International Standard 5707

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Milking machine installations — Construction and performance

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5707 was developed by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, and was circulated to the member bodies in April 1981.

It has been approved by the member bodies of the following countries :

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The member bodies of the following countries expressed disapproval of the document on technical grounds :

Czechoslovakia
Denmark
New Zealand

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Milking machine installations — Construction and performance

0 Introduction

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 high standard of hygiene and milk quality. In addition, the equipment must be effective and easy to use and test. This International Standard has been prepared jointly with the International Dairy Federation (IDF) and in consultation with the European Committee of Associations of Manufacturers of Agricultural Machinery (CEMA) and the International Committee on Recording the Productivity of Milk Animals (ICRPMA), and is intended to unify the many national standards which already exist.

During the preparation of this International Standard, it was recognized that for several of the requirements, for example those for pulsator ratio and regulator stability, more research information is necessary in order to establish their scientific basis.

1 Scope

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

2 Field of application

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

It does not apply to small mobile installations that have an individual vacuum pump for each unit.

It is not expected to apply in every respect to installations with special design features which are (or may be) available, such as, for example, single-pipe pipeline milking installations, milking installations with double vacuum systems, milk extraction without pulsation, and pulsation pump plants. Any claim for compliance with this International Standard relating to such equipment shall, therefore, indicate any requirements with which it does not comply.

3 References

ISO 49, *Malleable cast iron fittings threaded to ISO 7/1.*

ISO 228/1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1 : Designation, dimensions and tolerances.*

ISO 2037, *Pipes and fittings — Stainless steel tubes for the food industry.*

ISO 3918, *Milking machine installations — Vocabulary.*

ISO 4254, *Agricultural tractors and machinery — Technical means for providing safety.*[1]

ISO 6690, *Milking machine installations — Mechanical testing.*[1]

4 Definitions

For the purpose of this International Standard, the definitions given in ISO 3918 apply.

5 General

5.1 Tests for compliance

Characteristics established by mechanical testing are based on the tests specified in ISO 6690. Those tests shall, therefore, be used for the purpose of verifying compliance with the requirements of this International Standard.

1) At present at the stage of draft.

5.2 Power failure

Most milking machines depend on a public electricity supply which may occasionally fail. It is most important, therefore, that the installation is designed so that the user can arrange alternative means for operating the machine in cases of emergency.

5.3 Noise

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. Installations shall comply with requirements for noise level in national legislation.

5.4 Safety

All installations shall comply with the requirements for safety in national legislation and the requirements of ISO 4254.

6 Vacuum pumps

6.1 Effective reserve

The vacuum pump shall be of adequate capacity to meet the operating requirements (milking and cleaning) of the milking installation together with all other equipment operating during milking, whether continuously or intermittently, and creating a *demand for air. In addition, the pump shall have a minimum effective reserve* (ER), at the stated working vacuum, determined by the following formulae, as appropriate :

a) for pipeline plants, recorder plants, and independent air and milk transport plants :

$$ER^* = 100 + 25\,n$$

b) for bucket and direct-to-can plants :

$$ER = 40 + 25\,n$$

where

ER* *and* ER *are the effective reserve*, expressed in litres of free air per minute;

n is the number of milking units.

These formulae apply to plants having ten milking units or fewer.

For plants having more than ten units, the required effective reserve is :

— for pipeline recorder and independent air and milk transport plants 350 l/min of free air plus an additional 10 l/min of free air for each additional unit over ten units.

— for bucket and direct-to-can plants 290 l/min of free air plus an additional 10 l/min of free air for each additional unit over ten units.

Examples, rounded to integral values, are given in table 1.

The effective reserve shall be measured with all equipment connected.

Table 1 — Effective reserve

Number of milking units	Effective reserve, l/min of free air	
	Pipeline, recorder and independent air and milk transport plants	Bucket and direct-to-can plants
2	150	90
3	175	115
4	200	140
5	225	165
6	250	190
7	275	215
8	300	240
9	325	265
10	350	290
11	360	300
12	370	310
13	380	320
14	390	330
15	400	340
16	410	350
17	420	360
18	430	370
19	440	380
20	450	390

A calculated figure shall be added to the required effective reserve for equipment which does not operate during testing. For this purpose, the manufacturer shall state the air consumption, in litres per minute, of each component. The number of such components operating simultaneously shall be taken into consideration.

NOTE — For the operation of ancillary equipment, the installation of a separate vacuum system should be considered.

6.2 Vacuum pump capacity

The minimum capacity of the vacuum pump including the effective reserve shall be calculated as follows :

— For milking pipeline, recorder or independent air and milk transport milking machines the minimum capacity shall be 150 l/min plus 60 n l/min of free air for installations up to and including ten units, where n is the number of milking units.

— Where in-place cleaning and disinfection under vacuum is intended the minimum capacity shall be 330 l/min of free air.

— For installations over ten units the minimum capacity shall be 750 l/min plus 45 l/min of free air for each additional unit over ten.

— For bucket milking machines the minimum capacity shall be 50 plus 60 n l/min of free air for installations up to and including ten units, where n is the number of milking units.

— For bucket milking machines with more than ten units the minimum capacity shall be 650 l/min plus 45 l/min of free air for each additional unit over ten.

— To the capacities so obtained shall be added the air consumption of ancillary equipment that is not operated by a separate vacuum system (see 6.1).

Examples of calculations of vacuum pump capacity are given in tables 2 and 3.

Table 2 — Examples of calculations of vacuum pump capacity for pipeline milking machines

Number of units	In-place cleaning and disinfection under vacuum Calculation	Capacity l/min	Other methods of cleaning Calculation	Capacity l/min
2	330 Plus ancillary equipment[1]	330 100 430	150 + (60 × 2) Plus ancillary equipment[1]	270 100 370
5	150 + (60 × 5) Plus ancillary equipment[1]	450 100 550	150 + (60 × 5) Plus ancillary equipment[1]	450 100 550
8	150 + (60 × 8) Plus ancillary equipment[1]	630 120 750	150 + (60 × 8) Plus ancillary equipment[1]	630 120 750
12	750 + (45 × 2) Plus ancillary equipment[1]	840 200 1 040	Identical with in-place cleaning	
20	Rotary installation 750 + (45 × 10) Plus ancillary equipment[1]	1 200 100 1 300	Identical with in-place cleaning	

1) Assumed value for ancillary equipment (for example for vacuum operated cluster removers, gates, feeders) that is not operated by a separate vacuum system.

Table 3 — Examples of calculations of vacuum pump capacity for bucket milking machines

Number of units	Calculation	Capacity, l/min
6	50 + (60 × 6)	410
12	650 + (45 × 2)	740

6.3 Influence of altitude

In order to fulfil the requirements in 6.1 and 6.2 at altitudes higher than sea level, a vacuum pump with increased capacity, to compensate for the decrease in pump capacity and the increase in air consumption due to the lower atmospheric pressure, shall be installed (see ISO 6690).

For the purposes of this International Standard, the datum levels for atmospheric pressure at various altitudes are as given in table 4.

Table 4 — Atmospheric pressure at various altitudes

Altitude, m	Normal atmospheric pressure, kPa
up to 299	100
300 to 699	95
700 to 1 199	90
1 200 to 1 599	85
1 600 and over	80

6.4 Marking

The vacuum pump shall be marked with the following information in indelible lettering :

a) Range of speed and power consumption, in kilowatts.

b) Corresponding range of extraction capacity at 50 kPa, in litres per minute, expressed as free air at an atmospheric pressure of 100 kPa.

c) Type and identification, for example serial number or code.

d) Recommended lubricant, if used.

e) Name of manufacturer or supplier.

6.5 Exhaust

The exhaust from a lubricated vacuum pump should not discharge into a room. The exhaust pipe shall be as short as possible and shall not obstruct the passage of the exhaust air by the presence of sharp bends, T-pieces or unsuitable silencers. 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.

It is recommended that an oil separator is fitted to the exhaust pipe.

6.6 Prevention of reverse rotation

If the vacuum pump is not equipped with a non-return valve, a tap for restoring the vacuum system to atmospheric pressure shall be provided adjacent to the vacuum pump control switch.

6.7 Safety

All exposed moving parts associated with the prime mover and vacuum pump shall be fitted with effective guards. A switch to isolate the prime mover electrically shall be installed at or near the vacuum pump assembly.

6.8 Location

The vacuum pump shall be located as near to the milking installation as possible, shall be positioned in such a way that the speed can readily be measured, and shall be connected so that the extraction capacity can be measured.

Facilities shall be provided for measurement of the vacuum level.

If possible, the vacuum pump should be situated in a separate room.

7 Regulator

7.1 Marking

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

a) Manufacturer's name or supplier.

b) Designed working vacuum level.

c) Air flow capacity at the designed working vacuum level.

Adjustable regulators shall also be marked with this information, valid at a vacuum level of 50 kPa.

7.2 Suitability

The regulator or regulators shall be of a design suitable for the installation, of capacity at least equal to the pump capacity, and shall be capable of controlling the vacuum at designed working vacuum level.

7.3 Mounting

The regulator shall be rigidly mounted so as to be as free from vibration as possible, in such a position that moisture from the air pipeline cannot enter the regulator. The regulator of milking pipeline installations, of recorder installations and of independent air and milk transport installations shall be fitted on the interceptor or between the interceptor and receiver. The regulators of bucket milking installations shall be fitted on the interceptor or between the interceptor and the first connection to the air pipeline. The regulators of all installations shall be fitted to a clean and easily accessible spot where, for testing reasons, the air flow gauge can be attached.

To enable testing equipment to be connected into the air pipeline, a T-piece, having a swept branch of the same internal diameter as the air pipeline, shall be fitted in the air pipeline between the regulator and interceptor so that the axis of the branch is not below the horizontal.

NOTE — If more than one regulator is fitted to an installation, there may be a risk of interaction leading to instability. This can usually be overcome by providing each regulator with a separate connection to the air pipeline and spacing the regulators at intervals of not less than 500 mm.

If the regulator is fitted on the interceptor, a connection shall be provided at or near the inlet to the interceptor, of the same internal diameter as the air pipeline for the attachment of test equipment.

7.4 Sensitivity

The regulator shall control the vacuum so that, under testing conditions (see ISO 6690), the vacuum level will not increase by more than 2,0 kPa above that when all units are working.

7.5 Regulator leakage

The total air leakage through the regulator when it is nominally closed should not exceed 35 litres of free air per minute or 8 % of the rated pump capacity, whichever is the greater, at a vacuum level 2,0 kPa below that existing when all units (with the liners stoppered) and accessories, including the regulators, are operating.

NOTE — The relationship between the requirements for sensitivity and leakage, and the definitions of manual and effective reserve and regulator leakage are shown in figure 1, for the purpose of which the slight decrease in component consumption, when the working vacuum decreases, has been neglected.

8 Stability of system vacuum

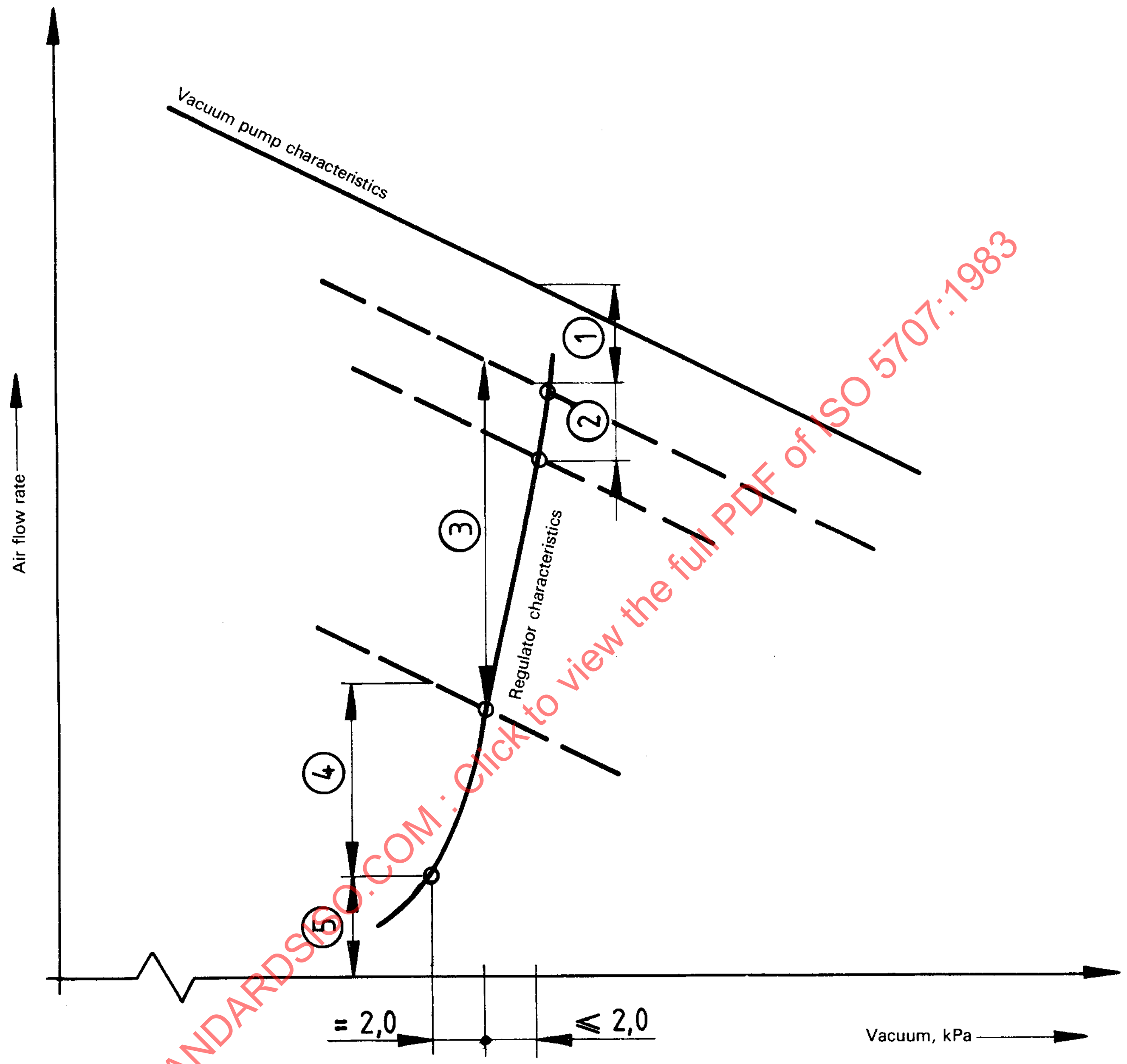
The stability of the vacuum in a milking pipeline machine or a recorder jar milking machine shall be such that, when tested under the conditions specified in ISO 6690, the product of the amplitude of vacuum variation and its duration measured in the short milk tube shall not exceed 20 kPa·s.

For a bucket or direct-to-can machine, the product of the vacuum variation and its duration measured in the vacuum tube shall not exceed 40 kPa·s.

9 Vacuum gauge

9.1 General

The vacuum gauge should not be less than 75 mm in diameter and the operating vacuum level should be indicated by a mark. The gauge shall be graduated at intervals of 2,0 kPa and should be adjustable. The error in vacuum indication with either increasing or decreasing vacuum level at any point above 10 % and below 90 % of the maximum scale value shall not exceed 1,6 % of the maximum scale value.



(1) Air consumption of common components including system leakage

(2) Air consumption of one unit

(3) Air consumption of all units

(4) Effective reserve

(5) Regulator leakage

(4)+(5) Manual reserve

Figure 1 — Relationship between requirements for sensitivity and leakage, and definitions of manual and effective reserve and total regulator leakage

9.2 Mounting

If possible, the gauge shall be mounted between the regulator and the milking installation in a place where it is readable by the operators during milking. The thread on the gauge connection shall comply with the requirements of ISO 228/1.

9.3 Gauges for portable installations

Vacuum gauges fitted to portable installations shall comply with the requirements of 9.1 and shall be damped against vibration.

10 Air pipeline

10.1 General

The air pipeline system shall be made of suitable material. The ends of all tubes shall be deburred before assembly. Metal bends shall have a minimum centreline radius in accordance with ISO 49. Ends of air pipelines shall be fitted with removable plugs or caps to facilitate cleaning. When installed, the system shall be firmly fixed and all sections shall be self-draining to automatic drain valves. If the air pipeline forms part of the cleaning circuit, the requirements of clause 15 concerning materials shall apply.

10.2 Internal diameter and air flow

The vacuum drop between the vacuum pump and the regulator under test conditions shall not exceed 2,5 kPa. The vacuum drop between the regulator and any point upstream in the air pipeline (milking vacuum) under test conditions shall not exceed 2,5 kPa.

Table 5 indicates the minimum internal diameters which have been found appropriate for various air flow rates in pipes used for the system, including the connection between the vacuum pump and the regulator, but excluding pulse relay lines.

Table 5 — Air flow rates in relation to minimum internal diameters

Air flow rate, l/min	Minimum internal diameter, mm
< 300	25
300 to 599	32
600 to 1 000	38
> 1 000	50

10.3 Connections

For bucket and direct-to-can milking machines, the air pipeline shall be connected directly to the interceptor.

For milking pipeline, recorder and independent milk and air transport milking machines, provision shall be made to prevent contaminated material from the vacuum system gaining access to the milk and milk from gaining access to the vacuum system.

10.4 Leakage

Leakage into the air pipeline system shall not exceed 5 % of the rated vacuum pump capacity.

11 Drain valves

Drain valves shall be made from materials resistant to corrosion and shall be designed for automatic operation. Sealing rings, if fitted, shall be manufactured from material which is resistant to both fat and cleaning and disinfecting fluids. In all cases, drain valves should be accessible.

12 Interceptor and sanitary trap

12.1 Interceptor

The interceptor shall be of suitable design and material and should be mounted in an accessible position adjacent to the vacuum pump. There should not be any intermediate connections into the air pipeline between the interceptor and the pump, except as is necessary for test purposes.

The interceptor shall be designed so as to prevent moisture and dirt from entering the vacuum pump. The internal diameter of the inlet and outlet of the interceptor shall be the same as that of the air pipeline. The interceptor shall be easy to inspect and clean and disinfect and shall incorporate an automatic vacuum cut-off. It shall also be provided with automatic drainage facilities. Interceptors shall be so situated that they cannot discharge the effluent in such a way that it could damage the electric motor of the vacuum pump or any other part of the installation. On fixed installations, the interceptor shall have a minimum effective capacity of 15 l.

12.2 Sanitary trap

Except where the vacuum and pulsation systems form part of the routine circulation cleaning and disinfection system, a sanitary trap should be fitted to milking pipeline and recorder jar milking machines to form the connection between the receiver vessel and the vacuum system. This trap should be transparent, should have provision for drainage and should be equipped with an automatic vacuum cut-off. The capacity of the trap should not be less than 3 l. It is an advantage to the operator if the trap is situated adjacent to the receiver and within sight during milking.

The sanitary trap shall be easy to clean and disinfect.

12.3 Connection between receiver and sanitary trap

The connection between the receiver and the sanitary trap shall be easy to clean and disinfect and should be transparent.

13 Vacuum taps

Vacuum taps shall be airtight when closed. An inner cross-sectional area corresponding to a diameter of not less than 7,5 mm for each unit is recommended. Alternatively, the maximum vacuum drop across the tap, at a vacuum level of 50 kPa in the air pipeline system and with an air flow through the tap of 120 litres of free air per minute, shall be not more than 10 kPa. The taps shall have stops to indicate the fully open, and fully closed, positions. They shall be firmly 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 air pipeline.

14 Pulsation systems

14.1 General

The pulsator shall be reliable in performance and easy to clean.

14.2 Performance data

The manufacturer shall provide figures for the following data obtained during normal working conditions :

a) pulsation rate;

b) pulsator ratio (as defined in ISO 3918).

After installation, the supplier shall guarantee that, with all pulsators working, the pulsator will perform in accordance with the data provided.

14.3 Pulsation rate

The manufacturer should indicate

a) the pulsation rate at the stated vacuum level and temperature;

b) the temperature range over which the pulsation rate will stay within ± 5 % of the stated rate;

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

d) the variation of pulsation rate within this range.

If the operator is required to adjust the pulsation rate, a simple method of adjustment shall be provided. If a special tool is required for adjustment, this tool shall be supplied with the pulsator.

14.4 Pulsator ratio

The pulsator ratio shall be within ± 5 units of percentage of the value stated by the manufacturer. Phase "*d*" of the pulsation chamber vacuum record shall be not less than 15 %.

Phase "*b*" of the pulsation chamber vacuum record shall be not less than 30 %.

If an installation is designed to operate with two pairs of teatcups pulsating alternately, the difference in the pulsator ratio between two teatcups in the same cluster shall not deviate by more than 5 units of percentage from the value stated by the manufacturer.

15 Milk system and cluster assembly

15.1 Food contact surfaces

Any part of the milking installation coming into contact with the milk shall comply with national legislations for food contact materials. Materials used in construction, which come into contact with cleaning and disinfecting fluids at normally used concentrations, shall be suitable for such contact and shall be easy to clean. Copper or copper alloys shall not be used in any part of the installation coming into contact with milk or cleaning and disinfecting fluids other than water.

15.2 Materials

The materials used for rigid components of the milking system (for example buckets, pipelines and jars) shall be austenitic stainless steel or heat-resistant glass or other suitable fat-resistant material complying with the requirements of 15.1. The materials used for flexible components (for example joint rings, teatcup liners) should be synthetic rubber or other suitable fat-resistant flexible material and shall comply with the requirements of 15.1. The materials used shall not impart any taint to the milk.

All milk contact surfaces shall be free from engraving or embossing. All metal milk contact surfaces shall have a surface roughness of $R_a \leqslant 3{,}0$ µm.

If cleaning and disinfecting procedures using boiling water are to be used, the materials used in construction shall be resistant to a temperature of 100 °C.

15.3 Requirements

The entire installation shall withstand a vacuum of 80 kPa. Leakage into the installation pipelines and the fittings shall not exceed 20 l/min.

There shall be provision for all parts of the system to be drained.

16 Bucket unit and direct-to-can

16.1 Capacity

The buckets or transport cans shall be of stated working capacity, of minimum 20 l. They, and all their fittings, shall be so designed and constructed that they can be easily cleaned and inspected.

16.2 Unit lids

The whole lid assembly shall be vacuum-tight. Gaskets shall make an effective vacuum seal and shall be easily removable for cleaning and disinfecting. If a sight glass is fitted, it should be effective and should indicate when milk flow stops. It shall not introduce any additional pressure drop.

17 Milk pipeline and fittings

17.1 Tubing

Tubing may be of any of the following materials :

a) Austenitic stainless steel of wall thickness not less than 1 mm, subject to usual commercial tolerances. Tubing complying with the requirements of ISO 2037 is suitable. The ends of the tubes shall be deburred.

b) Heat-resistant glass of minimum wall thickness 2,0 mm. The finish shall be appropriate to the type of connecting fitting to be used. If sleeve joints are to be used, the ends should be flamed, ground or subjected to other treatment to remove sharp edges.

c) Any other suitable material which complies with the requirements of clause 15.

17.2 Fittings

All fittings shall be of smooth bore and free from crevices. Branch fittings should be swept in the direction of milk flow.

If sleeve joints are used, a minimum gap of three times the wall thickness of the tube shall be left between tubes. Clamps may be used.

Unions shall be of materials complying with the requirements of 17.1. Joints in contact with milk, where both components are made from elastomers, shall not be used.

The minimum centreline radius for bends in air and milk transport pipelines (of all materials), but excluding the transfer pipeline and elbow below the recorder jar, shall be 75 mm.

18 Design of milking pipeline systems

18.1 Caution is advised when considering milking pipeline systems which have the dual function of providing milking vacuum and conveying milk. They shall be of the minimum practicable length and shall be designed in accordance with the following requirements.

18.2 Where practicable, the milking pipeline shall form a loop, the ends of which shall have separate full bore connection to the receiver vessel.

18.3 The internal diameter of the milking pipeline shall be such that the vacuum drop in the pipeline does not exceed 3 kPa with all units working.

The minimum internal diameter shall be determined in accordance with the total length of the pipeline and the rate of milk and air flow shall be calculated by the method given below. Alternatively, this can be obtained from tables 6 and 7.

NOTE — In small installations, the possibility that the milk flow rate for all units will be high is much greater than in large installations. The relationship C between the maximum milk flow rate and the average milk flow rate is given in figure 2.

The formula used for air flow rate and milk flow rate in tables 6 and 7 is

$$\left(\frac{Q_a}{5} + Q_m\right) \times n$$

where

Q_a is the air flow rate per unit;

Q_m is the average milk flow rate per unit × factor C (see figure 2);

n is the number of units.

The diameter of the pipeline may be derived by using this calculated figure in conjunction with figure 3 or figure 4 as appropriate.

Example

If Q_a = 10 l/min,

and Q_m = 2,25 kg/min × factor C

and n = 4 units (thus C = 1,38)

from the formula

$$\left(\frac{Q_a}{5} + Q_m\right) \times n$$

one obtains :

$$\left(\frac{10}{5} + 2,25 \times 1,38\right) \times 4 = 20,42$$

From figure 3, a single milk pipeline 40 m long should have a minimum diameter of 46 mm.

From figure 4, a loop line 100 m long should have a minimum diameter of 38 mm.

18.4 During milking, air shall only be deliberately admitted to the milking pipeline (i.e. from the teatcups through to the receiver vessel) at the cluster of the milking units, unless it is necessary for proper operation of a milk meter.

Table 6 — Recommendations for the maximum number of units on the milking pipeline

NOTE — This table is based on units of capacity 10 litres of free air per minute and a highest average flow rate of milk as given in table 7 for a maximum vacuum reduction of 3 kPa.

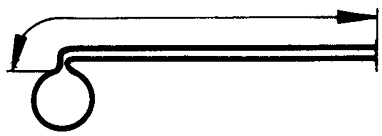
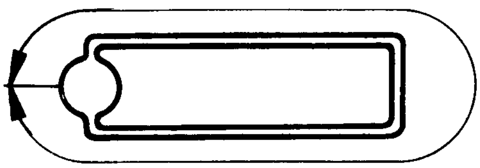
Type of milking pipeline	Internal diameter mm	Total length of the milking pipeline, m											
		10	20	30	40	50	60	80	100	150	200	300	400
		Number of units on the milking pipeline											
Single 	30	3	2										
	34	4	2	2									
	38	6	4	2	2								
	42	7	5	4	3	2	2						
	46	9	6	5	4	3	2	2					
	50	11	7	6	5	4	3	2	2				
	61	16	12	9	8	7	6	5	4	3	2	2	
	66	—	14	11	10	8	7	6	5	4	3	2	2
	73	—	16	13	12	10	9	8	7	6	4	3	2
Loop circuit 	30	—	7	6	5	4	3	3	2				
	34	—	10	8	7	6	5	4	3	2	2		
	38	—	13	10	9	8	7	6	5	4	3	2	
	42	—	15	12	11	10	8	7	6	5	4	3	2
	46	—	18	15	13	12	11	9	8	6	5	4	3
	50	—	—	20	16	14	13	11	10	8	6	5	4
	61	—	—	—	—	—	20	16	14	12	10	8	7
	66	—	—	—	—	—	22	20	16	14	12	10	8
	73	—	—	—	—	—	26	23	20	17	15	12	10

Table 7 — Highest average flow rate per unit

Number of units	Highest average flow rate per unit, kg/min
2	4,50
3	3,75
4	3,00
6	2,50
≥ 10	2,25

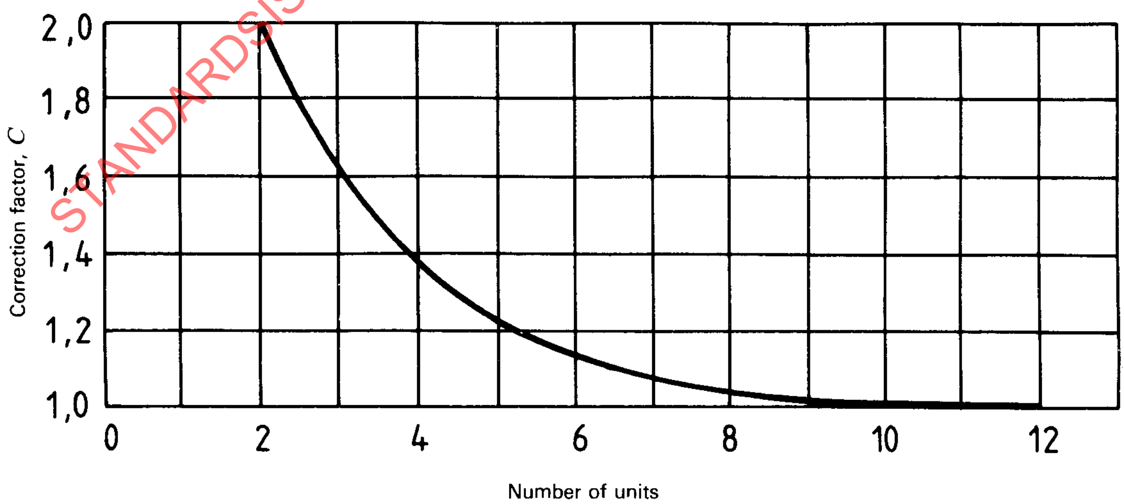


Figure 2 — Correction factor C

$$C = \frac{\text{Maximum milk flow rate}}{\text{Average milk flow rate}}$$

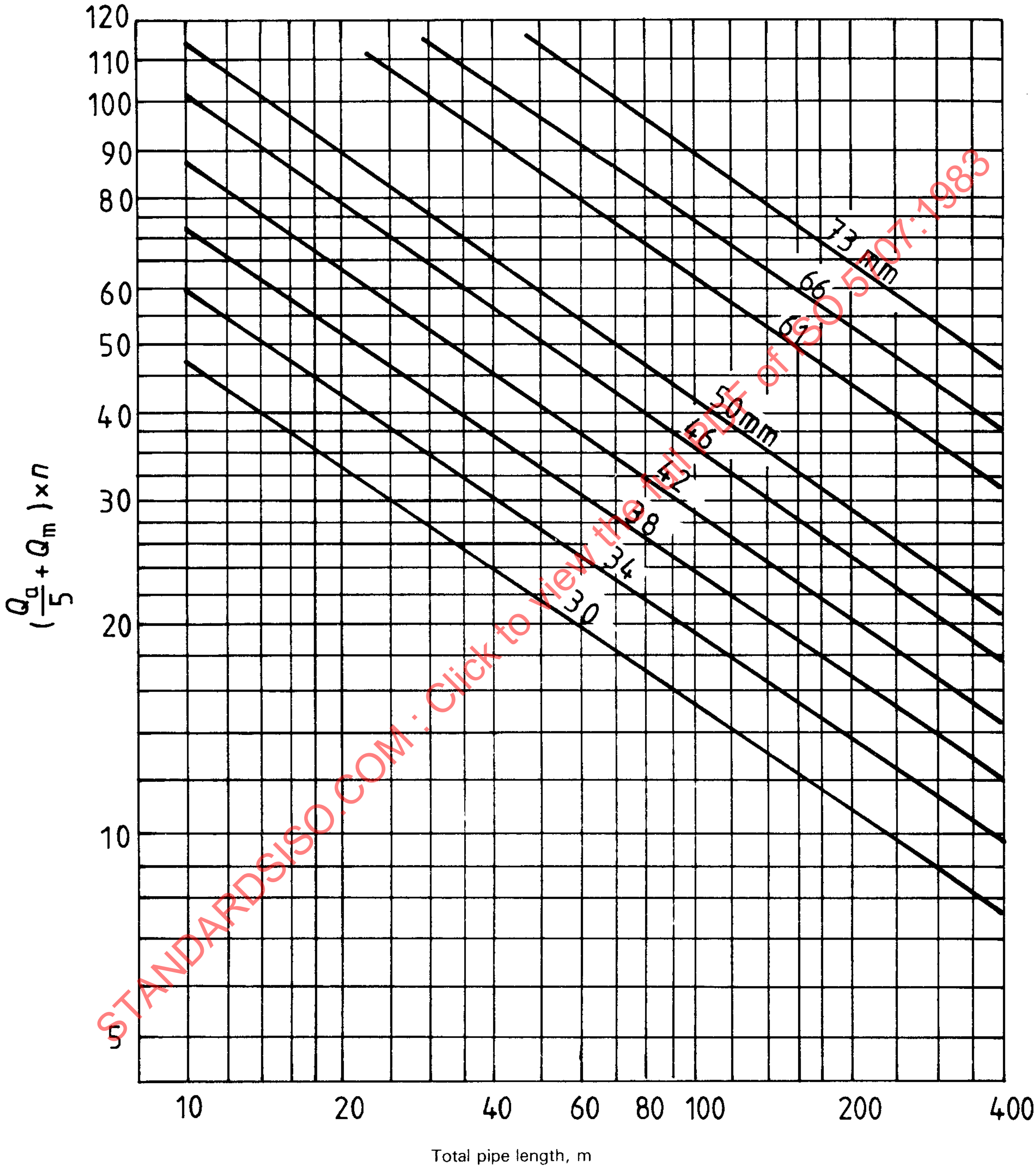


Figure 3 — Minimum diameter for a milking pipeline (not loop connected)
(for a maximum vacuum reduction of 3 kPa and a vacuum of 50 kPa)