized and approved in October 1995.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to apply the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

ANSI/ASAE S493 JUL93, *Guarding for Agricultural Equipment*
ANSI/ASME PTC 9-1974 (R1992), *Performance Test Code—Displacement Compressors, Vacuum Pumps and Blowers*
ASAE S300.2 JUL96, *Terminology for Milking Machines, Milk Cooling and Bulk Milk Handling Equipment*
ASAE EP445.1 JUL96, *Test Equipment and Its Application for Measuring Milking Machine Operating Characteristics*
IAMFES 3-A 63-00, *Sanitary Fittings for Milk and Milk Products*
IAMFES 3-A 606-03, *Accepted Practices for the Design, Fabrication and Installation of Milk Handling Equipment*
IAMFES 3-A 33-01, *Sanitary Standards for Polished Metal Tubing for Dairy Products*
IAMFES 3-A 2-08, *Sanitary Standards for Centrifugal and Positive Rotary Pumps for Milk and Milk Products*
IAMFES 3-A 18-01, *Multiple-use Rubber and Rubber-like Materials Used as Product Contact Surfaces in Dairy Equipment*
IAMFES 3-A 20-17, *Multiple-use Plastic Materials Used as Product Contact Surfaces in Dairy Equipment*
NFPA 70, *National Electrical Code*

3 Definitions

3.1 For definitions, see ASAE S300.

3.2 The word *shall* indicates a requirement for the installation to conform to this Standard, while the words *should* or *may* indicate a recommended practice.

4 General

4.1 Tests for compliance. Characteristics established by mechanical testing are based on the test(s) specified in ASAE EP445. Those tests shall be used for the purpose of verifying compliance with the requirements of this Standard.

4.2 Access for measurements. Some or all of the connection points identified below can be provided, if desired, by dismantling parts of the milking machine.

4.2.1 To enable measurement of effective reserve, manual reserve, regulation loss, regulation efficiency (and regulator leakage, if desired), a connection point for an air flowmeter shall be provided at or near the receiver in pipeline milking machines, or at or near the sanitary trap in weigh jar machines.

4.2.2 A connection point for an air flowmeter shall be provided at or near the vacuum pump(s) to enable measurement of pump capacity and system leakage.

4.2.3 Additional connection points shall be provided for measuring vacuum level at or upstream of the receiver in pipeline milking machines, at or near the regulator sensing point, and near the vacuum pump inlet.

4.3 Power failure. Most milking machines depend on a public utility for electric power supply, which may occasionally fail. The user should provide a suitable arrangement for an alternative electric power supply for operating the machine in cases of emergency.

4.4 Noise. Equipment should be designed and installed so that noise levels in the barn or parlor, and in the vicinity, are as low as practicable.

4.5 Safety. All installations shall comply with the requirements for safety in national legislation, with NFPA 70 for grounding and wiring, and with the requirements of ANSI/ASAE S493.

5 Materials and fabrication

Materials and fabrication practices used shall comply with IAMFES 3-A 606-03, as amended.

6 Vacuum pumps

6.1 Capacity. The vacuum pump(s) shall have adequate capacity to meet the operating requirements for milking and for cleaning of the system, including all ancillary equipment operating during milking, whether continuously or intermittently. If more than one vacuum pump is installed, it shall be possible to isolate the pump(s) not in use.

NOTE – See guidelines for vacuum pump sizing in informative annex A.

6.2 Effective reserve. In addition to meeting the operating requirements in 6.1, the vacuum pump(s) shall have sufficient effective reserve capacity so that the vacuum drop in or near the receiver does not exceed 2 kPa (0.6 in. Hg) during the course of normal milking, including teatcup attachment and removal, liner slips, and cluster fall-off when tested in accordance with 11.1 in ASAE EP445.

Effective reserve capacity shall be determined in accordance with 7.1 in ASAE EP445.

NOTES

1 In most milking systems, this performance specification should be achieved by providing an effective reserve within the range 1000 to 3400 L/min (35 to 120 ft^3/min). A simple formula for ensuring sufficient effective reserve is:

- a base allowance of 1000 L/min (35 ft^3/min)
- plus an incremental allowance of 20 to 30 L/min (0.7 to 1 ft^3/min) per unit.

2 Effective reserve should be increased to allow for vacuum-operated equipment that is not active during testing. The number of such components operating simultaneously should be taken into consideration. Ancillary equipment operated by a separate vacuum system need not be considered.

6.3 Influence of altitude. When vacuum pumps are operated at altitudes above sea level, vacuum pump sizing shall be adjusted using the values in table 1.

Table 1 – Elevation correction factors for vacuum pump rating

Elevation (above sea level) m	ft	Correction factor[1]
0	0	1.00
300	1000	0.96
600	2000	0.93
900	3000	0.90
1200	4000	0.87
1500	5000	0.83
1800	6000	0.80
2100	7000	0.77
2400	8000	0.74

[1] Correction factor times capacity at sea level equals true capacity at elevation.

6.4 Exhaust. The exhaust from a lubricated vacuum pump shall not discharge into a room. The exhaust pipe should be as short as possible and should not obstruct the passage of the exhaust air by the use of inadequately sized piping or unnecessary fittings. If possible, the exhaust pipe shall have a continuous slope away from the vacuum pump. If this cannot be achieved, a suitable moisture trap, with provision for drainage, shall be fitted. For lubricated vane-type pumps, it is recommended that an oil separator be fitted to the exhaust pipe.

6.5 Prevention of reverse rotation. The vacuum pump should be equipped with a non-return valve (check valve). If not, then a tap (cock) for admitting atmospheric air to the vacuum system shall be provided adjacent to the vacuum pump control switch.

6.6 Location. The vacuum pump shall be located so the pump speed can readily be measured. It shall be connected so the vacuum pump capacity can be measured in accordance with 8.2 in ASAE EP445. It should be located near the milking barn, stable, or parlor in a relatively clean and dry place.

6.7 Marking. The vacuum pump assembly shall be marked with the following information in indelible lettering:

- name of the manufacturer or supplier;
- type and identification (eg, model and serial number or code);
- the direction of rotation;
- the range of speed, rpm, and power requirement in kilowatts or horsepower;
- the corresponding range of extraction capacity at 50 kPa (15 in. Hg), expressed as free air at sea level, in L/min (ft^3/min) (see ANSI/ASME PTC 9);
- recommended lubricants and equivalents.

7 Vacuum regulation

7.1 Marking and specification

7.1.1 The regulator shall be marked with the following information in indelible lettering:

- name of the manufacturer or supplier;
- model;
- designed working vacuum range in kPa and in. Hg;
- airflow capacity at 50 kPa (15 in. Hg), expressed as free air at sea level, in L/min and ft^3/min.

7.1.2 The regulator leakage, expressed in L/min and ft3/min, at the upper and lower ends of the designed working range when the regulator is nominally closed, shall be stated by the manufacturer (see 7.3 in ASAE EP445 for test procedure, and 10.8 in ASAE S300 for definition).

7.2 Mounting

7.2.1 The regulator shall be mounted according to manufacturer's specifications to be as free from vibration as possible and positioned so moisture from the airlines cannot enter the regulator. The regulator should be mounted in a clean and readily accessible location. The vacuum sensor or regulator should be connected to the main airline as near to the sanitary trap as practicable.

NOTES

1 Only sensors designed so that they fulfill all hygiene requirements may be placed at the sanitary trap, or the receiver, or between them.

2 A long branch line for the regulator is acceptable provided that the line diameter is sufficient to ensure that regulation loss is less than 10%.

7.2.2 Unless specifically required by the manufacturer, the vacuum sensor shall not be mounted:

- between the vacuum pump and distribution tank;
- into the milkline or milk receiver;
- into the pulsator airline

7.3 Performance

7.3.1 Cluster fall-off. The mean equilibrium vacuum in the receiver should not fall more than 2 kPa (0.6 in. Hg) below the normal working vacuum when tested in accordance with 6.3 in ASAE EP445 with:

- one milking unit held fully open to admit air into systems with up to 32 units;
- two milking units held open in systems with more than 32 units.

NOTE – An initial, transient vacuum drop greater than 2 kPa (0.6 in. Hg) may indicate regulator undershoot. The subsequent equilibrium vacuum indicates the combined effects of the sensitivity and state of cleanliness of the vacuum regulator, the amount of manual reserve, and the head loss due to air flow in the connecting pipes and fittings.

7.3.2 Regulation loss. The total "unplanned" air leakage through the regulator when tested according to 7.2 in ASAE EP445 shall not exceed 10% of the manual reserve, at a vacuum level of 2 kPa (0.6 in. Hg) below the working vacuum.

NOTE – This implies that the regulation efficiency shall be at least 90%. That is, the effective reserve shall be at least 90% of the manual reserve.

8 Vacuum gauges

8.1 Accuracy. When a gauge is mounted and calibrated, the error measured according to 6.1 in ASAE EP445 shall not exceed 1 kPa (0.3 in. Hg) at the working vacuum level.

8.2 A gauge shall be mounted where it is readable during milking and should be visible from near the regulator.

NOTE – A vacuum gauge should be readable from the place where the milking machine is started. More than one vacuum gauge may be needed.

9 Airlines (vacuum pipelines)

9.1 The main airline(s) shall be of sufficient size to ensure a drop of not more than 2 kPa (0.6 in. Hg) from the vacuum pump to any point in the vacuum system when tested as per 6.2 in ASAE EP445

NOTE – See guidelines for sizing in informative annex B.

9.1.1 Pulsator airlines shall not be smaller than manufacturer's recommendations, and should not be smaller than the diameter shown in table 2.

Table 2 – Recommended minimum sizes for looped pulsator airlines

Number of units	Pipe diameter[1]
1 to 14	50 mm (2 in.)
15 or more	75 mm (3 in.)

[1] Metric = nominal ID. Inch = US pipe size

10 Drain valves

Provision shall be made for complete drainage of all milk and cleaning solution contact surfaces, when the vacuum is shut off. In all cases, drain valves shall be accessible.

11 Distribution tank, sanitary trap, and interceptor

11.1 Distribution tank. The distribution tank, if used, should be mounted in an accessible position. It shall be provided with automatic drainage facilities such that the effluent discharges to a safe and convenient location.

11.2 Sanitary trap. The sanitary trap shall comply with the appropriate section of IAMFES 3-A 606-03 as amended.

11.3 Interceptor. An interceptor may be fitted between the vacuum pump and the vacuum regulator. There shall be no intermediate connections into the airline between the interceptor and the pump, except as required for test purposes or connection of a safety valve. The interceptor shall incorporate a liquid-level operated vacuum shut-off and shall be provided with automatic drainage facilities. The internal diameter of the inlet and outlet of the interceptor should be not less than that of the air lines connected to it.

12 Stall-cocks

Stall-cocks shall be connected to the upper part of the pulsator airline. They should be firmly fixed to the airline to prevent displacement in relation to the pipeline orifices. Gaskets should not obstruct the stall-cock aperture. Stall-cocks should have stops at the fully open and fully closed positions, and they should be airtight when closed.

13 Pulsation systems

13.1 Performance data. The pulsation rate, pulsator ratio, and pulsator phases shall be measured according to clause 10 in ASAE EP445. The following data shall be provided:

- the pulsation rate at a nominal vacuum and temperature;
- the temperature range over which pulsators can be used;
- the variation of pulsation rate within this range;
- typical pulsation curves for a defined cluster or test apparatus with a specified volume;
- air consumption with defined cluster.

13.2 Pulsation rate. During test conditions, the pulsator rate shall not deviate more than +/- 3 cycles/min from the values provided by the installer.

13.3 Pulsator ratio. During test conditions, the pulsator ratio shall not differ more than +/- 5 units of percentage from the values stated by the manufacturer. Within a cluster, no two teatcups may vary from each other by more than 5 units of percentage except where the cluster is designed to provide differing ratios between the front and hind quarters.

13.4 Pulsator phases (see figure 3 in ASAE S300). Phase b shall be not less than 30%. Phase d shall be not less than 15% and not less than 150 ms. Vacuum variations during phases b and d shall not exceed 4 kPa (1.2 in. Hg).

NOTE – Wiring for electrically operated pulsators should be sufficient so that voltage drop will not impair pulsator function.

14 Design of milkline systems

14.1 Milklines should be designed so that stratified flow is the normal condition during milking. Stratified flow occurs when milk flows in the lower part of the milkline and air flows in a clear, continuous path above the milk. A milkline having a maximum vacuum drop of 2 kPa (0.6 in. Hg) from the receiver to any point in the milkline, under normal milking conditions, is considered to have stratified flow (see test method in clauses 11.2 of ASAE EP445). The normal flow condition means slug free conditions for at least 95% of the milking time. Occasional slugs in the milkline, which are almost unavoidable in practice, should not be regarded as evidence of an improperly designed system.

14.2 Milkline slope. A slope is a length of milkline having a continuous downward gradient toward the receiver. Milklines shall have a continuous gradient towards the receiver, with a minimum gradient of 0.8% (8 mm per meter, or 1 in. per 10 ft).

NOTE – Where practicable, milkline slope may be increased slightly near the receiver end of the milkline to compensate for the effects of bends or other fittings.

14.3 Where practicable, the milkline shall form a loop, the ends of which shall have separate full-bore connections to the receiver.

NOTE – The number of milking units that should be used on a milkline depends largely upon its diameter and slope. Guidelines are given in informative annex C for the recommended maximum number of units per slope that should be used to maintain stratified flow.

15 Milkline and fittings

15.1 Leakage. Air leakage into the milklines, meters, weigh jars, receiver, and the fittings shall not exceed 20 L/min (0.7 ft^3/min) plus an additional maximum of 2 L/min (0.07 ft^3/min) per unit.

15.2 Drainage. Provision shall be made for complete drainage of all parts of the milk system when vacuum is shut off.

15.3 Milk cocks and milk inlets. Milk cocks and milk inlets shall be positioned so the entry is above the centerline of the pipeline. They shall be easy to clean and disinfect. They shall have stops at the fully open and fully closed positions, and have closures that are readily applied and of sanitary design.

15.4 Tubing and fittings. Tubing and fittings shall be per IAMFES 3-A 33-01, as amended, per 3-A 606-03, as amended, and IAMFES per 3-A 63-00, as amended. Provision shall be made for inspection of the inside of the pipeline.

16 Weigh jars (recorder jars)

16.1 General. Weigh jars shall have an effective volume of not less than 23 kg (50 lb) or 23 L (0.8 ft^3) and incorporate a method of measurement.

16.2 Weigh jars shall be suitable for in-place washing and capable of withstanding a differential pressure of not less than 100 kPa (29.5 in. Hg). They shall have connections that are located to minimize the risk of carry-over of milk or foam into the vacuum system.

16.3 Weigh jars shall have an outlet of not less than 11 mm (0.43 in.) internal diameter.

16.4 Mounting. The jars should be rigidly fixed and set to ensure the greatest accuracy of calibration. The jars shall be fixed so that the scale can be easily read by the operator. Means shall be provided to prevent flattening of the milk hose due to direct pull or constant drag on the inlet nipple of the weigh jar.

17 Ancillary components of the milking unit

Devices, including necessary connecting tubes, fitted in a long milk tube shall not cause an additional vacuum drop of more than 5 kPa (1.5 in. Hg) measured in the cluster (at a milk flow rate of 5 kg/min (11 lb/min) and an airflow of 8 L/min (0.3 ft^3/min)), compared with the same milking unit without those devices, when measured in accordance with annex A in ASAE EP445. Milk meters used at every milking shall comply with this requirement. Those used periodically for milk recording should also comply with this requirement.

18 Flexible tubes

18.1 Short milk tubes. The internal diameter of short milk tubes shall not be less than 9 mm (0.35 in.) along their full length when the tubes are in the milking position.

18.2 Milk hoses. The internal diameter of the milk hose for single-outlet milk claws shall not be less than 14 mm (0.56 in.). Milk hoses should be as short as practicable and shall not exceed 2.7 m (9 ft) in length.

18.3 Long pulse tubes (air tubes). The internal diameter of long pulse tubes shall not be less than 7 mm (0.28 in.) except in the case of installations with alternating pulsation, where the internal diameter shall not be less than 6 mm (0.24 in.).

18.4 Short pulse tubes (air tubes). The internal diameter of short pulse tubes shall not be less than 5 mm (0.20 in.).

19 Cluster assemblies

19.1 Internal dimensions of teatcup shell. The internal dimensions of the shell shall not restrict the operation of the liner. The liner and shell combination shall provide a means to indicate if the liner is twisted or means to prevent the liner from twisting in the shell.

19.2 Claw. A means shall be provided to shut off the milking vacuum for cluster removal. Air leakage through the vacuum shut-off valve when closed shall not exceed 2 L/min (0.07 ft^3/min).

NOTE – Means should also be provided to limit the airflow through the cluster during attachment.

20 Receivers

The receiver shall be capable of withstanding a differential pressure of not less than 100 kPa (29.5 in. Hg). It shall be suitable for in-place cleaning. Gaskets shall be designed for easy cleaning, and they shall be easy to remove.

21 Releasers

21.1 A releaser, if fitted into the installation, shall be adequate to handle the maximum rate at which milk, cleaning, and sanitizing solutions are released into the system. The releaser should be capable of discharging the milk without undue formation of foam.

21.2 Pneumatic releasers. Data on air consumption of pneumatic releasers at the maximum milk flow rate shall be provided.

21.3 Centrifugal or positive rotary pumps. Milk pumps shall comply with IAMFES 3-A 02-08, as amended. The operation of a centrifugal or positive rotary milk pump shall be controlled by the quantity of milk in the receiver.

22 In-place cleaning and disinfection

22.1 Installations designed for in-place cleaning and disinfection shall be constructed so all milk contact surfaces are capable of being effectively cleaned and disinfected. Attachments such as filters, mastitis detectors or indicators, surface coolers, and ancillary equipment not specifically designed for circulation cleaning and disinfection should be removed for separate cleaning and disinfection.

22.2 Pre-cooling

22.2.1 Where in-line cooling equipment is fitted, means, preferably automatic, shall be provided to stop the flow of coolant during the washing cycle.

22.2.2 In-line coolers shall be installed with appropriate ancillary equipment so that they can be cleaned-in-place without impairing the effectiveness of cleaning the rest of the system.

23 Instructions for use and maintenance

23.1 Full written instructions shall be provided for operating, cleaning, and sanitizing the installation (including the temperature range at which the installation should be cleaned and sanitized and the cleaning chemicals recommended). Written instructions for routine servicing including replacement of individual parts shall be provided, together with all manuals supplied by the equipment manufacturer.

23.2 The results of a post-installation test and system evaluation as outlined in ASAE EP445 shall be provided.

23.3 Instructions should be readily available to the operator.

Annex A
(informative)
Guidelines for vacuum pump sizing

A1 Vacuum pump capacity for milking

The recommended pump capacity for new installations is based on the following allowances.

1000 L/min (35 ft^3/min) for the basic effective reserve.

An additional 60 to 70 L/min (2 to 2.5 ft^3/min) for each milking unit, to cover:

- 20 to 30 L/min (0.7 to 1 ft^3/min) per milking unit for the incremental component of effective reserve;
- pulsator consumption of 30 L/min (about 1 ft^3/min) per unit;
- claw air admission of 10 L/min (0.35 ft^3/min) per unit;

Air leaks, frictional losses, and pump wear. To allow for all of these contingencies, the calculated airflow requirements should be multiplied by a factor of 1.2 to 1.3, to cover:

– system leakage	5 to 10% of pump capacity
– regulation loss	5% of pump capacity (5 to 10% of the manual reserve)
– frictional losses	3% of pump capacity (2 kPa drop from pump to receiver)
– pump wear	5 to 10% of pump capacity
Total	18 to 28%, which is approx 1.2 to 1.3.

In well-designed systems with low air leakage, low frictional losses and correct regulator location, an extra 20% (that is, a factor of 1.2) is more than adequate. Therefore, the recommended **basic** pump capacity =

$$(1000 + 1.2 \times 70n) \text{ L/min} = (1000 + 85n) \text{ L/min}$$

or

$$(35 + 1.2 \times 2.5n) \text{ ft}^3\text{/min} = (35 + 3n) \text{ ft}^3\text{/min}$$

where

n is the number of milking units.

The vacuum pump(s) and motor(s) should be selected to provide at least the basic pump capacity at the normal operating vacuum for the system (which is not necessarily 50 kPa, or 15 in. Hg).

A2 Additions to the basic pump capacity for milking

There may be other additions to the basic pump capacity for particular systems, to cover:

- "air lubricated" regulators, which require an extra 200 to 800 L/min (7 to 28 ft^3/min);
- some types of milk meters with an air vent (up to 15 L/min, 0.5 ft^3/min, per meter);
- milk sweeps, and air sweeps for some back-flush systems (check manufacturer's specifications);
- an extra allowance, perhaps, for cleaning (see following section A3).

A3 Vacuum pump capacity for air-injected CiP cleaning systems

With proper system design and control of air and liquid flowrates, the vacuum pump capacity required for efficient cleaning is less than that required for efficient milking. Most milking systems will have sufficient vacuum pump capacity for air-injected CIP washing if sized according to the following relationship:

$$\text{Vacuum pump capacity for cleaning} = Qc + (n \times Qs)$$

where:

Qc is flowrate of cycled air admission (L/min or ft^3/min from table A3) to produce a slug velocity of 7 m/s (23 ft/s) in each milkline loop;

n is the number of milking units;

Qs is steady air usage of 60 L/min (2 ft^3/min) per milking unit to cover pulsator consumption, cluster air vents, system leakage and regulation loss.

Table A3 – Air injection rate to produce slug speeds of 7 m/s (23 ft/s)

Milkline Diameter (nominal ID)	Air flowrate
48 mm (2 in.)	390 L/min (14 ft^3/min)
60 mm (2.5 in.)	570 L/min (20 ft^3/min)
73 mm (3 in.)	790 L/min (28 ft^3/min)
98 mm (4 in.)	1300 L/min (49 ft^3/min)

The minimum air requirement for cleaning is when only one air injector is open at any one time. For example, a double-12 parlor with one 3 in. milkline loop would need a minimum vacuum pump capacity of:

$(28) + (24 \times 2) = 76$ ft^3/min for cleaning,

compared with

$35 + (24 \times 3) = 107$ ft^3/min for milking.

The median air requirement is when two flow circuits each receive cycled air-injection simultaneously, plus the basic incremental allowance of 60 L/min (2 ft^3/min) per unit. For example, a double-24 parlor with two 3 in. milkline loops would need a minimum vacuum pump capacity of:

$(2 \times 28) + (48 \times 2) = 152$ ft^3/min for cleaning,

compared with

$35 + (48 \times 3) = 179$ ft^3/min for milking.

The maximum air requirement for cleaning would be when two air injectors are open at any one time, and the incremental allowance (Qs) has to be increased from 60 up to 95 L/min (from 2 up to 3.3 ft^3/min) per unit to cover the extra air vent in some types of jetters. Such a system might require an extra vacuum pump for washing unless the two air injectors are sequenced so that only one is open at any time. Using the example of a double-24 parlor with two 3 in. milkline loops, the minimum vacuum pump capacity for cleaning would be:

$(2 \times 28) + (48 \times 3.3) = 214$ ft^3/min without sequenced air injection

compared with

$28 + (48 \times 3.3) = 186$ ft^3/min with sequenced air injection.

Annex B
(informative)
Recommended minimum sizes (mm or inches internal diameter) for main airlines

Vacuum pump capacity L/min free air	Approx. length of main airline (m of straight pipe) 5	15	20	25
1500	50 mm	75	75	75
2000	75	75	75	5
3000	75	75	75	100
4000	100	100	100	100
5500	100	100	100	100
7000	100	150	150	150
8500	150	150	150	150
10000	150	150	150	150

Vacuum pump capacity ft^3/min free air	Approx. length of main airline (feet of straight pipe) 10	20	40	60	80	100	200
50	2 in.	2	3	3	3	3	3
70	3	3	3	3	3	3	3
100	3	3	3	3	4	4	4
150	4	4	4	4	4	4	4
200	4	4	4	4	4	4/6	6
250	4	4	6	6	6	6	6
300	6	6	6	6	6	6	6
400	6	6	6	6	6	6	6

NOTE – 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 maximum vacuum drop of 2 kPa (0.6 in. Hg) between the vacuum pump and receiver. 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.

These tables include an allowance for the equivalent length (m or feet of straight pipe) of one distribution tank, one sanitary trap, and eight elbows. If the system includes more than eight elbows, then use the next pipe length column to the right for every three additional elbows.

In systems with two receivers, the theoretical maximum air flowrate in the two separate airlines between the distribution tank and the sanitary traps may be halved. The size of these split lines can be reduced according to the values in the table corresponding to half the vacuum pump capacity.

Annex C
(informative)

Design guidelines and recommendations for maximum number of units per milkline slope to assume stratified flow

These guidelines are based on the fastest-milking 5% of cows in the US and France, ie, a mean peak milking rate of 5.5 L/min (12 lb/min) per cow.

Steady air admission within the range 10 to 20 L/min (0.35 to 0.7 ft^3/min) per unit through claw air vents and air leaks is assumed in the calculations.

The guidelines assume that the cross-sectional area of the milkline(s) is not substantially reduced by fittings.

A slope of 0.8% is equivalent to 8 mm drop per m of run (1 in. drop in 10 ft).

A slope of 1.2% is equivalent to 12 mm drop per m of run (1.5 in. drop in 10 ft).

Table C1 – Milking parlors: looped milkline with units attached simultaneously by *careful* operators. Transient air admission of 100 L/min (3.5 ft^3/min) per milkline slope

Nominal milkline size	Maximum number of units per slope Slope 0.8%	1.0%	1.2%	1.5%	2.0%
48 mm (2 in.)	2	3	3	4	5
60 mm (2.5 in.)	6	6	7	9	10
73 mm (3 in.)	11	13	14	16	19
98 mm (4 in.)	27	30	34	38	45

Table C2 – Milking parlors: looped milkline with units attached simultaneously by *typical* operators. Transient air admission of 200 L/min (7 ft^3/min) per milkline slope.

Nominal milkline size	Maximum number of units per slope Slope 0.8%	1.0%	1.2%	1.5%	2.0%
48 mm (2 in.)	1	1	2	2	3
60 mm (2.5 in.)	4	4	5	6	8
73 mm (3 in.)	9	10	12	13	16
98 mm (4 in.)	24	27	31	36	41

Table C3 – Stanchion barns: looped milklines with units attached every 30 seconds per slope. Transient air admission of 100 L/min (3.5 ft^3/min) per milkline slope.

Nominal milkline size	Maximum number of units per slope Slope 0.8%	1.0%	1.2%	1.5%
48 mm (2 in.)	2	3	3	4
60 mm (2.5 in.)	6	9	*(9)	*(9)
73 mm (3 in.)	*(9)	*(11)	*(13)	*(16)

NOTE – Asterisk indicates an unlimited number of units when they are attached at 30-s intervals. If more than one operator is attaching units on the same slope, the attachment rate may be quicker than one unit every 30 s. If so, then the guideline figures in table C1 could be used.