INTERNATIONAL STANDARD

ISO 5707

Second edition
1996-07-01

Milking machine installations — Construction and performance

Installations de traite mécanique — Construction et performances

Reference number
ISO 5707:1996(E)

Contents

International Organization for Standardization
Case Postale 56 • CH-1211 Geneva 20 • Switzerland

Printed in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organisations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 5707 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, in collaboration with the International Dairy Federation (IDF) and the International Committee for Recording the Productivity of Milk Animals (ICRPMA), now named the International Committee for Animal Recording (ICAR).

This second edition cancels and replaces the first edition (ISO 5707:1983), which has been amended based on new scientific knowledge, field experiences and technical development.

Annexes A, B and C of this International Standard are for information only.

Introduction

This International Standard was developed in response to worldwide demand for minimum specifications for milking machine installations. The basic requirements for the construction and performance of milking machines for animals are determined by the physiology of the animal and the need for a standard of high hygiene and milk quality. In addition, the equipment has to be effective, easy and safe to use and test.

Since most milking machines depend on a public electricity supply that fails occasionally, alternate means for operating the machine in such emergencies should be installed.

It is important to design and install the equipment so that noise levels in the cowshed or parlour and in the vicinity are as low as practicable and comply with requirements in national legislation.

Milking equipment and connection to milk storage facilities on the farm should be designed and maintained to minimize turbulence, frothing, foaming or agitation, thereby reducing physical damage to the milk fat and the development of free fatty acids.

Further safety and hygiene requirements will be covered by legislation that will be the subject of other International Standards.

Milking machine installations — Construction and performance

1 Scope

This International Standard specifies the minimum performance requirements and certain dimensional requirements for satisfactory functioning of milking machines. It also specifies requirements for materials, construction and installation.

This International Standard is applicable to milking machines intended for milking cows and water buffaloes. The qualitative requirements apply also to installations for milking sheep and goats.

This International Standard is not expected to apply in every respect to installations with special design features that are (or may be) available, such as:

— single-pipe pipeline milking installations;

— milking installations with double vacuum systems;

— milk extraction without pulsation;

— pulsation pump plants;

— small mobile installations that have an individual vacuum pump for each unit;

— separate air and milk transport milking machines;

— milking installations with compressed air pulsation systems or other special pulsation characteristics.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subjected to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 228-1:1994, *Pipe threads where pressure-tight joints are not made on the threads - Part 1: Dimensions, tolerances and designation.*

ISO 3918:—[1], *Milking machine installations — Vocabulary.*

ISO 4288:—[2], *Geometrical Product Specification (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture.*

ISO 6690:—[3], *Milking machine installations — Mechanical tests.*

ISO/TR 12100-1:1992, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology.*

ISO/TR 12100-2:1992, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications.*

IEC 335-2-70:1993, *Safety of household and similar appliances — Part 2: Particular requirements for milking machines.*

3 Definitions

For the purposes of this International Standard, the following definition and those given in ISO 3918 apply.

3.1 ancillary equipment: all equipment powered by the same vacuum source as for the extraction of milk, but not directly used for milk extraction from an animal.

4 General

4.1 Tests for compliance

The requirements in this International Standard for characteristics established by mechanical testing are based on the tests described in ISO 6690, which shall, therefore, be applied for verifying compliance with this International Standard.

NOTE — The performance of an installation incorporating special design features is often difficult to determine under dry testing conditions. Special performance characteristics that are not covered by the requirements in this International Standard should be described and specified by the manufacturer in the instruction handbook.

4.2 Access for measurements

The connection points identified below can be accessed by dismantling parts of the milking machine.

4.2.1 To enable measurement of effective reserve, regulation loss and regulator leakage, a connection point shall be provided:

— at or near the receiver, upstream of the sanitary trap in pipeline milking machines;

— at the sanitary trap, or near the sanitary trap on the milking vacuum line, in recorder milking machines;

— between the regulator sensing point and the first vacuum tap in bucket or direct-to-can milking machines.

This connection point corresponds to point A1 in ISO 3918:—, figures 1, 2 and 3.

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1) To be published. (Revision of ISO 3918:1977)

2) To be published. (Revision of ISO 4288:1985)

3) To be published. (Revision of ISO 6690:1983)

In bucket and transport-can milking machines the connection point A1 is also used to measure airline leakage.

The connection shall have the same internal diameter as the airline or 48 mm, whichever is smaller.

4.2.2 To enable an air flow meter to be connected to measure milk system leakage and airline leakage in pipeline and recorder milking machines, a T-piece shall be fitted in the airline between the sanitary trap and the vacuum pump, so that the axis of the branch is above the centreline of the pipeline. The branch of the T-piece shall have the same internal diameter as the airline or 48,5 mm, whichever is smaller.

See measurement point A2 in ISO 3918:—, figures 2 and 3.

4.2.3 Additional connection points shall be provided for measuring vacuum level:

— at point A1 (Vm) or upstream of this point;

— near the regulator sensing point (Vr); and

— near the vacuum pump inlet (Vp).

See measurement points Vm, Vr and Vp in ISO 3918:—, figures 1, 2 and 3.

NOTES

1 The connection point at, or upstream of, A1 is called Vm. In a pipeline milking machine Vm can be any point in the milking system in, or upstream of, the receiver. In a recorder milking machine Vm can be in the milking vacuum line or in the nearest convenient recorder jar. In a bucket milking machine Vm can be combined with the connection point Vr or the nearest convenient vacuum tap.

2 These connection points should be at least five pipe diameters from any elbows, air inlet points, or other fittings creating air turbulence.

4.2.4 To enable measurement of exhaust back pressure, a suitable connection point shall be provided on the exhaust line near the vacuum pump outlet.

This connection point corresponds to point Pe in ISO 3918:—, figures 1, 2 and 3.

4.2.5 Means shall be provided to isolate the vacuum pump from the installation to facilitate the measurement of vacuum pump capacity.

4.3 Safety

Installations shall comply with the relevant safety requirements given in ISO/TR 12100-1 and ISO/TR 12100-2. The electrical components shall comply with the relevant safety requirements given in IEC 335-2-70.

NOTE — The significant hazards which require action to reduce risk are: crushing, shearing and slipping, tripping and falling hazards; electrostatic phenomena and external influences on electrical equipment; noise; unhealthy postures, inadequate local lighting and hazards caused by failure of the energy supply or disorder of the control system.

4.4 Cleaning

It shall be possible to check the installed cleaning and disinfecting system in accordance with the supplier's specification for the system.

NOTES

1 The critical factors in a circulation cleaning system are:

— design and installation of the equipment;

— volume of solutions used in the cleaning and disinfecting process;

— minimum temperatures of the solutions used in the cleaning and disinfecting process;

— chemical strength of the cleaning and disinfecting solutions;

— flow rates and the distribution of the cleaning and disinfecting solutions throughout the plant.

2 A velocity range of 7 m/s to 10 m/s is preferred, for the cleaning of pipelines with water-slugs.

3 Any recommended cleaning and disinfecting procedure that has been followed, is expected to:

— leave milk contact surfaces visibly free from milk residues and other deposits;

— leave surfaces free from undesirable residues of cleaning and disinfecting chemicals; and

— reduce the count of viable bacteria to an acceptable level.

4.5 Material

All components that are subjected to a vacuum shall be designed and constructed to withstand a minimum vacuum of 90 kPa, without permanent distortion.

Materials that may involve danger if damaged, such as glass, shall be designed using a safety factor of 5 against external pressure (i.e. 5 x 90 kPa).

All materials in contact with milk or cleaning solutions, whether used for rigid components (for example, buckets, pipelines or recorder jars) or flexible components (for example, joint rings, teatcup liners), shall be constructed to withstand the maximum temperature used in the plant as specified in the instructions. In addition, such materials, when used in accordance with the manufacturer´s recommendations, shall not impart a taint to the milk.

All milk contact surfaces shall be free from engraving or embossing. All metal milk contact surfaces, except for welded seams, shall have a surface roughness, R_a, less than or equal to 2,5 μm when tested in accordance with ISO 4288. Surface roughness, R_a, on welded seams shall not exceed 16 μm.

Copper or copper alloys shall not be used in any part of the installation that may come into contact with milk or cleaning and disinfecting fluids other than water.

NOTE — Materials that come into contact with cleaning and disinfecting fluids, at normal use concentrations, should be suitable for such contact. Materials that also come into contact with milk should be made from materials resistant to both milk fat and cleaning and disinfecting solutions.

4.6 Instructions for use and maintenance

The installer shall provide written instructions for:

— operating procedures;

— cleaning and disinfecting procedures for the installation, including consumption of water;

— the maximum temperature at which the installation can be cleaned and disinfected; and

— the chemicals recommended.

Instructions shall also be given for routine servicing, including the replacement of individual parts.

The instructions shall be written in, at least, one of the official languages of the user's country.

At least the following design details shall also be provided:

a) the nominal vacuum level;

b) the vacuum pump capacity and rotational frequency at 50 kPa;

c) the effective reserve, plus an indication of any allowance;

d) the maximum number of units or maximum milk flow rate per slope of the milkline;

e) the releaser milk pump's discharge rate at 50 kPa working vacuum and 20 kPa discharge pressure;

f) the air consumption of vacuum-driven ancillary equipment, where fitted, at the maximum milk flow rate;

g) the pulsation rate and the pulsator ratio.

If it is intended that the user shall make adjustments, the manufacturer shall provide instructions for such adjustments. If special tools are required, these shall be supplied with the installation.

5 Vacuum pumps

The vacuum pump shall be capable of meeting the operating requirements (milking and cleaning) of the milking installation, together with those of other equipment, whether operating continuously or intermittently during milking and which create a demand for air.

NOTE — In addition to meeting the operating requirements, the vacuum pump should have sufficient capacity so that the vacuum drop in or near the receiver does not exceed 2 kPa during the course of normal milking, including cup attachment and removal, liner slip or cluster falls.

For calculation of pump capacity, see examples in annex A. Capacity shall be measured in accordance with ISO 6690:—, subclause 5.3.

If more than one vacuum pump is installed, it shall be possible to isolate the pump(s) not in use.

5.1 Effective reserve

The installation shall have a minimum effective reserve determined in accordance with table 1 for installations equipped with automatic shut-off valves at the milking units.

For installations without automatic shut-off valves at the milking units the minimum effective reserve in table 1 shall be increased by 80 l/min for bucket milking machines and by 200 l/min for the other types of milking machines.

The effective reserve shall be measured in accordance with ISO 6690:—, subclause 5.2.

Annex A gives examples of minimum effective reserve calculated in accordance with table 1 together with the calculation of allowances.

Table 1 —: Minimum effective reserve with automatic shut-off valve at the milking unit

Number of units n	Minimum effective reserve [1], in l/min of free air	
	Milking pipeline and recorder	Bucket milking machines
$2 \leq n \leq 10$	$200 + 30n$	$80 + 25n$
> 10	$500 + 10(n - 10)$	$330 + 10(n - 10)$

1) Plus addition for ancillary equipment in accordance with clause 17.

5.2 Influence of altitude

For installations at altitudes of less than or equal to 300 m, an atmospheric pressure of 100 kPa shall be assumed for calculating effective reserve in accordance with 5.1.

To fulfil the requirements at altitudes greater than 300 m, a vacuum pump with increased capacity shall be installed, as given by the calculation in A.5.

5.3 Exhaust

The exhaust shall not obstruct the passage of the exhaust air by sharp bends, T-pieces or unsuitably designed silencers.

An oil separator shall be fitted to the exhaust pipe of oil-lubricated vacuum pumps. Either the exhaust pipe shall have a continuous slope away from the vacuum pump or a moisture trap, with provision for drainage, shall be fitted.

NOTE — The exhaust pipe should not discharge into a closed room, where foodstuff is stored or processed, nor where persons or animals could be present.

5.4 Prevention of reverse flow through vacuum pump

Automatic means shall be provided to prevent reverse flow of air from the exhaust through the vacuum pump.

5.5 Location

The vacuum pump shall be located so that the vacuum drop in the airline fulfils the requirements in 8.3. The vacuum pump shall be installed so that its speed and the extraction capacity and vacuum level can be measured.

NOTE — The vacuum pump should be isolated from the milking parlour and milk room in a well-ventilated position.

5.6 Marking

The vacuum pump shall be indelibly marked with the following information:

a) the direction of rotation;

b) the range of speed and power consumption in kilowatts;

c) the corresponding range of extraction capacity at 50 kPa, expressed as free air at an atmospheric pressure of 100 kPa;

d) the type and identification, for example serial number or code;

e) the recommended lubricant, if used;

f) the name of the manufacturer or supplier.

The pump manufacturer shall also state the maximum permissible exhaust back pressure, measured in accordance with ISO 6690:—, subclause 5.4.

6 Vacuum regulation

6.1 Mounting

The regulator shall be mounted rigidly and in accordance with the manufacturer's specifications.

In pipeline and recorder milking machines the sensing point of the regulator shall be connected between the interceptor and the receiver or in the receiver.

NOTE — Only sensors designed so that they fulfil the hygiene requirements may be placed at the sanitary trap or the receiver or between them.

In bucket milking installations the sensing point of the regulator shall be connected between the interceptor and the first connection to the airline, or on the interceptor.

NOTES

1 The regulator should be installed in a place and manner to minimize noise for the operator(s) and to ensure that clean air enters the regulator.

2 The sensing point for the regulator should be as near the sanitary trap as practicable or, where there is no sanitary trap, the first milking unit.

6.2 Regulation sensitivity

The regulator(s) shall control the vacuum level such that, when tested in accordance with ISO 6690:—, subclause 5.5, the increase in vacuum level does not exceed 1 kPa.

6.3 Regulation loss

The total regulation loss when tested in accordance with ISO 6690:—, subclause 5.6, shall not exceed 35 l/min of free air or 10 % of the manual reserve, whichever is the greater.

6.4 Regulator leakage

The total air leakage through the regulator or regulators when tested in accordance with ISO 6690:—, subclause 5.7, shall not exceed 35 l/min of free air or 5 % of the manual reserve, whichever is the greater, at a vacuum level of 2 kPa below the working vacuum at the regulator sensing point.

6.5 Marking and specification

The regulator shall be marked indelibly with the following information:

a) name of manufacturer or supplier;

b) mark and type;

c) designed working vacuum range;

d) air flow capacity at 50 kPa working vacuum, expressed as free air at an atmospheric pressure of 100 kPa.

The regulator manufacturer shall also state the air flow capacity at the upper and lower end of the designed working vacuum range.

7 Vacuum gauge

7.1 General

Over the vacuum range from 20 kPa to 80 kPa the vacuum gauge shall indicate intervals of 2 kPa or less. When mounted and calibrated, the error measured in accordance with ISO 6690, subclause 5.8, shall not exceed 1 kPa at the working vacuum level.

NOTES

1 A vacuum gauge of accuracy class 1,6 that is calibrated in place will meet this requirement.

2 The accuracy class is the maximum permissible error expressed as a percentage of the pressure range for the gauge.

7.2 Mounting

A vacuum gauge shall be mounted in accordance with the manufacturer´s instructions, between the regulator and the first unit of the installation, and where it can be read during milking. The thread on the gauge connection shall comply with the requirements of ISO 228-1.

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

8 Airlines

8.1 General

When installed, the airlines shall be rigidly fixed and all sections shall be self-draining to automatic drain valves. Where an airline forms part of the cleaning circuit, the material used shall comply with 4.5.

Bends shall have a minimum centreline radius of 45 mm.

8.2 Cleaning

To facilitate cleaning of the airlines, they shall be fitted with flush taps, removable plugs or caps. Loop circuits shall be provided with a valve or other device, to control the direction of flow and to ensure complete flushing when the system is cleaned.

8.3 Internal diameter and air flow

When determined in accordance with ISO 6690:—, subclause 5.12:

— the vacuum drop between the vacuum pump and the measuring point at or near the connecting point A1, shall not exceed 3 kPa;

— the vacuum drop between the regulator sensing point and test point at or near the receiver shall not exceed 1 kPa; and

— the vacuum drop between the working vacuum at the measuring point at or near the connecting point A1 and the maximum pulsation chamber vacuum shall not be more than 2 kPa.

NOTE — As a design guideline, the airlines and system should be designed for a vacuum drop of less than 2 kPa between the vacuum pump and the receiver.

Annex B gives guidelines for the required internal diameter of the airlines based on the specified vacuum drop and the effective length of the pipe system at a given average air flow.

8.4 Leakage

When determined in accordance with ISO 6690:—, subclause 5.9, leakage into the airline system shall not exceed 5 % of the pump capacity.

9 Interceptor and sanitary trap

9.1 Interceptor

An interceptor shall be fitted near the vacuum pump, between the vacuum pump and the regulator.

There shall not be any intermediate connections into the airline between the interceptor and the vacuum pump, except as required for test purposes or connection of a safety valve.

NOTE — A safety valve may be fitted to protect the pump from effects of high vacuum levels caused by the activation of the vacuum shut-off valve in the interceptor.

The internal diameter of the inlet and outlet of the interceptor shall be not less than that of the airlines. The interceptor shall incorporate a liquid level operated vacuum shut-off and shall be provided with automatic drainage facilities. On fixed installations the interceptor shall have a minimum effective volume of 15 l, as measured in accordance with ISO 6690:—, clause B.1.

NOTE — The effective volume should be adequate to facilitate washing of the main airline and should be determined by the airline sizes.

The interceptor shall have an opening to facilitate inspection and cleaning.

9.2 Sanitary trap

Except where the vacuum and pulsation systems form part of the routine circulation cleaning and disinfection system, a sanitary trap shall be fitted to pipeline milking machines and recorder milking machines to form the connection between the receiver vessel and the vacuum system.

The sanitary trap shall have provision for drainage and shall be equipped with a liquid level operated shut-off valve.

The manufacturer shall state the effective volume of the sanitary trap, measured in accordance with ISO 6690:—, clause B.2.

Any transport of impurities shall be detectable, for example by use of transparent sections.

NOTE — It is an advantage to the operator if the trap is situated adjacent to the receiver and within sight during milking.

Where there is no provision for cleaning-in-place (CIP) of the sanitary trap(s), the receiver(s) and the receiver airline, this line shall be designed to drain towards the sanitary trap(s).

10 Pulsation system

The pulsation rate, pulsator ratio and phases shall be measured in accordance with ISO 6690:—, subclause 5.11.

10.1 Design data

The manufacturer shall provide the following data:

a) the pulsation rate and pulsator ratio at a nominal vacuum and specified temperature;

b) the temperature range over which the pulsation rate will stay within ± 3 cycles/min;

c) the temperature range over which the pulsators can be operated;

d) the variation of pulsation rate within this range;

e) typical pulsation chamber vacuum records for a defined cluster;

f) air consumption with defined cluster connected under specified operating conditions;

g) designed air flow measured at the mounting point of the pulsator.

10.2 Pulsation rate

The pulsation rate shall not deviate more than ± 3 cycles/min from the values given by the installer.

10.3 Pulsator ratio

The pulsator ratio shall not differ more than ± 5 units of percentage from the values given by the installer. The pulsator ratios of all pulsators in an installation shall not vary from each other by more than 5 units of percentage.

Within a cluster, no two teatcups may vary from each other by more than 5 %, except where the cluster is designed to provide different ratios between the front and hind quarters.

10.4 Pulsation phases

Phase b shall be not less than 30 % of a pulsation cycle. Phase d shall be not less than 15 % of a pulsation cycle and shall be not less than 150 ms.

Vacuum drop during phase b shall not be more than 4 kPa below maximum pulsation chamber vacuum, and the vacuum during phase d shall not be more than 4 kPa.

11 Milk system

11.1 Leakage

Leakage into the installation milklines, recorder jars, receiver and the fittings shall not exceed 10 l/min, plus 1 l/min per milk cock in a pipeline installation, when tested in accordance with ISO 6690, subclause 5.10. In milking parlours the leakage shall not exceed 10 l/min, plus an additional maximum of 2 l/min per unit.

11.2 Drainage

Provisions shall be made for complete drainage of all parts of the milk system.

11.3 Milk cocks and milk inlets

Milk cocks and milk inlets shall cause no additional vacuum drop compared to a defined straight milk inlet when tested in accordance with ISO 6690, clause A.4.

Milk cocks and milk inlets shall be fitted to the upper half of the pipeline.

11.4 Milklines

Milklines shall be one of the following types:

a) austenitic stainless steel pipelines, having a minimum wall thickness of not less than 1 mm and deburred ends;

b) heat-resistant glass pipelines, having a minimum wall thickness of 2 mm;

c) any other pipeline that complies with 4.5.

Provisions shall be made for inspection of the inside of the milkline.

11.5 Design of milklines

The internal diameter of the milkline shall be such that the vacuum drop between the receiver and any point in the milkline does not exceed 2 kPa with all units operating at the designed milk and air flow rates.

The internal diameter of the milkline can be determined in accordance with annex C.

If the milkline is installed to form a loop, then each end of the loop shall have a separate full-bore connection to the receiver vessel. If several loops are used, two ends may be grouped together directly in front of the receiver to form a single line which has an adequate cross-sectional area determined in accordance with annex C for the combined milk and air flow rates.

If the milkline is mounted above the animal, the centreline shall not be more than 2 m above the animal standing level.

Milklines shall have a continuous and even fall towards the receiver, with a minimum of 2 mm per metre of pipe. Equipment that can cause obstruction or reduction in vacuum, for example filters, shall not be used.

Branches in the milkline shall be swept in the direction of milk flow. The minimum centreline radius for bends shall be 75 mm.

The milkline shall not have enlargements or restrictions that can obstruct milk flow or drainage.

During milking, air shall be deliberately admitted to the milkline only at the cluster of the milking units, except where necessary for proper operation of a milk meter or other devices. This air consumption shall then be stated by the manufacturer.

12 Bucket milking machines

12.1 Bucket units

The manufacturer of buckets and transport cans shall state the effective working volume, measured in accordance with ISO 6690:—, clause B.4.

A non-return valve shall be fitted between the airline and the bucket, so that the bucket can be moved to another vacuum tap without losing the vacuum in the bucket.

The installer shall specify the length and internal diameter of the vacuum tube.

The capacity at the end of the long milk tube shall be at least 65 l/min when tested in accordance with ISO 6690, subclause 5.13.

12.2 Vacuum taps

The vacuum drop across the tap shall not exceed 5 kPa with an air flow of 150 l/min of free air through the tap, measured in accordance with ISO 6690, subclause 5.15.

The taps shall have stops at the fully open and fully closed positions. The taps shall be fixed to the air pipeline to prevent displacement in relation to the pipeline orifices. Gaskets shall not obstruct the tap aperture. The taps shall be connected to the upper part of the pipe.

For taps connected by means of a special adapter, the adapter shall be considered as part of the tap.

13 Milk recording equipment

NOTE — For official yield control the requirements to be met are stated by the International Committee for Animal Recording (ICAR).

13.1 Recorder jars

Recorder jars shall comply with the following requirements:

a) the manufacturer of recorder jars shall state the effective volume, measured in accordance with ISO 6690:—, clause B.4;

b) it shall be possible to inspect the inside of the recorder jar for cleanliness;

c) the internal diameter of the outlet shall not be less than 18 mm;

d) the milk inlets shall fulfil the pressure drop requirement given for milk inlets in 11.3.

NOTES

1 Connections should be placed to minimize the risk of carry-over of milk or froth into the vacuum system.

2 Recorder jars should be designed or fitted with a means of ensuring even distribution of cleaning and disinfecting fluid over the internal surface during washing, without adversely affecting the vacuum in the recorder jar during milking.

14 Attachments in the milking vacuum system

Devices fitted in the long milk tube, including connecting tubes, shall not cause any additional vacuum drop greater than 5 kPa at a milk flow rate of 5 kg/min, compared with the same milking unit without those devices, when measured in accordance with ISO 6690:—, clause A.2.

15 Long milk tubes

Means shall be provided to prevent flattening of the long milk tube due to direct pull or constant drag on the milk inlet.

The internal diameter shall be not less than 12,5 mm. For high-level milking pipelines the maximum internal diameter of the long milk tube shall be 16 mm.

The installer shall specify length and internal diameter of the long milk tube and shall state the air flow rate at the end of the long milk tube as described in ISO 6690:—, subclause 5.13.

The long milk tube should be as short as practicable.

16 Cluster assembly

Except where the liner vacuum is deliberately varied by cyclic air admission, one-way valves or other means of regulating liner vacuum, the manufacturer shall state the maximum milk flow (in litres per minute per cluster) and shall specify the pulsation characteristics and air admission in order to meet the test conditions specified in ISO 6690, clause A.3.

Means shall be provided to limit the air flow through the cluster or teatcup during attachment.

NOTE — The liner vacuum should be the basis for all vacuum levels in the milking machine. Both research and field experience indicate that a mean claw working vacuum, within the range 32 kPa to 40 kPa during the peak flow rate period of milking, is a good compromise level that ensures that most animals will be milked quickly, gently and completely.

The nominal vacuum for a particular installation should be chosen depending on factors such as:

— height of the inlets to the milkline, recorder jar or bucket in relation to the mean udder height;

— average peak milking rate of the herd;

— bore and length of the long milk tube;

— any additional restrictions to milk and air flow due to ancillary fittings in the long milk tube;

— the amount of air admission at the claw; and

— the liner and pulsation characteristics.

16.1 Teatcup

The shell and liner shall be marked to identify manufacturer and type. The internal dimensions of the shell shall not restrict the operation of the liner.

The manufacturer shall provide the following data:

a) the diameter of the liner barrel when assembled in the teatcup, measured at a point 75 mm from the mouthpiece lip of the liner;

b) the diameter of the mouthpiece lip.

For non-circular liners, the maximum and minimum diameters of the barrel shall be stated.

The liner and shell combination shall be provided with means to indicate if the liner is twisted or means to prevent the liner from twisting in the shell.

NOTE — To reduce the likelihood of milk plugs in the short milk tube and impacts against the teat, the diameter of the short milk tube should be at least 10 mm and, if conical, the larger diameter should be near the bottom of the shell.

16.2 Vacuum shut-off

Means shall be provided to shut off the liner vacuum before the cluster removal.

Leakage through the vacuum shut-off valve when it is closed shall not exceed 2 l/min, measured in accordance with ISO 6690, subclause 6.1.

16.3 Air vent and leakage

The total air admission per cluster from the air vent and the air leakage, shall not exceed 12 l/min. The air vent(s) shall be dimensionally constant and shall admit at least 4 l/min of free air at the nominal working vacuum level.

Leakage into each cluster assembly with the liners plugged and the vacuum shut-off valve opened shall not exceed 2 l/min. The air admission and air leakage shall be measured and calculated in accordance with ISO 6690, subclause 6.2.

NOTE — The air vent should be positioned to avoid unnecessary turbulence in the milk to limit free fatty acid development.

17 Ancillary equipment

For all types of equipment demanding air during milking or cleaning the manufacturer shall state the maximum air demand.

Where ancillary equipment does not operate during testing and is not operated by a separate vacuum system, the manufacturer of such equipment shall state the minimum addition to the calculated effective reserve.

18 Receiver

It shall be possible to inspect the inside of the receiver for cleanliness. The receiver shall have a minimum effective volume of 18 l, measured in accordance with ISO 6690, clause B.3.

NOTE — The receiver inlet(s) should be so shaped that excessive formation of foam during milking is avoided.

19 Releaser

19.1 General

A releaser when fitted in the installation, shall be adequate to deal with the maximum rate at which milk and cleaning and disinfecting fluids flow through the system.

There shall be no air leaks in the releaser or between the receiver and the releaser. Flow of milk from the releaser to the receiver shall be prevented. Leakage in the releaser shall be checked in accordance with ISO 6690, subclause 5.14.

NOTE — The releaser should be capable of discharging the milk without undue formation of foam. The releaser should not harm the milk.

19.2 Control of releaser milk pumps

The operation of a milk pump shall be controlled by the quantity of milk in the receiver.

20 Delivery line

Means shall be provided at every low point to permit drainage of the delivery line, filters and any in-line cooling equipment.

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

If a restriction needs to be fitted in the delivery line to reduce milk flow to a level suitable for an in-line cooler or where an in-line cooler restricts flow below that which needed for cleaning and disinfection, means shall be provided to open or bypass the restriction during the washing cycle.

Annex A

(informative)

Vacuum pump capacity — Effective reserve plus tolerances

A.1 Effective reserve

The minimum effective reserve for milking based on 5.1 and the equations given in table 1 for different numbers of milking units between 2 and 20 is given in table A.1. For more than 20 milking units, the formulas given in table 1 shall be used.

Table A.1 — Minimum effective reserve for milking

Number of milking units	Minimum effective reserve [1], in l/min of free air			
	Pipeline and recorder milking machines		Bucket milking machines	
	with shut-off	without shut-off	with shut-off	without shut-off
2	260	460	130	210
3	290	490	155	235
4	320	520	180	260
5	350	550	205	285
6	380	580	230	310
7	410	610	255	335
8	440	640	280	360
9	470	670	305	385
10	500	700	330	410
11	510	710	340	420
12	520	720	350	430
13	530	730	360	440
14	540	740	370	450
15	550	750	—	—
16	560	760	—	—
17	570	770	—	—
18	580	780	—	—
19	590	790	—	—
20	600	800	—	—

1) Add the air required for ancillary equipment, in accordance with A.3.

A.2 Air demand for cleaning

Milk and transfer lines are usually cleaned by a mixture of air and cleaning solution transported and agitated by the vacuum difference to achieve effective cleaning by slug speeds of 7 m/s to 10 m/s.

Other washing systems may not need increased pump capacity.

Where washing systems rely on high pump capacity to achieve the air speed necessary to produce slugs for washing this capacity, q_{clean} , in litres per minute, can be calculated from:

$$q_{clean} = \frac{\pi d^2}{4} \times v \times \frac{p_a - p_w}{p_a}$$

where

d is the internal diameter of the tube, in decimetres;

v is the air and slug speed in the milk tube, in decimetres per minute;

p_a is the actual atmospheric pressure during the test, in kilopascals;

p_w is the vacuum level when washing the plant, in kilopascals.

Table A.2 gives the air capacity for some milk pipe dimensions and working vacuum levels at an atmospheric pressure of 100 kPa. It also gives the air flow in the pipe at the vacuum level in the pipe to be used for calculations for plants at high altitudes.

Table A.2 — Air demand for cleaning at a speed of 8 m/s and under atmospheric pressure of 100 kPa

Internal milk pipe diameter	Air demand for cleaning l/min			Flow in pipe
	Vacuum level, kPa			
mm	40	45	50	l/min
34	261	240	218	436
36	293	269	244	488
38	326	299	272	544
40	362	332	301	603
44	438	401	365	729
48	521	477	434	868
50	565	518	471	942
60	814	746	678	1 356
66	985	903	821	1 641
73	1 205	1 104	1 004	2 008
98	2 171	1 990	1 809	3 619

NOTE — To calculate the air demand for cleaning at higher altitudes, i.e. where atmospheric pressure is less than 100 kPa, use the last line in table A.2 and multiply the value by $(p_a - p_w)/p_a$.

A.3 Ancillary equipment

Ancillary equipment can be divided into three groups:

a) equipment running continuously during milking;

b) equipment that demands a quantity of air for a short time during milking;

c) equipment only operating before or after the milking.

For equipment of the type defined in a) the minimum air demand, from the manufacturer's statement in accordance with clause 17, should be added when calculating the pump capacity and effective reserve, respectively.

For equipment of the type defined in b) the ancillary equipment uses the same vacuum supply simultaneously as the milk extraction. In many cases it is not necessary to take their demands into account, as ancillary equipment used during milking consumes only small quantities of air during a short time. Such equipment includes cluster removers and gate cylinders. However this equipment may demand a high instantaneous air flow that should be considered when sizing the air tubes.

For equipment of the type defined in c) there is no need to take its capacity into account when calculating the vacuum pump capacity for milking.

A.4 Calculations of vacuum pump capacity

The capacity of the vacuum pump should be capable of withdrawing all air from the milking plant whether it is reserve capacity, air used to run pulsators, air inlets, leakages or any other use.

A.4.1 Calculate the demand for all equipment continuously running or demanding air during milking and during cleaning such as pulsators, air inlets and vacuum operated milk pumps. The milking units and the pulsators should be regarded as continuously running.

Check the air flow rate for equipment that demands air for a short time.

A.4.2 Add the effective reserve from A.1 and the air flow demand during milking from A.4.1

A.4.3 Add the air demand for cleaning from A.2 and the air flow demand during milking from A.4.1.

A.4.4 Take the higher of the values calculated in A.4.2 and A.4.3.

A.4.5 Add 10 l/min plus 2 l/min for each fixed milking unit or 1 l/min for each milk cock, for leakages into the milk system determined in accordance with 11.1.

A.4.6 Add leakages in the airlines, which have been determined in accordance with 8.4, stating 5 % of the rated pump capacity or, if smaller, the leakage level claimed by the installer.

A.4.7 Add the regulation loss, in accordance with the manufacturer's information or that determined in accordance with 6.3, stating 10 % of the manual reserve.

A.4.8 Calculate the pressure drop in the main air line, in accordance with annex B, and add it to the desired working vacuum level of the plant. The derived values for air flow and vacuum level are the bases for choosing the vacuum pump.

A.4.9 For vacuum levels other than 50 kPa or ambient conditions other than those normal at sea level the factor H specified in table A.3 should be used as a multiplier to correct the derived air flow.

Table A.3 — Standard atmospheric pressures (p_a), and correction factors H at various altitudes

Altitude	Normal atmospheric pressure p_s	Correction factor, H		
		Vacuum level of the pump (p) kPa		
m	kPa	40	45	50
< 300	100	0,80	0,89	1,00
from 300 to 700	95	0,84	0,94	1,07
from 700 to 1 200	90	0,88	1,00	1,16
from 1 200 to 1 700	85	0,93	1,08	1,28
from 1 700 to 2 200	80	1,00	1,19	1,45

NOTES

1 These values are based on a volumetric efficiency, η_V , equal to 0,9, calculated from:

$$\eta_V = \frac{p_{max}}{p_a}$$

where p_{max} is the depression, in kilopascals, at the inlet of the pump when completely closed, measured at atmospheric pressure, p_a .

2 p_{max} or the value of volumetric efficiency can be obtained from the constructor.

A.5 Prediction of vacuum pump capacity at altitudes

To be able to choose a suitable pump size, the calculated air demand has to be corrected to nominal values for pump data.

To select the correct size of pump, the corrected air flow from A.4.9 has to be multiplied by H to allow comparisons with pump capacities rated at 100 kPa ambient atmospheric pressure. The correction factor, H, shall be calculated from:

$$H = \frac{p_{max} - \frac{p_N p_s}{p_{an}}}{p_{max} - p}$$

where

p_{max} is the vacuum level at the totally closed pump inlet during the test, in kilopascals;

p_N is the nominal vacuum level at the pump inlet, in kilopascals;

p_s is the standard atmospheric pressure at the altitude of the plant, in kilopascals;

p_{an} is the nominal atmospheric pressure, in kilopascals;

p is the vacuum level, at the pump inlet (actual or calculated), in kilopascals.

NOTES

1 This formula for determining H is principally the same as the formulae for determining K_1 and K_2 in ISO 6690:—, subclause 7.2.

2 Considerations should also be taken to the fact that the maximum power of most electric motors will decrease at high altitude, because of the decrease in the cooling capacity of the air. This means that a motor will be hotter and thus allow a lower maximum load. This information can be obtained from the manufacturer of the motor.

A.6 Example of prediction of a vacuum pump capacity

A.6.1 Data

a) A herringbone milking parlour with 12 milking units direct to line, automatic cluster removers and automatic shut-off valves at claw situated 1 300 m above sea level.

b) One milker.

c) Working vacuum level: 44 kPa.

d) Milk pipe diameter: 48,5 mm.

e) Air consumption for each pulsator: 25 l/min.

f) Air inlet in the clusters: 10 l/min.

g) Maximum air flow for each automatic cluster remover: 50 l/min.

A.6.2 Calculations

In accordance with 5.1 the effective reserve capacity for milking will be

$$500 \text{ l/min} + (12 - 10) \times 10 \text{ l/min} = 520 \text{ l/min}$$

In accordance with note 2 in 4.4 and the formula in A.2 the air demand for cleaning at 44 kPa should be 498 l/min for a pipe with a diameter of 48,5 mm.

As the altitude for the plant is 1 300 m the air demand for cleaning could be adjusted to the lower atmospheric pressure.

The atmospheric pressure at 1 300 m is 85 kPa (table A.3). The last column in table A.2 must be used, which gives by interpolation 886 l/min. To obtain the capacity necessary at cleaning, multiply this value by $(p_s - p) / p_s$:

$$q_{\text{clean}} = 886 \times (85 - 44)/85 \text{ l/min} = 427 \text{ l/min}$$

If many recorders or automatic cluster removers are operated simultaneously, the total demand from them might exceed the effective reserve or air demand for cleaning. In such a case, that demand has to be the base for sizing.

With one milker it is likely that not more than two automatic cluster removers are operated simultaneously which gives a maximum demand of 2 × 50 l/min = 100 l/min, which is less than the necessary effective reserve and need therefore not to be taken into account.

Air consumption for the milking units (air inlets and pulsators) will be 12 × (10 + 25) l/min = 420 l/min. The milking units will consume about the same amount of air during milking and cleaning.

Total air demand during milking will be 520 l/min + 420 l/min = 940 l/min (A.4.2).

Total air demand during cleaning will be 427 l/min + 420 l/min = 847 l/min (A.4.3).

In this example the capacity for milking is the larger and therefore the base for the pump dimensioning (A.4.4).

Leakages into the milk system: 10 l/min + (2 × 12) l/min = 34 l/min (A.4.5).

Total: 940 l/min + 34 l/min = 974 l/min.

Regulation loss is 10 % of the manual reserve. The effective reserve was 520 l/min and is smaller than the manual reserve. Consequently:

manual reserve = 520 l/min × 100/(100 – 10) = 578 l/min

regulation loss = 578 l/min × 10/100 = 58 l/min

total: 974 l/min + 58 l/min = 1 032 l/min

Leakages into the airlines are equal to 5 % of the pump capacity (A.4.6), that is

vacuum system leakage: 1 032 l/min × 5/(100 – 5) = 54 l/min

total: 1 032 l/min + 54 l/min = 1 086 l/min

With a pressure drop of 3 kPa between pump and measuring point the vacuum level at the pump will be:

44 kPa + 3 kPa = 47 kPa (8.3).

Correction for the higher altitude in accordance with table A.3 for the altitude of 1 300 m and a vacuum of 47 kPa will give a factor H = 1,16 which gives, for an atmospheric pressure of 100 kPa and a vacuum level of 50 kPa, a nominal pump capacity of:

1 086 l/min × 1,16 = 1 260 l/min

The minimum nominal capacity of the pump must therefore be 1 260 l/min.

Annex B

(informative)

Determination of the minimum internal diameter of airlines

B.1 Vacuum drop due to air flow in straight smooth pipelines

The pressure drop, up to about 3 kPa, in a smooth vacuum airline, usually in plastics or stainless steel, can be calculated from :

$$\Delta p = 27{,}8 l \times \frac{q^{1{,}75}}{d^{4{,}75}} \quad \text{...(B.1)}$$

where

Δp is the pressure drop in the pipe, in kilopascals;

l is the length of the pipe, in metres;

q is the flow in the pipe, in litres per minute in free air;

d is the internal diameter of the pipe, in millimetres.

Since the flow in the pipe and the maximum allowed pressure drop are usually known, this equation can be written as:

$$d = \sqrt[4{,}75]{\frac{27{,}8 l q^{1{,}75}}{\Delta p}} \quad \text{...(B.2)}$$

Table B.1 gives the pipeline diameters for a single smooth pipeline in accordance with formula B.2 at 100 kPa atmospheric pressure and 50 kPa vacuum. This equation is generally used for sizing the main airline.

Table B.2 gives the pipeline diameters for looped smooth pipelines, at 50 kPa vacuum and 100 kPa atmospheric pressure, provided that both ends are connected to a pipe with at least twice its cross-sectional area. The table is based on equation B.2, applied to the case of two pipes of equal length with the same flow, and considering that the total length is the sum of the lengths of each pipe (branch); calculations were made, for example, with $l/2$ and $q/2$. This table should be used for the sizing of the pulsator airline.

Table B.1 — Recommended minimum pipeline diameters for a design limit of 1 kPa vacuum drop due to air flow in straight smooth pipelines

Air flow	Minimum internal diameter, mm									
	Pipe length, m									
l/min	5	10	15	20	25	30	40	50	60	70
100	15	18	19	21	22	22	24	25	26	27
200	20	23	25	27	28	29	31	32	34	35
300	23	27	29	31	32	34	36	37	39	40
400	26	30	32	34	36	37	40	42	43	45
500	28	32	35	37	39	41	43	45	47	49
600	30	34	38	40	42	43	46	48	50	52
700	32	36	40	42	44	46	49	51	53	55
800	33	38	42	44	46	48	51	54	56	58
900	35	40	44	46	48	50	54	56	58	60
1 000	36	42	45	48	50	52	56	58	61	63
1 200	38	44	48	51	54	56	60	62	65	67
1 400	41	47	51	54	57	59	63	66	69	71
1 600	43	49	54	57	60	62	66	69	72	74
1 800	45	52	56	60	63	65	69	72	75	78
2 000	46	54	58	62	65	68	72	75	78	81
2 500	50	58	63	67	71	73	78	82	85	88
3 000	54	62	68	72	76	79	83	87	91	94
3 500	57	66	72	76	80	83	88	93	96	99
4 000	60	69	75	80	84	87	93	97	101	104
4 500	63	72	79	84	88	91	97	102	106	109
5 000	65	75	82	87	91	95	101	106	110	113
5 500	67	78	85	90	94	98	104	109	114	117
6 000	70	80	88	93	98	101	108	113	117	121
6 500	72	83	90	96	100	104	111	116	121	125
7 000	74	85	93	99	103	107	114	119	124	128

NOTES

1 As pressure drop and pipe length are proportional, diameters for pressure drops of 2 kPa and 3 kPa can be calculated using the values given in this table corresponding to one-half of the pipe length (for 2 kPa) and one-third of the pipe length (for 3 kPa).

2 Equivalent lengths for inlets and outlets to tanks, elbows and T-pieces should be added to the length, see table B.5.

Table B.2 — Recommended minimum pipeline diameters for a design limit of 1 kPa vacuum drop due to air flow in straight looped smooth pipelines

Air flow	Minimum internal diameter, mm											
	Pipe length, m											
l/min	40	60	80	100	120	140	160	180	200	220	240	280
100	16	17	18	19	20	21	21	22	22	23	23	24
150	19	20	21	22	23	24	25	25	26	27	27	28
200	21	22	24	25	26	27	28	28	29	29	30	31
250	22	24	26	27	28	29	30	31	31	32	33	34
300	24	26	28	29	30	31	32	33	34	34	35	36
350	25	28	29	31	32	33	34	35	36	36	37	38
400	27	29	31	32	34	35	36	36	37	38	39	40
450	28	30	32	34	35	36	37	38	39	40	40	42
500	29	31	33	35	36	38	39	40	41	41	42	43
550	30	33	35	36	38	39	40	41	42	43	44	45
600	31	34	36	37	39	40	41	42	43	44	45	47
650	32	35	37	39	40	41	43	44	45	46	46	48
700	33	36	38	40	41	43	44	45	46	47	48	49
800	34	37	40	42	43	45	46	47	48	49	50	52
900	36	39	41	43	45	47	48	49	50	51	52	54
1 000	37	41	43	45	47	49	50	51	52	53	54	56
1 200	40	43	46	48	50	52	53	55	56	57	58	60
1 400	42	46	49	51	53	55	56	58	59	60	62	64
1 600	44	48	51	54	56	58	59	61	62	63	65	67
1 800	46	50	54	56	58	60	62	64	65	66	67	70
2 000	48	52	56	58	61	63	64	66	68	69	70	72

NOTE — Equivalent lengths for inlets and outlets to tanks, elbows and T-pieces should be added to the length, see table B.5.

B.2 Vacuum drop due to air flow in straight galvanized pipelines

The pressure drop, up to about 3 kPa, in galvanized vacuum airlines, can be calculated from:

$$\Delta p = 18{,}74 l \times \frac{q^2}{d^5} \qquad \text{...(B.3)}$$

where

Δp is the pressure drop in the pipe, in kilopascals;

l is the length of the pipe, in metres;

q is the flow in the pipe, in litres per minute in free air;

d is the internal diameter of the pipe, in millimetres.

Since the flow and the maximum allowed pressure drop are usually known, this equation can be written as:

$$d = \sqrt[5]{\frac{18{,}74 l q^2}{\Delta p}} \qquad \text{...(B.4)}$$

Table B.3 gives pipeline diameters for a single galvanized pipeline in accordance with formula B.4 at 100 kPa atmospheric pressure and 50 kPa vacuum. This table is generally used for sizing the main airline.

Table B.4 gives the pipeline diameters for looped galvanized pipelines, at 50 kPa vacuum and 100 kPa atmospheric pressure, provided that both ends are connected to a pipe with at least twice its cross-sectional area. The table is based on equation B.4, applied to the case of two pipes of equal length with the same flow, considering that the total length is the sum of the lengths of each pipe (branch); calculations were made, for example, with $l/2$ and $q/2$. This table should be used for the sizing of the pulsator airline.

The pipe diameter derived from equation B.4 or tables B.3 and B.4 should be increased by about 5 % to allow for deposits that might settle.

Table B.3 — Recommended minimum airline diameters for a design limit of 1 kPa vacuum drop due to air flow in straight galvanized pipelines

Air flow	**Minimum internal diameter**, mm									
	Pipe length, m									
l/min	5	10	15	20	25	30	40	50	60	70
100	16	18	19	21	22	22	24	25	26	27
200	21	24	26	27	28	30	31	33	34	35
300	24	28	30	32	33	35	37	38	40	41
400	27	31	34	36	38	39	41	43	45	46
500	30	34	37	39	41	43	45	47	49	50
600	32	37	40	42	44	46	49	51	53	54
700	34	39	42	45	47	49	52	54	56	58
800	36	41	45	47	50	51	54	57	59	61
900	38	43	47	50	52	54	57	60	62	64
1 000	39	45	49	52	54	56	60	62	65	67
1 200	42	49	53	56	58	60	64	67	69	72
1 400	45	52	56	59	62	64	68	71	74	76
1 600	47	54	59	63	65	68	72	75	78	80
1 800	50	57	62	66	69	71	75	79	82	84
2 000	52	60	65	68	72	74	79	82	85	88
2 500	57	65	71	75	78	81	86	90	93	96
3 000	61	70	76	80	84	87	92	97	100	103
3 500	65	75	81	86	89	93	98	103	107	110
4 000	68	79	85	90	94	98	104	108	112	116
4 500	72	82	89	95	99	103	109	114	118	122
5 000	75	86	93	99	103	107	113	119	123	127
5 500	78	89	97	103	107	111	118	123	128	132
6 000	80	92	100	106	111	115	122	128	132	136
6 500	83	95	104	110	115	119	126	132	137	141
7 000	86	98	107	113	118	122	130	136	141	145

NOTES

1 As pressure drop and pipe length are proportional, diameters for pressure drops of 2 kPa and 3 kPa can be calculated using the values given in this table corresponding to one-half of the pipe length (for 2 kPa) and one-third of the pipe length (for 3 kPa).

2 Equivalent lengths for inlets and outlets to tanks, elbows and T-pieces should be added to the length, see table B.5.

Table B.4 — Recommended minimum airline diameters for a design limit of 1 kPa vacuum drop due to air flow in straight looped galvanized pipelines

Air flow	**Minimum airline diameter**, mm											
	Pipe length, m											
l/min	40	60	80	100	120	140	160	180	200	220	240	280
100	16	17	18	19	20	21	21	22	22	23	23	24
150	19	20	21	22	23	24	25	25	26	27	27	28
200	21	22	24	25	26	27	28	28	29	29	30	31
250	23	24	26	27	28	29	30	30	31	32	33	34
300	24	26	28	29	30	31	32	33	34	34	35	36
350	26	28	30	31	32	33	34	35	36	36	37	38
400	27	30	31	33	34	35	36	37	38	38	39	40
450	29	31	33	34	36	37	38	39	39	40	41	42
500	30	32	34	36	37	38	39	40	41	42	43	44
550	31	34	36	37	39	40	41	42	43	44	44	46
600	32	35	37	38	40	41	42	43	44	45	46	47
650	33	36	38	40	41	42	44	45	46	47	47	49
700	34	37	39	41	42	44	45	46	47	48	49	50
800	36	39	41	43	45	46	47	49	50	51	51	53
900	38	41	43	45	47	48	50	51	52	53	54	56
1 000	39	43	45	47	49	50	52	53	54	55	56	58
1 200	42	46	49	51	53	54	56	57	58	59	60	62
1 400	45	49	52	54	56	58	59	61	62	63	64	66
1 600	47	51	54	57	59	61	63	64	65	67	68	70
1 800	50	54	57	60	62	64	66	67	69	70	71	73
2 000	52	56	60	62	65	67	68	70	72	73	74	77

NOTE — Equivalent lengths for inlets and outlets to tanks, elbows and T-pieces should be added to the length, see table B.5.

B.3 Frictional equivalents of bends and fittings

Losses in bends and fittings such as elbows, T-fittings, inlets and outlets to tanks can be regarded as having the same frictional loss as a piece of straight pipe. These equivalent lengths of pipe should be added to the total pipe length when calculating the pressure drop in an airline. Table B.5 gives equivalent lengths for various fittings.

Table B.5 — Equivalent length of pipe for various fittings

Cause of leakage	Number of pipe diameters	Approximate equivalent length of pipe in metres m Pipe diameter, mm				
		38	50	63	75	100
Elbows						
45° sharp	8 to 10	0,3	0,5	0,6	0,8	0,9
90° short radius (R/D = 0,75) [1)]	35 to 40	1,4	1,8	2,4	3,0	3,6
90° medium radius (R/D = 1,8) [1)]	15 to 20	0,7	0,9	1,1	1,2	1,8
T-pieces						
Through flow	15 to 20	0,7	0,9	1,1	1,2	1,8
Side flow	40 to 45	1,6	2,1	2,4	2,7	4,2
Swept side-flow	20 to 25	0,9	1,1	1,2	1,5	2,2
Tanks and traps						
Sudden contraction	20 to 25	0,9	1,1	1,2	1,5	2,2
Sudden expansion	40 to 45	1,6	2,1	2,4	2,7	4,2
Sanitary trap, distribution tank, receiver [2)]	60 to 70	2,5	3,2	3,6	4,2	6,4

1) R/D is the internal outer radius of the elbow divided by the internal diameter of the pipe.

2) One expansion point and one contraction point.

B.4 Examples

B.4.1 Main airline

Determination of the dimensions of the vacuum airline between receiver and vacuum pump for the plant described in A.6.

The nominal air flow rate for the pump should be at least 1 260 l/min. Nearest available pump size has a nominal capacity of 1 400 l/min.

The vacuum airline will be in plastics. Table B.1 for smooth pipelines should therefore be used. A design limit for the pressure drop is 2 kPa.

The airline length from pump to receiver is 15 m, consisting of 5 elbows (90° medium radius), one T-piece and a distribution tank.

Table B.1 gives for a pipeline length of 7,5 m (15 m/2, due to the 2 kPa drop) a diameter of about 50 mm.

The elbows, T-piece and tank will restrict the air flow in a similar manner as a piece of straight pipeline (table B.5, 50 mm tube diameter) having a length of $5 \times 0,9 + 1 \times 0,9 + 1 \times 3,2 = 8,6$ m.

The total length of the pipeline for evaluation of the diameter will be: 15 m + 8,6 m = 23,6 m.

Refer back to table B.1 for a length of 23,6 m/2, that is 11,8 m. The table gives a diameter of about 48 mm.

B.4.2 Pulsator airline

Determine the dimensions of the looped galvanized pipeline for the plant described in A.6.

Number of pulsators: 12.

Air consumption for each pulsator: 25 l/min.

Length of the pulsator airline: 40 m.

Total air consumption for individual pulsators is: 12 × 25 l/min = 300 l/min.

NOTE — Where clusters are controlled so that groups of teat cups pulsate together the airflow during phase a should be considered as the air consumption for the pulsators.

Cluster removers are connected to the same airline.

Two cluster removers consume: 100 l/min.

Total air consumption in the pulsator airline: 300 l/min + 100 l/min = 400 l/min.

Table B.4 gives a pipe diameter of 27 mm.

Four elbows gives a pipe length of about: 4 × 0,7 m, or 3 m.

NOTE — The new pipe length (43 m) will not give any increased diameter (see table B.4).

After increasing the diameter by 5 % to allow for deposits that might restrict the pipe, the pulsator airline diameter should be at least 29 mm.

Annex C

(informative)

Determination of the minimum internal diameter of milklines

C.1 General

The installer and client should agree on the designed flow conditions based on expected peak milk flow rates for the herd and the expected rate of unit attachment (see C.2), and the criteria for air and milk flow given in C.3 and/or C.4. The installer should then summarize the design conditions and specify them as part of the purchase contract. Example calculations are given in C.5.

Flow conditions in dual-purpose milklines change frequently because of the variation in milk flow rate from individual animals and the interaction of multiple milking units. Ideally, milk should flow in the lower part of the pipeline with a clear continuous space above for the much larger volume of air to pass over it. This flow condition is known as stratified flow. In practice, flow typically varies between stratified flow and slug flow. Slug flow occurs whenever slugs of milk fill the entire cross-section of the milkline.

Slug flow conditions almost always induce transient drops in milkline vacuum greater than 2 kPa. Other things being equal, chronic slugging in the milkline is likely to have much the same effects, on milking performance and milk quality, as raising the milkline height by about 300 mm to 500 mm, i.e., slower milking and more liner slips because of lower mean liner vacuum, and higher acid degree values.

Milkline vacuum almost always remains stable within ± 2 kPa of the receiver vacuum under stratified flow conditions. Therefore, the performance limit of 2 kPa given in 11.5 essentially means that stratified flow should be the normal flow condition in the milkline. The "normal flow condition" should be understood to mean slug-free conditions for at least 95 % of the milking time for the herd. Occasional slugs in the milkline, which are almost unavoidable in practice, should not be regarded as evidence of a system failure. Occasional slugging may adversely affect milking performance, or increase the risk of mastitis, only if the transient drop in milkline vacuum is sufficient to cause one or more teatcups to slip or fall. Because acid degree values are higher with slug flow conditions, occasional slugging may have a marginal effect on milk quality.

Factors influencing the effective milk-carrying capacity of a milkline include the following:

a) **diameter:** increasing the internal diameter d has the greatest single effect. The potential milk-carrying capacity of a milkline is proportional to about d^5;

b) **slope:** in milklines that are nearly horizontal (0,2 % to 0,4 % slope) the milk flow rate is affected mainly by the air flowing over the milk surface. Friction between the air and milk surfaces causes the milk to flow because of the momentum transfer from air to milk. Greater milkline slope increases the influence of gravity as an additional driving force causing milk flow. Increasing milkline slope reduces the risk of slug flow by reducing the average fill depth for any given milk flow rate.

Regions of lower slope or "flat spots" in a milkline usually reduce its effective milk-carrying capacity. The likelihood of milkline slugging is influenced more by such flat spots than by the overall mean slope, in much the same way as the strength of a chain is limited to that of its weakest link. The effective slope of a milkline may be reduced by any bends or other fittings which increase the equivalent length of the line. Therefore, it may be necessary to compensate by increasing the slope of a milkline in the region of any bends, especially those near the receiver, where both the milk and air flow rates are highest;

c) **air admission:** the rate of constant ("steady") air admission through air vents and constant leaks has a relatively minor influence on slug formation, over the range of 4 l/min to 12 l/min per unit, compared with the effects of intermittent air flows. Intermittent ("transient") air admission has a marked effect on milkline slugging because the relative velocity of air to liquid is the dominant factor influencing the transition from stratified flow to slug flow. The frictional drag of air on the milk surface raises it into waves, the first stage of slug formation. Transient air admission induces slugging at much lower air and liquid flow rates, compared with the effects of steady air admission;

d) **looped versus dead-ended milklines:** the benefits of looping the milkline result from the reduction in air flow rate per slope when a milking unit is changed or a liner slip occurs. Air flow rate per slope is reduced because the air can flow to the receiver through both arms of the loop in accordance with the easiest flow path;

e) **length:** when stratified flow is the normal flow condition, corrections are not needed for milkline length. Under all but the most extreme conditions, milkline line length is not limiting and it is not an important design factor for specifying milkline size. In near-horizontal milklines, however, the momentum transfer from air to milk causes an unavoidable vacuum drop in the air phase so that vacuum drop in the far end of the milkline is proportional to length. Therefore, this vacuum drop has to be used as a dimensioning criterion for near-horizontal milklines;

f) **milk inlet:** the guidelines in this annex are based on experimental studies using perpendicular inlets connected at intervals varying from 500 mm to 2 000 mm and mounted above the horizontal diameter of the milkline. Spacing of milk inlets appeared to have only minor influence on the effective milk-carrying capacity over this range. Effective capacity of a milkline might be increased marginally by use of oblique, or tangential oblique, milk inlets mounted so that milk and air enter the line in the direction of flow towards the receiver;

g) **other components:** components such as milk meters (especially the fill-and-dump types) may influence the rate of instantaneous milk flow into a milkline. The design and action of milk cocks may have a marked influence on the instantaneous flow rate of transient air admitted when a milking unit is moved from one stall to another. The length and bore of long milk tubes, the bore of short milk tubes and the claw design, will all affect the amount of transient air admitted when clusters are attached or detached, or when teatcups slip or fall.

   Such model-specific factors are not dealt with in this annex. Nevertheless, they should be considered when designing a milkline system to meet the 2 kPa performance limit, especially when the predicted maximum milk flow rate (see C.2) is near the upper limit for any chosen set of designed milk and air flow rates (see C.3, C.4 or C.5).

C.2 Predicted maximum milk flow rates in milklines

Maximum milk flow rate can be predicted from typical flow rate curves for individual animals together with the expected average rates of attachment of milking units. Table C.1 shows examples of the predicted maximum milk flow rate for a group of cows with a mean peak milking rate of 4 l/min and 5 l/min per cow and units attached at different intervals. The model for 4 l/min is based on flow rate measurements of cows in high-producing Friesian-Holstein herds in France and the USA. It assumes: a delay of 30 s from cluster attachment to the start of the period of peak flow rate, a peak flow rate period of 4 l/min during 120 s, and a mean milking time of 5,5 min per cow which corresponds to an average flow rate of 2,6 l/min.

The model for the higher mean peak flow rate is based on the 20 % of cows which were the fastest to be milked in the French and American herds. Their mean peak milking rate was 5 l/min per cow. The upper limit of the 95 % confidence interval for this fast-milking group of cows was 5,5 l/min in the US herds. Although mean peak flow rates tend to increase slightly with higher herd production levels, the correlation is weak. The French studies indicate a much stronger association between higher production and increasing duration of the peak flow rate period.

As a general guideline, a mean peak flow rate of 4 l/min per cow will be sufficient for most herds. In very high-producing herds, or for unusually fast-milking herds, the calculations should be based on a mean peak flow rate of 5 l/min per cow. The mean peak flow rate of cows in any herd can be estimated, if desired, in one or more of the following ways:

a) mean peak flow rate, $\overline{q_{max}}$, in litres per minute, is closely correlated (coefficient of correlation, r = 0,81) with the average milking rate, $\overline{q}$, (litres of milk per cow divided by her milking time in minutes) of a representative group of cows in accordance with the regression:

$$\overline{q_{max}} = 0{,}2 + 1{,}5\overline{q} \qquad \text{...(C.1)}$$

b) mean peak flow rate, $\overline{q_{max}}$, in litres per minute, is highly correlated (r = 0,92) with the average amount of milk, $\overline{V_2}$, in litres, obtained from a representative group of cows in the first two minutes of milking in accordance with the regression:

$$\overline{q_{max}} = 0{,}5 \times \left(1 + \overline{V_2}\right) \qquad \text{...(C.2)}$$

c) mean peak flow rate, in litres per minute, is numerically equal to the mean quantity of milk, in litres, obtained from a representative group of cows in their second minute of milking (r = 0,89).

Table C.1 — Maximum predicted milk flow rate in milklines

Table C.1 — Maximum predicted milk flow rate in milklines

Attachment intervals s	Milk flow rate 1) l/min	Maximum milk flow rate, l/min Number of units per slope 2)																			
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
5	4	8	16	24	32	40	48	56	64	72	80	88	96	102	108	114	120	126	132	136	140
	5	10	20	30	40	50	60	70	80	90	100	110	120	126	132	138	144	150	156	160	164
10	4	8	16	24	32	40	48	54	60	66	70	74	78	81	83	85	86.5	86.5	86.5	86.5	86.5
	5	10	20	30	40	50	60	66	72	78	82	86	90	93	95	97	98.5	98.5	98.5	98.5	98.5
20	4	8	16	24	30	35	39	42	44	44	44	44	44	44	44						
	5	10	20	30	35	41	45	48	50	50	50	50	50	50	50						
30	4	8	16	23	28	30	31	31	31	31	31	31	31								
	5	10	20	28	33	35	35	35	35	35	35	35	35								
50	4	8	15	18	19	19	19	19	19	19	19										
	5	10	18	21	22	22	22	22	22	22	22										
70	4	8	13	13.5	13.5	13.5	13.5	13.5	13.5	13.5											
	5	10	15	15.5	15.5	15.5	15.5	15.5	15.5	15.5											
90	4	8	11	11	11	11	11	11	11												
	5	10	13	13	13	13	13	13	13												

1) Average peak flows per cow and for different attachment intervals.

2) Underlined figures indicate maximum flow (independent of the number of units).