Teagasc/IMQCS Recommendations for the installation and testing of milking machines

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RECOMMENDATIONS FOR THE INSTALLATION AND TESTING OF MILKING MACHINES

Recommendations for the installation and testing of milking machines

Introduction

This manual has been prepared by the Irish Milk Quality Co-Operative Society (IMQCS). IMQCS has its registered office at 84 Merrion Square, Dublin 2. The organization was incorporated in 1989 with the aim to improve milk quality standards in Ireland, to ensure that Irish milking machine installation and testing standards exceed the best international standards.

This manual combines Irish Milk Quality Co-operative Society (IMQCS) Guidelines and ISO standards (International Standards Organisation) (ISO 5707 (2007), ISO 6690 (2007) and ISO 3918 (2007) into a reference guide for all milking machine installers and advisers in the Republic of Ireland. The manual also contains information on some equipment and topics related to milking machines which are outside the scope of the ISO standards. The IMQCS guidelines and ISO standards have been developed to ensure best practice in the installation and testing of milking machines and are not a legal requirement.

The basis of the manual is compliance with existing standards, directives and legislation and agreed installation practices for the fitting of new milkline and recorder parlour plants for bovines.

The manual applies only to the main milking facility (which is usually a parlour) and does not apply to new bucket plants. Where possible and practicable the recommendations shall be applied to existing installations.

The IMQCS has informed each person who is listed in its Register of Certified Milking Machine Testers and Installers of the importance of complying with these recommendations. IMQCS is not in a position to police adherence to these recommendations and cannot accept any responsibility for any loss or damage of any nature which might be incurred by non-compliance with these recommendations.

The use of "shall" indicates that a clause is mandatory for compliance with these recommendations, whereas, "should" clauses are recommended on the grounds of good practice.

The term 'manufacturer' is used in these recommendations to refer to the original equipment manufacturer (OEM) and 'installer' is the actual installer. This is in contrast to CE documentation in which the 'installer' is defined as the manufacturer. In a situation where a main contractor provides a complete milking installation consisting of components from more than one manufacturer he has responsibility to all CE and ISO standards requirements for the complete installation and therefore deemed to be the manufacturer of the complete installation. If a main contractor provides an individual component (e.g., pulsation system) in an existing installation he shall be responsible only for the CE and ISO requirements of that component.

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PERFORMANCE REQUIREMENTS

1. PERFORMANCE REQUIREMENTS

ISO 5707 Milking machine Installations-Construction and Performance specifies minimum performance and information requirements and certain dimensional requirements for satisfactory functioning of milking machines for milking and cleaning.

1.1 Tests for compliance

The methods for performance testing referred to in this manual are specified in ISO 6690.

1.2 Access for measurements

1.2.1 General

a) Connection points for measuring airflow and vacuum shall be provided.
b) Dismantling is acceptable to access connection points.
c) All connection points and their location shall be described in the user's manual.

1.2.2 Airflow measuring connections (Figure 1)

A1: to enable measurement of effective reserve, manual reserve and regulator leakage:

a) For bucket or direct-to-can milking machines connection to be between the regulator sensing point and the first vacuum tap.
b) For pipeline milking machines connection to be at or near the receiver(s), upstream of the sanitary trap(s).
c) For recorder milking machines connection to be at or near the sanitary trap(s) on the milking vacuum line(s)

A2: to enable measurement of leakage into the vacuum and milk systems

a) Connection to be between the vacuum pump(s) and the sanitary trap(s) or the first vacuum tap.

Note: *When not in use, test connections shall not form a trap for liquids. Connections shall have the same internal diameter as the airline or (48.5±2) mm, whichever is smaller.*

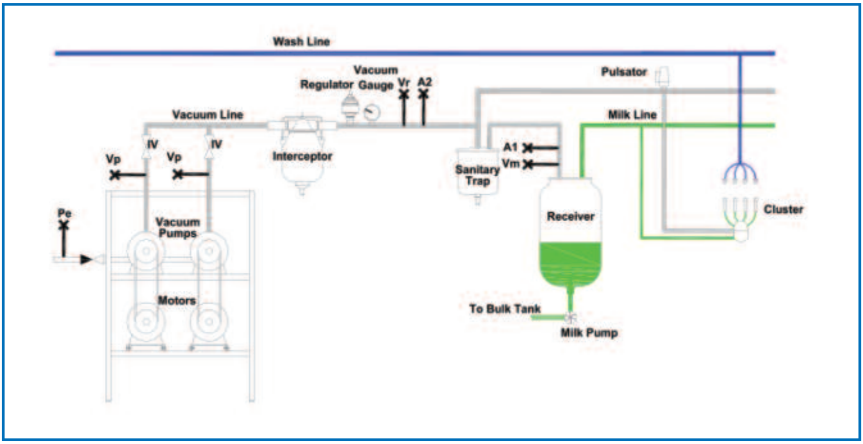

Figure 1: Location of test points in ISO standards (ISO 3918) tees +isolation valves (IV)

1.2.3 Vacuum and airflow measuring connections (Figure 1).

The following measuring points shall be provided for a vacuum or an airflow meter:

a) $\mathbf{V_m}$ at or upstream of the measuring point **A1.**

b) $\mathbf{V_r}$ near each regulator sensing point.

c) $\mathbf{V_p}$ near each vacuum pump inlet.

d) $\mathbf{P_e}$ Connection for measurement of exhaust backpressure of the vacuum pump outlet.

e) In a pipeline milking machine, **Vm** can be any point in the milking system, or upstream of the receiver. In a recorder jar milking machine, **Vm** can be in the milking vacuum line or in the nearest convenient recorder jar. In a bucket milking machine, **Vm = Vr** and can be combined with the nearest convenient vacuum tap.

f) All test connections shall be at least five pipe diameters from any bends, air inlet points or other fittings creating air turbulence.

g) If the regulator sensing point is on a branch, there shall be two measuring points **Vr**, one to measure the vacuum drop in the airline upstream of this branch and the other one to determine the regulator leakage near the regulator sensing point.

h) Means shall be provided to isolate vacuum pump(s) to measure vacuum pump capacity.

i) It is necessary that the pulsators can be stopped or disconnected to measure leakage into the vacuum system and of air used to produce pulsation.

1.2.4 Additional IMQCS recommendations for test points and isolation valves

a) Airflow test points shall consist of a tee-piece complete with a test valve and "nipple" the valve and "nipple" bores shall not be less than 38mm. Alternative means for the connection of airflow meters are acceptable provided that their operation does not necessitate the use of tools.

b) Isolation valves shall be fitted to the main airline near the vacuum pump on the interceptor side of the test tee-piece and on the sanitary trap airline between sanitary trap and main airline.

c) Isolation valve bore shall be equal to the bore of the airline in which it is fitted.

d) A separate vacuum pump to operate feeders is preferred but is not necessary where there is adequate vacuum pump capacity.

e) When a separate vacuum is not provided, means shall be provided to isolate ancillary equipment, such as vacuum feeder, ACRs, vacuum gates, water heater controls, teat sprayers, etc.

SAFETY AND HYGIENE

2. SAFETY AND HYGIENE

a) Installations shall comply with the relevant safety requirements given in ISO 12100-1 and ISO 12100-2. The electrical components shall comply with the relevant safety requirements given in IEC 60335-2-70.
b) Installations shall comply with the hygiene requirements given in ISO 14159.
c) The equipment has to be effective, easy and safe to use and test.

MATERIALS

3. MATERIALS

a) All components that are subjected to a vacuum shall be designed and constructed to withstand a minimum vacuum of 90 kPa, without permanent distortion.
b) 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).
c) All materials in contact with milk or cleaning solutions whether used for rigid components (for example, pipelines or recording 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 taint to the milk.
d) 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 ® less than or equal to 2.5μm when tested in accordance with IS EN ISO 4288.
e) Surface roughness (Ra), on welded seams shall not exceed 16μm.
f) Copper or copper alloys shall not be used in any part of the installation that may come in contact with milk or cleaning and disinfecting fluids other than water.
g) Materials that come into contact with milk shall be resistant to both milk fat and cleaning and disinfecting solutions.

USER´S MANUAL

User´s Manual

4. USER'S MANUAL

4.1 General

a) The User's Manual written in at least one of the country's official languages shall specify a system of measures that ensure that the function, safety and hygiene of the milking machine are maintained during its intended lifetime. This includes instructions for routine servicing and replacement of individual parts. An indication shall be given as to whether particular actions should be performed by the user or if other suitably qualified personnel are needed.

4.2 Installation details

At least the following installation details shall be provided:

a) Mounting dimensions, space requirements and critical building dimensions.
b) Recommended ambient conditions for the different parts of the milking machine.
c) Minimum electrical power supply and earthing (grounding) requirements.
d) Minimum water supply and drainage requirements.
e) Nominal working pressure and capacity of a compressed air system.
f) Amount of airflow and vacuum for cleaning.
g) The minimum required airflow use of vacuum-driven ancillary equipment.

4.3 Instructions for use

At least the following instructions shall be provided:

a) Start up, operating and shut down procedures.
b) The effective reserve, as calculated and as measured.
c) Recommended cleaning and disinfecting procedures, including temperatures and chemicals, and components requiring manual cleaning.
d) The maximum temperature at which the installation can be cleaned and disinfected.
e) Definition of any manual intervention, such as manual actuation of valves or replacement of single use items such as filters, along with the appropriate time intervals.
f) Procedures necessary to avoid contamination of the milk from cleaning solutions and from, withheld, abnormal and undesirable milk.
g) The maximum number of units or maximum milkflow per slope of the milkline.
h) Procedures for introducing animals new to milking installations.

VACUUM SYSTEM

5 VACUUM SYSTEM

5.1 General

a) The ultimate goal is to maintain vacuum at teat end within the intended range. The machine shall be capable of adequate vacuum control and operators shall use the machine with reasonable care and in accordance with the user's manual.

5.2 Vacuum regulation

5.2.1 Vacuum deviation: The working vacuum (Vm), after a defined start-up period shall be within ± 2 kPa of the nominal.

5.2.2 Regulation sensitivity: Shall not to exceed 1 kPa.

5.2.3 Regulation loss shall not exceed 35 l/min of free air or 10 % of the manual reserve, whichever is the greater.

5.2.4 Regulation characteristics and effective reserve

a) Regulation overshoot shall be less than 2 kPa
b) One of the following requirements shall be fulfilled:
   1. Vacuum drop and undershoot during cluster fall-off test shall be less than 2 kPa. This requirement is more appropriate for large milking systems and where the operators are less careful during attachment
   2. The minimum effective reserve given in Table's 1-4 is more appropriate for small milking systems (< 8 units)
c) In large milking systems the effective reserve should be sufficient to maintain working vacuum (Vm) within ± 2 kPa during the course of normal milking, including teatcup attachment and removal, liner slip or teatcup/cluster fall, for at least 99 % of the milking time.

5.3 Vacuum pumps

5.3.1 Vacuum Pumps - General

a) The vacuum pump shall have adequate airflow capacity to meet the requirements for milking and cleaning including air used by all ancillary equipment operating during milking and cleaning, whether continuously or intermittently.
b) If more than one vacuum pump is used, it shall be possible to isolate pump(s) not in use.

5.3.2 Influence of altitude

Vacuum pump capacity decreases with altitude.

5.3.3 Exhaust

a) The exhaust shall not obstruct the passage of the exhaust air by sharp bends, T-pieces or unsuitably designed silencers.
b) Means shall be provided to minimize oil discharge from oil-lubricated vacuum pumps into the environment, for example with an oil separator, collection or recirculation system fitted in the exhaust pipe.
c) Moisture from the exhaust shall be prevented from entering the vacuum pump, for example by fitting a moisture trap or having the exhaust pipe with a continuous slope away from the vacuum pump.
d) The exhaust should not discharge into a closed room where foodstuffs are stored or processed, or where persons or animals are present.

5.3.4 Prevention of reverse flow through vacuum pump

a) Automatic means shall be provided to prevent reverse flow of air from the exhaust, which may contaminate the milk system.

5.3.5 Location

a) The vacuum pump shall be located so that airline vacuum drop recommendation (5.6.2) shall be achieved using airlines with reasonable diameter.
b) The vacuum pump shall be installed so that its capacity, vacuum and

where applicable, speed can be easily measured.

c) The vacuum pump(s) should be placed in a well-ventilated and non-freezing area isolated from the milking parlour and milk room.

5.3.6 Additional IMQCS recommendations for vacuum pumps

a) The farmer shall provide adequate working space around the vacuum pump to facilitate maintenance and checking.
b) The farmer shall provide adequate drainage in the pump house.
c) The vacuum pump and associated prime mover shall be mounted on a rigid frame and have guards which provide effective protection to all accessible moving parts as per Health and Safety Authority guidelines. The minimum standard of belt guard is outlined in IS EN 294:1994.
d) Safety guards may be opened only if safety is not compromised in any way.
e) The farmer should provide a standby power source for the vacuum pump.

5.3.7 Additional IMQCS recommendations for exhausts

a) Exhausts shall be fitted and shall be vented to outside the pump room, or into a container buried underground and vented to the outside.
b) A silencer shall be fitted to the exhaust pipe to reduce the time weighted average noise level. Additional measures, e.g., doors, ceilings and sumps may be necessary to achieve acceptable noise levels in the normal working areas, i.e., dairy, parlour and yard.
c) An oil trap shall be fitted or the exhaust shall be sloped away from the vacuum pump towards an oil collection container.
d) Exposed exhausts, which may be a burn hazard, shall have a suitable hazard warning sign.

5.4 Vacuum regulator

5.4.1 Regulator leakage shall not exceed 35 l/min of free air or 5 % of the manual reserve, whichever is greater.

5.4.2 Vacuum regulator shall be mounted in a readily accessible location and be protected from moisture from the milking machine and installed in a place and manner in which it does not take in excessive dust.

The regulator should be installed in a place and manner so as to minimize noise for the operator(s).

5.4.3 Examples of location of sensing point for vacuum regulator.

a) In pipeline and automatic milking machines, either between the interceptor and the sanitary trap or on the sanitary trap or in the receiver.

b) In recorder milking machines, either between the interceptor and the sanitary trap or on the sanitary trap or in the milking vacuum line.

5.4.4 Additional IMQCS recommendations for vacuum regulators

a) Isolation valves shall be fitted to the regulator air admission valve and remote sensing point to facilitate testing except where the valve(s) interferes with the function of the sensing point.
b) Remote sensing point(s) shall be fitted on the cow side of the regulator air admission valve according to manufacturer's recommendations.

5.5 Vacuum gauge

5.5.1 Vacuum Gauge - General

a) Shall indicate intervals of 2 kPa or less from 20 kPa to 80 kPa.
b) Gauge error shall not exceed 1 kPa at the working vacuum.

5.5.2 Mounting

a) Gauge is readable by the operator (milker) while milking.
b) More than one vacuum gauge may be needed.

5.6 Airlines

5.6.1 Airlines-general

a) Airlines shall be sloped to a readily accessible drain valve.
b) Airlines shall be self-draining when the vacuum is shut off.
c) Airlines shall have provision for cleaning and inspection.

5.6.2 Airlines-internal diameter and airflow

a) Airlines shall be large enough so vacuum drop does not seriously affect milking machine function.
b) Vacuum drop between **Vm and Vr** shall, therefore, not exceed 1 kPa.
c) When **Vp > Vm** the higher vacuum at **Vp** increases power consumption and decreases the vacuum pump capacity. **Vp** should preferably not exceed **Vm** by more than 3 kPa.

5.6.3 Additional IMQCS recommendations for airlines

a) All airlines shall be either galvanized steel, rigid plastic or stainless steel.
b) All airlines shall have reamed ends for the fitting to the tee pieces, bends and joint fittings and be clamped and fixed to prevent sagging. Rigid plastic or stainless steel piping shall have welded, socketed or sealed couplers on joints, bends and tee pieces, be clamped and fixed to prevent sagging and be sufficiently protected to avoid accidental damage by cows or operators.
c) Bends shall be swept with a minimum centerline radius of 1.5 times the diameter. Pulsation airlines should not be more than 2.1m above the cow standing.

d) Pulsation airlines shall have a tap or bung fitted at the ends to facilitate adequate washing. Pulsator and relay entries shall be into the top or side of pulsation airlines.
e) An ancillary airline should be of rigid material and shall be sloped to a drain valve to facilitate drainage and shall have a tap or bung fitted at the end to facilitate adequate washing.

5.7 Interceptor

a) Shall be fitted near the vacuum pump, between the vacuum pump and the regulator.
b) There shall not be any intermediate connections into the airline between the interceptor and the vacuum pump, except as required for test purposes or for the connection of a safety valve.
c) A safety valve may be fitted to protect the pump from effects of high vacuum caused by the activation of any vacuum shut-off valve in the interceptor.
d) Means shall be provided to prevent liquids trapped in the interceptor from entering the vacuum pump.
e) Interceptor(s) shall have automatic drainage facilities.
f) It shall be possible to inspect and clean the inside of the interceptor(s).
g) The effective volume of the interceptor(s) shall be given in the user's manual and should be adequate to facilitate washing of the airlines (as determined by airline sizes).

5.8 Sanitary trap

a) A sanitary trap shall be fitted between the milk system and the vacuum system in pipeline and recorder milking machines.
b) The sanitary trap shall be located between the receiver vessel and the vacuum system, except where the vacuum and pulsation systems form part of the routine circulation cleaning and disinfection system.
c) The sanitary trap shall have provision for drainage and means to minimize liquid entry into the vacuum system.
d) Effective volume of the sanitary trap shall be stated in the User's Manual.
e) It shall be possible for the operator to detect the presence of milk and/or cleaning solutions in the sanitary trap when the machine is running.
f) It is an advantage if the sanitary trap is visible to the operator during milking.
g) Where there is no provision for circulation cleaning of the sanitary trap(s), the receiver(s) and the receiver airline, this line shall be designed to drain towards the sanitary trap.

5.9 Leakage into the vacuum system

a) Leakage into the vacuum system shall not exceed 5 % of the vacuum pump capacity at the working vacuum and for capacity-controlled vacuum pumps at the pump's maximum capacity.

5.10. Additional IMQCS recommendation for sanitary trap(s)

a) The sanitary trap shall be fitted with a automatic cut-off valve.

PULSATION SYSTEMS

6. PULSATION SYSTEMS

6.1 Design data that shall be included in the User's Manual:

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 ± 5% of the nominal pulsation rate.
c) The temperature range over which the pulsators can be operated and the variation of pulsation rate within this range.
d) Typical pulsation chamber vacuum records for a defined milking unit.
d) Total air use with a defined milking unit connected under specified operating conditions.
e) Deliberate variations in pulsation rate and pulsator ratio, e.g., in conjunction with stimulation and changes in milkflow.

6.2 Pulsator airline

a) Vacuum drop between working vacuum (Vm) and maximum pulsation chamber vacuum shall be no more than 2 kPa.

6.3 Pulsation rate, pulsator ratio and pulsation chamber vacuum phases

a) The pulsation rate shall not deviate more than ± 5 % from intended values given in the User's Manual. Note: Pulsation rate is typically between 50 cycles/min and 65 cycles/min for cows.
b) The pulsator ratio shall not differ more than ± 5 units of percentage from the values given in the User's Manual.
c) The pulsator ratios shall not vary from each other by more than 5 units of percentage.

d) Limping shall not be more than 5 units of percentage except where the milking unit is designed to provide different ratios between the fore- and hindquarters.
e) Phase b shall be not less than 30 % of a pulsation cycle and phase d shall be not less than 150ms.
f) Vacuum drop during Phase b shall not be more than 4 kPa below maximum pulsation chamber vacuum.
g) Vacuum during Phase d shall not be more than 4 kPa.

6.4 Additional IMQCS recommendations for pulsation systems

a) Simultaneous or alternate pulsation patterns are acceptable.
b) Pulsation relays shall be de-synchronized to reduce the amplitude of vacuum fluctuations within the pulsation airlines.
c) Long pulse tubes shall have a minimum bore of 9.5 mm for simultaneous pulsation or 7 mm for alternate pulsation.
d) Pulsation relays and pulsators should be capable of being washed through the long pulse tubes.
e) A breather airline shall be fitted. Clean air may be sourced inside or outside the milking parlour. If clean air is sourced inside the milking parlour a filter shall be fitted to the manufacturer's specification. If clean air is sourced outside the milking parlour the breather airline shall have end pieces angled downwards and meshed.
f) The fitting of breather airlines shall not alter the pulsation performance.
g) The pulsation air consumption should typically be within the range of 25-35 litres per minute per unit and shall not exceed 45 litres per minute per unit.
h) The pulsation "a phase" shall be less than 22%.

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MILK SYSTEM

7 MILK SYSTEM

7.1 General

a) It shall be possible to inspect the inside of the milk system for cleanliness.
b) Any air that is deliberately admitted into the milk system shall be stated in installation instructions.

7.2 Design of milklines

a) Vacuum drop between the receiver and any point in the milkline shall not exceed 2 kPa with all units operating at the designed milkflow and airflow.
b) Diameter and slope shown in Table 1 for a mid-level plant are based on milkflow per cow of 5kg/min, 100 l/min transient airflow per slope and 1.5% slope.
c) If installed in a loop, each end shall have a separate full-bore connection to the receiver. If several loops, two ends may be grouped together directly in front of the receiver to form a single line with adequate cross-sectional area for the combined designed milkflow and airflow.
d) Milklines shall have a continuous fall towards the receiver for drainage.
e) Equipment that can cause an obstruction or a reduction in vacuum, milkflow or drainage, such as enlargements, restrictions or filters, shall not be used.
f) Minimum centre-line radius for bends shall be 1.5 times the diameter.
g) Milklines should be installed to minimize the milk lift and preferably no more than 2 m above the animal standing level.

7.3 Additional IMQCS recommendations for milklines

a) Milklines and milk diversion lines shall have a slope towards the receiver vessel of 1% or greater.
b) The highest point of the long milk tube should ideally not be greater than 2.1m above the cow standing and preferably 1.7m or less.
c) All saddle type "nipples" shall have a protrusion into the milkline to prevent poor alignment with the hole in the milkline due to rotation of the saddle. This protrusion shall not protrude more than 0.8 mm past the inner surface of the milkline.
d) Rubber joints or bends may not be used in milklines; plastic or stainless steel unionized cone seal connections are acceptable.
e) All bends in milkines shall be stainless steel with a centreline radius not less than 1.5 times the diameter.
f) All milklines shall have a stainless steel end entry "nipple" or a side entry "nipple" no more than 30 mm from the blank capped end. In either case, the end of the milkline should be capable of being inspected, i.e., a removable end piece on the milkline. This does not preclude this use of valving systems at the end of milklines to facilitate washing.
g) Where "nipples" are welded on to a milkline, the inside of the weld shall be flared and suitably dressed.

h) The stainless steel shall be cut at 90° at all milking joints; this necessitates using mechanical cutting equipment.
i) For mid-level parlours curved (swan neck) entries are preferred to straight entries for milklines when swing over arms, milk meters and/or ACRs are not used.
j) Stainless steel of 0.9mm (gauge 20) wall thickness or greater and quality "Standard 304 Dairy Tubing" shall be used in milklines.
k) Provision shall be made for the inspection of the inside of milklines.
l) The vertically dropping section (into the receiver) of the milkline shall be less than 300 mm.
m) Air injection or other appropriate washing systems shall be used with milkline greater than 48.5 mm in bore.
n) The highest point of each long milk tube (at each unit) before entering milklines and milk diversion lines shall be equal except where valving systems are used to control the flow of wash solution between the lines.
o) Milk entries shall be in the top third of the milk pipeline in pipeline milking plants.

7.4 Additional IMQCS recommendations for washlines in milkline plants

a) Washlines shall be of adequate bore as shown in Tables 1-5, as appropriate.
b) All saddle type "nipples" shall have a protrusion into the washline to prevent poor alignment with the hole in the washline due to rotation of the saddle. This protrusion shall not protrude more than 0.8 mm past the inner surface of the washline.
c) Rubber joints or bends may not be used in washlines; plastic or stainless steel unionised cone seal connections are acceptable. All bends in washlines should be stainless steel, with a centreline radius not less than 1.5 times the diameter.
d) All washlines shall have a stainless steel end entry "nipple" or a side entry "nipple" no more than 30 mm from the blank capped end. In either case, the end of the washline should be capable of being inspected, i.e., a removable end piece on the washline. This does not preclude the use of valving systems at the end of washlines to facilitate washing.
e) The stainless steel shall be cut at 90° at all washline joints; this necessitates using mechanical cutting equipment.
f) Washline entries shall be into the top or top-third of the pipeline.
g) Stainless steel of 0.9mm (gauge 20) wall thickness or greater and quality "Standard 304 Dairy tubing" shall be used in washlines. This does not preclude the use of inspection windows in washlines.
h) When closed circulation is required for plants with diaphragm pumps, a method for the safe connection of the suck-up tube to the return tubes shall be provided.
i) A suitable mechanism should be installed for the safe uptake and return of detergent solutions to avoid accidental splashing of chemicals.

7.5 Additional IMQCS recommendations for milk transfer lines in recording jar plants

a) All saddle type "nipples" shall have a protrusion into the milk transfer lines to prevent poor alignment with the hole in the milk transfer line due to rotation of the saddle. This protrusion shall not protrude more than 0.8 mm past the inner surface of the milk transfer line.
b) Rubber joints or bends may not be used in milk transfer lines; plastic or stainless steel unionized cone seal connections are acceptable. All bends in milk transfer lines should be stainless steel with a centreline radius not less than 1.5 times the diameter.
c) All milk transfer lines shall have a stainless steel end entry "nipple" or a side entry "nipple" no more than 30 from the blank capped end. In either case, the end of the milk transfer line should be capable of being inspected, i.e. a removable end piece on the milk transfer line. This does not preclude the use of valving systems at the end of milk transfer lines to facilitate washing.
d) The stainless steel shall be cut at 90° at all milk transfer line joints; this necessitates using mechanical cutting equipment.
e) Stainless steel of 0.9mm (gauge 20) wall thickness or greater and quality "Standard 304 Dairy Tubing" shall be used in milk transfer lines.
f) Provision shall be made for the inspection of the inside of milk transfer lines.
g) The milk transfer line should not be higher than two thirds of the height of the recording jar when it is intended to "milk though the jars".
h) Milk transfer line slopes shall be 1% or greater.

7.6 Additional IMQCS recommendations for milking vacuum/wash lines in recording jar plants

a) All saddle type "nipples" shall have a protrusion into the milking vacuum/wash lines to prevent poor alignment with the hole in the milking vacuum/wash line due to rotation of the saddle. This protrusion shall not protrude more than 0.8 mm past the inner surface of milking vacuum/wash line.
b) Rubber joints or bends may not be used in milking vacuum/wash lines; plastic or stainless steel unionised cone seal connections are acceptable. All bends in milking vacuum/wash lines should be stainless steel with a centreline radius not less than 1.5 times the diameter.
c) All milking vacuum/wash lines shall have a stainless steel end entry "nipple" or a side entry "nipple" no more than 30 mm from the blank capped end. In either case, the end of the milking vacuum/wash line should be capable of being inspected, i.e., a removable end piece on the milking vacuum/wash line. This does not preclude the use of valving systems at the end of milking vacuum/wash lines to facilitate washing.
d) Where "nipples" are welded on to a milk transfer line, the inside of the weld shall be flared and suitably dressed.
e) Three-way valves shall be full-bore stainless steel or other suitable food grade material.

f) Three-way or equivalent valves shall be easily accessible.
g) The vacuum supply to the milking vacuum/wash line may come from the sanitary trap, receiver or receiver airlines.
h) The milking vacuum/wash line shall slope towards the 3-way valve (or equivalent) for drainage purposes.

7.7 Additional IMQCS recommendations for milk recording equipment

a) The highest point of the long milk tube should ideally not be greater than 2.1m above the cow standing and preferably 1.7m or less. .
b) Recording jars shall be rigidly fixed in a vertical position consistent with accurate measurement of milk volume.
c) Recording jars shall be graduated to allow milk recording in units of 0.5 kg from 2 kg upwards.
d) Recording jars shall be fitted with a spreader device to distribute the wash over the jar surface without excessively restricting airflow.
e) The milking vacuum/wash line “nipple” on the recording jar shall have a minimum bore of 16mm.
f) The milking vacuum/wash tube connected to recording jars shall have a minimum bore of 15mm.
g) A facility shall be provided for agitating the milk, removing a sample and draining the recording jar contents.
h) The exit “nipple” bore at the base of the recording jar and the transfer tubes bore shall be at least 18mm.
i) All milk meters shall be International Committee for Animal Recording (ICAR) approved.

7.8 Air leakage: Air leakage shall not exceed 10 l/min, plus 2 l/min for each milking unit.

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

7.10 Milk inlets: Shall be fitted to the upper half of a pipeline.

7.11 Diversion of milk:

a) There shall be provisions to ensure that withheld, abnormal or undesirable milk cannot be mixed with normal milk.

7.12 Receiver

a) Receiver shall have sufficient volume to accommodate slugs of liquid which may be formed during milking and cleaning and the volume shall be stated in the installation instructions.
b) Inlet(s) should be shaped to limit formation of foam during milking.

7.13 Releaser

7.13.1 General

a) Releaser shall be adequate to deal with the maximum flow at which milk, cleaning and disinfecting fluids flow through the system.
b) The releaser milk pump's discharge flow at 50 kPa working vacuum and typical discharge pressures shall be stated in the instructions for installation.
c) There shall be no air leaks in the releaser or between the receiver and the releaser.
d) Back-flow of milk from the releaser shall be prevented.

7.13.2 Control of releaser milk pumps

a) Milk pump operation shall be controlled by the quantity of milk in the receiver so that flooding of the receiver or mixing of air and milk is avoided.

7.14 Delivery line

a) Means shall be provided at every low point to permit drainage of the delivery line, filters and any in-line cooling equipment.
b) If compressed air is used to purge milk, this air shall be free from contaminants.
c) The method of air injection should prevent unnecessary formation of free fatty acids.
d) Means (preferably automatic) shall be provided to stop flow of coolant in in-line cooling equipment during the wash cycle.
e) If a restriction needs to be fitted in the delivery line to reduce milkflow to that suitable for an in-line cooler or where an in-line cooler restricts flow below that needed for cleaning and disinfection, means shall be provided to open or bypass the restriction during the washing cycle.

MILKING UNIT

8 MILKING UNIT

8.1 General

Milk contact surfaces shall be accessible for convenient visual inspection.

8.2 Teatcup

a) Shell and liner shall be marked to identify manufacturer and type.
b) Liner and shell combination shall be provided with a means of indicating if the liner is twisted or a means of preventing the liner from twisting in the shell.
c) The internal dimensions of the shell shall not restrict the operation of the liner.
d) User's Manual shall include air use caused by a teatcup fall-off or cluster fall-off and sufficient data to be able to choose the liner for a herd.

8.3 Additional IMQCS recommendations for milking clusters

a) The effective volume of each claw shall not be less than 150 ml.
b) Where an air admission hole is present in the claw, it shall allow a constant 6 – 12 l/min air admission and the air bleed shall be located above the normal level of milk in the claw.
c) Claw entry “nipples” shall be designed to allow short milk tubes to be sealed during cluster attachment.
d) Claw milk exit “nipples” shall be at least 12.5 mm in bore.
e) Claws may be designed for simultaneous or alternate pulsation. Double or single pulse tube claw spigots shall be installed for alternate or simultaneous pulsation, respectively. The use of Y pieces to convert alternate claws to simultaneous is not allowed.
f) Shells shall have pulse “nipples” fitted at the short milk tube end and shall have clear identification marks.
g) Only Moorepark recommended liners should be fitted. Liners/clusters with independent data on milking characteristics including slip data shall be acceptable.
h) All liners shall have a brand name, an identification number and alignment indicators.
i) Only liners recommended by the manufacturer for the specific installation shall be fitted.

8.4 Teatcup attachment: Means shall be provided to limit the airflow through the cluster or teatcup until attachment.

8.5 Teatcup removal

a) Means shall be provided of shutting off the vacuum to the liner before teatcup removal.
b) If vacuum is reduced only as a result of the air vent(s), the leakage of the claw shut-off shall be less than 2 l/min for a claw and less than a quarter of the air vent admission for individual teatcups.

c) Teatcup removal shall be initiated by one of the following:
   i) If milkflow is not present after a specified time.
   ii) When the milkflow has ceased or has gone below a specified flow.
   iii) When a specified total machine-on time has elapsed.
   iv) By human intervention.
d) This initiation together with the limits shall be described in the User's Manual.

8.6 Vacuum shut-off: It shall be possible to shut off vacuum to the liner when not milking.

8.7 Air vent and leakage

a) Total air admission per cluster shall be at least 4 l/min and shall not exceed 12 l/min for cows at the nominal working vacuum.
b) Air vent(s) shall be made of a rigid material.
c) Where there is a risk of slugs in the short milk tube at designed milkflow, means shall be applied to avoid them.
d) The above quantitative requirements do not apply to quarter milking, or clusters with deliberate cyclic air admission or other specific designs. In such cases, the total air admission per cluster or teat cup shall be stated in the User's Manual.
e) Air vents necessary for proper operation of milk meters, automatic teatcup valves or other devices may add air admission. This air use and location shall be stated in the User's Manual.
f) Leakage into each cluster assembly with the liners and air vent(s) plugged and the vacuum shut-off valve opened shall not exceed 2 l/min.
g) Air vents should be positioned to avoid unnecessary turbulence in the milk.

8.8 Vacuum in the milking unit

a) User's Manual shall state, for specified milkflows:
   i) The desired average liner vacuum and/or the desired average liner vacuum during phase b and phase d of the pulsation chamber vacuum record.
   ii) The corresponding nominal vacuum in the milkline based on the average vacuum drop.

Note: Both research and field experience indicate that a mean liner vacuum within the range 32 kPa - 42 kPa during the peak flow period of milking for cows ensures that most cows will be milked quickly, gently and completely.

b) The effect on the milking vacuum conditions shall be stated in the User's Manual. For non-standard devices not originally fitted to a milking unit between the cluster and the milkline or milking vacuum line.

8.9 Milk recording equipment

8.9.1 General: Milk recording equipment shall comply with the requirements given in 8.10. The requirements for official yield recording are stated by the International Committee for Animal Recording (ICAR).

8.9.2 Recorder jars shall comply with the following requirements:

a) Effective volume shall be stated in the User's Manual.
b) Internal diameter of the outlet shall be not less than 18 mm for cows.
c) Connections should be placed to minimize the risk of carry-over of milk or froth into the vacuum system.
d) Recorder jars should have means of ensuring even distribution of cleaning and disinfecting fluids over the internal surface during washing without adversely affecting the vacuum in the recorder jar during milking.

8.10 Attachments to the milking unit

a) Devices, including additional necessary connecting tubes, fitted between the cluster or teatcup and the milkline or milking vacuum line, shall not cause any additional vacuum drop greater than 5 kPa at a milkflow of 5 kg/min for cows compared with the same milking unit without those devices.

8.11 Long milk tubes

a) Means shall be provided to minimise the risk of flattening.
b) Where milk is lifted by means of airflow, the maximum internal diameter of the long milk tube shall be:
   i) 16 mm for cows
   ii) Where long milk tubes are attached to single teatcups it is advisable to use tubes with a smaller diameter
c) The length and the internal diameter of long milk tubes shall be specified in the user's manual with the airflow at the end of the long milk tube measured in accordance with ISO 6690.
d) The long milk tubes shall be short as is practicable.

CLEANING

9 CLEANING

a) The cleaning system shall be designed and installed so that cleaning and disinfecting solutions cannot enter the milk.
b) Methods of verifying that the cleaning system is operating properly, and any components that shall be manually disassembled or hand cleaned shall be specified in the User's Manual.
   The success of a circulation cleaning system depends on: design and installation ensuring adequate circulation volume, velocity and contact time of cleaning solutions; temperature and concentration appropriate to the type of cleaning and sanitizing solutions used.
c) A velocity range of 7 m/s to 10 m/s is preferred for the cleaning of pipelines containing liquid-slugs. It is expected that any cleaning procedure will:
   i) Leave milk contact surfaces visibly free from milk residues and other deposits.
   ii) Leave surfaces free from undesirable residues of cleaning and disinfecting chemicals.
   iii) Reduce the count of viable bacteria to an acceptable level on milk contact surfaces.

Cleaning

9.1 Additional IMQCS recommendations for milk pumps and milk filters

a) Milk pumps shall have adequate output for milking and washing.
b) Drain valves shall be fitted to allow routine drainage of milk pumps.
c) All milk pumps shall be operated intermittently by milk level or weight.
d) An inline milk filter shall be fitted in all milking installations.
e) Where a plate cooler is fitted, the milk filter shall be fitted between the milk pump and the plate cooler.
f) The milk filter assembly shall be adequately sized to suit to the flow rate of the milk pump.
g) Only stainless steel or other food grade material shall be used in milk filter assemblies.
h) Inline filters shall be mounted vertically with the drain/cap at the base.

VACUUM SYSTEM - MILKING MACHINE INSTALLATIONS - MECHANICAL TESTS (ISO 6690)

10. VACUUM SYSTEM - MILKING MACHINE INSTALLATIONS-MECHANICAL TESTS (ISO 6690)

10.1 General requirements and preparation.

10.1.1 General

a) To keep the plant in good condition, periodic checking is recommended. If the effective reserve has not changed it is not necessary to carry out further tests on the vacuum regulator or pump capacity tests.

10.1.2 Preparation before testing

a) Start the vacuum pump and put the milking machine into the milking position with all milking units connected. Teatcup plugs shall be in the milking position. All vacuum-operated equipment associated with the installation shall be connected including those not operating during milking. Allow the vacuum pump to run for at least 15 minutes before taking any measurements.

10.2 Vacuum regulation

10.2.1 Test of vacuum regulation deviation

With the milking machine running in accordance with 10.1.2, record the working vacuum at the receiver and compare it with the nominal vacuum.

10.2.2 Regulation sensitivity

10.2.2.1 With the milking machine operating in accordance with 10.1.2 with liners plugged, connect a vacuum meter to the connection point Vm.

10.2.2.2 Record the vacuum as the working vacuum for the milking machine.

10.2.2.3 Shut off all milking units and record the vacuum. The milking machine shall then be in the same state as during milking but with no milking unit in operation.

10.2.2.4 Calculate the regulation sensitivity as the difference between the vacuum measured with no milking units in operation (10.2.2.3) and that with all units operating (10.2.2.2).

10.2.3 Regulation loss

10.2.3.1 With the milking machine operating in accordance with 10.1.2 with liners plugged, connect the airflow meter with a full-bore connection to connection point A1 with the airflow meter closed. Connect a vacuum meter to the connection point Vm.

10.2.3.2 Record the vacuum as the working vacuum for the milking machine.

10.2.3.3 Open the airflow meter until the vacuum decreases by 2kPa and record the airflow.

10.2.3.4 Stop any airflow through regulators that admit air.

10.2.3.5 Decrease the vacuum by opening the airflow meter to drop the vacuum 2 kPa.

10.2.3.6 Calculate the regulation loss as the difference between the airflows recorded in 10.2.3.5 and 10.2.3.3

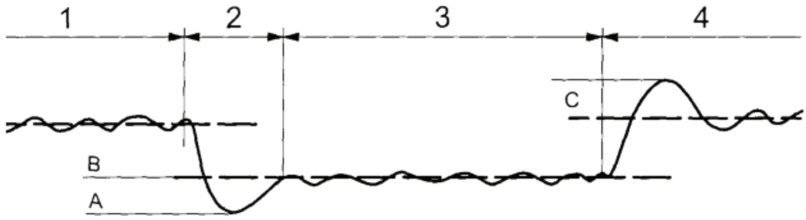


Figure 2: Regulation undershoot, vacuum drop and regulation overshoot for rapid changes in air admission

Key		
	A undershoot	1 Phase 1: no teatcup open
	B vacuum drop	2 Phase 2: teatcup(s) are open
	C overshoot	3 Phase 3: teatcup(s) open 4 Phase 4: teatcup(s) are closed

10.2.4 Tests of regulation characteristics

10.2.4.1 The regulation characteristics are preferably tested in the fall-off and attachment tests.
Milking unit with automatic shut-off valve:
a) Use one cluster with shut-off valve enabled (fall-off test)
b) Use one teatcup, with the shut-off valve in attachment position (attachment test).
c) Figure 2-Regulation undershoot, vacuum drop and regulation overshoot for rapid changes in air admission

10.2.4.2 With the milking machine operating with liners plugged connect a vacuum recorder to measuring point Vm.

10.2.4.3 Record the vacuum for 5 s to 15 s: Phase 1 of Figure 2.

10.2.4.4 While recording, open one teatcup or one cluster and record for 5 s to 15 s after the vacuum has stabilized: Phases 2 and 3 of Figure 2. If there are 32 or more clusters or teatcups (for quarter milking) are connected, open one cluster or teatcup per every 32 clusters.

10.2.4.5 While recording, close the teatcup or cluster and record for 5 s to 15 s after the vacuum has stabilised: Phase 4 of Figure 2.

10.2.4.6 Calculate the average vacuum during 5 s of Phase 1.

10.2.4.7 Find the minimum vacuum of Phase 2.

10.2.4.8 Calculate the average vacuum during 5 s of the stable part of Phase 3.

10.2.4.9 Find the maximum vacuum of Phase 4.

10.2.4.10 Calculate the average vacuum during 5 s of the stable part of Phase 4.

10.2.4.11 Calculate the fall-off vacuum drop or the attachment vacuum drop (B in Figure 2) as the average vacuum (Phase 1) minus the average vacuum in 10.2.4.8 (Phase 3).

10.2.4.12 Calculate the regulation undershoot (A in Figure 2) as the average in 10.2.4.8 (Phase 3) minus the minimum vacuum in 10.2.4.7 (Phase 2).

10.2.4.13 Calculate the regulation overshoot (C in Figure 2) as the maximum in 10.2.4.9 (Phase 4) minus the average vacuum in 10.2.4.10 (Phase 4).

10.2.5 Effective reserve for milking

10.2.5.1 With the milking machine operating in accordance with 10.1.2, connect the airflow meter with a full-bore connection to connection point A1 with the airflow meter closed. Connect a vacuum meter to the connection point Vm.

10.2.5.2 Record the vacuum as the working vacuum for the milking machine.

10.2.5.3 Open the airflow meter until the vacuum decreases by 2kPa from the value in 10.2.5.2.

10.2.5.4 Record the airflow through the airflow meter.

10.3 Vacuum pumps

10.3.1 Vacuum pump capacity

10.3.1.1 With the machine operating in accordance with 10.1.2 record the vacuum at the vacuum pump measuring connection Vp as the working vacuum from the pump.

10.3.1.2 Isolate the vacuum pump from all other parts of the installation. Connect the airflow meter directly to the vacuum with a full-bore connection.

10.3.1.3 Record the airflow meter reading at the same vacuum as recorded in 10.3.1.1as the pump capacity at the working vacuum.

10.3.2 Vacuum pump exhaust back pressure.

10.3.2.1 With the vacuum pump operating in accordance with 10.3.1.1, measure and record the exhaust back pressure at the connection point Pe.

10.4 Vacuum regulator leakage

10.4.1 With the milking machine operating in accordance with 10.1.2, connect the airflow meter with a full-bore connection to connection point A1 with no airflow through it. A vacuum meter shall be connected to connection point Vr.

10.4.2 Record the vacuum as the regulator working vacuum.

10.4.3 Decrease the vacuum by 2 kPa by opening the airflow meter and record the airflow.

10.4.4 Stop the airflow through regulator(s).

10.4.5 Open the airflow meter and decrease the vacuum to the same as in 10.4.3 and record the airflow.

10.4.6 Calculate the regulator leakage as the difference between the airflow recorded in 10.4.5 and that in 10.4.3.

10.5 Vacuum gauge error

10.5.1 With the milking machine and vacuum regulator operating, but with no milking unit operating, and the test vacuum meter connected to connection point Vr, record the values on the vacuum gauge of the plant and the test vacuum meter.

10.5.2 Record the difference between these two values as the error of the gauge.

10.6 Vacuum drop in airline

10.6.1 With the milking machine operating in accordance with 10.1.2, connect the airflow meter with a full-bore connection to point A1 with no airflow through it. A vacuum meter shall be connected to point Vm. Record the vacuum as the working vacuum for the milking machine.

10.6.2 Open the airflow meter until the vacuum at Vm decreases by 2kPa and record the working vacuum.

10.6.3 Move the vacuum meter to regulator connection point Vr and record the working vacuum.

10.6.4 Calculate the vacuum drop between Vm and Vr as the difference between the vacuum recorded in 10.6.2 at Vm, and that recorded in 10.6.3 at Vr, with the same airflow in both cases.

10.6.5 Move the vacuum meter to vacuum pump connection point Vp and record the working vacuum.

10.6.6 Calculate the vacuum drop between Vm and Vp as the difference between the vacuum recorded in 10.6.2 at Vm, and that recorded in 10.6.5, at Vp, with the same airflow in both cases.

10.7 Leakage in vacuum system

10.7.1 With the milking machine operating in accordance with 10.1.2 with all units plugged connect the airflow meter with a full-bore connection to point A2 with no airflow through it. Connect a vacuum meter to point Vr or Vp.

10.7.2 Record the vacuum as the regulator or vacuum pump working vacuum.

10.7.3 Isolate the vacuum system from the milk system. Stop the airflow through the vacuum regulator.

10.7.4 Adjust the airflow meter until the vacuum is the same as that recorded in 10.7.2. Record the working vacuum at the vacuum pump connection point Vp.

10.7.5 Isolate the vacuum pump from the rest of the vacuum system. Connect the airflow meter directly to vacuum pump with a full-bore connection.

10.7.6 Open the airflow meter until the working vacuum at the vacuum pump becomes the same as recorded in 10.7.4 Calculate the vacuum system leakage as the difference between the airflow recorded with the vacuum system disconnected (10.7.6) and the airflow with the vacuum system connected (10.7.4).

PULSATION SYSTEM

11. Pulsation system

11.1 Pulsation rate, pulsator ratio, pulsation vacuum phases and vacuum drop in pulsator airline.

11.1.1 With the milking machine operating in accordance with 10.1.2 let the pulsator(s) run for at least 3 minutes and measure working vacuum at Vm.

11.1.2 Connect the pulsation analyzer to the pulse tube. Record five pulsation chamber cycles and analyze the results to determine the maximum pulsation chamber vacuum, the average pulsation rate, the average pulsator ratio and the average duration of phases a, b, c, and d. These values shall be obtained for every pulsator and the average limping shall be calculated. Phase b shall be checked to ensure that the vacuum is not less than the maximum pulsation chamber vacuum minus 4 kPa. Phase d shall be checked to ensure that the vacuum never exceeds 4 kPa.

11.1.3 Calculate vacuum drop in the pulsator airline as the difference between the vacuum recorded in 11.1.1 and the lowest value of maximum pulsation chamber vacuum as derived in 11.1.2.

MILKING SYSTEM

12. MILK SYSTEM

12.1 Slope of milkline

12.1.1 Calculate the minimum slope of each branch between the receiver and the most distant milk inlet from the receiver. The minimum slope shall be given for a 5 m section of each branch. Find the average slope over a series of 5m distances along the milkline, and choose the lowest value to present the minimum slope of the branch. Slope shall be given in mm/m with a positive value meaning falling towards the receiver.

Milk System

12.2 Milk system leakage

12.2.1 With the milking machine operating in accordance with 10.1 2, connect the airflow meter with a full-bore connection to connection point A2 with no airflow through it. Connect vacuum meter to connection point Vr or Vp.

12.2.2 Record the vacuum as the regulator or vacuum pump working vacuum.

12.2.3 Stop the airflow through the vacuum regulator. Stop or isolate the pulsators and all vacuum operated equipment. Plug all air admissions.

12.2.4 Adjust the airflow meter until the vacuum is the same as the vacuum recorded in 12.2.2. Record the airflow.

12.2.5 Isolate the milk system.

12.2.6 Open the airflow meter until the vacuum becomes the same as recorded in 12.2.2.

12.2.7 Calculate the milk system leakage as the difference between the airflows 12.2.6 and 12.2.4.

MILKING UNIT

13. MILKING UNIT

13.1 Teatcup or cluster fall-off air inlet.

13.1.1 With the milking machine operating without the vacuum regulator, and airflow meter connected to point A1 with a full-bore connection and a vacuum meter connected to point Vm, adjust the airflow meter until the vacuum is 50 kPa.

13.1.2 Open one teatcup or one cluster with the shut-off valve open and adjust the airflow meter until the vacuum is the same as 13.1.1.

13.1.3 The cluster or teatcup consumption is the difference in airflow.

13.2 Leakage through shut-off valves of milking units

13.2.1 Connect a flowmeter between the long milk tube and the cluster or teatcup under test.

13.2.2 With the shut-off valve in take-off position, measure the airflow and record this value as the leakage through the shut-off valve.

13.3 Air vent and leakage into teatcup or cluster

13.3.1 Connect a flowmeter between the long milk tube and the claw or teatcup under test.

13.3.2 Connect the flowmeter to the vacuum system (milkline or airline) and record the working vacuum for the milking machine.

13.3.3 Plug the teatcup(s) and open any cluster shut-off valve.

13.3.4 Record the airflow through the flowmeter as the total air admission.

13.3.5 Close the air vent and record the airflow through the flowmeter as the air leakage.

13.3.6 Calculate the difference between the airflows as the air vent admission.

13.4 Measuring the vacuum in the cluster (Appendix C)

13.4.1 Record the vacuum in the milkline, at the teat end and in the pulsation chamber with the specified liquid flows equally divided between all teatcups of the cluster.

13.4.2 Calculate the working vacuum in the milkline, the average teat end vacuum and, during Phases b and d, the average teat end vacuum.

13.5 Measurement of the vacuum drop from accessories attached in the long milk tube

13.5.1 The effect of milk meters or accessories inserted in the long milk tube shall be registered by measuring the average liner vacuum in a specified milking unit both with and without the accessories connected, and by comparing the results. Details of the measurement procedure are given in Appendix C.

13.6 Airflow at the end of the long milk tube

13.6.1 Check the length and internal diameter of the long milk tube.

13.6.2 With the milking machine operating with all units plugged connect a vacuum meter to the connection point Vm. Record the vacuum as the working vacuum for the milking machine.

13.6.3 Connect the airflow meter and a vacuum meter to the end of the long milk tube instead of the claw or teatcup.

13.6.4 Record the vacuum at the end of the long milk tube with the airflow meter closed and with an air inlet of 10 l/min.

13.6.5 Open the airflow meter until the vacuum at the end of the long milk tube is 5 kPa lower than the vacuum measured above.

13.6.6 Record the reading of the airflow meter as the airflow at the end of the long milk tube.

TABLES

Table 1: Midi-level milkline plants with 2 stalls/unit

No. Units	Milkline Bore (mm)	Effective Reserve for Washing (l/min)	Effective Reserve for Milking (l/min)	Sanitary Trap E. Volume (l)	Wash Line Bore (mm) Minimum	Main Airline Bore (mm)	Estimated Pump Capacity (l/min)
4	48.5	443	320	10	38	48.5	771
6	60	678	380	10	38	48.5	1155
8	60	678	440	10	38	60	1290
10	60	678	500	10	48.5	60	1426
12	73	1004	520	10	48.5	60	1899
14	73	1004	540	20	48.5	60	2029
16	73	1004	560	20	48.5	60	2160
18	73	1004	580	20	48.5	73	2291
20	73	1004	600	20	48.5	73	2422
22	73	1004	620	20	48.5	73	2553
24	73	1004	640	20	60	73	2683
26	98	1809	660	20	60	73	3662
28	98	1809	680	20	60	73	3793
30	98	1809	700	20	60	98	3924
32	98	1809	720	20	60	98	4055
34	98	1809	740	20	60	98	4185
36	98	1809	760	20	60	98	4316
38	98	1809	780	20	60	98	4447
40	98	1809	800	20	60	98	4578

The pump capacity is an informative value only and incorporates a large safety factor, the adequacy of a vacuum pump should be determined by verifying the system meets the effective reserve requirements.

Note: The above table shows reserves for milking and cleaning. The "cleaning reserve" or air demand for cleaning may be reduced where cleaning by air injection is not used or where the air cleaning system does not use the assumed demand.

In the ISO standards and IMQCS recommendations it is only necessary for the machine to either meet the reserve requirement during milking or pass the attachment and fall off tests. If energy saving technologies are used which can reduce the effective reserve (e.g., variable speed vacuum pumps) then the plant should pass the attachment and fall off tests.

For number of units ≤10 effective reserve = 20 + 30 N
For number of units >10 effective reserve = 50 + 10 (N-10)
N = Number of units

Table 2: Midi-level recording jar plants with 2 stalls/unit

No. Units	*Milkline Bore (mm)*	*Effective Reserve for Washing (l/min)*	*Effective Reserve for Milking (l/min)*	*Sanitary Trap E. Volume (l)*	*Wash Line Bore (mm) Minimum*	*Main Airline Bore (mm)*	*Estimated Pump Capacity (l/min)*
4	38	272	320	10	38	48.5	789
6	48.5	443	380	10	38	48.5	1128
8	48.5	443	440	10	38	60	1337
10	48.5	443	500	10	48.5	60	1606
12	48.5	443	520	10	48.5	60	1831
14	48.5	443	540	20	48.5	60	2057
16	48.5	443	560	20	60	60	2282
18	60	678	580	20	60	73	2612
20	60	678	600	20	60	73	2816
22	60	678	620	20	60	73	3021
24	60	678	640	20	73	73	3225
26	73	1004	660	20	73	73	3772
28	73	1004	680	20	73	98	3976
30	73	1004	700	20	73	98	4181
32	73	1004	720	20	73	98	4385
34	73	1004	740	20	73	98	4590
36	73	1004	760	20	73	98	4794
38	73	1004	780	20	73	98	4999
40	73	1004	800	20	73	98	5203

The pump capacity is an informative value only and incorporates a large safety factor, the adequacy of a vacuum pump should be determined by verifying the system meets the effective reserve requirements.

Note: The above table shows reserves for milking and cleaning. The "cleaning reserve" or air demand for cleaning may be reduced where cleaning by air injection is not used or where the air cleaning system does not use the assumed demand.

In the ISO standards and IMQCS recommendations it is only necessary for the machine to either meet the reserve requirement during milking or pass the attachment and fall off tests. If energy saving technologies are used which can reduce the effective reserve (e.g., variable speed vacuum pumps) then the plant should pass the attachment and fall off tests.

Table 3 : Double up low level milkline plants with 1 stall/unit

No. Units	Milkline Bore (mm)	Effective Reserve for Washing (l/min)	Effective Reserve for Milking (l/min)	Sanitary Trap E. Volume (l)	Wash Line Bore (mm) Minimum	Main Airline Bore (mm)	Estimated Pump Capacity (l/min)
4	48.5	532	440	10	38	48.5	1136
6	60	814	520	10	38	60	1699
8	60	814	560	10	38	60	1960
10	60	814	600	20	38	60	2222
12	73	1205	640	20	38	73	2895
14	73	1205	680	20	38	73	3156
16	73	1205	720	20	38	73	3418
18	73	1205	760	20	38	73	3679
20	73	1205	800	20	38	98	3941
22	73	1205	840	20	38	98	4202
24	73	1205	880	20	48.5	98	4464
26	98	2171	920	20	48.5	98	5743
28	98	2171	960	20	48.5	98	6005
30	98	2171	1000	20	48.5	98	6266
32	98	2171	1040	20	60	98	6528
34	98	2171	1080	20	60	98	6789
36	98	2171	1120	20	60	98	7051
38	98	2171	1160	20	60	98	7313
40	98	2171	1200	20	60	98	7574

The pump capacity is an informative value only and incorporates a large safety factor, the adequacy of a vacuum pump should be determined by verifying the system meets the effective reserve requirements.

Note: The above table shows reserves for milking and cleaning. The "cleaning reserve" or air demand for cleaning may be reduced where cleaning by air injection is not used or where the air cleaning system does not use the assumed demand.

In the ISO standards and IMQCS recommendations it is only necessary for the machine to either meet the reserve requirement during milking or pass the attachment and fall off tests. If energy saving technologies are used which can reduce the effective reserve (e.g., variable speed vacuum pumps) then the plant should pass the attachment and fall off tests.

Table 4 : Double up midi-level milkline plants with 1 stall/unit

No. Units	Milkline Bore (mm)	Effective Reserve for Washing (l/min)	Effective Reserve for Milking (l/min)	Sanitary Trap E. Volume (l)	Wash Line Bore (mm) Minimum	Main Airline Bore (mm)	Estimated Pump Capacity (l/min)
4	48.5	443	440	10	38	48.5	1042
6	60	678	520	10	38	60	1557
8	60	678	560	10	38	60	1818
10	60	678	600	20	38	60	2080
12	73	1004	640	20	38	73	2683
14	73	1004	680	20	38	73	2945
16	73	1004	720	20	38	73	3206
18	73	1004	760	20	38	73	3468
20	73	1004	800	20	38	73	3729
22	73	1004	840	20	38	98	3991
24	73	1004	880	20	48.5	98	4252
26	98	1809	920	20	48.5	98	5362
28	98	1809	960	20	48.5	98	5624
30	98	1809	1000	20	48.5	98	5885
32	98	1809	1040	20	60	98	6147
34	98	1809	1080	20	60	98	6408
36	98	1809	1120	20	60	98	6670
38	98	1809	1160	20	60	98	6931
40	98	1809	1200	20	60	98	7193

The pump capacity is an informative value only and incorporates a large safety factor, the adequacy of a vacuum pump should be determined by verifying the system meets the effective reserve requirements.

Note: The above table shows reserves for milking and cleaning. The "cleaning reserve" or air demand for cleaning may be reduced where cleaning by air injection is not used or where the air cleaning system does not use the assumed demand.

In the ISO standards and IMQCS recommendations it is only necessary for the machine to either meet the reserve requirement during milking or pass the attachment and fall off tests. If energy saving technologies are used which can reduce the effective reserve (e.g. variable speed vacuum pumps) then the plant should pass the attachment and fall off tests.

Table 5 : Double up midi-level recording jar plants with 1 stall/unit

No. Units	Milkline Bore (mm)	Effective Reserve for Washing (l/min)	Effective Reserve for Milking (l/min)	Sanitary Trap E. Volume (l)	Wash Line Bore (mm) Minimum	Main Airline Bore (mm)	Estimated Pump Capacity (l/min)
4	38	272	440	10	38	48.5	1039
6	38	272	520	10	38	60.0	1389
8	38	272	560	20	38	60.0	1693
10	38	272	600	20	48.5	60.0	1996
12	48.5	443	640	20	48.5	73.0	2300
14	48.5	443	680	20	48.5	73.0	2604
16	48.5	443	720	20	60	73.0	2907
18	48.5	443	760	20	60	73.0	3211
20	48.5	443	800	20	60	73.0	3515
22	48.5	443	840	20	60	73.0	3818
24	48.5	443	880	20	73	98.0	4122
26	60	678	920	20	73	98.0	4425
28	60	678	960	20	73	98.0	4729
30	60	678	1000	20	73	98.0	5033
32	60	678	1040	20	73	98.0	5336
34	60	678	1080	20	73	98.0	5640
36	60	678	1120	20	73	98.0	5944
38	60	678	1160	20	73	98.0	6247
40	60	678	1200	20	73	98.0	6551

The pump capacity is an informative value only and incorporates a large safety factor, the adequacy of a vacuum pump should be determined by verifying the system meets the effective reserve requirements.

Note: The above table shows reserves for milking and cleaning. The "cleaning reserve" or air demand for cleaning may be reduced where cleaning by air injection is not used or where the air cleaning system does not use the assumed demand.

In the ISO standards and IMQCS recommendations it is only necessary for the machine to either meet the reserve requirement during milking or pass the attachment and fall off tests. If energy saving technologies are used which can reduce the effective reserve (e.g. variable speed vacuum pumps) then the plant should pass the attachment and fall off tests.

Table 6 : Recommended sizes of diversion line

Peak flow 4kg/min

	Slope %		
Internal diameter (mm)	1.0	1.5	2.0
35	1	1	1
48.5	4	6	7
60	9	12	16
73	21	25	31
98	60	unlimited	unlimited

Peak flow 5kg/min

	Slope %		
Internal diameter (mm)	1.0	1.5	2.0
35	0	1	1
48.5	3	4	5
60	7	10	12
73	16	25	unlimited
98	43	unlimited	unlimited

Note: The tables above show the number of cows with an average peak milkflow of both 4kg/min and 5 kg/min. It is recommended that all main milklines are sized at 5kg/min as the average peak flow rate for new milking installations. It is preferable that diversion lines should be sized using the same criteria.

APPENDICES

Appendices

Appendix A : Measurement and Calculations

Table A1: Regulation characteristics

No.	Parameter	Air inlet in		Automatic shut-off valve in operation	Vacuum kPa	
		Teatcup	Cluster		Measure	Limit(s) kPa
1	Average vacuum in the milk system	No	No			-
2	Minimum vacuum during air inlet	Yes	No	Yes/No[a]		-
3	Average vacuum during air inlet	Yes	No	Yes/No[a]		-
4	Maximum vacuum during stop of air inlet	No	No	-		-
5	Average vacuum after stop of air inlet	No	No	-		-
6	Attachment vacuum drop (1-3)	-	-	-		2
7	Regulation undershoot (3-2)	-	-	-		2
8	Regulation overshoot (4-5)	-	-	-		2
9	Average vacuum in the milk system	No	No	-		-
10	Minimum vacuum during air inlet	Yes[b]	Yes[b]	Yes		-
11	Average vacuum during air inlet	Yes[b]	Yes[b]	Yes		-
12	Maximum vacuum during stop of air inlet	No	No	-		-
13	Average vacuum after stop of air inlet	No	No	-		-
14	Fall-off vacuum drop (9-11)	-	-	-		2
15	Regulation undershoot (11-10)	-	-	-		-
16	Regulation overshoot (12-13)	-	-	-		2

[a]) During the operation as in during attaching, delete what does not apply.
[b]) Air inlet in teatcup: for quarter milking; in cluster; with claw; delete what does not apply.

Table A2: Installation vacuum, regulation sensitivity and vacuum drop

No.	Parameter	Milking unit	Airflow at A1	Connection point	Vacuum kPa	
					Measure	Limit(s)
1	Vacuum on plant vacuum gauge	No	No	-		-
2	Vacuum near plant vacuum gauge	No	No	Vr		-
3	Vacuum gauge accuracy (1-2)	-	-	-		1
4	Vacuum in the milking system	No	No	Vm		-
5	Working vacuum for the milking machine	Yes	No	Vm		
6	Regulation Sensitivity (4-5)	-	-	-		1
7	Vacuum regulation deviation (nominal vacuums -5)	-	-	-		±2
8	Regulator working vacuum	Yes	No	Vr		-
9	Working vacuum for the vacuum pump	Yes	No	Vp		-
10	Vacuum pump exhaust back pressure	Yes	No	Pe		-
11	Vacuum in the milk system at effective reserve	Yes	Yes	Vm		-
12	Working vacuum at regulator at effective reserve	Yes	Yes	Vr		-
13	Vacuum drop receiver -regulator (12-11)	-	-	-		1
14	Working vacuum at vacuum pump at effective reserve	Yes	Yes	Vp		-
15	Vacuum drop receiver -vacuum pump (14-11)	-	-	-		3
16	Lowest value of maximum pulsation chamber vacuum	Yes	No	Short pulsation tube		-
17	Vacuum drop receiver -maximum pulsation chamber vacuum (5-16)	-	-	-		2

Table A3: Measurement and calculation of airflow.

No.	Parameter	Vacuum regulator	Milking units	Connection point		Airflowl/min	
				Vacuum	Airflow	Measure	Limit(s)
1	Effective reserve	Yes	Yes	Vm	A1		
2	Airflow with regulator	Yes	Yes	Vr	A1		-
3	Manual reserve	No	Yes	Vr	A1		-
4	Regulation Loss (1-3)	-	-	-	-		
5	Airflow without regulator	No	Yes	Vr	A1		-
6	Regulator leakage (2-5)						
7	Vacuum pump capacity at 50kPa	No	No	Vacuum pump	Vacuum pump		
8	Vacuum pump capacity at working vacuum	No	No	Vp	Vacuum pump		-
9	Airflow with vacuum system	No	No	Vp or Vr	A2		-
10	Leakage into vacuum system (8-9)	-	-	-	-		
11	Airflow with milk system	No	No	Vp or Vr	A2		-
12	Leakage into milk system (9-11)	-	-	-	-		

Airflow in the installation- Addition of airflow for accessories operated during milking but not in test

Equipment	Airflow l/min
Gate Cylinder	
Cluster remover	
Milk meter	
Releaser	
Other	

Airflow use and vacuum for cleaning.

Milklines and milk transfer lines are usually cleaned by a cleaning solution transported and agitated by the vacuum difference to achieve effective cleaning. Slug speeds of 7 m/s to 10 m/s optimize this cleaning action. To achieve these slug speeds it might be necessary to use a higher vacuum pump capacity than that necessary for milking. Other washing systems may not need increased vacuum pump capacity.

Table A4 gives the air capacity for some milkline dimensions and working vacuums at an atmospheric pressure of 100 kPA.

Table A4: Airflow for cleaning at a speed of 8 m/s and under atmospheric pressure of 100 kPa

Internal milkline Diameter	Airflow admission (l/min) to produce slug flow for cleaning at a vacuum of		
mm	40 kPa	45 kPa	50 kPa
34	261	240	218
36	293	269	244
38	326	299	272
40	362	332	301
44	438	401	365
48	521	477	434
50	565	518	471
60	814	746	678
63	985	903	821
73	1205	1104	1004
98	2171	1990	1809

Ancillary equipment

Ancillary equipment can be divided into three groups:

a) Equipment running continuously during milking
b) Equipment that uses a quantity of air for a short time during milking
c) Equipment only operating before or after the milking session.

For equipment of typed defined in (a) the minimum airflow use shall be added when calculating the pump capacity and effective reserve.

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

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

Calculations of vacuum pump capacity based on effective reserve requirements.

1. The vacuum pump(s) shall have adequate capacity to meet the performance requirement for milking and cleaning. This includes air used by all ancillary equipment operating during milking and cleaning, whether continuously or intermittently.
2. Calculate the airflow used for all equipment continuously running or using airflow during milking and during cleaning such as pulsators, air inlets and vacuum-operated milk pumps. The milking units and the pulsators shall be regarded as continuously running. Check the airflow for equipment that uses air for a short time.
3. Add the effective reserve from Tables 1-4 to the airflow use during milking from 2 above.
4. Add the airflow use for cleaning from Table A4 to the airflow use during milking from 2 above.
5. Take the higher of the values calculated in 3 and 4.
6. Add 10l/min, plus 2 l/min for each milking unit, for leakage into the milk system and add airflow admitted deliberately into the milk system.
7. Add leakages in the airlines.
8. Add the regulation loss.
9. The derived values for airflow and vacuum are the basis for choosing the vacuum pump.

Example of prediction of a vacuum pump capacity

Data:

a) A herringbone milking parlour with 12 milking units direct to line, automatic cluster removers and automatic shut-off valves at claw situated <300m above sea level
b) One milker
c) Working vacuum: 50 kPa
d) Milkline diameter: 73 mm
e) Airflow use for each pulsator: 35 l/min
f) Airflow inlet in the clusters: 12 l/min
g) Airflow for ancillary equipment per cluster: 12 l/min
h) Wash slug speed 8 m/s
i) Peak milkflow 5 kg/min
j) Milkline slope 1.5%

Calculations:
The effective reserve capacity for milking will be: 500 + {(12 – 10) x 10} = 520 l/min. The airflow use for cleaning at 50 kPa should be 1004 l/mm for a milkline with a diameter of 73 mm. (Table A4).

Airflow use for the milking units (claw air inlets + pulsators) will be 12 x(12 + 35) l/min = 564 l/min. The milking units will consume about the same amount of airflow during milking and cleaning.

Total airflow use during milking will be 520 l/min + 564 l/min =1084 l/min.

Total airflow use during cleaning will be 1004 l/min + 564 l/min =1568 l/min
In this example the capacity for cleaning is the larger and therefore will be the first basis of calculating the pump capacity.

Leakage into the milk system: 10 l/min + (2 x 12) l/min =34 l/min

Losses due to ancillary equipment 12x12= 144 l/min

Total :1568 l/min + 34 l/min + 144 l/min = 1746 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 x 100/(100 – 10) = 578 l/min
- Regulation loss = 578 l/min x 10/100 = 58 l/min
- Total: 1746 l/min + 58 l/min = 1804 l/min

Leakages into the airlines are equal to 5% of the pump capacity that is
- Vacuum system leakage: 1804 l/min x 5/(100 – 5) = 95 l/min;
- Total: 1804 l/min + 95 l/min = 1899 l/min

The minimum nominal capacity of the vacuum pump must therefore be 1899 l/min.

Appendix B: Test procedures, Calibration, Test report and Inspection Service Check List

Testing Procedures

Requirements

a) It is recommended that milking machines be tested at least twice per year.
b) Maintenance should not be carried out before testing an installation where a known or perceived problem exists.
c) The test results shall be recorded in a Test Report, which contains, at a minimum, the information in the recommended IMQCS Test Report.
d) Where faults are found in a milking machine, the faults and appropriate recommendations shall be indicated in the Test Report.
e) Post installation instrument testing of any milking machine shall be carried out in order to fully complete the Test Report. Subsequent routine instrument testing may be confined to the items in ***bold italic*** type in the IMQCS Test Report.
f) A post installation visual examination of the milking machine for compliance with installation standards shall be completed and included in the Test Report.
g) If a specific problem is being investigated the appropriate tests to be carried out shall be at the discretion of the tester.
h) Visual examination of milking machine parts needing routine maintenance and/or replacement shall be completed at all routine tests and included in the Test Report.
i) Visual examination for cleanliness consistent with the proper function and good hygiene standards should be carried out at all routine tests.
j) The visual observation of safety features within the parlour and dairy is important, but advice and comments shall always be within the tester's experience and qualifications; refer to a suitably competent person when in doubt.

Health and Safety Requirement: Ear protection shall be used where noise levels exceed 85d (A), e.g., measuring vacuum pump capacity. Rotating parts may pose a health hazard, eg., measuring vacuum pump speed.

Calibration

A calibration service for airflow meters, electronic pulsation analysers and vacuum meters is available at Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co Cork. A laboratory milkflow simulator is also available at Teagasc, Moorepark Dairy Production Research Centre for establishing vacuum losses in milking systems. The flow simulation data provides design guidelines for optimum design of milking systems.

Test Report

Name: ______________________________

Address: ______________________________

____

____

____

Date: ______________________________

Previous Test Date: ______________________________ Next Test Date: ______________________________

Plant Type: ______________________________

No. Units: ______________________________

Farmer’s: ______________________________

Signature: ______________________________

Tester’s: ______________________________

Signature: ______________________________

Airflow and Vacuum Regulator Tests				
1.	Operating vacuum - AFM at test point near receiver Farm gauge vacuum level	(kPa)	Operating vacuum level recommended	(kPa)
2.	Pump capacity - AFM direct to pump	(l/min)	(l/min) (l/min) (l/min)	
3.	AFM at test point near regulator - teatcup plugs inserted, air pipeline added only, regulator plugged	(l/min)	Airline leakage (2-3) (l/min)	
4.	Add milking system, close claw air admission	(l/min)	Milking system leakage (3-4)	(l/min)
5.	Open air admission at claws	(l/min)	Claw air admission (4-5)	(l/min)
6.	Add ancillary equipment connected to milkline	(l/min)	Milking system ancillary equipment usage (5-6)	(l/min)
7.	Add pulsators - all units milking	(l/min)	Pulsation usage (6-7) (l/min)	
8.	Add ancillary equipment connected to airline	(l/min)	Airline ancillary equipment usage (7-8)	(l/min)
9.	Manual Reserve - (receiver) Drop vacuum 2kPa - all units milking, regulator plugged	(l/min)		
10.	Effective Reserve (receiver) - Add regulator, drop vacuum 2kPa - all units milking	(l/min)	Required reserve (l/min)	
11.	Regulator sensitivity – with and without milking units operating	(kPa)	Regulator sensitivity (11-1)	(kPa)
12.	Exhaust backpressure (positive pressure)	(kPa)		
13.	Vacuum drop –one unit open		Regulator leakage (9-10)	(l/min)

Pulsation Tests				
	Rate c/min	**Ratio "a+b"**	**"a" value**	**"d" value**
Maximum				
Minimum				

Pulsation Graphs Attached: yes / no
LIMPING (<5%)

Faults and recommendations	
Faults	
Recommendations	

Inspection - service check list

Check	**Correct**		**Rectified**	
	Yes	**No**	**Yes**	**No**
Vacuum Pump				
Belt guard fitted and in good condition?				
Is there adequate oil in the pump on arrival?				
Height of oil in reservoir adequate?				
Pump receiving adequate lubrication?				
Is recommended milking machine oil being used (incorrect oil will shorten pump life)?				
Is there a tee piece and ball valve for airflow meter?				
Vac pump capacity test point and isolation valve fitted?				
Backpressure measurement tap fitted? (on the exhaust line near the vacuum pump outlet)				
Exhaust as large in bore as the pump outlet?				
Are the oiler wicks in good condition and the pump is receiving adequate lubrication?				
Are the pulleys in good condition?				
Are the pulleys tight?				
Are the belts in good condition?				
Are the belts tight? (About 12mm play in belts with thumb pressure)				
Is there a safety switch fitted functionally?				
No excess vacuum pump noise/vibration?				

Check	Correct		Rectified	
	Yes	No	Yes	No
Interceptor				
Fitted?				
Is gasket on lid satisfactory?				
Is automatic drain valve functioning correctly?				
Does the interceptor appear to be clean?				
Automatic cut–off fitted?				
Is the shut-off float functioning correctly?				
Automatic drain valve fitted?				
Drain valve NOT discharging on other equipment?				
Internal diameter for the inlet and outlet NOT less than that of the airlines.				
Vacuum line				
No restriction in the main airline at the Interceptor?				
No restriction at sanitary trap?				
Is the automatic drain valve functioning correctly?				
Is the airline vacuum line clean internally?				
Is there an adequate fall in the airline and in the correct direction towards a drain?				
Is vacuum line rigidly fixed.				
Vacuum line fitted with flush taps and removable plugs / caps.				
Vacuum Regulator				
Is air intake clean?				
Is valve clean?				
Is valve seating clean?				
Are the diaphragms in good condition?				
Located between interceptor and sanitary trap?				
Test point and isolation valve fitted? (near receiver, upstream of sanitary trap or on interceptor)				
Sensor (if fitted) nearer cow than vacuum pump?				
Is the sensor positioned correctly(top of line, away from bends)?				
Is the regulator rigid and upright?				
Is the regulator joined by a full bore connection to the main airline or interceptor?				
Regulator sensor tube is not less than 450mm from a tee or bend?				
Was a service kit fitted?				
Vacuum gauge installed between regulator and the first unit.				
Vacuum gauge visible during milking				

Check	Correct		Rectified	
	Yes	No	Yes	No
Sanitary Trap				
Fitted?				
Is gasket on lid satisfactory?				
Is drain valve/wash tube functioning correctly?				
Does the sanitary trap appear to be clean?				
Automatic cut-off fitted?				
Is the shut-off float functioning correctly?				
Isolation valve fitted?				
Can the sanitary trap be shut off during milking?				
Automatic drain valve or CIP?				
Drain valve NOT discharging on other equipment?				
Is the sanitary trap being CIP washed?				
If no CIP, do receiver(s) and receiver airlines drain towards the sanitary trap(s)?				
Pulsation line				
Is the automatic drain valve functioning correctly?				
Is the pulsation line clean internally?				
Is there an adequate continuous fall in the pulsation line and in the correct direction?				
Tap at end of the line for washing purposes?				
Is pulsation line rigidly fixed?				
Airflow test point fitted to the end of the pulsation line?				
Pulsation line fitted with flush taps and removable plugs / caps.				
Pulsation				
Are pulsators/relays clean?				
Have the pulsation relay kits been changed at recommended service intervals?				
Is there a filtered air supply fitted?				
Are filters on air supply to relays clean and free from unnecessary restrictions?				
Is the clean airline free from debris?				
Are pulsators and relay tubes in good condition and without leaks?				

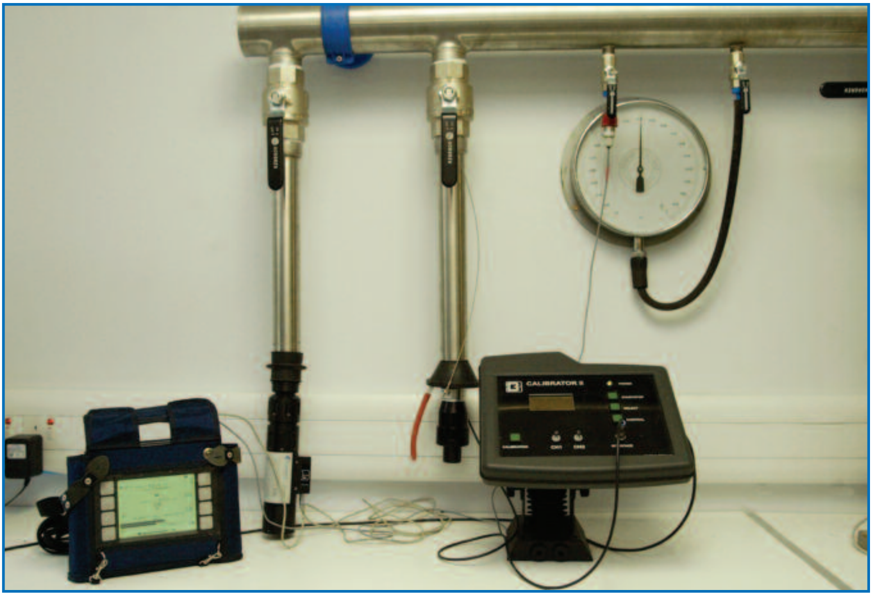
Check	Correct		Rectified	
	Yes	No	Yes	No
Rubber Tubing Condition				
Are long milk tubes satisfactory?				
Are long pulse tubes satisfactory and correctly sized?				
Are short pulse tubes satisfactory?				
Are long and short jetter tubes satisfactory?				
Tubes to cluster removers satisfactory?				
Are milk transfer tubes from recorder jars satisfactory?				
Is other rubberware satisfactory?				
Long Pulse Tube Bores				
Alternate – at least 7 mm?				
Simultaneous – at least 9.5 mm?				
Claws				
Are claws clean?				
Are the air admission holes fully opened?				
Are claw bowls, gaskets, nipples and shut-off valves satisfactory?				
Have the claw kits been changed at recommended intervals?				
Are all claw bowls free from cracks?				
Are auto-shutoffs fitted?				
Liners				
Have the liners been changed at recommended intervals? (2000 cow milkings)				
Are liners fitted approved by the manufacturer?				
No holes in liners or short milk tubes?				
Are the liners and short milk tubes free from cracks?				
Are the anti-twist indicators aligned correctly?				
Liner manufacturer and type marked?				
Are liners approved (original or copies)				
Shell manufacturer and type marked?				
Long Milk Tubes				
Is bore 13mm or greater?				
Are tubes free from excessive loops?				

Check	Correct		Rectified	
	Yes	No	Yes	No
Milkline				
Milkline inlets into the top or top third of milkline and aligned correctly?				
Is there an adequate continuous fall in the milkline and in the correct direction (towards the receiver)?				
Each milkline has a separate entry into receiver?				
milkline not restricted at receiver entry point?				
Has the milkline remained rigidly supported?				
Is the end of the milkline blank?				
Highest points of milk lift less than 2.1m above cow standing?				
Drainage tap present at every low point/filter/inline cooling?				
If compressed air is used to purge milkline is filtered air used?.				
Recorder Jars				
Is the recording jar unit free from leaks?				
Are the hand controls functioning correctly?				
Are other rubber parts in good condition?				
Jar vacuum recovery time? (to within 4kpa of system vac in 4 seconds)				
Automatic Cluster Removers				
Are the ACR cords in good condition?				
Milk Meters				
Are the valves/diaphragms in good condition				
Has a service kit been fitted?				
Have the meters been calibrated?				
Diversion valves				
Have the diaphragms been changed in accordance with the recommended service intervals?				
Centrifugal Milk Pump				
Was a new seal kit/non return valve fitted?				
Is the non-return valve in good condition?				
Is the wiring in good condition?				
Are all unions and joints tight and leak free?				

Check	Correct		Rectified	
	Yes	No	Yes	No
Diaphragm Milk Pump				
Belt in good condition?				
Belt tensioned correctly?				
Belt guard checks				
Are pulleys tight and in good condition?				
Is there adequate oil in the pump on arrival?				
Is the pump timed correctly?				
Record strokes/min				
Manual / liquid level operation / Variable speed				
Non return valves ok?				
Is diaphragm/s condition good?				
Are all unions and joints tight and leak free?				
Wash line				
Are entries into wash line into the top or top third?				
Jetters				
Are jetter manifolds clean?				
Autowasher				
Are autowasher dosing tubes in good condition?				
Is the autowasher functioning to the manufacturer's guidelines?				
Has the autowasher been calibrated for dosing volumes?				

Appendix C: Laboratory and Parlour Tests of Vacuum in the Milking Unit

Note: This section describes tests for measuring vacuum in the milking unit. Normally these tests are carried out by equipment manufacturers for the design of milking units and are generally not conducted on farms. These tests should be performed by specially trained personnel.



C.1 Suitable measuring equipment

C.1.1 Vacuum meter

C.1.2 Data acquisition equipment that can simultaneously record the vacuum in the liner, in the pulsation chamber and in the milkline.

C.1.3. Artificial teats, for example, in accordance with Figure C.1 and Table C.1. The outlet holes are intended to be closed by the liner. To achieve effective shut off, it is important to position the teat such that the closed liner will cover the holes in the teat. It is recommended to have the teatcups fixed and the teats flexibly connected to the liquid source in order to avoid leakage between teat and mouthpiece.

If the combination of teatcup and artificial teat being tested does not stop liquid flow during Phase d, shut-off valves for the liquid may be used. Such shut-off valves for the liquid shall be directly upstream of the artificial teat.

Suitable means shall be used to ensure that the liquid pressure supplying the teats remains constant at about 3kPa to 5 kPa.

C.1.4 Water flow meters, with a minimum accuracy as specified in C.4.

C.1.5 An airflow meter, with an accuracy at least equal to that specified in C.4 to measure the air vent in the cluster.

Table C.1 – Artificial Teat Dimensions

Diameter, A mm	25
Outlet hole diameter, B mm	4.5
Number of outlets holes	1 or 2

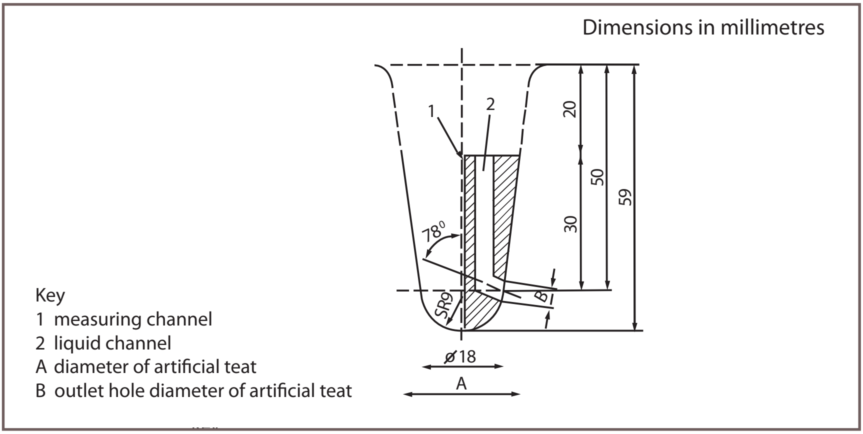


Figure C.1 – Artificial Teat

C.2 Test conditions

Vacuum levels and vacuum variations shall be measured while drawing water through artificial teats. The milking unit shall work normally.

C.3 Description of the connection to the plant

The connection to the plant shall be described by:

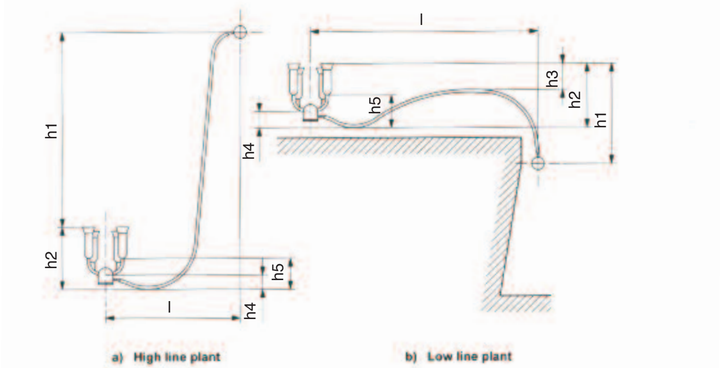
a) the length and internal diameter of the long milk tube:
b) the shape of the long milk tube (see Figure C.2), determined by
   - the vertical distance between the teat base and the milkline axis (h1)
   - the vertical distance between the teat base and the lowest point of the long milk tube (h2)
   - the vertical distance between the teat base and the highest point of the long milk tube (h3)

- the vertical distance between the claw and the lowest point of the long milk tube (h4)
- the vertical distance between the top of the (short) milk tube at the teacup and the lowest point of the long milk tube (h5)
- the horizontal distance between the centre of the udder and the milkline axis (l)
- a description of any device fitted in the milking unit between the cluster and the milkline;

c) the description of the milk inlet valve;
d) the description of the vacuum tap

When comparing milking units, the length of the long milk tube shall be so matched that the distance h1 and l will be the same for all units.

To be able to compare measuring results the dimension h1 should preferably be 1300 mm for high line and 700 mm for low line plants.



Key

h_1 vertical distance between the teat base and the milkline axis
h_2 vertical distance between the teat base the highest point of the long milk tube
h_3 vertical distance between the teat base the highest point of the long milk tube
h_4 vertical distance between the centre of the udder and the milkline axis
h_5 vertical distance between the top of the (short) milk tube at the teatcup and the lowest point of the long milk tube
l horizontal distance between the claw and the milkline axis

NOTE Additional measurements may be recorded to fully describe the test configuration.

Figure C2 – Representative shape of the long milk tube

C.4 Liquid and airflow

The water flow shall be specified and measured with an error of less than 0.1 kg/min. The water temperature shall be between 15°C and 22°C.
The airflow through the air vent shall be measured.
The air admission shall be (8± 0.5) l/min for cows.

C.5 Vacuum in milkline

The vacuum in the milkline shall be constant during the test, within 1 kPa, measured close to the milk inlet at the upper side of the tube.

C.6 Measuring point

The measuring point shall be at the artificial teat end.

The measurement should preferably be made by means of a built-in transducer in the artificial teat. A transducer connected to the measuring point by a tube may be acceptable if it is proved that the measurement can be made with sufficient frequency response.

C.7 Measuring period

A measuring period shall be chosen as a full number of pulsation cycles and shall be at least 5 pulsation cycles. The number of cycles shall be recorded.

C.8 Results

C.8.1 General

Based on the measured values, one or more of the following parameters shall be calculated and presented as results. The maximum error in those calculated values for vacuum variations shall be 10% of this value or kPa, whichever is the greatest.

C.8.2 Average liner vacuum

The average vacuum during the measuring period shall be calculated as defined in ISO 3918.

C.8.3 Average liner vacuum during Phase b

The average vacuum during Phase b of the pulsation waveform is the average of the average registered values during phase b of the pulsation waveform in each measured pulsation cycle during the measuring period.

C.8.4 Average liner vacuum during Phase d

The average vacuum during Phase d of the pulsation waveform is the average of the average registered values during Phase d of the pulsation waveform in each measured pulsation cycle during the measuring period.

Appendix D - Milk Cooling

Cooling milk on the farm has two main aims, to inhibit bacterial spoilage and to extend storage on the farm so as to minimise milk transport costs. Good hygiene in all aspects of milk production is essential to the production of quality milk and the growth of bacteria during the storage interval must also be curtailed. Bacteria in milk increases very quickly at body temperature and even milk with a low initial count will sour rapidly. When cooled by well water to between 15^{O}C and 20^{o}C the growth rate is restricted and milk produced under hygienic conditions will retain good quality for a period of up to 15 to 20 hours. However, when the storage period exceeds this limit, further cooling by refrigeration is necessary. The storage temperature and also the time to reach the storage temperature, which is normally 4^{o}C are both important. Hence refrigerated bulk milk coolers must be designed and selected to cool the milk to 4^{o}C within a specified time. This cooling period should not extend beyond the normal milking time by more than one hour at peak. The general recommendation is to cool to 6^{0}C for everyday collection (ED), 4^{0}C for every second day collection (E2D) and 3^{0}C for every third day collection (E3D).

Bacterial Growth Rate in milk

The effects of time and temperature on bacterial growth in farm milk are outlined in Table D1. The starting Total Bacterial Count (TBC) is 5000. The dilution effects of milking additions may be offset by blend temperature increases during milking.

Table D1 : The effect of time and temperature on bacterial growth in farm milk

Milk Storage Temperature (^{0}C)	Expected TBC after storage for		
	2 days	3 days	4 days
2*	5,000	15,000	50,000
4	10,000	30,000	100,000
6	30,000	100,000	1,000,000

**cooling to 2^{0}C is technically difficult*

Recommendations for extended storage:

- Fast cooling rate, i.e., avoid high blend temperatures
- Accurate temperature control during storage (3 - 4^{0}C)
- Excellent hygiene from teat to tank

Milk Cooling Options

1. Direct Expansion (DX)
2. Ice-Bank (IB) with either in-tank ice-builder or external ice-builder
3. DX or IB plus single stage plate cooler with water from either deep well, shallow well or mains
4. DX or IB plus single stage plate cooler with chilled water from either the tank or chiller unit
5. DX or IB plus double stage plate cooler with water from either deep well, shallow well or mains and chilled water.

Pre-cooling

Effective pre-cooling of milk can lead to energy savings and enhance the keeping quality of the milk. Pre-cooling of milk in-line by well or mains water before it enters the tank has a number of advantages. These include:

1. Economy – cooling costs can be reduced by up to 50% depending on the temperature and supply of water and the operational efficiency of the cooler, e.g. water to milkflow ratio;
2. Milk quality – pre-cooling ensures a lower milk blend temperature, which helps to curtail growth of bacteria;
3. The tepid water from the pre-cooler can be used for udder washing, yard washing and for stock drinking water;
4. Condensing unit size can be reduced, provided pre-cooling to less than 18^{o}C can be consistently achieved. This is advantageous where power supply is limited; and
5. Back up cooling – a pre-cooling system provides a useful auxiliary system in the event of condensing unit failure;

6. Pre-cooling milk will reduce cooling times when comparing equivalent systems.

Some of the benefits of pre-cooling will be undone if the bulk tank cooling unit is not installed and maintained properly. It is important to ensure a good airflow to and from the condensing unit (radiator). Anything that restricts the supply of fresh air and/or causes the recirculation of warm air will increase running costs, increase cooling times and reduce compressor life. It is very common to see condensing units on farms that are damaged and partially blocked, and recirculating warm air.

Plate Coolers

A plate cooler fitted to the discharge side of the milk pump is the most popular pre-cooling system, mainly due to its high efficiency and compactness. The plate cooler consists of a sandwiched arrangement of stainless steel plates, with the milk and cooling water flowing in opposite directions through spaces between alternate plates. The spaces between the plates are small, so the milk filter must be located before the plate cooler to prevent debris from entering and accumulating in the plate cooler. Water filter(s) may be necessary if foreign matter or minerals are present in the water supply.

The water flow rate should be adjusted to about double the measured milkflow rate for optimum efficiency in milk cooling, thereby reducing the milk temperature to within 3-5^{o}C of the inlet cooling water (Table D2). At a higher water flow rate only a marginal reduction in milk outlet temperature is achieved. At a lower water flow rate, a reduction of milk temperature to within 5-10^{o}C of the inlet water temperature could be expected. Table D2 also shows the effect of water inlet temperature on plate cooler performance.

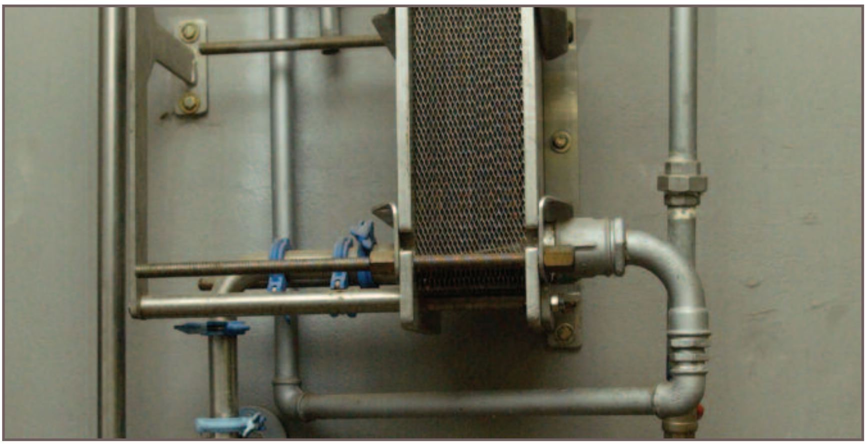


Table D2: Plate cooler, milk and water outlet temperature (^{O}C) as affected by water inlet temperature and water to milkflow ratio. Milk inlet temperature 35^{O}C

Water Inlet (^{O}C)	Water/milk 1:1 Milk ^{O}C	Water/milk 1:1 Water ^{O}C	Water/milk 2:1 Milk ^{O}C	Water/milk 2:1 Water ^{O}C	Water/milk 3:1 Milk ^{O}C	Water/milk 3:1 Water ^{O}C
10	20	27	15	20	14	17
15	22	28	19	23	18	21
20	25	30	23	27	22	25

Source: M.G. Fleming and J. O'Keeffe, Teagasc, Moorepark Research Centre

Plate Cooler Size

As well as water temperature and water to milkflow rate, the size of the plate cooler is also important. Under-sizing the plate cooler will result in reduced cooling efficiency. The plate cooler should be sized according to the milkflow rate. For a single stage plate cooler the number of plates generally required is given in Table D3.

Oversizing the plate cooler where continuously operating diaphragm pumps are used should be avoided, because air from the diaphragm pump passing through the residual milk in the cooler can cause milkfat damage and cleaning difficulties. This may occur with older plants, but present day milking machine standards insist that all types of milk pumps are operated intermittently. Centrifugal pumps have always had to be operated intermittently to prevent them from dry running and damaging seals.

Table D3: Number of plates required in a single bank model M plate cooler (each plate is 120 mm x 632 mm)

No. of plates	Plate cooler capacity (milkflow rate)	
	Gal/hr	*Litres/hr*
18	200	900
20	250	1,140
24	300	1,360
30	400	1, 820
36	500	2 ,270
42	600	2,730
48	700	3,180
54	800	3,640

Source: M.G. Fleming and J. O'Keeffe, Teagasc, Moorepark Research Centre

Plate Cooler Installation

Plate coolers should be mounted so as not to pose a bang hazard for the operator. Pick a location that will be convenient for use by the operator. Ensure that the plumbing work is well planned and installed. The pipe sizes should be sized to cope with the flow rates intended.

Two-Stage Plate Coolers

The best pre-cooling performance is got using a two-stage plate cooler with water from either a deep well, shallow well or mains and chilled water. The chilled water can be produced from either an in-tank or external ice builder. With ice bank tanks the chilled water is generally pumped initially through the plate cooler and later through water jackets in the tank to maintain the storage temperature. The ice builder should ideally be able to cope with two milkings to make the best use of night rate electricity. A properly installed setup can pre-cool the milk to within 1-3^{0}C of the recommended storage temperature. An ice builder can also be used in conjunction with a direct expansion tank. This arrangement can be used with a smaller condenser on the direct expansion tank, which will keep the milk at the correct temperature between milkings and save the built-up ice for after milking. Well water is more suitable than water from the public supply because it is generally much cooler and is usually cheaper where water charges are per unit volume. The extra investment needed to allow more effective pre-cooling, e.g., to install a water chiller, a two-stage plate cooler, etc., should follow a careful cost/benefit analysis.

Centrifugal Milk Pumps

There are many options to choose from when it comes to deciding on a milk pump. At present centrifugal milk pumps are preferred because of their higher flow rates. Higher flow rates are needed for circulation cleaning of modern milking machines. Centrifugal pumps are cheaper than diaphragm pumps and are arguably more hygienic and more straight-forward to install however increase the noise levels in the milker's pit.

Milk pumps must be sized according to the maximum flow conditions. This is always during cleaning. Therefore during milking the pump capacity will exceed milkflow and drain the receiver jar. This leads to a stop start milk pumping pattern and continue pumping is used for cleaning. The use of variable speed controllers on milk pumps allows the pump to match the milkflow into the receiver as it varies over the course of the milking.

Variable Speed Milk Pumps

Various control strategies for milk pumps can be selected from; simple on/off, step changes, to continuously variable speeds. Peak flow rates through the milk pump during milking are reduced roughly by half by the use of variable speed with an optimum control strategy. Furthermore, there is a threefold increase in the time the milk pump is pumping, which slows down the milkflow rate through the plate cooler, thereby reducing cooling time. This strongly favours the use of these types of variable speed centrifugal pumps for large throughput milking machines. Plate coolers used to pre-cool the milk before entering the bulk tank are selected according to milkflow rate. Variable speed pumping match plate cooler expected flow rate much more closely. It has been shown that that the maximum flow rate is up to 80% higher than the average flow rate used to size the plate cooler. This applies to the continuously variable speed controls strategies. If the peak flow rate of milk through the plate cooler is reduced the peak flow rate of water needed to maintain cooling efficiency can also be reduced. To improve efficiency further, a solenoid valve may be fitted in the water line to the cooler. This solenoid valve is wired to the liquid level controller on the milk pump and ensures that water flows only when the milk pump operates and thus helps to conserve water. The solenoid should have a time delay of no longer than 20-30 seconds which will allow the water to continue to flow for a short time after the milk pump has stopped. This will improve the performance of the plate cooler. It is not good practice to insert a restrictor between the milk pump and the filter. A restrictor will reduce the flow rate through the filter and plate cooler, but it may also cause milk fat damage and possibly froth in the milk.

Diaphragm Milk Pumps

Diaphragm milk pumps are used in many milking installations throughout the country. From the point of view of milk pre-cooling, a pipeline milking system (without recording jars) with an intermittently operating diaphragm milk pump is a good arrangement. Typical output of diaphragm milk pumps under full flow is 1300 - 1800 l/h (290 - 400 gal/h) for a single diaphragm milk pumps and 2600 - 3600 l/h (580 - 800 gal/h) for a double diaphragm milk pumps. Within these ranges the flow rate of diaphragm pumps can be set by using different combinations of pulley sizes. Where froth is a problem, diaphragm pumps can clear froth from the milk receiver jar, but to do this the pump must be switched over to continuous pumping, at least until the froth is gone. Diaphragm milk pumps intermittingly controlled will not pump away froth, because the froth floats on top of the milk. Where a milk diversion line is installed; a good arrangement is to install a diaphragm pump for the milkline and an ordinary centrifugal for the diversion line. Both pumps are switched to continuous pumping during washing. In a situation of up-grading, extending or even building a new parlour effective use can be made of an existing single or double diaphragm pump in conjunction with a centrifugal for circulation cleaning with or without a diversion line. If an existing diaphragm pump output is inadequate for the increased milkflow rate of the extra units, say when cows are at peak, the centrifugal pump is installed in parallel with the diaphragm pump. There are two sets of probes in the receiver jar. The set nearer the bottom of the receiver controls the diaphragm pump and the set near the top controls the centrifugal pump. The diaphragm pump pumps milk for most of the time, but if the milk level in the receiver reaches the upper probes the centrifugal pump cuts in to lower the level quickly. When the level drops below the upper probes the centrifugal pump cuts out again. Both pumps are run continuously during washing. Installing a diversion line with this arrangement requires an additional centrifugal milk pump.

Matching up the Components

Matching milk pumps, plate coolers and milk filters is not easy. More often than not it is based on practical experience. It can either be planned on the basis of the milk collected over an hour, which can be linked to the Tables D3 and D4, which also show their capacities in litres per hour. An alternative approach, more in keeping with the ISO standards and the cyclic nature of the milkflow over the course of the milking, is to base it on a peak milkflow of 5 litres per minute per unit. This should cope with all situations but may be fine tuned to particular installations if lower flow rates are found workable in practice.

Milk Filtering

An inline milk filter should be fitted in all milking installations. Where a plate cooler is fitted the filter should be fitted between the milk pump and the plate cooler. Generally, milk filters should be mounted vertically with the drain/cap at the base. The filter should be plumbed so that sediment is collected on the outside of the filter sock. Mount the filter high enough so that an operator is not forced to bend down when changing a filter sock.

For effective filtering and trouble free operation it is essential to match filter sock sizes to milk pump sizes, types and flow rates. Table D4 outlines a range of filter sock sizes for different milkflow rates. The weight of material that manufactures use in in-line filter socks varies from 60-155 g/m^2. The most common one used is 75 g/m^2. The 75 g material will filter particles as small as 70 microns (one fourteenth of a millimetre). Apart from the size, there is no information on the packaging indicating the quality of filter socks.

The flow rate of each filter will vary depending on the:

- fat content of the milk
- pumping pressure of the milk pump
- weight of material per square metre used in the sock
- temperature of the milk

As an example of the resistance in the filter material a 25mm (1") diameter round disc of 75-gram material with a 3m head of pressure (4.3 psi or 0.7 bar) using water, has a flow rate of only 28 litres per minute (8.5 gallons per minute). Table D4 shows filter sock sizes for different milkflow rates.

Table D4: Filter sock sizes for different milkflow rates

Filter Sock Size	Flow rate up to
430mm x 75mm sock (17" x 3")	1500 litres/hour (330 gals/hour)
600mm x 75mm sock (24" x 3")	3000 litres/hour (660 gals/hour)
600mm x 100mm sock (24" x 4")	4500 litres/hour (990 gals/hour)
650mm x 150mm	6500 litres/hour (1430 gals/hour)
2 x 600mm x 100mm socks positioned in parallel (2 x 24" x 4")	9000 litres/hour (1980 gals/hour)

Milk Cooling Costs

Table D5 shows litres of milk which can be cooled with one unit (kWh) of electricity with direct expansion (DX) and ice bank (IB) tanks, cooling to 4^0C and 3^0C. One kWh is one unit of electricity. It follows from the cooling rates shown in Table D5 that in order to cool 4500 litres (1000 gallons) of milk to 4^0C, 60 units of electricity would be used with a DX tank and 90 units with an IB tank - without taking pre-cooling into account. Night rate electricity and pre-cooling must be taken into account to get a true picture of running costs.

Table D5: Litres cooled per kWh (unit of electricity)

Litres cooled per kWh (gals.)		
	Cooled to 4^0C	Cooled to 3^0C
DX	75 (16.5)	68 (15)
IB	50 (11)	45 (10)

Table D6 outlines the cost of cooling 4500 litres (1000 gals.) with direct expansion (DX) and ice bank (IB) tanks, cooling to 4^0C and 3^0C.

Table D6: Cost of cooling 4500 litres (1000 gals.) on normal 'Domestic Rural' electricity rate

Cost (€) per 4500 litres		
	Cooled to 4^0C	*Cooled to 3^0C*
DX	*10.24*	*11.29*
IB	*15.35*	*17.06*

Table D7 shows the present cost of cooling 4500 litres (1000 gals.) with direct expansion (DX) and ice bank (IB) tanks, cooling to 4^0C and 3^0C where a proportion of Nightsaver rate electricity is used for cooling. The IB tank is costed using 70% night rate and the DX tank using 25%.

Table D7: Cost of cooling 4500 litres (1000 gals.) with Nightsaver electricity

Cost (€) per 4500 litres cooled		
	Cooled to 4^0C	Cooled to 3^0C
DX*	8.94	9.86
IB*	9.92	11.03

**70% IB and 25% DX on Nightsaver rate and no pre-cooling*

Table D8 shows the cost of cooling 4500 litres (1000 gals.) with direct expansion (DX) and ice bank (IB) tanks, cooling to 4^0C and 3^0C where a proportion of Nightsaver rate electricity is used for cooling. The IB tank is costed using 100% Nightsaver rate and the DX tank using 50%.

Table D8: Cost of cooling 4500 litres (1000 gals.) with Nightsaver electricity

Cost (€) per 4500 litres cooled		
	Cooled to 4^0C	*Cooled to 3^0C*
*DX**	*7.65*	*8.44*
*IB**	*7.60*	*8.44*

**100% IB and 50% DX on Nightsaver rate and no pre-cooling*

Table D9 outlines the savings that can be made by pre-cooling with a plate cooler where; 50% of the cooling is done by the plate cooler with a 2:1 water to milk ratio; 4500 litres is the amount of milk cooled; standard 'Domestic Rural' electrical rate is used; mains water is charged at €4 per 4500 litres and 1.25 units of electricity are used to pump each 4500 litres of water with a deep well submersible pump. Table D9 shows the costs cooling to 3^0C only.

Table D9: Savings (€) using a plate cooler

	No plate cooling	Shallow well	Deep well submersible	Deep well surface pump	Mains water
DX	11.29	6.07	6.07	7.13	13.00
IB	17.06	8.96	8.96	10.58	15.5

**100% IB and 50% DX on Nightsaver rate and no pre-cooling*

Table D10 shows the cost of cooling 4500 litres (1000 gals.) with direct expansion (DX) and ice bank (IB) tanks, cooling to 3^0C where different proportions of night rate electricity and 50% pre-cooling with well water are used.

Table D10: Cost of cooling 4500 litres (1000 gals.) to 3^0C with different combinations of Nightsaver rate electricity and 50% pre-cooling

Cost (€) per 4500 litres cooled		
	With 25% night rate for DX and 70% night rate for IB and 50% pre-cooling	With 50% night rate for DX and 100% night rate for IB and 50% pre-cooling
DX	5.36	4.65
IB	5.94	4.65

Looking at all the tables with all the costs may be confusing but each shows the costs calculated for a possible cooling scenario. It is interesting to note that the costs reduce depending on the use made of Nightsaver rate and pre-cooling. Table D10 shows that, for that scenario, with the correct use of Nightsaver rate and pre-cooling there is little to choose from between the DX and IB in terms of running costs. If we take an average for Table D10 [Pre-cooled milk] of, say, €5 to cool 1000 gallons the annual cost of cooling milk for a farmer supplying 50,000 gallons would only amount to about €250.

The costs outlined in the tables are based on modern efficient refrigeration units, in good condition and well maintained. The costs are likely to be considerably higher with older type compressors, where maintenance is neglected or where condensers are damaged.

Night Rate Electricity

Most dairy farmers are on the ESB 'Domestic Rural Nightsaver' rate. There is an extra standing charge in addition to the normal 'Domestic Rural' scheme of €6.20 every two months. The charge for Units [kWh] on Nightsaver is now as follows:

Day Units: 17.06 c/Unit [kWh]
Night Units: 8.44 c/Unit [kWh]

'Domestic Rural Nightsaver' is available from 11.00pm to 8.00am GMT, i.e., 11pm to 8am in wintertime and 12 midnight to 9am in summertime. The cost of Units on the normal 'Rural Domestic' rate is: 15.97 cent/unit. This is 1.09 cent/unit cheaper than the day rate on the new 'Domestic Rural Nightsaver'.

Bulk Tank Sizing

To calculate the capacity of the bulk tank you require you need to know how many milkings you need to store at peak. It is 5 milkings for E2D collection and 7 for E3D collection. Other factors are the number of cows now and in, say, 5 years time and the yield per cow, e.g., 30 litres/day at peak (6.5 gals/day):

Example: Herd Size: 50
Bulk tank capacity for E2D: 50 x 30 x 2.5 = 3750 litres (825 gals)
Bulk tank capacity for E3D: 50 x 30 x 3.5 = 5250 litres (1155 gals)

The size of the dairy may decide the type or make of tank you buy, i.e. differences in dimensions between manufacturers and between types of tank, e.g. DX may fit in where IB would not. Allow at least 600mm around the tank for cleaning. Extra space may of course be required for other equipment e.g. wash trough, work space at the wash trough, etc. Allow sufficient headroom above tank for sampling, inspection, service, etc. headroom of 2m above standing platform is recommended. Get detailed written quotation stating: model of tank, rated capacity, make, model and HP of condensing unit(s), details of automatic washer, details of new pre-cooling system or modifications to existing system, rough sketch of where tank and any ancillary equipment fits into dairy and clarification of who does what with regard to any building work, plumbing, electrical or modifications to milking machine.

Notes

Notes