FOREWORD

Milking Machine Management, Volume 1, is the sixth in a series of management manuals published by Veepro Holland and the first of two volumes on milking machines. The cooling and storage of milk, and testing of the milking machine will be described in Volume 2. Through these manuals Veepro Holland aims to provide you with useful management information. Dairy cattle worldwide have to be managed well to utilise their genetic potential to full extent.

No single booklet can cover every subject as diverse and complex as dairying. Nor will probably everyone associated with dairying agree on all points covered in one publication. But we of Veepro Holland believe the combination of this manual and other publications on the subject may broaden your knowledge about milking machines and will subsequently contribute to a healthy and highly productive herd.

Veepro Holland is indebted to those who contributed to this manual, particularly Ing. Wim Rossing of the Institute of Agricultural Engineering (IMAG-DLO) of Wageningen and Ing. Kees de Koning of the National Reference Centre for Livestock Production (IKC) of the Ministry of Agriculture, Nature Management and Fisheries at Lelystad for their constructive criticism.

We would like to thank the IPC-Livestock/Dairy Training Centre 'Friesland' at Oenkerk for their valuable assistance in the preparation of this manual.

Many thanks also to those associations and publishers who permitted us to use various data and illustrations.

VEEPRO HOLLAND
INTRODUCTION

The milking machine is probably the most important piece of farm equipment at a dairy farm. Each day of the year begins and ends with milking. It should be kept in mind that the milking machine has got to milk cows twice a day, no matter what happens. For this reason, proper understanding of the milking machine and regular maintenance is of utmost importance.

In handmilking the pressure is increased by squeezing the fingers around the teat so the teat sphincter will open. The approach in machine milking is different; instead of increasing the pressure within the teat, one lowers the pressure outside the teat canal, which causes the teat sphincter to open, while a pulsating vacuum between the teatcup and the liner forces the liner to open and close, thus stimulating blood circulation.

The major changes over the years related to plumbing and ironwork of the milking machine, made the transition from a bucket milking system to a milking parlour possible. But no matter the design of the milking machine or parlour, they all work according to the same way principle.

We will now have a closer look at the milking machine and the way it functions. The testing and maintenance of milking equipment and the cooling and storage of milk will be described in Volume 2 of Milking Machine Management. The cleaning, disinfection, and maintenance of milking equipment is described in the Proper Milking Management manual.

THE CONSTRUCTION AND FUNCTION OF THE MILKING MACHINE

The milking machine consists of the following key components:

- the vacuum pump
- the vacuum pipeline
- the interceptor, vacuum tank or moisture trap
- the vacuum regulator or controller
- the vacuum gauge
- the vacuum and drain taps
- the pulsators
- the milk pipeline
- the cluster assembly and/or buckets
- the recorder jars and milkmeters
- the sanitary trap
- the receiver unit
- the milk pump and milk filter

The basic lay-outs of the main types of milking machines are shown in figure 1 (see page 4).
The vacuum pump
The function of the vacuum pump is to rapidly extract air continuously from the milking machine system. An air/vacuum pipeline connects the vacuum pump to all the parts of the system where vacuum is required and is together with the vacuum pump regarded as the lungs of the milking machine system. Most milking machines operate at a set vacuum level between 40-50 kPa. This is sufficient to extract milk out of the teats. Under normal weather conditions the atmospheric pressure is about 100 kPa (1 bar) or 29.53" Hg or 75 cm Hg. See table 1 for conversions.
The capacity of the vacuum pump is the volume of air (at atmospheric pressure) displaced under working conditions and at a known number of pump revolutions per minute. The capacity of the vacuum pump is expressed in litres of free air per minute and should be larger than the sum of the reserve capacity, the combined "air consumption" of the milking units and pulsators, and other ancillary equipment to maintain vacuum at a certain level. The required size of the vacuum pump will depend on:

- the type of the installation (either buckets

Table 1 Conversion table for units of pressure

<table>
<thead>
<tr>
<th>kPa vacuum</th>
<th>inches Hg vacuum</th>
<th>cm Hg vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>44</td>
<td>13</td>
<td>33</td>
</tr>
<tr>
<td>47</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>37</td>
</tr>
</tbody>
</table>
or milk pipeline with jars or milkmeters)
- the number of milking units
- the ancillary equipment
- the number of milkers
- the cleaning system
- the geographic altitude

When installing a milking machine, the minimum standards have to be closely observed, such as those of the International Standards Organisation (ISO). The current ISO standards are under revision. Table 2 gives some examples for the desired vacuum pump capacity.

### Table 2
Recommended minimum free air capacity of the vacuum pump in litres per minute and number of units at sea level. (Source: IKC).

<table>
<thead>
<tr>
<th>Number of milk ing units</th>
<th>Bucket type installation</th>
<th>Milk pipeline installation (circulation cleaning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>250 l./min.</td>
<td>330 l./min.</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>425</td>
</tr>
<tr>
<td>5</td>
<td>400</td>
<td>675</td>
</tr>
<tr>
<td>6</td>
<td>530</td>
<td>1000</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>1400</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>1700</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>2000</td>
</tr>
</tbody>
</table>

Atmospheric pressures and distances above sea level will change the output of the vacuum pump. Table 3 shows the correcting factor for true capacity.

### Table 3
Elevation correction factors for calculation of the correct size of vacuum pumps.

<table>
<thead>
<tr>
<th>Elevation in metres above sea level</th>
<th>Multiplier factor for needed pump capacity</th>
<th>Normal atmospheric pressure in kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 300</td>
<td>1.00</td>
<td>100</td>
</tr>
<tr>
<td>300 - 700</td>
<td>1.07</td>
<td>95</td>
</tr>
<tr>
<td>700 - 1200</td>
<td>1.16</td>
<td>90</td>
</tr>
<tr>
<td>1200 - 1700</td>
<td>1.28</td>
<td>85</td>
</tr>
<tr>
<td>1700 - 2200</td>
<td>1.45</td>
<td>80</td>
</tr>
</tbody>
</table>

The vacuum pipeline

The air pipes connect the vacuum pump to the various milking units and are usually made of galvanised steel or PVC. The lowest possible number of elbows and tees is recommended and the installation of knee-pieces should be avoided under all circumstances, owing to their high air resistance. If the vacuum pipe is part of the cleaning circuit, it should be made of stainless steel, glass or PVC.

The pipes should be properly supported to prevent sagging, which is often seen in many older machine milking installations. Make sure that the vacuum pipeline can withstand an internal pressure of up to 200 kPa at all prevailing temperatures. The internal pipeline diameter should be such that a drop in vacuum in the pipes does not exceed 2 kPa. See table 4 for standards for vacuum pipeline diameter.

### Table 4
Standards for the minimum vacuum pipeline internal diameter in relation to the quantity of air extracted per minute at a constant air flow for pipelengths shorter than 30 metres. (Source: IKC).

<table>
<thead>
<tr>
<th>Airflow litres/minute</th>
<th>Internal diameter</th>
<th>Section surface area in cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 200</td>
<td>25 mm (1&quot;)</td>
<td>5.0</td>
</tr>
<tr>
<td>200 - 600</td>
<td>38 mm (1.5&quot;)</td>
<td>11.3</td>
</tr>
<tr>
<td>600 - 1000</td>
<td>50 mm (2&quot;)</td>
<td>20.4</td>
</tr>
<tr>
<td>1000 - 1700</td>
<td>63 mm (2.5&quot;)</td>
<td>31.2</td>
</tr>
<tr>
<td>&gt; 1700</td>
<td>76 mm (3&quot;)</td>
<td>45.3</td>
</tr>
</tbody>
</table>
The interceptor
An interceptor vessel or moisture trap is fitted close to the vacuum pump to collect moisture and dirt, preventing it from entering the vacuum pump in order to avoid damage. It should be fitted in a position where it is easily accessible for cleaning. It is recommended to provide it with a float valve which closes off the vacuum when liquids (milk or water) within the interceptor rises too high, and a self-sealing flap valve on the outlet which automatically opens when the pump is switched off. In accordance with the milking system in use, the interceptor should have a minimum capacity of at least 15 litres but preferably more.

The vacuum regulator
The vacuum regulator is the brain of the entire machine milking system and should automatically maintain a steady, desired vacuum level. The regulator may be operated by either a spring, weight or diaphragm. The regulator is pre-set at the desired vacuum level, so when the vacuum in the plant increases above the pre-set level, atmospheric air is admitted into the system until the required vacuum is reached. If the vacuum drops during milking, the vacuum regulator might not function properly, the pump capacity might not be large enough, the pump is running too slow or there are serious leaks. Fluctuations in vacuum should be prevented since this might increase the risk of damaging the teats and cause infections. The regulator must be fitted in the vacuum line between the interceptor and the first vacuum tap, but close to the interceptor. In view of the importance of the vacuum regulator, it should be easily accessible for periodic inspection, cleaning and maintenance.

The vacuum gauge
The vacuum gauge indicates the vacuum level within the milking machine system. Its position should be behind the vacuum regulator for checking whether the vacuum pump and regulator are working correctly. For checking the vacuum level during milking it is recommended to place a second gauge in the milking parlour.

The pulsators
The pulsator is a device which connects the room between the teatcup (shell) and liner to vacuum or to atmospheric pressure.

The milking parlour is the heart of the dairy farm
To facilitate reading, the diameter of the gauge should be at least 75 mm. In the past, gauges were calibrated in barometric units (0-30 inches Hg or 0-76 cm Hg), but today a scale from 0-100 kPa is universally applied. See table 1 for conversions (see page 4).
expressed in cycles per minute. For efficient milking the pulsation rate should be in the range of 50 to 65 cycles per minute. Alternating versus simultaneous pulsation systems are often debated. Millions of cows have been milked with either system with good results. Research and practical experience appear to be marginally in favour of alternating pulsation.

The working of the liner and shell
What happens can best be understood by studying figure 2. The air pressure within the space between the shell and liner is altered from atmospheric pressure to the same level as the vacuum inside the liner (under the teat end).

The liner opens when vacuum is applied and closes when connected with atmospheric pressure. The pulsation system is the heart of the milking machine. The pulsator can be controlled pneumatically or electromagnetically, and be self-contained or operated by a master pulsator which operates a number of relays. Electromagnetic pulsators are preferred because of their more constant functioning. The pulsator can be fitted on the lid of the bucket or be placed on the vacuum pipe.

The speed of milk extraction depends upon the time ratio between the opening and closing phase of the teatcup liner. A pulsator ratio with a wide 'open' time enables faster milking, but a too wide ratio may not provide sufficient closing time to facilitate proper teat massage and stimulation.

A steady vacuum during milking is of utmost importance for good udder health. Most pulsators are designed for ratios between 50 : 50 and 70 : 30. In general the optimum ratios are between 60 : 40 and 70 : 30. The pulsation rate is the number of times the liner opens and closes and is

Vacuum or open phase
A steady vacuum on the inside of the liner is realised via the long milk tube. When the pulsator is in the vacuum phase there will be vacuum on the inside and the outside of the liner. This means there is no vacuum difference, resulting in an opened liner. With the liner wall in straight position, the vacuum is applied to the teat end for milk extraction. We call this situation the milking phase.
Atmospheric or closed phase
The pulsator switches to another phase and the vacuum within the long/short pulse tubes is replaced by atmospheric pressure. This causes the liner to squeeze below the teat, because there is vacuum inside the liner. The closing of the liner wall has two effects. It massages the teat and allows for blood circulation around the end of the teat, because now there is no vacuum applied to the teat end. At the same time the milk flow stops. This is known as the rest phase.

The milk pipeline
Many dairy farmers prefer a pipeline milking installation to a bucket installation to avoid the tedious and repetitious work of changing and emptying buckets. The milk pipeline installation makes milking less tiresome and increases the number of milkings per hour. The pipeline milking system is used in tied-up cow barns and in milking parlours.

The milk pipeline must be made of stainless steel or glass and is used to convey the milk from the milk clusters to the milk receiver. The pipeline diameter is dependent on the number of milking units, the milk speed, the length and slope of the pipeline, and the air inlet. The flow of milk in the pipeline should take up about 1/3 to 1/2 of the cross section of the pipe diameter. The speed of the milk flow is determined by the slope of the pipeline and the amount of air flowing from the cluster units. In milking parlours the pipeline should slope about 1 cm for each 1 metre (1%) of length. Try to avoid raising of the pipeline over feeding lanes or corridors. Under all circumstances the milk flow should be smooth and uniform.

Through gravity the milk flows into the clawpiece and after admission of air the milk is conveyed into the milk recorder jar or milk pipeline. For proper functioning of milk transport to high-level milk pipelines in stanchion barns and in milking parlours the vacuum level should be in the range of 48 - 50 kPa. However, this high-level vacuum together with air admittance may increase the splitting of fat globules, and consequently raise the acidity level of milk fat. Nevertheless, when using the recommended size of high-level milk pipelines the transport of milk will be smooth and will not interfere with the machine milking performance.

In an effort to overcome milk transportation problems and to maintain stable vacuum levels in milking pipelines the low-level milk pipeline with larger diameters in milking parlours was successfully developed. It is recommended to install the milk pipeline below the elevated floor surface of the cows and underneath the curb. As a result, the vacuum fluctuations due to transport of milk in the long milk tube are minimized. The recommendations for the maximum number of units and different internal diameters of milk pipelines are listed in table 5.

Cluster assembly and/or buckets
The cluster assembly consists of 4 teat cups, the milk claw, the long milk tube and the long pulse tube. The teatcup can be further divided into a steel shell, a rubber liner, a short milk tube and a short pulse tube. The diameters of the long and short milk tubes should be (at least) 14 and 10 mm, respectively.
Table 5
Recommendations for the maximum number of units on milk pipelines of different internal diameters for an average milk production of 15 kg per milking. (Source: IKC).

<table>
<thead>
<tr>
<th>Type of milking pipeline</th>
<th>Internal diameter in millimetres and inches</th>
<th>Total length in metres of the milk pipeline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Single milk pipeline</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Circuit milk pipeline</td>
<td></td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

In bucket installations the milk is conveyed from the cow to the bucket and afterwards emptied into a milkcan or milk storage tank. The buckets must be made of stainless steel and have a capacity of up to 20 litres. The bucket system is the most simple way of machine milking and is used in small herds and with just freshened cows (colostrum).

During recent years new additional components were developed to simplify the work and to assist the milker. The application of most ancillary equipment takes place mainly towards the end of the milking process of each individual cow. The milk flow detectors and the automatic cluster removal (ACR) are briefly described.

**Milk flow detectors**

Most milking units usually incorporate a provision for visual observation when the milk flow is coming to an end and to overcome blindmilking. This is often done with transparent components or inserts, such as pieces of transparent tubes joining the liners to the short milk tubes, transparent covers on claw bowls or a short piece of transparent tube inserted in the long milk tubes. It does not always give an instant clear indication of the milk flow, because the inner surface of the transparent tubes are often covered by a layer of milk. To overcome this problem the milker can use a milk flow detector.

Figure 3 shows a milk flow detector consisting of a float and a float-chamber. The end of milk flow detector shown in fig. 3 has a self-clearing orifice. A central tube shaped to fit a conical seat in the chamber outlet, has a notch in the bottom edge to form a metering orifice. The tube is flanged at the top and surrounded for most of its height by a sliding float (Fig. 3a). During the peak flow milking period, the central tube is lifted off its seat (Fig. 3b).
Proper dimensions of the cluster assembly enable smooth milking.

Cluster removal in cases where the flow rate is variable towards the end of milking and before the milk flow is established. The detectors are usually made inoperative by built-in delays for the first 2 minutes of milking.

Some other types have an operating system based on the electrical conductivity of milk. As soon as the milk flow stops, the electrical circuit between two probes is disconnected, thus determining the end of milking. The milk flow detector detects the end of milking (below 0.2 kg/min.) and activates the electric valve at the cylinder so that the cylinder is connected to the vacuum. The vacuum supply on the cluster will be disconnected and the cluster is removed from the udder.

At the predetermined end of milking flowrate, a magnet in the float operates an external reed switch. The manufacturers recommend that the clusters be removed as soon as the milk flow is below 0.2 kg/minute. The metering orifice is self-cleaning and these detectors cannot work if the metering orifice becomes blocked.

**Automatic cluster removal (ACR)**

For milking parlours a fully or a semi-automatic cluster removal system is designed to remove the cluster from the cow at the end of milking. Most manufacturers use a piston and cylinder for the power unit. The cylinder is connected to the vacuum supply of the milking machine through an electric magnet valve device, and the piston to the milking cluster through a nylon cord. The cluster removal sequence is mostly initiated by a milk flow detector. The milk flow detector activates the cluster removal equipment when the milk flow from the cow becomes less than 0.2 kg/minute for a period varying from 15 to 30 seconds. The delay is to avoid premature cluster removal in cases where the flow rate is variable towards the end of milking and before the milk flow is established. The detectors are usually made inoperative by built-in delays for the first 2 minutes of milking.

An automatic cluster-removal system enables an increase in the number of cows to be milked.

**Milk-recording with jars and milk meters**

The most important information for feeding and selection of dairy cows is the daily milk yield of each individual cow.
Commonly, milking parlours are equipped with a rigidly mounted glass milk recorder jar for individual daily milk recording. It enables the milk produced by each cow to be seen and measured and, if necessary, rejected from the regular milk supply.

**The milk recorder jar and electronic milk meters**
For official milk recording the jar has to be calibrated and should be fitted with provisions for milk sampling. At large-scale dairy farms these data can be measured by electronic milk meters and may be integrated with a computer-linked identification and management system. Often, these milk production data are part of a fully comprehensive management programme. However, at most farms, a less expensive system is used.

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**The milk-recorder jar shows the most important farm management information**

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Milk metering by the Tru Test milk meter
In the absence of a recorder jar milk meters are available to measure individual cow yields, for instance once a week or for official milk recording. A constant proportion (about 2.5%) of the throughput is divided from the main flow and is collected in a measuring flask which is calibrated to indicate the yield. The milk in the flask is a proportional sample and is suitable for milk analysis. These meters are made of rigid transparent plastics and are light in weight. They are suitable for use with pipeline milking machines in cow sheds and by field technicians of the milk-recording associations.

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**The sanitary trap**
The sanitary trap should be installed in all milk pipeline and milk recording jar systems. The sanitary trap is an extra safeguard to prevent milk and/or water from entering the vacuum system. It also prevents any contamination of milk with any non-desirable liquids which may have entered the vacuum system. It should be made of glass or stainless steel and be fitted with an automatic cut-off valve and have at least an effective capacity of about 3 litres.

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**The receiver unit**
All milk pipelines terminate at the receiver unit which functions as a liquid-air separator. At the same time this unit is feeding a releaser which transfers milk from the milk receiver to the milk storage tank by means of a milk pump. Most receivers are made of glass or stainless steel and should have a capacity of at least 18 litres, but preferably between 40 and 50 litres. The receiver has a built-in electronic device at two different levels which is connected to the milk pump. The milk level in the receiver activates the milk pump on/off switch.

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**The milk pump and milk filter**
The inlet of the milk pump is connected to the lower outlet of the receiver unit. Most pumps are of the centrifugal type and made of stainless steel. They are easy to dismantle for servicing and inspection. Between the milk pump and filter there is a one-way valve to avoid milk flowing back after the milk pump has been switched off. All milk must be pumped through a milk filter into the milk storage tank. After each milking the filter should be disposed of for hygienic reasons.
SUMMARY

It remains evident that proper knowledge of the milking machine and extra attention paid to the system pays back doubly. The healthier the cows, the higher the milk production. The milking machine is a very important piece of equipment requiring as much attention as the cows themselves. When it operates at optimum efficiency, the dairyman’s herd, as well as his balance sheet, will flourish.

The general guidelines for good milking machine management are:

1. visit and consult other dairy farmers about their experience with milking machines;
2. select a capable consultant for proper designing of the milking machine installation;
3. make sure that your dealer offers adequate know-how and after-sales service;
4. install your milking machine installation according to the required specifications;
5. ensure sufficient capacity of the vacuum pump at your geographic altitude;
6. use the desired diameters of pipes for vacuum and milk transport;
7. maintain the desired level of vacuum under all circumstances;
8. check and calibrate the vacuum gauge on a regular basis to maintain accuracy;
9. regularly check the rate of pulsation (cycles) per minute and pulsation ratio;
10. keep your milking machine in optimal working order through regular maintenance.
FURTHER REFERENCES

- Milking; Lecture notes by IPC-Livestock/Dairy Training Centre ‘Friesland’

Earlier publications:

- Reproduction Management
- Young Stock Management
- Foot Care Management
- Feeding Management, Volume 1
- Feeding Management, Volume 2
Dairy Training Centre Friesland (DTC-Friesland) is established by various Dutch farmers’ organisations and controlled by the Ministry of Agriculture. The Centre conducts a variety of international training programmes and courses. We also provide consultancy and management services.

All courses have a strong practice-oriented character based on the training concept of learning by doing. The practical training is very intensive; one instructor deals with groups of six students and for subjects like milking even with three students only. DTC-Friesland offers training in the following subjects:

- **Dairy Husbandry**
  - machine- and handmilking, milking machines, milk hygiene
  - feeding, ration calculation, feedplans, quality of feedstuffs
  - fertility management, heat detection
  - breeding, use of A.I., culling, body conformation
  - housing, tying/cubicle systems, hygiene
  - health, mastitis control, hoofcare
  - calf rearing
  - farm economics
  - farm administration

- **Forage production**
  - pasture management
  - fodder crops
  - silage making
  - farm machinery

- **Milk processing**
  - manufacture of cheese, butter, yoghur, ice-cream, etc.
  - milk collection and payment systems
  - marketing
  - management of a dairy unit

- **Sheep husbandry**
- **Dairy goat husbandry**
- **Intensive beef production**
- **Horse keeping and animal traction**
- **Teaching methodology**

Visits to farmers’ organisations, A.I.-stations, Health and Extension service etc. are integrated in the courses to provide a good picture of the dairy sector in the Netherlands.
AD HOC COURSES

Our major activity is the organisation of ad hoc courses on request, preferably for groups of a multiple of six participants. These training programmes are tailor-made and completely designed according to the requirements of the client. The courses deal with one or more of the earlier mentioned subjects. Duration of the courses varies from 1 week to several months.

The courses are conducted in English. For some special subjects training can be provided in French, Spanish or German as well.

If facilities are available locally, our staff is prepared to conduct courses abroad as well.

SIX-WEEKS COURSE: MODERN DAIRY FARM MANAGEMENT

This course is especially designed for persons in charge of a large-scale dairy enterprise, and includes all aspects involved in managing a dairy herd. The course offers a good opportunity to refresh one’s knowledge and learn about recent developments in dairy farm management. The course is conducted annually in September/October. However, for groups of at least six persons it can be organized at any time during the year.

TRAINING FACILITIES AND STAFF

The centre has four farms, each with a different management system. One farm is especially equipped for international courses. The total stock at the four farms includes 250 dairy cows, 50 fattening-bulls, 45 dairy goats, 85 sheep and 12 Friesian horses. Additionally, the centre maintains close relations with twenty neighbouring farms which are used for practical training. Our staff consists of fifty dedicated and well-qualified trainers. All have up-to-date knowledge of modern dairy farm management, and over 70 man-years experience is present in various dairy development projects throughout the world.

ACCOMMODATION

A newly constructed hostel provides full board and lodging in single or double bedrooms. The hostel provides an international kitchen, and many recreational facilities. Social excursions are organised during the weekends to enable the students to get acquainted with the Dutch culture.

For more detailed information on the activities of DTC Friesland, please contact:

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