THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Section 11 - Guidelines for Testing, Approval and Checking of Milk Recording Devices

Section 11 – Milk Recording Devices

Version October, 2020

Network. Guidelines. Certification.

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Change Summary

Date of Change	**Nature of Change**
July 17	Reformated using new template.
July 17	Table of contents added.
July 17	Heading numbers and heading text edited for clarity and removal of redundant text.
July 17	Update within document references to reflect change in numbering if headers.
July 17	Merge static appendices into this guideline. Remove application form and replace with link to application form on ICAR website. Update references to appendices to be internal links to annexes in this document.
August 17	Add captions and numbers to all tables, figures and equations.
August 17	Add Tables, Figures and Equations to table of contents.
August 17	Replaced formulas since they were unreadable.
August 17	Added drawing 1 and drawing 2.
August 17	Stopped Track change sand accepted all previous changes.
August 17	Moved the file to the new template (v2017_08_29).
August 17	Updated version to August 2017. Corrected punctuation in summary of changes. Corrected missing automatic cross-references.
August 17	Replaced url’s with links to “here”.

October 17	Update version to October. Add hyperlink to periodic checking of recording devices on page 23 and remove same link from home page of ICAR Guidelines.
October 17	Fix annex numbering – make second Annex 8 into Annex 9 an d add new Appendix 10 (Periodic Checking of Approved Meters. Hints for the Sample Taker and Farmer).
October 17	Applied template, fixed links to the web file of the periodic checking. Fixed some wrong bullet alphabetic
Oct 2020	Fixed some errors: • In points 5.3 and 6.1.1 there are references to tables 11.2 and 11.6 which not exist • Point 8 – link doesn't work • Equation 11 was written two times

1 Introduction

Animal milk recording is a basic prerequisite for herd/flock management purposes as it is also the basic element of herd improvement and breeding programs. To measure milk yield of animals many kinds of milk recording devices have been developed in the past.

Since 1984 ICAR has developed rules, standards and recommendations for testing, approval and periodic checking of milk recording devices. In this Section 11 standards for milk recording devices are described for cows, buffaloes, goats and sheep.

This section is a part of the International Agreement of Recording Practices of ICAR (Point 14 of the Agreement).

2 Definitions

A milk recording device has the function to:

a. Measure the milk yield per individual milking of an animal (whole udder or per quarter).

b. Provide a representative sample of this milk or perform an on-farm analysis of the milk on relevant parameters (at least fat and protein content).

without significantly affecting the normal milking procedure and the quality of the harvested milk.

Measuring principles in general are based on weighing principles or direct or indirect measuring of volume by volumetric principles or others like infrared principles. In most cases a milk recording device consists of a milk meter and a more or less integrated sampler. In some cases the sampler is a separate device more or less independent from the milk recording device. In all cases the approval is given to the milk recording system (device), meaning the combination of milk meter and sampler or the combination of milk meter and milk analyser.

Milk analysers in combination with milk meters can measure milk flow and milk components (for instance fat, protein, lactose and somatic cells) . Data generated by these devices can be used in daily management and in official milk recording. Other parameters which can be measured by the same equipment are for example measuring blood in milk, urea, hormones and so on. Such parameters are more related with farm management.

On farm analysers for the relevant parameters in the milk can be divided in:

a. In line analyser. An in line analyser is installed in the milk pipeline and performs the analysis during the milking process (real time) or at the end in a representative aliquot of the whole milking

b. At line analyser. An at line analyser is installed besides the production line and is used to analyse a representative sample of the whole milking. These devices are likely to be located near the milking unit but not exclusively.

In this document the term 'milk analyser' refers to an in line analyser only.

Note: Any combination of milk meter and sampler or milk analyser must be tested to achieve an ICAR approval.

Reference is made to standards for milking equipment. These standards are:

a. ISO 3918 Milking Machine Installations. Terms and definitions.

b. ISO 5707 Milking Machine Installations. Construction and performance.

c. ISO 6690 Milking Machine Installations. Mechanical testing.

d. ISO 20966 Automatic Milking Installations - Requirements and testing.

e. IDF Bulletin 265: Determination of FFA in milk and milk products.

f. ICAR Guidelines on On-farm Milk Analysis (under construction)

The following abbreviations are used in this document:

a. MRDs for a Milk Recording Device including a sampler

b. MRDa for a Milk Recording Device including a milk analyser

3 Requirements for milk recording devices and systems

For the purposes of official milk recording only devices are valid which meet the definitions of ISO 3918. Milk recording devices are to be designed to operate under the normal conditions of machine milking as defined in ISO 5707 and ISO 20966. Materials used in the manufacturing of milk recording devices must comply with the requirements of ISO 5707 / 20966 and the legal provisions in the country of a member organization. Manufacturers shall specify the precise conditions under which a recording device is designed to operate properly within the scope of this guideline and provide written operating instructions.

The milk recording device should have a measuring and sampling capacity for a milk yield of at least:

a. 40 kg for cattle.

b. 15 kg for buffalo.

c. 6 kg for goats.

d. 3 kg for sheep.

3.1 Reading scale

The graduated scale of a jar or tube must be permanently fixed to the wall in a suitable dark color to contrast with the milk to be measured. It is required that the measuring tube of portable meters can be easily checked for verticality at reading (for example by continuous lines encircling the tube at 5 kg intervals).

Note. In case of removable measuring tubes: only the approved type of tube may be used for recording.

The unit of measurement is mentioned in table 1 The scale shall consist of a vertical line of 1 mm wide the full height of the scale with horizontal lines to one side of the vertical line. The numerical value of each kilogram interval shall be indicated in figures of 5 mm minimum height, at the far end of the horizontal line mid-way down the line. Primary intervals shall be indicated by lines of 15 mm length and 0.5 to 1.0 mm thickness; secondary interval shall be indicated by lines of 10 mm length and 0.25 to 0.5 mm thickness. An example of the measuring scale is given in Figure 1.

The graduations of the scale and the minimal scale representation (length of scale representing 1 kg milk) differ per animal species and shall be as reported in Table 1.

Table 1. Units of measurement for all species.

Species	Interval	Minimal scale representation
Cattle	primary : 1.0 kg secondary: 0.2 kg	10 mm / kg
Buffalo	primary : 1.0 kg secondary: 0.2 kg	25 mm / kg
Goat and sheep	primary : 1.0 kg secondary: 0.1 kg	40 mm / kg or liter

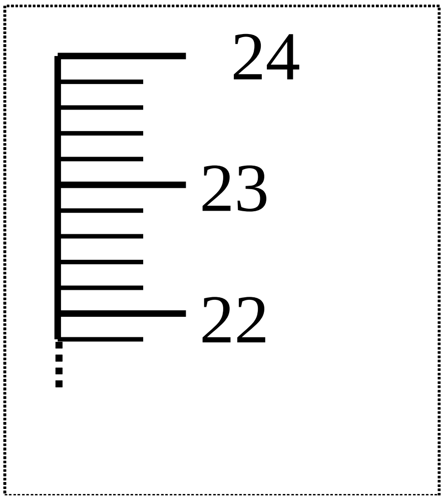


Figure 1. Example of a measuring scale for milk yield.

3.2 Yield display

In systems where the meter is connected to a computer system, and this device is used for official milk recording, a print or electronic file must be available. The file must include cow ID, amount of milk, time of milking and the position where the cow was milked. The printout or file must contain every milking on recording day. In case a display is used, it shall consist of easily legible figures at least 5mm in height, which can be read at any level of ambient light. The display shall indicate the milk yield in kilograms with increments depending on the species:

a. For cows and buffalos increments of no more than 0.2 kg; for preference increments of 0.1 kg.

b. For sheep and goat increments of no more than 0.1 kg; for preference increments of 0.05 kg.

3.3 Sampling

The sample shall be:

a. Representative for all the milk collected during that milking.

b. Sufficient amount for analyzing the milk composition.

A minimum volume of 25 ml shall be taken at the minimum recordable milk yield depending on the species: 2 kg for cattle and buffaloes and 0.3 kg for goat and sheep.

Note. The sufficient amount for analyzing is depending on the country and varies between 25 ml and 50 ml. In cases samples of evening and morning milking are combined, 25 ml sample per milking is sufficient in all countries. When evening and morning milking are separately analyzed, in some countries a higher amount of sample can be prescribed.

The sampler shall be easily accessible, sampling tubes or bottles (when used) shall be easy to place and remove. In parlors where jars are mounted below the cow standing level, consideration shall be given to the means of sampling. If sampling is to be done directly from a tap at the base of the jar, then:

a. The distance from the base of the tap nozzle to the operator's floor should be no less than 0.2 meters.

b. The operational conditions must comply with local and/or national health and safety requirements.

c. The tap shall be so located and or constructed that contamination of the air flow used for mixing the milk is avoided.

Where milk sampling is done by a remote sampling device, then it shall be designed and constructed so that:

a. The operational conditions must comply with local and/or national health and safety requirements.

b. It can be included in the washing circuit.

c. Carry-over of milk between animals is prevented (to be proven in a test procedure).

3.4 Jars

Materials, construction and installation of a milk recording jar shall comply with the requirements of ISO 5707. The jars shall be installed so that the yield can be easily read and a sample can be taken without a risk for personal injury e.g. from animal kicks or trapping by moving parts of the installation. Recording jars shall be installed so that the distance between the operator's floor and the bottom of the graduated scale shall not exceed 1.60 m.

The milk release mechanism from the recording jar shall be milk tight and shall prevent milk from passing between the jar and the transfer pipe in either direction except when milk is deliberately released. The mechanism shall be as close to the jar as is practical. Where air admission is used as the means of mixing milk, then the air admission hole shall be adjacent to the milk release mechanism to eliminate the risk of some milk not being mixed with the bulk of the milk from the current animal.

3.5 Milk meters

A milk meter shall be designed to permit easy reading and handling by the operator while it is attached to the milking equipment. In addition, it shall be resistant to all conditions encountered in its normal working environment (i.e. during milk measuring and sampling, washing, disinfecting and, when applicable, transport). All parts subject to wear and tear shall be easily replaceable. The conditions for assembling of electronic milk meters are given by the manufacturer of the meter. If a milk meter is fitted with a calibration device or calibration option, adequate precautions shall be taken to prevent unauthorized alteration of settings.

3.6 In-line milk analyser

The milk analyser shall:

a. Give a value for fat and protein, representative for all the milk collected during that milking.

b. Not effect the milk in any way.

A milk analyser shall be designed to permit easy reading and handling by the operator while it is attached to the milking equipment. In addition, it shall be resistant to all conditions encountered in its normal working environment (i.e. during milking, washing, disinfecting and, when applicable, transport). All parts subject to wear and tear shall be easily replaceable. The conditions for assembling of milk analysers are given by the manufacturer of the device. If a milk analysers is fitted with a calibration device or calibration option, adequate precautions shall be taken to prevent unauthorized alteration of settings.

A milk analyser shall at least analyse fat and protein content, or as the total amount in that milking or as percentage of the milk. Other parameters as lactose, urea and somatic cells are not obliged, but could be a part of the approval test on request of the manufacturer. In that case they have to fulfil the requirements also.

Note. Next to the parameters mentioned above, also parameters as for instance conductivity, blood and progesterone can be measured in milk. As for these parameters no accuracy limits are yet set, they are not a part of the requirements for milk recording devices.

Milk analysers can be used for different types of milk (cow, buffalo, goat, sheep). The requirements are (in first instance) based on cow milk. For other species the milk analysers have to fulfil the same requirements until specific requirements are set per species.

3.7 Limits of error for milk yield and milk composition

The limits of error for both milk yield and fat percentage (in case of a milk recording device with sampling) are presented in Table 2 both for recording on the test day and daily recording of milk production. Moreover bias and standard deviation shall have an uniform distribution over the range of measured values using a test for homoscedasticity or heteroscedasticity. In case of daily recording of milk production, the milk production should be the average of at least 5 days.

Table 2. Limits of error for milk yield and fat percentage per species for milk recording devices with a sampler (both test day recording and daily recording).

	Milk yield			Fat percentage		
Species	Range	Standard deviation[1]	Bias[2]	Range	Standard deviation	Bias
Cattle	2 - 10 kg	0.50kg	0.2 kg	2 – 7 %	0.10 % fat	0.05 % fat
	> 10 kg	5 %	2 %			
Buffalo	1 - 6 kg	0.30 kg	0.12 kg	3 – 15 %	0.30 % fat	0.10 % fat
	> 6 kg	5 %	2 %			
Goat and Sheep	0.3 - 0.8 kg	0.04kg	0.025 kg	2 – 12 %	0.20 % fat	0.10 % fat
	> 0.8 kg	5 %	3 %			

[1]In kg or in percentage of mean reference yield.
[2]In kg or in percentage of the reference yield.

In case of a milk recording device with a milk analyzer, the requirements for milk yield as given in Table 2 apply also for these devices.

The requirements for milk composition are given in Table 3 for the compulsory elements fat and protein and in Table 4, for the elements which are not obliged. An approval for these elements can be achieved on request of the manufacturer.

The requirements in Table 3 and Table 4 are based on the ICAR-guidelines for On-farm Analysis (refer to Section 13 of the ICAR Guidelines).

Table 3. The accuracy limits for on-farm milk analyzers in milk recording for fat and protein (compulsory elements for approval of milk analyzers).

Accuracy	Range	St. Dev.	Bias
Fat	2.0-6.0 g/100g	0.25 g/100g	0.13 g/100g
	5.0-14.0 g/100g	0.25 g/100g	0.25 g/100g
Protein	2.5-4.5 g/100g	0.25 g/100g	0.13 g/100g
	4.0-7.0 g/100g	0.25 g/100g	0.25 g/100g

Table 4. The accuracy limits for on-farm milk analyzers in milk recording for lactose, urea and SCC (non-compulsory elements for approval of milk analyzers).

Accuracy	Range	St. Dev.	Bias
Lactose	4.0-5.5 g/100g	0.25 g/100g	0.13 g/100g
Urea	10 – 70 mg/100g	15.0 mg/100 g	3.0 mg/100 g
SCC	0-2000	25 %	13 %

3.8 Effects on milking and milk quality

A milk recording device including a sampler or milk analyser shall:

a. Have none or a limited effect on the teat end vacuum as stated in ISO 5707 and measured according ISO 6690.

b. Have none or a limited effect on Free Fatty Acids in the milk, measured according to Annex 3. Test method for effect on FFA, where is stated that the effect of the milk recording device on FFA shall be less than the effect of a reference milk recording device;

c. Have none or a limited effect on the bacteriological quality of the milk. The milk recording device shall not accumulate milk soil and/or bacteria, using the cleaning procedure described by the manufacturer.

3.9 Automatic milk recording systems

Automatic milk recording systems record milk yield and a) take samples of milk or b) perform milk analysis without human supervision or interference. Automatic sampling systems are well-known in automatic milking systems, but could also be used in milking parlors. Systems for automatic milk recording shall fulfil all the requirements as stated in sections 3.1 to 3.7 above and shall:

a. Deliver electronic data. The file must include cow ID, amount of milk, time of milking and the position where the cow was milked. The file must contain every milking during the recording period.

b. Have no mismatches of animal identification with milking time, milk production and sample identification/results of the milk analyser.

c. Have a success rate in reading animal identification of at least 98 % (and must have the technical capability of 100% correct identification at recording).

d. Indicate if a milking is a complete milking (at least 80 % of the expected milk yield is collected).

e. Take samples each time an animal is milked and take care that samples are properly treated and/or stored to ensure the quality of the sample for analyses or perform milk analysis each time an animal is milked.

f. Have a capacity to record and sample all the animal milkings within the intended sampling period;

g. Have a rate of sampling / milk analysing to ensure no or minimal delay of the milking of the next animal.

h. In case of sampling: the sampling unit shall meet with ergonomic demands (weight, construction, connectivity, accessibility of critical places, portability).

4 Procedures for approval

Only records from milk recording devices, including samples or milk analysers, approved by ICAR are accepted for official milk recording. A new milk recording device, milk recording system produced by a manufacturer or any other third party can be used for official milk recording only after it has been approved as defined in this Section 11. Member organizations can only approve the use of milk recording devices first approved by ICAR.

The following exceptions apply:

a. Cattle: Meters in use before 1 January 1992 that have been previously accepted by the ICAR member organization, can be used after this date.

b. Buffalo: Meters in use before 1 January 1997 that have been accepted by the ICAR member organization, can be used after this date.

c. Sheep and goats: Meters in use before 1 January 1995 that have been accepted by the ICAR member organization, can be used after this date.

4.1 Role of ICAR and the Test Centres

a. The bodies of ICAR involved in approval of milk recording devices are:

b. Secretary General of ICAR on behalf of ICAR Board.

c. Sub-Committee for Recording Devices.

d. Service-ICAR. ICAR has established Service-ICAR s.r.l. (a 100 % daughter of ICAR) to deal with the contractual and financial transactions between manufacturers, test centers and ICAR.

e. Test Centers. The approval tests are carried out by the ICAR approved test centers in different countries (see Annex 1. Approved test centres as of July 2017).

The procedure for an approval looks like follows:

a. The manufacturer or any other interested party must send a formal test application to ICAR/Service ICAR secretariat by filling the related application form available here on the ICAR website.

b. Service-ICAR will consult the Chairman of the Sub-Committee for Recording Devices to establish the test procedure and select the test centre to perform the test.

c. The test centre prepares the test protocol describing the test procedure, time schedule and test budget. Service-ICAR will then issue the formal contracts both with the manufacturer/test applicant and the selected test centre.

d. The applicant of the test is obliged to pay Service-ICAR the fee for the test before the ICAR test starts.

e. The test centre conducts all the necessary test procedures, analyses the results and submits a confidential test report to Service-ICAR which sends a copy of the report to the test applicant and a copy to each member of the Sub-Committee for their comments and/or endorsements to the Chairman.

f. Within a month the Chairman will inform ICAR / Service-ICAR secretariat of the Sub-Committee's approval or non-approval of the device.

g. The Secretary General of ICAR will sign the ICAR approval letter and the accompanied approval certificate which are sent to the test applicant without delay.

4.2 Submission for approval

When a new milk recording device is to be submitted for an approval test, the test applicant must provide to Service-ICAR a list of devices with serial numbers, from which the required number of test devices can be randomly selected by the test centre. The number of serial numbers and devices to choose from and to be chosen, differs per species and type of milk recording device, see Table 5 and Table 6.

Table 5. Number of devices needed for an approval test.

Species	Cattle	Buffalo	Goat and/or sheep
Number on list with serial numbers	50	30	30
Number of devices for laboratory test	2	2	2
Number of devices for field test	8	8	4 / species
Number of farms for the field test	2	2	1 / species
Number of reserve devices	1 (optional)	1 (optional)	1 (optional)

In case of milk recording devices with a milk analyser, from a list of 50 serial numbers 2 devices will be chosen for the laboratory test and 6 devices for the field test, from which 4 devices will be installed in a milking parlour and two devices in automatic milking systems (robot), see Table 6.

Table 6. Number of milk recording devices with milk analysers needed for an approval test.

	Laboratory	Parlour	Robot
Number on list with serial numbers	50	50	50
Number of devices for laboratory test	2		
Number of devices for field test		4	2
Number of farms for the field test		1	1
Number of reserve devices		1 (optional)	

In case of permanently installed devices, they can be selected from already installed devices on two farms. In case of milk recording devices intended for both goat and sheep, 4 devices shall be installed on a goat farm and 4 devices (all out of the same batch), on a sheep farm. The use of a reserve device is optional. In case of a problem with a device the reserve meter can replace the faulty device (see 5.2.3 below). Results of the reserve meter are excluded from the final analysis if not needed as replacement. In case of automatic milk recording systems, a selection will be made out of 10 units by the test centre (see 4.4 below):

a. An operating manual of the device.

b. A calibration test procedure to test the device annually in the field (see 6.2 below). The validity of this procedure will be tested during the field test. It is preferred that this procedure can be conducted without milking cows; for instance by a test with water or whatever method is appropriate. The method for testing has to be provided by the manufacturer, the test centre tests for validity and reproducibility of the proposed testing method.

The manufacturer/test applicant is responsible for the correct installation and calibration of the devices in the laboratory and on the farms. After installation the test centre will conduct the tests without representatives of the manufacturer/test applicant present.

4.3 Modified milk recording devices

If approved milk recording devices are modified in hardware and/or software, influencing the measurement or the testing routine, the manufacturer is responsible to report the modification(s) to the Chairman of the Sub-Committee for Recording Devices. He will consult the test centre responsible for the original approval test. Based on the information gathered the Chairman of the Sub-Committee for Recording Devices will present to the manufacturer the plan of the required retest, if any, that has to be done to give an ICAR approval for the device modification. The manufacturer reports the device modification to ICAR on the normal test application form and in case a retest is required it is contractually then managed by Service-ICAR as done with the full tests.

4.4 Automatic milk recording systems

An automatic milk recording system is a combination of automatic recording of milk production and automatic sampling / automatic milk analyses. In most cases the recording of milk production and automatic milk analyses is performed on daily basis and the automatic sampling is performed on the test day only. In case the automatic sampling system is combined with more types of milking systems and/or more types of milk meters, each combination has to be tested for approval.

The test procedure for approval of milk recording devices is adjusted to the situation with automatic milk recording systems on the following points:

a. In case the milk meter used in automatic milk recording is of an already approved type, the laboratory test is omitted.

b. The test will be carried out by testing 2 out of a series of at least 10 milk recording/sampling devices. Both devices should be tested in two milk recorded herds. The farms will be chosen by the ICAR test centre from a list of farms given by the manufacturer/test applicant or dealer.

c. In the case of automatic (voluntarily) milking systems, the device tests will be carried out as part of the normal daily milking routine of the chosen farms.

d. For each test herd, at least 50 valid recordings will be taken (milk yield + samples) from no less than 40 animals.

e. All readings will be checked for correct identification and combination of animal identification, milking time and milk production.

f. The test will check that correct identification of sample bottles can be maintained even in case the sampling procedure fails due to mechanical or software problems.

g. The manufacturer/test applicant provides the test centre with a user manual of the sampling device and gives instructions about handling of the sampling system (connection with the milking system, power-supply, tubes etc.). This user manual will be an integral part of the ICAR test. Following the user manual; the test centre connects the sampling system to the milking system and carries out the test procedure. The user manual must also give instructions to check the correct functionality and temperature of the sampling device..

5 Approval test

A full device approval test has two main elements, the laboratory test and the field tests.

5.1 Laboratory test

The objective of this test is to evaluate the device under several field conditions in order to assure that the device will give sufficient results. Therefore in the laboratory test the performance of the milk recording device is measured under different circumstances of flow rate, vacuum level, air bleed and tilting. Also the influence of the milk recording device on FFA and claw vacuum level is recorded. Two devices have to be available for testing and depending on the test one or both devices are tested.

A test rig is used, consisting of an artificial udder and a standard cluster (see ISO 6690), a pulsation system and a vacuum level and air inlet in the cluster which can be set to the test demands.

Test solution

It is preferred that water, with an additive (salt or acid) to increase the conductivity as given by the manufacturer (mS/cm), is used instead of milk. However, depending on the measuring principle, it can be necessary to use fresh milk or artificial milk, as indicated by the manufacturer. In case of artificial milk the manufacturer is obliged to provide the artificial milk. In case water or artificial milk is used and the measurement principle of the milk meter is volumetric, a compensation for density should be calculated, based on the assumed density of milk of 1.030 for cows, 1.032 for goat and 1.036 for buffalos and sheep. For reference quantity the fluid is weighed with an accuracy of 0.01 kg for cattle and buffalo and 0.005 kg for goat and sheep.

For a number of tests (f.i. influence of free fatty acids) the use of fresh milk, direct from a milking installation, is necessary. The milk shall be kept on a temperature of 30±2°C until used in the tests. The milk shall be of healthy animals and shall have a normal composition.

Test conditions

The minimum time per test shall be at least 2 minutes for each flow rate. The device is tested at the vacuum level recommended by the manufacturer or, when no vacuum level is recommended, by the intermediate vacuum level used in the test for influence of vacuum level (40 kPa for cattle and buffalo, 38 kPa for sheep and goat). A tolerance in the vacuum level of ±0.5 kPa is acceptable. The air bleed in the cluster shall be 10 l free air/min for cattle and buffalo and 6 l free air/min for goat and sheep.

The device shall be mounted in a height relative to the cluster as is recommended by the manufacturer. The outlet of the milk recording device to the bucket or jar, used for reference, shall be mounted comparable to field circumstances. In any case blockage of the outlet must be avoided.

The following tests are performed:

5.1.1 Influence of flow rate on accuracy and sampling

Both devices are tested, with at least 20 measurements per device and, at least 3 measurements per flow rate. The different flow rates for testing are depending on species:

a. Cattle: 1.0, 2.0, 3.0, 6.0, 9.0 and 12.0 kg/min

b. Buffalo: 0.3, 0.6, 1.2, 2.5, 4.0 and 6.0 kg/min

c. Goat and sheep: 0.3, 0.6, 1.2, 2.0, 3.0 and 5.0 kg/min

Deviation (milk meter - reference, milk analyser - reference) and/or sample percentage are plotted against flow rate.

The milk meter should work properly for flow rates up to 9.0 kg for cattle, 4.0 kg/min for buffalo and 3.0 kg for goat and sheep; at higher flow rates the meter should still work. Properly in this regard means that repeatability and correlation are such that the device will give sufficient results under field conditions.

5.1.2 Influence of vacuum level on accuracy and sampling

One device is tested using the flow rates and number of repetitions mentioned in 11.5.1.1. at different vacuum levels depending on species:

a. Cattle and buffalo: 30, 40 and 50 kPa

b. Goat and sheep: 30, 38 and 45 kPa

Deviation (milk meter - reference) and sample percentage shall be plotted against flow rate and vacuum level.

Note. In case of testing a MRDa, this test on sample percentage is only needed when sampling is a part of the procedure (i.e. differed time analysis).

Note. If the test in 5.1.1 is performed at one of the vacuum levels stated in 5.1.2, the results of 5.1.1 can also be used for this test.

5.1.3 Influence of air bleed

One device is tested at one of the vacuum levels as stated in 11.5.1 with different air bleeds and a flow rate depending on species (See Table 7).

Table 7. Flow rate and air bleeds to be tested for influence of air bleed.

Species	Flow rate (kg/min)	Air bleeds (l free air/min)
Cattle	5	0, 4, 12, 20, 30
Buffalo	2.5	0, 4, 12, 20, 30
Goat and sheep	2	0, 4, 8 , 16, 30

Per air bleed at least 3 repetitions should be made. The deviation (milk meter - reference) and/or sample percentage shall be plotted against air bleed.

Note. In case of testing a MRDa, the test on sample percentage is only needed when sampling is a part of the procedure (i.e. differed time analysis).

5.1.4 Influence of tilting the device

One device is tested at the recommended vacuum level and standard air bleed at a flow rate depending on species and at inclinations as mentioned in Table 8.

Table 8. Flow rate and inclination to be tested for influence of tilting.

Species	Flow rate (kg/min)	Positions
Cattle	5	Horizontal, 5 degrees to left, right, front and back
Buffalo	2.5	Horizontal, 5 degrees to left, right, front and back
Goat and sheep	2	Horizontal, 5 degrees to left, right, front and back

Per position air at least 3 repetitions should be made. The deviation (milk meter - reference, and sample percentage shall be plotted against position.

Note. In case of testing a MRDa, this test on sample percentage is only needed when sampling is a part of the procedure (i.e. differed time analysis).

5.1.5 Effect of the milk recording device on teat end vacuum

Milk recording devices shall meet the standards described in ISO 5707. The devices shall be tested by comparing the vacuum in the cluster with and without the milk recording device according to ISO 5707 and ISO 6690. However, if the manufacturer specifies a particular type of cluster assembly for use with the milk meter, then that type shall be used.

5.1.6 Effect of the milk recording device on free fatty acids

The effect of the milk recording device on FFA during the test (without milk sampling device or with sampling device when this is an integral part of the milk meter) shall not be more than the effect of the reference milk meter (see Annex 3. Test method for effect on FFA). The test procedure is described in Annex 3. Test method for effect on FFA.

5.1.7 Evaluation of method for Calibration Test

The method of calibration testing, as given by the manufacturer, will be tested on two milk meters including the milk analysers when appropriate and evaluated for use in the field.

5.1.8 Evaluation of cleaning properties of the milk recording device

A technical evaluation of the cleaning properties of the milk recording device (MRDs or MRDa) will be performed. The evaluation shall give information about:

a. Design of the internal and external parts of the device (e.g. lack of dead ends, unreachable parts for cleaning fluid etc.).

b. Sufficient turbulence during cleaning of the milk recording device (device in cleaning mode).

c. Special needs for cleaning (e.g. extra cleaning fluid).

5.2 Field test

Field tests have to be carried out to assess the performance of the milk recording device (MRDs and MRDa) under field conditions. These tests are to be carried out under normal milking conditions on farms with a, for the breed and country, representative level of production and a normal distribution of milk quantities, flow rates and fat percentages.

It is known that milking machine characteristics and milk flow rate have major effects on the accuracy of milk recording devices with samplers and milk analysers. The milking installations on the farms where the tests are conducted have to comply with ISO 5707.

5.2.1 Test procedure

Milk quantity given by the milk meters is compared with the milk quantity of the reference. For reference the whole amount of milk produced during the milking of a given animal is collected in a suitable bucket and the weight of that milk is measured using a scale with an accuracy of $\pm$0.02 kg for cows and buffalos and $\pm$0.01 kg for goat and sheep. The amount of reference milk is corrected for the amount of samples taken for analysis of fat percentage.

In case of a MRDs duplicate samples are taken from the milk collected in the bucket (reference) and duplicate samples are taken from the milk collected by the sampler. In all cases milk in the bucket and sampler has to be mixed thoroughly before taken samples. When for any observation no duplicate sample is available (it is not possible to take two samples), this sample should be analyzed twice if possible and the results will be treated as duplicates. Samples are analyzed for fat percentage by an accredited laboratory.

In case of a MRDa, the results of the milk analyser are compared with the reference samples.

As flow rate could influence the accuracy for yield, sampling and milk components, it is advised to record average and maximum flow rate of each milking (or at least machine on time). These data could be used in the statistical analyses and the results could replace a part of the laboratory test (see 5.1.1 above).

In each test run at least 40 readings per device has to be done. If necessary, such a farm test may take one or more consecutive days. Valid readings have minimum and maximum values for quantity and fat percentage, depending on species, as specified in Table 9.

Table 9. Valid reading in the field test per species (minimum and maximum).

Species	Milk production (reference)	Fat percentage (reference)	Protein percentage (reference)[a]
Cattle	2 - 40 kg	2 - 7 %	2,5 - 5 %
Buffalo	1 - 15 kg	3 - 15 %	3 - 8 %
Goat	0.3 - 6 kg	2 - 8 %	3 - 7 %
Sheep	0.3 - 6 kg	2 – 12 %	3 – 8 %

[a]Protein content is only needed for milk analysers.

5.2.2 Cleaning and disinfection

Tests of effectiveness of cleaning and disinfecting of the milk recording devices shall be carried out during the farm tests on all the devices under test by a visual inspection. In case of residues found, additional information shall be gathered from bulk milk quality and/or ATP measurements. With the ATP method, swabs will be taken on parts of the device where cleaning and disinfecting could be ineffective (or less effective than expected), e.g. on the top of the meter, in different chambers, in samplers or tubes.

The milk meter has passed the test if:

a. There are no visible residues on milk contact surfaces.

b. Bulk milk quality and/or ATP show no raise in number of bacteria/ATP levels.

5.2.3 Faulty device in test

In case one milk recording device fails due to poor calibration or technical defect where the other devices pass the test, then:

a. The test centre may decide to replace the faulty device with the reserve device and have it installed and tested, or

b. The test centre may ask the manufacturer to repair and/or calibrate the device and then retest that device.

In the report to ICAR it will be stated which milk recording device is replaced or retested and why.

5.2.4 Handling and operation

In case relevant handling or operational problems occur in the first test run, the manufacturer shall be informed and allowed to solve the problem before the second run, without in any way affecting the accuracy of the milk recording device (MRDs or MRDa). Any remarks about handling and operation of the milk recording device in the field, made by the people involved in testing (including the farmers), should be noted in the report, also the problems which are solved during the test period.

5.3 Analysis (statistical)

A software program performing the statistical analysis, graphics and conclusions is available for each species. The software is owned by ICAR and has been made available to the ICAR test centers.

All milk recording devices in test must fulfil both the standards for bias and standard deviation of accuracy for milk yield and fat content (See table 2). If the reference values for yield or fat percentage are outside the limits for valid readings (Table 6), these readings for yield or fat percentage will not be used in the analyses. If the values of duplicate samples for fat percentage differ with more than 0.10% these readings should be omitted. The average of the duplicates of the reference and of the milk recording device is calculated and used in the analyses.

The difference between the reference and the milk recording device is calculated for yield and for fat percentage and the difference is compared with the reference value. Even the extreme results for differences between reference and milk recording device should be used in calculations, unless there is a reason to assume an error has been made or the milk recording device has been broken. There shall be no fewer than 35 readings left for one milk recording device for both yield and fat percentage; otherwise a retest of that milk recording device will be necessary.

Statistical treatment is done to find out if outlier data exist in the remaining data and in what way the data may modify the assessment of the bias related to the milk recording device. The standards for bias should be fulfilled both with and without outlier data. The standards for reproducibility should be fulfilled with all data.

Both bias and reproducibility are also tested for homoscedasticity. There is homoscedasticity if the residuals of the regression of the differences between milk recording device yields and reference yields on these reference yields are identically and independently distributed. Homoscedasticity is tested by a X^2 test that compares the matrix of variance covariance of the estimators of the coefficients of regression obtained under the assumption of heteroscedasticity, with the same matrix obtained under the assumption of homoscedasticity.

First, homoscedasticity of the residuals of the regression is tested. If there is homoscedasticity of the residuals, the current rule concerning calculation of the standard deviation of reproducibility and the conditions of acceptability of a milk recording device are maintained (see 5.3.1 and 5.3.2 below).

If homoscedasticity is not proven by the specific test it means that there is heteroscedasticity. Then the variance of residuals is not similar according to different classes of results and test of the standard deviation of reproducibility is done per class of reference yield for each milk recording device. Classes for yield and fat content are depending on the species. In each class a standard deviation of reproducibility is calculated and compared to a threshold value that depends on the average of the reference yields for the class. For each class the current procedure done for all data is applied (see 5.3.1 and 5.3.2 below). If the standard deviation of reproducibility according to ICAR's requirements fails for one (or more) class, the milk recording device is rejected. The minimum number of measurements for a class of reference yield is fixed as 10. The statistical analysis is also described in the flow chart - see Annex 4. Flow chart statistical analysis for dairy cows on page 36.

5.3.1 Milk yield

Estimate the correlation between these differences and the reference yields.

If the correlation is not significant (P>0.05), it is assumed that the bias of the milk recording device is independent of the yield. Use the mean difference between the reference and milk recording device yields as the bias of the milk recording device, and use the standard deviation of the differences as the reproducibility of the milk recording device.

If the correlation is significant (P<0.05), it is assumed that the bias of the milk recording device is dependent on the yield. Calculate the regression of the differences on the reference yields, and use the residual standard deviation about the regression line as the reproducibility of the milk recording device.

In both instances, plot the observed differences, the expected bias and the maximum acceptable bias against yield. If the expected bias falls outside the acceptable limits at any point within the range of observed reference yield the milk recording device is rejected.

5.3.2 Fat percentage (valid for testing samplers)

Estimate the correlation between the difference and reference.

If the correlation is not significant (P>0.05), it is assumed that the bias of the milk recording device is independent of the fat content of the milk. Use the mean difference between the reference and milk recording device samples as the bias of the milk recording device. Use the standard deviation of the differences between the means for the reference samples and the means for the milk recording device samples as an estimate of the accuracy of the milk recording device.

If the correlation is significant (P<0.05), it is assumed that the bias of the milk recording device is dependent on the fat content of the milk. Calculate the regression of the differences between reference samples and milk recording device samples on the overall mean fat content at each observation, and use the residual standard deviation about the regression line as an estimate of reproducibility of the milk recording device.

In both instances, plot the observed differences, the expected bias and the maximum acceptable bias against the overall mean fat content for each observation. If the expected bias lies outside the acceptable limits at any point within the range of observed fat contents the milk recording device is rejected.

5.3.3 Milk components (valid for milk analysers only)

For all milk components in the approval test of a milk analyser, the data will be analysed according to the procedure described in “Guidelines on on-farm milk analyses”.

Remark: in contrast to the 'Guidelines on on-farm milk analyses' the number of farms and readings do differ. In stead of 5 farms and 100 readings, in the procedure described in this document 2 farms (1 automatic milking system, 1 milking parlor) are used with respectively 2 and 4 devices. For each device, 40 valid readings are needed, as is usual for testing the accuracy for yield. So, in total 240 readings will be used for analyses on milk components

5.4 Approval of recording devices/systems

The Test Centre will compile a test report which will be send to the chairman of the Sub-Committee for Recording Devices. The Sub-Committee will discuss the results and will advice the Board of ICAR regarding the approval status. Finally the Board of ICAR will endorse the approval of the recording device/system.

Following the notification of the approval of a milk recording device / system from ICAR to the member organizations and the manufacturer they must comply with the following conditions:

a. The manufacturer will tag all the ICAR approved devices supplied to the market with a non-removable ICAR issued label which contains the name of the manufacturer, name and unique serial number of the device, year of approval, species identification and ICAR logo.

b. The manufacturer will supply ICAR and its member organizations with the description of the calibration procedure of the device and the instructions on how to use the milk recording device (milk meter and sampler or milk analyser). This information will be made available by ICAR here on the ICAR website.

c. The manufacturer will provide the member organizations with all the relevant technical information on the device.

d. Once a year each manufacturer is responsible to give ICAR a report as defined in 5.4.1 below.

e. Once a year each member organization will give ICAR a report as defined in 5.4.2.

5.4.1 Manufacturer annual report on ICAR approved devices in market

ICAR will once a year (in January) contact the manufacturers of ICAR approved milk recording devices, and ask them to confirm which of the ICAR approved device models, listed on the ICAR website are still in production and sold in various countries and report of any possible hard- or software modification/s made on the approved devices since the previous year report.

The manufacturer will in particular be responsible to declare:

a. Names and models of ICAR approved devices manufactured that year.

b. Modification/s, if any, made on an approved device in own production.

c. Other companies with right to use/manufacture their device, and under which name.

d. If yes, responsible to report any modification/s done by the other company.

e. List of countries the devices are in market.

The manufacturer signs the document and sends it to ICAR secretariat in Rome within one month from the date of the ICAR letter.

5.4.2 Member Organization report on satisfaction with devices in use

ICAR will once a year (in spring period) contact each member organization and request a report on milk recording devices in use in their member herds. In particular the report should include the following information:

a. Names and models of ICAR approved devices currently in use.

b. Field reports, if any, on devices which since the previous year report have not met calibration requirements described in 6.2 and 6.3 below.

c. Copies of written member complaints to manufacturer/dealer about device problems on member farms.

5.4.3 Annual analysis by Recording and Sampling Devices Sub-Committee

The Recording and Sampling Devices Sub-Committee analyses the annual reports from the manufacturers and member organizations. In case of sufficient evidence of problems with a given device the Sub-Committee will communicate the evidence to the manufacturer for its response and action. The Sub-Committee may withdraw/suspend the device approval if the manufacturer in the given time has not solved the problem.

In case of withdrawal/suspension of a device approval ICAR will inform its member organizations that from a given date new installations with that device will no more be ICAR approved and thus, recording data no more considered as official.

In case the approval of a milk recording device is withdrawn/suspended the devices already in use before the date of the suspension/ withdrawal may however be used for official milk recording after that date.

6 Installation and calibration test

All scales, balance beams and spring scales used as reference should be calibrated at the beginning of a test and the accuracy should be at least within 0.02 kg.

6.1 Installation test

After installing milk recording devices in a new parlour or an extended parlour the performance of the device has to be tested by means of an installation test. This test is carried out in agreement with the member organization and/or in collaboration with the technician of the manufacturer or an authorized dealer. The manufacturer or the dealer is responsible for the installation, calibration and testing of the devices before the acceptance test is carried out. Before the acceptance test the devices have to be numbered according the numbers of the places in the parlour.

An installation test for a milk recording device consists of a milking test and, depending on the prescriptions for calibration testing, of a parameter check for the calibration. Only if results of the installation test are within the limits for this test, the device may be used for official milk recording.

6.1.1 Milking test

Step 1

Record three test observations with the milk meter and the reference and calculate the difference between the milk meter and the reference. The calibration of the milk meter is considered correct if the average difference is less than or equal to 150 % of the limits for bias according to table 2 and the average difference of all the devices on the farm shall be less than or equal to 100% of the limits for bias according to table 2. No further observations are necessary.

Step 2

If the difference is exceeding the test limits, the milk recording device(s) involved shall be recalibrated, 3 new readings per device shall be done and the calculation and checking mentioned in step 1 shall be repeated.

Step 3

If the difference is still larger than 150% of the limits, 3 more readings shall be done and the average difference of six readings will be calculated. The calibration of the milk meter is considered correct if the average difference is less than or equal to 150% of the limits for bias according to Table 2. If not, the milk meter is not acceptable and readjustment, repair or replacement has to be done by the manufacturer, after which the above procedure has to be repeated.

Note: In some situations the milk recording device needs more than three observations for a correct milking test. In this case the procedure as given by the manufacturer and approved by ICAR has to be used.

6.1.2 Reference test

In case each device has an individual calibration factor, this factor will be recorded before the milking test following the procedure of the manufacturer and the results of the reference method will be stored following the instructions of the Member Organization. In case the device is adjusted during the milking test, the reference test has to be redone after adjustment.

6.2 Calibration tests of on farm installed milk recording devices

The calibration test has to be carried out at least once a year due to maintenance reasons (wear and tear) according to the manufacturer's requirements. The calibration test also includes check on accuracy. Different procedures can be followed to do the calibration test regarding accuracy:

a. The milk recording device can be tested according the procedure for calibration testing given by the manufacturer. The testing procedure and the limits of error can be found in the manual of the manufacturer and in section 17 (Annex 10. Periodic checking of approved meters. Hints for the sample taker and farmer) below. In case the recording device includes a milk analyser, the accuracy for analysing fat and protein content shall be part of the calibration test.

b. An electronic computerized milk recording device / system can be subjected to an automatic check of errors as part of a milk recording program (this procedure can be given by a manufacturer, member organization or software suppliers). The procedure must be approved by ICAR as prescribed in 6.2.1 below.

c. The procedures under a) and b) above can be extended by comparing milk yield and fat percentage and protein percentage (in case of milk analysers) of the bulk tank with the results of the recording day. If differences exceed 5% an investigation is necessary and a check of milk recording devices in accordance with 6.1.2 above, (or some other suitable method) may have to be carried out.

6.2.1 Computerized solutions for periodic checking

It is here assumed that all of the computerized methods presented below adhere to and respect the following statements:

a. If the computerized methods are applied as outlined then they can replace the annual routine accuracy test. The requirement is to run these statistical checks at least once per year but for best practice in quality assurance it is recommended to run this more frequently throughout the year, for instance at time of milk recording visits.

b. These methods have to be used for routine test only and not for the installation test.

c. While the computerized method will identify deviating meters it does not replace the aspect of routine meter maintenance as recommended by the manufacturer

Other methods / procedures than the following ones can be subjected by the manufacturers, member organizations or software suppliers, but they must be approved by ICAR.

6.2.1.1 Several milking stand installations

Use of expected milk yield - Principles

A comparison between expected milk yield and milk yield measured by the milk meter is used to estimate whether a milk meter is out of calibration or not. The expected milk yield can be estimated from various calculations (see Table 10). When the calculation uses a "herd factor" (calculations n°2 and n°4 in Table 10), it increases the accuracy of expected yield estimation (see Table 12 on page 40). There are no significant differences between calculations using a herd factor and no significant differences between 5 to 10 milkings / days for one type of calculation. **Thus, the best compromise between accuracy and data amount is the calculation from last 5 milkings at Mn (nth milking of the day) corrected by a herd factor (i.e. calculation n°4 in Table 10).**

Step 1: Calculation of expected milk yield

Table 10. Expected milk yield calculations.

	Expected milk yield calculations
1	**Yields average on the last X days and time elapsed since last milking:** $\left(\frac{\sum_{i=1}^{x}(y1+y2)i}{X}\right)$ * time elapsed from last milking
2	**Yields average on the last X days and time elapsed since last milking * "herd factor":** $\left[\left(\frac{\sum_{i=1}^{x}(y1+y2)i}{X}\right)\right]$ * time elapsed from last milking x $\left[\frac{hn\ (current\ milking)}{\left(\frac{\sum_{i=1}^{x}(h1+h2)i}{X}\right) * time\ elapsed\ from\ last\ milking}\right]$
3	**Yields average on the last X milkings at M_n** $\frac{\sum_{i=1}^{x} yni}{X}$
4	**Yields average on the last X milkings at M_n * "herd factor"** $\frac{\sum_{i=1}^{x} yni}{X} * \frac{hn\ (current\ milking)}{\left(\frac{\sum_{i=1}^{x} hni}{X}\right)}$

with:

y_1 and y_2: milk yield of a cow at milking M1 (= first milking) or M2 (= second milking).
y_n: milk yield of cow n at milking Mn (n=1 or 2)
h_1 and h_2 : milk yield average of the herd at milking M1 or M2
h_n: milk yield average of the herd at milking Mn (n=1 or 2)
X: number of previous days / milkings

NB : The previous calculations of expected milk yield and examples are also possible with three (3) or four (4) milkings per day

Step 2: Calculation of cow deviation

For each cow, an expected milk yield is calculated. Then, the difference between the expected milk yield and the yield measured by the milk meter is calculated using Equation 1.

Equation 1. Cow deviation.

$$Cow\ Deviation\ (kg) = Measured\ yield\ (kg) - Expected\ yield\ (kg)$$

Step 3: Calculation of the milk meter deviation for one milking

For each milk meter, the deviation is calculated using Equation 2.

Equation 2. Deviation (%).

$$Deviation\,(\%) = \frac{sum\,of\;\;cow\,deviations\,(kg)\;\;for\;this\;milk\;meter}{sum\,of\;\;Expected\;\;yields\,(kg)\,of\;\;these\,cows\;\;for\;this\;milk\;meter} * 100$$

$$Deviation\,(\%) = \frac{sum\,of\;\;cow\,deviations\,(kg)\;\;for\;this\;milk\;meter}{sum\,of\;\;Expected\;\;yields\,(kg)\,of\;\;these\,cows\;\;for\;this\;milk\;meter} * 100$$

Step 4: Average deviation calculation for one milk meter

The average deviation is calculated **from a minimum of at least 9 consecutive milkings with a recommended maximum of 20 milkings**. It is desired to have an equal representation of milkings in calculation of average meter deviation. For herds milking three times daily, 9 consecutive milkings representing three days is the required minimum for calculation of the average meter deviation. The same logic would apply to herds milking four times daily.

Decision rule

If the average deviation of the milk meter is within the range of ± 3%, the milk meter's calibration is considered as correct.

If the average deviation exceeds these limits, the milk meter's calibration shall be confirmed with the manufacturer manual calibration test (6.2 above) or with a milking test (6.1.1 above).

If more than 20% of the milk meters of the installation are out of the deviation limits with this method, it is recommended to perform a manual calibration test on all of them.

Use conditions/requirements

The use of this method requires reliable electronic cow identification. There must be as well a connection between the milking parlour, the identified cows and the computer.

The method can be used for validation of meters if the milking parlour has at least 8 milking stands. If less than 8 stands in the parlour then the method and results can only for be used as a qualitative tool to indicate to the technician the meters that require attention.

The random distribution of the cows over the stands increases the accuracy of the method.

Before 30 days of lactation, milk yields are not stationary enough to estimate a reliable expected yield (Pérochon *et al.*, 1996). Thus, these data must be deleted before the calculation. Consequently, it is recommended not to use this method in the calving period (if grouped calvings).

Milk yields equal to 0 are considered as being unusual and are deleted before the calculation.

In step 3, before to calculate the milk meter deviation, a relative difference between the expected milk yield and the yield measured by the milk meter is calculated for each cow using Equation 3. If this difference is higher than 30% or lower than -30%, the data is deleted.

Equation 3. Relative cow deviation (%).

$$\text{Relative cow deviation (\%)} = \frac{Measured\ yield\ (kg) - Expected\ yield\ (kg)}{Expected\ yield\ (kg)} * 100$$

$$Relative\ cow\ deviation\ (\%) = \frac{Measured\ yield\ (kg) - Expected\ yield\ (kg)}{Expected\ yield\ (kg)} * 100$$

An application example of this method is in Application example of the expected milk yield method on page 40 .

6.2.1.2 Model of De Mol and André (2009)

Principles

This method uses a Dynamic Linear Model (DLM, West and Harrison, 1989).

The average milk yield per stand and milking session is calculated over all milkings on that stand. The resulting stand average is compared with the overall average. The deviation will be close to zero for a properly working meter. A DLM is based on a comparison per milking session of the average per stand with the overall average. This model is described by Equation 4.

Equation 4. Dynamic Linear Model.

$Deviation_{ms} = AveYield_{ms} - AveYield_{m}$ $Deviation_{ms} = AveYield_{ms} - AveYield_{m}$ **(1)**

with:

$Deviation_{ms}$: deviation for milking session m and stand s (kg)

$AveYield_{ms}$: average milk yield for milking session m and stand s (kg)

$AveYield_{m}$: average milk yield for milking session m (kg)

It is assumed that the stand deviation is a factor relative to the average milk yield for a milking session as in Equation 5:

Equation 5. Model of stand deviation.

$Deviation_{ms} = \mu_{ms} \times AveYield_{m}$ **(2)**

The stand deviation factor μ_{ms} will be close to zero if the milk meter is recording correctly, positive if the milk meter recordings are too high or negative if the milk meter recordings are too low.

A formulation with an observation equation and system equation is needed for the application of DLM (Dynamic Linear Model).

The observation equation given by Equation 6.

Equation 6. Observation equation for DLM.

$Y_t = F_t'\theta_t + v_t,\ v_t \sim N[0, V_t]$ **(3)**

with:

Y_t: observation vector

θ_t: parameter vector describing the state of the system

F_t: design matrix describing the relation between the state and the observation

v_t: observational error

The system equation is given by :

Equation 7. System equation in DLM.

$\theta t = G_t \theta_{t-1} + \omega_t, \omega_t \sim N[0, W_t]$ **(4)**

with:

G_t: system matrix, describing the relation between the current and the previous state parameters

ω_t: system error

This model is applied for each stand s and milking session m ($t \equiv m$) with the following implementation:

$Y_m = Deviation_{ms}$ - the observed deviation for stand s and milking session m (kg)

$\theta_m = \mu_{ms}$ - the stand deviation factor

$F_m = AveYield_m$ - average milk yield for milking session m (kg)

$G_m = I$ - identity matrix, assuming that the state is locally constant

With this implementation, the observation equation (3) states that the stand deviation factor of the overall average is observed. The system equation (4) states that it is expected that the factor does not change in time. The model estimates the stand deviation factor per stand after each milking session.

Decision rule

An alert is given when the stand deviation factor differs significantly from zero using a significance level of 0.05. When it is the case, the milk meter calibration shall be confirmed with the manufacturer manual calibration test (6.2 above) or with a milking test (6.1.1 above).

If more than 20% of the milk meters are out of calibration with this method, it is recommended to proceed to a manual calibration test on all of them.

Use conditions/requirements

This model is fitted with a procedure for analyzing Dynamic Linear Models ((DLM's) - by way of example only this model used a statistical package by Genstat (Payne *et al.*, 2006). The number of milkings is used as a weighting factor, discount factors are used to regulate the adaptation speed. The discount factors have been chosen such that the likelihood of the fitted model is maximal and the serial correlation of the observation errors is low.

The use of this model requires a connection between the milking parlour and the computer.

The random distribution of the cows over the stands increases the accuracy of the method.

This model will not work if the cows are divided over the stands based on production characteristics.

Milkings with zero yield must be excluded from the statistical analysis.

6.2.1.3 Model of Trinderup (2009)

Principles

The effect of different factors (date, milking time and days in milk) on milk yield is estimated. A statistical treatment on the residuals reveals if a milk meter is out of calibration or not. The model is described as following:

Step 1: Model of the lactation curve per cow as in Equation 8.

Equation 8. Lactation curve model.

$$Yi = \alpha_1(Date_i) + \alpha_2(Milking_i) + \beta_1*DIM_i + \beta_2*DIM^2_i + \beta_3*DIM^3_i + \beta^4*1/DIM_i + \beta_5(Milking_i)*DIM_i + \beta_6(Milking_i)*DIM^2_i + \beta_7(Milkingi)*DIM^3_i + \beta^8(Milking_i)*1/DIM_i + a(Cow_i) + \varepsilon_i$$

with:

Y_i:	observed milk yield (kg)
Cow_i:	cow identification
$date_i$:	date of milking
DIM_i:	days in milk
$Milking_i$:	classification of milking according to time of day (two times: am/pm; three times: am/pm/night)
ε_i:	residual (kg)

Step 2:

The residuals per milk meter are smoothed as an average over a period of 4 days. The deviation between the mean residuals of any given milk meter and the mean residuals of all other milk meters is calculated.

Decision rule

If the deviation of the milk meter is within the range of ± 3%, the milk meter's calibration is considered as correct.

If the deviation exceeds these limits, the milk meter calibration shall be confirmed with the manufacturer manual calibration test (see 6.2) or with a milking test (see 6.1.1 above).

If more than 20% of the milk meters are out of the deviation limits with this method, it is recommended to proceed to a manual calibration test on all of them.

Use conditions/requirements

The application of this model requires a statistical software.

The model was developed to be used for data from minimum 30 days. If the herd is milked two times per day it is equivalent to 60 milkings, if the herd is milked three times per day it is equivalent to 90 milkings.

The use of this model requires reliable electronic cow identification. There must be as well a connection between the milking parlour, the identified cows and the computer.

The model can be used for milking parlours with at least 8 milking stands.

For a higher reliability, it is recommended that the cows are distributed randomly over the milking stands.

N.B.: If data from a shorter period is to be used, the model can be reduced. For example if only 4 days of data is used, the model in step 1 can be reduced to that given by Equation 9:

Equation 9. Example of reduced model with four days of data.

$$Y_i = \alpha_2\,(Milking_i) + \beta_5\,(Milking_i)*DIM_i + a\,(Cow_i) + \varepsilon_i$$

6.2.1.4 Automatic Milking Systems (AMS) Comparison between robot milk meter and the tank

Principles

A comparison between the milk weight collected in the tank and the sum of milk weights measured by the milk meter of the robot and sent to the tank between 2 milk collections is used for estimating if the milk meter is out of calibration or not.

a. Step 1: Calculation of the milk meter deviation for one collection
b. Step 2: Average deviation calculation

The average deviation is calculated from a minimum of **at least 3 collections and with a recommended maximum of 5 collections**.

In case of irregular collection dates and times, we recommend calculating the average deviation by Equation 10 (rather than an average of deviations calculated in step 1):

Equation 10. Model for computing deviation (%).

$$Average\ deviation\ (\%) = \frac{\sum_{i=1}^{x}(milk\ weighed\ by\ AMS\ milk\ meter)i \mid \sum_{i=1}^{x}(Collected\ milk)i}{\sum_{i=1}^{x}(Collected\ milk)i} *$$

$$100\text{Average deviation } (\%) = \frac{\sum_{i=1}^{x}(milk\ weighed\ by\ AMS\ milk\ meter)i \mid \sum_{i=1}^{x}(Collected\ milk)i}{\sum_{i=1}^{x}(Collected\ milk)i} *100$$

With:

X = milk collection number (= 3 to 5)

Decision rule

If the average deviation of the milk meter is **within the range of ±3%,** the calibration of the milk meter is considered as correct.

If the deviation exceeds these limits, the milk meter's calibration shall be confirmed with the manufacturer manual calibration test (see 6.2) or with a milking test (see 6.1.1).

Use conditions / requirements

The use of this method requires knowing the milk destination of milk weights measured by the milk meter. It also requires the dates and exact times of milk collections and a reliable cow identification.

The gauge precision of the tank and the tank level need to be checked at least once a year.

To apply this method, the tank volume needs to be converted into a weight. At 4°C, the mean milk density used is 1.0340 (Ueda, 1999).

N.B.: The method can be used for validation of meters if the AMS has 1 box only. If more than 1 box then the method and results can only for be used as a qualitative tool to indicate the overall deviation of boxes to the technician.

An application example of this method is situated in Application example of the comparison between AMS and tank on page 44.

6.3 Calibration test of portable milk recording devices

The calibration test has to be carried out at least once a year. The milk recording device shall be tested according the procedure for calibration testing as set by the manufacturer or other approved procedures as described in 6.2 above. The testing procedure and the limits of error can be found in the manual of the manufacturer and on the ICAR-website.

7 Quality assurance and control

The approval of milk recording devices as described in this Section 11 is focused on the technical performance of milk meters and samplers. The validity of the data is also dependent on the whole procedure of sampling, handling of samples, relating data to animals, both in automatic systems and human operated systems.

To ensure proper data, checks should be made on:

a. Combining animal identification with milk production and sample identification.

b. Completeness of sampling (less than 1% samples missing).

c. Completeness of production recording (less than 1% of animals missing).

d. Completeness of animal recording (less than 2% missing in automatic recording systems, less than 1% missing in human operated systems) .

e. Sampling accuracy by comparing the fat content on the test day with the fat content of bulk milk.

f. Sampling and analysing accuracy by comparing the milk components given by the milk analyser on the test day with the milk components of the bulk milk (only in case of milk analysers).

g. Proper handling of samples (less than 1% samples that could not be analyzed).

Moreover the quality assurance certificate program of ICAR can be mentioned in this respect.

7.1 Test day policy utilizing proper recording practices when using electronic milk meters and electronic ID simultaneously

7.1.1 Definition

On test day, utilizing on-farm electronic milk meters with on-farm electronic identification (hereby addressed as ID) information, it has been substantiated numerous times that not all ID programs are complete, accurate and successful. Realizing that there are currently on-farm electronic milk metering devices standards that are in place it is the intent of this publication to substantiate the proper use and guidelines of electronic ID usage on test-day to give the most accurate and precise information possible for use in genetic evaluations and management practices.

7.1.2 Examples of proper recording systems/practices on test day

First group of cows entering milking parlor all need to be visually identified and cross-referenced to the electronic ID system; henceforth two stalls are randomly selected to observe on each group to insure proper ID test day procedures - to substantiate verification of visual observation a paper trail or computer notebook protocol would be used to insure accuracy.

First group of cows entering milking parlor all need to be visually identified and cross-referenced to the electronic ID system; henceforth every fifth group is visually identified to insure proper ID for test day procedures - to substantiate verification of visual observation a paper trail or computer notebook protocol would be used to insure accuracy.

First group of cows entering milking parlor all need to be visually identified and cross-referenced to the electronic ID system; henceforth each first and last animal is visually identified to insure proper ID for test day procedures - to substantiate verification of visual observation a paper trail or computer notebook protocol would be used to insure accuracy.

It is advisable that if there are any misidentified animals then proper notification needs to be made to the dairy producer as to the problem discovered and the entire test day needs to be completed using visual identification until the problem is corrected.

7.1.3 Validation

It is advisable the electronic ID system should have inbuilt validation checks/software to ensure each row has the correct cow sequence. Such checks would include but not limited to:

a. "Cross out" check - in the event cow A is "read" by sensor but withdraws her head and is "passed out" by another cow B, then when cow A enters properly the sequence is corrected....

b. "Random Check" - the system can be programmed on recording day so that the electronic system selects a % of units at random on each row for checking - operator must verify cow at the selected units (accept button) and only when all selected units are "accepted" is the row allowed out....

c. "Narrow Entrance funnel" - as most errors occur at entry-gate to row, it is advisable for parlor installations to have entrance funnel of "one cow length" thereby distancing the jostling activity from sensors.

Note. Experts from manufacturers should be consulted here to decide and agree on the best way to "build" quality checks into the system.

7.2 Test day policy utilizing proper recording practices when obtaining milk samples on individual animals

7.2.1 Definition

On test day, various sample vial recordings are used in the world-wide marketplace that adhere to proper test day procedures; however as has been identified by various entities, shortcuts are being made that limit proper identification of samples with individual cows on test day. With the milk sample platform being used for disease, genetics, DNA, and health tests along with the routine component test day requirements it is essential that all milk samples collected on test day be properly identified to the corresponding animal that it is collected from using proper collecting procedures.

7.2.2 Examples of proper recording of sample vials on test day

Each animal is recorded on sample vial with name or number corresponding to animal ID that is used on-farm that corresponds with proper laboratory practice procedures.

Each animal is recorded on sample vial using bar graph information systems that corresponds with proper laboratory practice procedures.

Each animal is recorded on sample vial via RFID chip installed or embedded within the sample vial that corresponds with proper laboratory practice procedures.

It is advisable that every sample vial is properly identified with the corresponding correct cow ID in whatever system is approved for proper usage that will follow proper laboratory practice procedures.

8 Annex 1. Approved test centres as of July 2017

The list of approved test centre is available here on the ICAR website.

The conditions for the ICAR-approval of a test centre for testing milk recording devices are:

a. A candidate laboratory sends to ICAR a letter of interest to become an ICAR Test Centre.

b. The Sub-Committee Recording Devices after a visit to and evaluation of the applicant facilities recommends to ICAR Board the approval as appropriate.

c. On behalf of the ICAR Board authorization, Service ICAR will make an initial 3-year test center agreement with the new test centre.

d. The first test carried out by a new test centre shall be a supervised test under the Sub-Committee Recording Devices after which the Sub-Committee may certify that the new test centre is able to comply with the ICAR test procedures.

e. Service-ICAR negotiates the individual test fees with the test centre.

9 Annex 2. Reference meters and flow rates

Some tests of the milk recording meters have to be done by comparing results with reference meters and flow rates. A reference milking unit shall be used when testing the influence of a milk meter on teat end vacuum. Reference flow rates are used to describe the function at different levels. A reference milk meter shall be used also to test the milk meter influence on free fatty acids (FFA) in the milk.

The reference milking unit for dairy cattle, buffalo, sheep and goats should be representative of those widely used in a large number of countries.

9.1 Water flow rates

The reference value is 5.0 kg/min.

9.2 Air flow rates

The reference value is 12.0 l/min for cattle and buffalo and 8.0 l/min. for goats and sheep. See IDF publication IDF small ruminants.

9.3 Reference meter for Cattle and buffalo

When testing the milk meter influence on free fatty acids (FFA) according to Annex 3. Test method for effect on FFA on page 35, the Tru Test HI model with 13 mm inlet and outlet shall be used as reference milk meter.

9.4 Goats and sheep

No reference milk meter.

10 Annex 3. Test method for effect on FFA

The effect of the milk recording device on FFA during the test (with and without sampling device if the sampling device is not a fixed part of the milk recording device) shall be measured and compared with the effect of the reference milk recording device. The test milk shall be preferably from cows in late lactation or from cows whose milk is known to be susceptible to lipolysis. The test shall be preferably carried out on a low line setup (see the ISO 6690 annex A) because electronic milk recording devices are mostly used on low line systems. The vacuum level has to be set at the level recommended for the test milk recording device, or if not specified, at 42 kPa. Care shall be taken that the tubes are arranged so that the slope and the lifting height are the same for the test milk recording device and the reference milk recording device. At least 50 liters of fresh milk must be available for each test series. The test series has to be done within one to three hours from the milking. All the milk has to be mixed thoroughly and kept at a temperature of 30°C ± 2°C. All samples are taken in duplicate and kept for one hour in cold running tap water (10-12°C) and then stored for 24 to 28 hours at 4°C before being analyzed. The analyzing methods are described in IDF bulletin nr. 265 (1991) "Determination of free fatty acids in milk & milk products". A sample of the (unused) milk has to be taken before and after the test series, to check a possible (unwanted) increase in FFA. The difference between these two samples shall be less than 0.08 meq/100 g milk fat. The testing sequence (no milk recording device, milk recording device under test with and without a sampler, reference milk recording device) shall be in a random order. Each test series shall be carried out four times at a flow rate of 3 kg/min and four times at a flow rate of 1 kg/min. The airflow shall be set to 12 l/min for cattle and buffalo and 8 l/min for goats and sheep. Between 10 and 12 kg of milk have to pass through the milk recording device in each test run.

The influence on FFA of any milk recording device shall be expressed as the difference in FFA between using only the cluster and using the cluster and the milk recording device. The statistical analysis shall not indicate a negative influence ($P<0.05$) of the milk recording device in test compared to reference milk recording device.

11 Annex 4. Flow chart statistical analysis for dairy cows

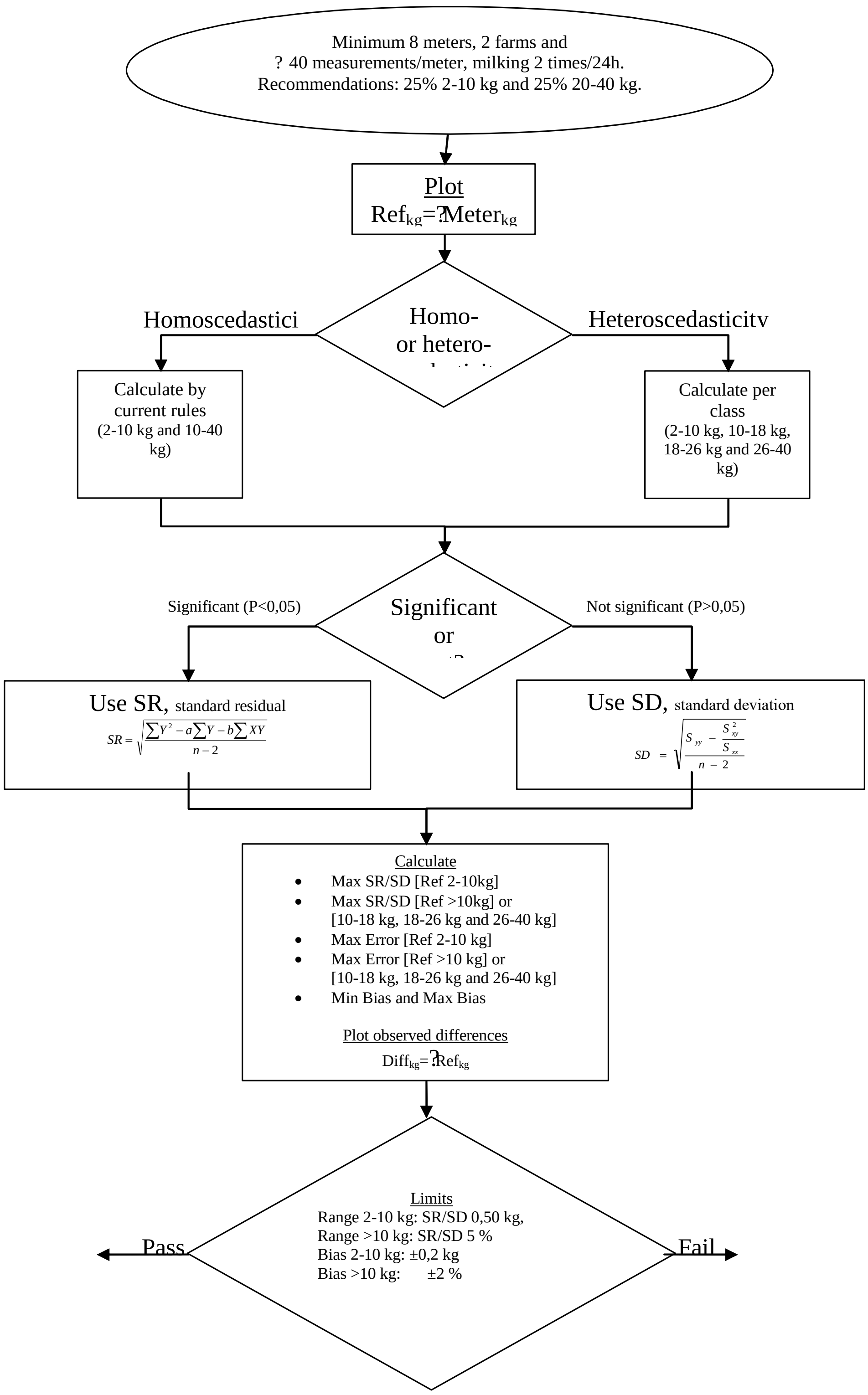


Figure 2. Flow chart statistical analysis for dairy cows.

12 Annex 5. Conditions for assembling of electronic milk meters

To guarantee a good control and functioning of the electronic milk meter, and also to facilitate the periodic maintenance, it is recommended that the electronic milk meters have to be installed in accordance with the following conditions.

a. Place of the display

- The display and the milk meter are connected as a logical unit. Moreover the display will be placed as far as possible above the milk meter.
- The milk meter and the display are both completed with a clear numbering.

b. Installation of the meter near the pit edge

It is recommended to install the meter near the pit edge. In this place the accessibility and the control of the functioning of the meter during milking are best guaranteed. The following principles apply:

- Installation according to Drawing 1.
- Sample-taking device needs to be easily accessible.
- Sample-taking device has to be installed at minimum 20 cm height (distance r1) from the bottom to the floor.

c. Installation of the meter under the pit edge. In case it is not possible to install the meter near the pit edge, the meter can be installed under the pit edge according to the following conditions:

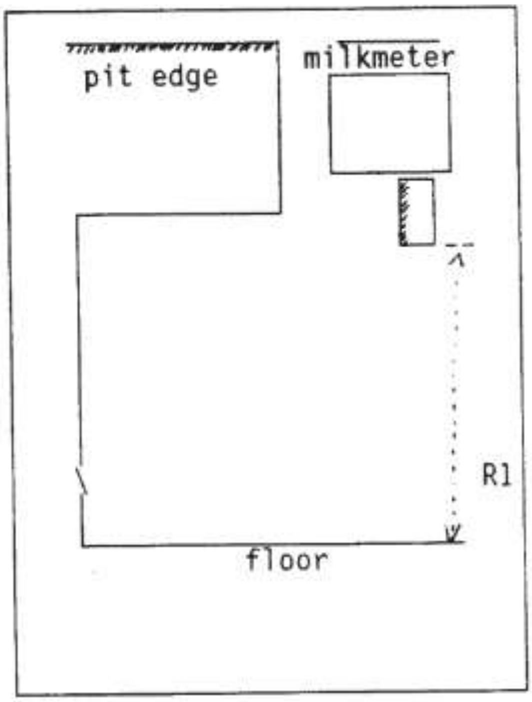
- Installation according to Drawing 2.
- Standards for the distances R1, R2 and R3 are as in Table 11.

Table 11. Distance standards for electronic milk meter installation.

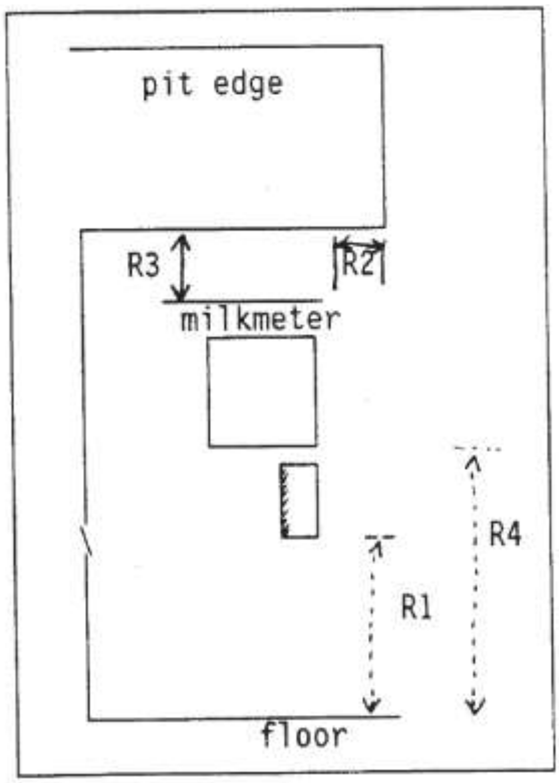
Distance	Minimum	Maximum
R1	20 cm	-
R2	-	10 cm
R3	5 cm	20 cm
R4	40 cm	-

- Sample-taking device needs to be easily accessible.
- No other equipment or pipes should be installed in front of the milk meter or the sample-taking device.

d. In all situations a good illumination of the milking parlor is recommended.



Drawing 1. Installation of meter near the pit edge.



Drawing 2. Installation of the meter under the pit edge.

13 Annex 6. Performance checking of a beam balance with two scale beams

a. Required visual checks: Legibility of scales, position of supports.

b. Check function of fixing screw at the top scale beam and stops of weights.

c. The beam balance with two scale beams is to be suspended at eye-level, using a stable fixing device.

d. Both scale beams are to be set to "0". If both pointers are in vertical position, the zero setting is correct.

e. Attach a weight of 10.0 kg.

f. The top scale beam shall be brought into an appropriate lateral position, ensuring a stable horizontal position and a co-ordinated position of both vertical pointing devices. The indicated weight shall be 10.0 kg ± 0.2 kg.

g. At the top scale beam the indicated weight shall be modified at a level of + 0.1 kg and - 0.1 kg. It is to be checked whether the scale is reacting on this actions.

h. The top scale beam is to be fixed at the zero-position.

i. The lower scale beam shall be brought into an appropriate lateral position, ensuring a stable horizontal position and co-ordinated positions of both vertical pointing devices. The indicated weight shall be 10.0 kg ± 0.2 kg.

j. At the lower scale beam the indicated weight shall be modified at a level of + 0.1 kg and - 0.1 kg. It is to be checked whether the scale is reacting on this actions.

k. The required demands are fulfilled, if the zero-level is maintained, the indicated weight is corresponding to the test weight of 10 kg ± 0.2 kg and if the beam balance is reacting on modifications of 0.1 kg.

14 Annex 7. Spring balance

a. The weight of the test vessel (tare weight) shall be measured before the first milk of a recording session enters the bucket. The tare weight shall be applied for the whole recording session. The net weight of the pointing device (adjustable) shall be set at zero and fixed in this position in an appropriate way. If no mechanical setting and/or fixing is possible, the amount of the tare weight shall be written into the relevant list of milk recording data and shall be used for calculation of the real milk yield of each cow.

b. The same test vessel must be used for weighing the milk from each animal over the whole recording session.

c. The same person shall read the weights during the whole recording session.

d. Final milk weight is read from the stable pointing device.

e. The accuracy resolution of a spring balance has to be no less than 0.1 kg.

15 Annex 8. Example of calculations

15.1 Application example of the expected milk yield method

Table 12. Concordance correlations between measured milk yield and expected milk yield for different calculations (Rouzaut & Allain, 2011).

Expected milk yield calculation	Concordance correlation			Data amount
	X=5	X=7	X=10	
1	0.946	0.947	0.948	52191
2	0.954	0.956	0.957	52191
3	0.935	0.936	0.935	53276
4	0.957	0.958	0.958	53276

Step 1: Calculation of expected milk yield

Table 13. Example for calculation of expected milk yield using 5 last milkings at M1 for cow n°4044.

Date	Time	Measured milk yield (kg) y_i	Herd yields average (kg) h_i
2011-06-04	M_1	y_1=20.2	h_1=14.7
	M_2	y_2=12.2	h_2=9.5
2011-06-05	M_1	y_1=18.8	h_1=14.4
	M_2	y_2=10.2	h_2=8.6
2011-06-06	M_1	y_1=19.2	h_1=14.4
	M_2	y_2=10.8	h_2=9.1
2011-06-07	M_1	y_1=16.3	h_1=14.2
	M_2	y_2=10.3	h_2=9.1
2011-06-08	M_1	y_1=17.2	h_1=14.4
	M_2	y_2=10.2	h_2=8.6
2011-06-09	M_1	y_1=18.4	h_1=14.4
	M_2	y_2=10	h_2=8.4

5 days back

Current milking

Therefore, expected milk yield estimation for current milking is given by Equation 11.

Equation 11. Expected milk yield for current milking.

$$\text{Expected Milk Yield} = \frac{\sum_{i=1}^{5} y1i}{5} * \frac{h1(current\ milking)}{\left(\frac{\sum_{i=1}^{5} h1i}{5}\right)} = \frac{20.+18.8+19.2+16.3+17.2}{5} * \frac{14.4}{\left(\frac{14.7+14.4+14.4+14.2+14.4}{5}\right)} = 18.3\text{ kg}$$

Step 2: Calculation of cow deviation

Equation 12. Cow deviation (kg).

$$\text{Deviation (\%)} = \frac{\textit{Sum of cow deviations (kg) for this milk meter}}{\textit{Sum of Expected yields (kg) of these cows for this milk meter}} * 100 = \frac{0.1+0.3+0.9+2.1}{18.3+14.5+14.7+13.0} * 100 = 2.6\%$$

$$Cow\ Deviation\ (kg) = Measured\ yield\ (kg) - Expected\ yield\ (kg) = 18.4 - 18.3 = 0.1\ kg$$

Step 3: Calculation of the milk meter deviation for one milking

Example: On the 2011-06-09, milking M1, milk meter n°5 (from a 28 stands rotary milking parlour)

Table 14. Deleted data.

Cow	Expected yield (kg)	Cow deviation (kg)	Relative cow deviation (%)
4044	18.3	0.1	0.5
7072	14.5	0.3	2.0
7138	14.7	-0.9	-6.5
7122	13.5	4.3	31.9 ← Deleted data
8541	13.0	2.1	13.9

$$\text{Deviation (\%)} = \frac{\textit{Sum of cow deviations (kg) for this milk meter}}{\textit{Sum of Expected yields (kg) of these cows for this milk meter}} * 100 = \frac{0.1+0.3+0.9+2.1}{18.3+14.5+14.7+13.0} * 100 = 2.6\%$$

$$\text{Deviation (\%)} = \frac{\textit{Sum of cow deviations (kg) for this milk meter}}{\textit{Sum of Expected yields (kg) of these cows for this milk meter}} * 100 = \frac{0.1+0.3+0.9+2.1}{18.3+14.5+14.7+13.0} * 100 = 2.6\%$$

Table 15. Deviation calculation of milk meter no. 5 in June 2011.

Date	Milking	Deviation (%)	Smoothing on 10 milkings (%)	Smoothing on 20 milkings (%)
01/06/2011	M1	0.8		
01/06/2011	M2	-2.1		
02/06/2011	M1	-2.3		
02/06/2011	M2	-2.6		
03/06/2011	M1	-0.2		
03/06/2011	M2	0.2		
04/06/2011	M1	-0.2		
04/06/2011	M2	2.5		
05/06/2011	M1	-3.5		
05/06/2011	M2	-0.6	-0.8	
06/06/2011	M1	-0.5	-0.9	
06/06/2011	M2	-0.6	-0.8	
07/06/2011	M1	2.3	-0.3	
07/06/2011	M2	-4.3	-0.5	
08/06/2011	M1	-0.3	-0.5	
08/06/2011	M2	0.9	-0.4	
09/06/2011	M1	2.6	-0.2	

Date	Milking	Deviation (%)	Smoothing on 10 milkings (%)	Smoothing on 20 milkings (%)
09/06/2011	M2	-2.2	-0.6	
10/06/2011	M1	-0.3	-0.3	
10/06/2011	M2	-1.6	-0.4	-0.6
11/06/2011	M1	5.9	0.2	-0.3
11/06/2011	M2	6.3	0.9	0.1
12/06/2011	M1	1.1	0.8	0.2
12/06/2011	M2	4.5	1.7	0.6
13/06/2011	M1	4.9	2.2	0.9
13/06/2011	M2	4.3	2.6	1.1
14/06/2011	M1	0.3	2.3	1.1
14/06/2011	M2	-2.9	2.3	0.8
15/06/2011	M1	-1.5	2.1	0.9
15/06/2011	M2	-4.3	1.9	0.7
16/06/2011	M1	-3.7	0.9	0.6
16/06/2011	M2	3.6	0.6	0.8
17/06/2011	M1	2.4	0.8	0.8
17/06/2011	M2	-1.9	0.1	0.9
18/06/2011	M1	0.3	-0.3	0.9
18/06/2011	M2	-2.5	-1	0.8
19/06/2011	M1	-0.1	-1.1	0.6
19/06/2011	M2	-3.5	-1.1	0.6
20/06/2011	M1	1.4	-0.8	0.7
20/06/2011	M2	-0.5	-0.5	0.7
21/06/2011	M1	0.3	-0.1	0.4
21/06/2011	M2	-1.3	-0.5	0
22/06/2011	M1	1.8	-0.6	0.1
22/06/2011	M2	-2.1	-0.6	-0.3
23/06/2011	M1	-0.1	-0.7	-0.5
23/06/2011	M2	-1.5	-0.6	-0.8
24/06/2011	M1	-1.4	-0.7	-0.9
24/06/2011	M2	-4.6	-0.8	-1
25/06/2011	M1	-1.7	-1.1	-1
25/06/2011	M2	-2.9	-1.4	-0.9
26/06/2011	M1	2.5	-1.1	-0.6
26/06/2011	M2	-4.8	-1.5	-1
27/06/2011	M1	3.3	-1.3	-1
27/06/2011	M2	1.6	-1	-0.8
28/06/2011	M1	-1.9	-1.1	-0.9
28/06/2011	M2	3.3	-0.7	-0.6
29/06/2011	M1	-2.2	-0.7	-0.7
29/06/2011	M2	0.9	-0.2	-0.5
30/06/2011	M1	1.5	0.1	-0.5
30/06/2011	M2	2.8	0.7	-0.3

Step 4: Milk meter average deviation calculation

Example for the last 10 milkings (26th to 30th of June from Table 15):

Average deviation (%) = Average deviation from the last 10 milkings =

$$\frac{2.8+1.5+0.9-2.2+3.3-1.9+1.6+3.3-4.8+2.5}{10}=0.7\% \rightarrow Correct\ milk\ meter$$

Example for the last 20 milkings (21th to 30th of June from Table 15):

Average deviation (%)= average deviation from the last 20 milkings =

$$\frac{(2.8+1.5+0.9-2.2+3.3-1.9+1.6+3.3-4.8+2.5-2.9-1.7-4.6-1.4-1.5-0.1-2.1+1.8-1.3+0.3)}{20}=0.3\% \rightarrow Correct\ milk\ meter$$

A graphic representation of the results on a longer period can also be done. That allows visualizing the deviation evolution and the occasional events occurring on the last weeks.

An example of a graphic representation for one milk meter (n°5) on the month of June is shown below. Three curves are represented: no smoothing, smoothing on 10 milkings and on 20 milkings.

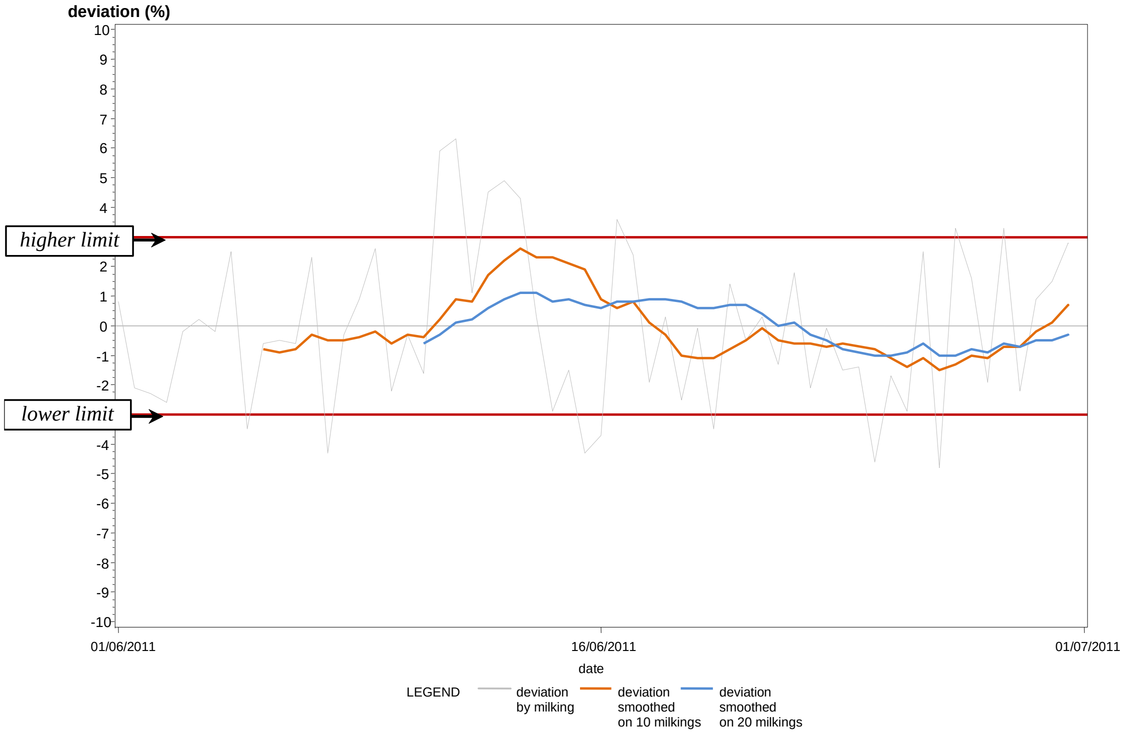


Figure 3. Graphical presentation of results.

15.2 Application example of the comparison between AMS and tank

Step 1: Calculation of the milk meter deviation for one collection

Table 16. Example of data recorded by an AMS between 2 milk collections (from the 16 to 18 April).

Milking start	Milking end	Cow id	Milk yield (kg)	Milk Destination
16/04/2011 12:08	16/04/2010 12:15	51	9.7	Tank
16/04/2011 12:16	16/04/2010 12:23	58	14	Tank
16/04/2011 12:23	16/04/2010 12:31	45	7.5	Tank
16/04/2011 12:31	16/04/2010 12:40	4	13.8	Tank
16/04/2011 12:40	16/04/2010 12:53	19	11.8	Tank
16/04/2011 13:29	16/04/2010 13:44	33	19.5	Tank
16/04/2011 13:44	16/04/2010 13:50	50	16.9	Drain
16/04/2011 13:51	16/04/2010 14:08	60	10.9	Tank
16/04/2011 14:08	16/04/2010 14:19	53	9.9	Tank
16/04/2011 14:19	16/04/2010 14:30	37	8.1	Tank
16/04/2011 14:31	16/04/2010 14:37	11	6.2	Tank
16/04/2011 18:14	16/04/2010 18:27	26	10.2	Tank
16/04/2011 18:28	16/04/2010 18:38	24	11.3	Tank
16/04/2011 18:38	16/04/2010 18:47	16	17.2	Tank
16/04/2011 18:48	16/04/2010 18:57	42	11.6	Tank
16/04/2011 18:58	16/04/2010 19:06	15	10.2	Tank
16/04/2011 19:07	16/04/2010 19:15	38	7.1	Tank
16/04/2011 19:15	16/04/2010 19:22	47	13.2	Tank
16/04/2011 19:22	16/04/2010 19:27	30	8.6	Tank
16/04/2011 19:28	16/04/2010 19:36	32	12.5	Tank
16/04/2011 19:37	16/04/2010 19:44	56	16.2	Tank
16/04/2011 19:44	16/04/2010 19:50	5	15.5	Tank
16/04/2011 19:51	16/04/2010 19:58	20	11.9	Tank
⋮	⋮	⋮	⋮	⋮
18/04/2011 11:11	17/04/2010 11:21	28	14.1	Tank
18/04/2011 11:21	17/04/2010 11:28	27	16.3	Tank
18/04/2011 11:28	17/04/2010 11:40	19	9.9	Tank
18/04/2011 11:40	17/04/2010 11:46	59	16.7	Tank
18/04/2011 11:46	17/04/2010 11:53	48	14.5	Tank
18/04/2011 11:53	17/04/2010 12:00	9	11.1	Drain
18/04/2011 12:21	17/04/2010 12:31	20	11.6	Tank
18/04/2011 12:31	17/04/2010 12:43	33	13.9	Tank
18/04/2011 13:25	17/04/2010 13:31	39	7.9	Tank
18/04/2011 13:31	17/04/2010 13:39	49	11.7	Tank
18/04/2011 13:39	17/04/2010 13:49	31	10.1	Tank
18/04/2011 13:49	17/04/2010 13:55	47	8.1	Tank
18/04/2011 13:55	17/04/2010 14:14	60	16.8	Tank
18/04/2011 14:15	17/04/2010 14:26	41	19.2	Tank

Milk collection on 16/04/2011 13:05

Sum of milk weights recorded by AMS and **sent to the tank** between the 2 collections

Milk collection on 18/04/2011 13:05

Table 17. Deviation calculation of the milk meter on several milk collections.

Collection date	Collection time	Tank volume (l)	Milk weight in the tank (kg)	Sum of milk yields measured by the milk meter (kg)	Deviation (%)
16/04/2011	13:05	/	/	/	/
18/04/2011	13:05	2400	2481.6	2475	-0.3
20/04/2011	13:05	2494	2578.8	2575	-0.2
22/04/2011	13:05	2434	2516.8	2509.6	-0.3
24/04/2011	13:05	2321	2399.9	2389.1	-0.5
26/04/2011	13:05	2364	2444.4	2424.9	-0.8

Step 2: Average deviation calculation

Average deviation for the last 3 collections (22 to 26 April from Table 17):

$$\text{Average deviation (\%)} = \frac{\sum_{i=1}^{3}(\textit{Milk weights measured by AMS milk meter})i \mid \sum_{i=1}^{3}(\textit{Collected milk})i}{\sum_{i=1}^{3}(\textit{Collected milk})i} * 100$$

$$\frac{(2429.9+2389.1+2509.6)\mid(2444.4+2399.9+2516.8)}{2444.4+2399.9+2516.8} *100 \rightarrow 0.5\%\,\textit{correct milk meter} \quad =$$

Average deviation for the last 5 collections (18 to 26 April from Table 17):

$$\text{Average deviation (\%)} = \frac{\sum_{i=1}^{5}(\textit{milk weights measured by AMS milk meter})i \mid \sum_{i=1}^{5}(\textit{collected milk})i}{\sum_{i=1}^{5}(\textit{collected milk})i} *100$$

$$= \frac{(2429.9+2389.1+2509.6+2575+2475)\mid(2444.4+2399.9+2516.8+2578.8+2481.6)}{2444.4+2399.9+2516.8+2578.8+2481.6} *100 = 0.4\% \rightarrow \textit{correct milk meter}$$

A graphic representation (Figure 4 of the results allows visualizing the deviation evolution.

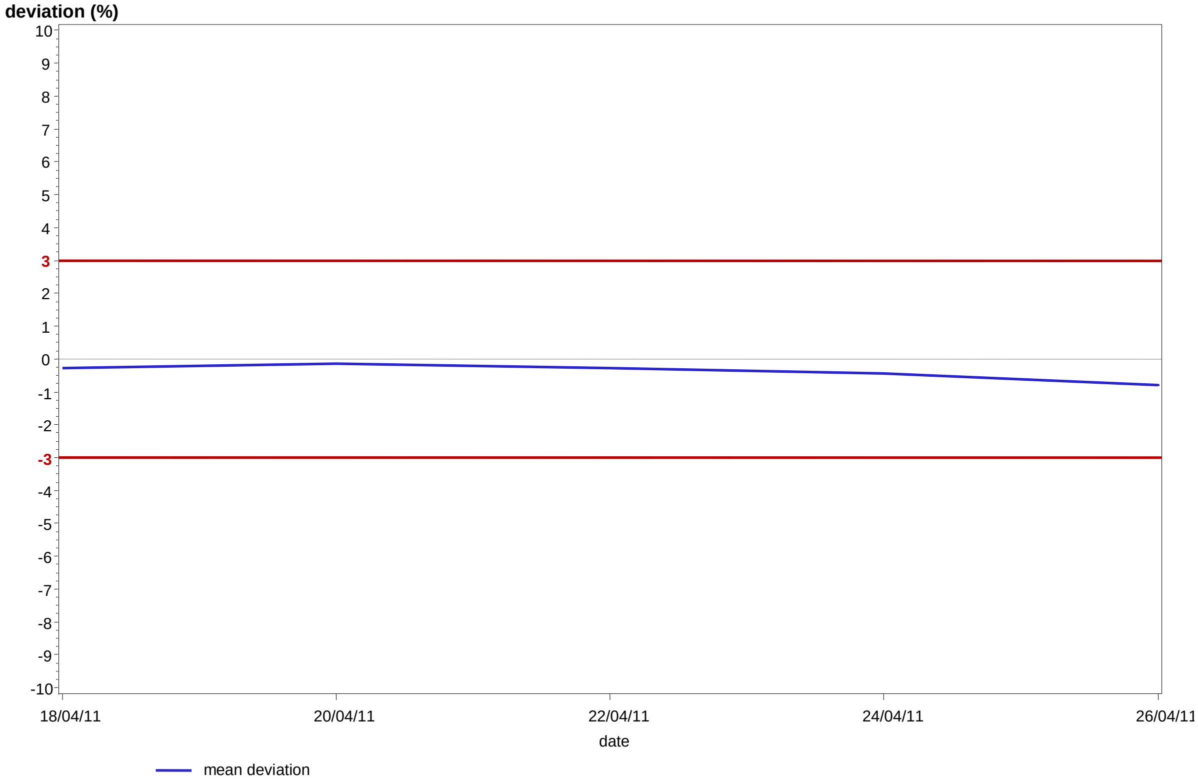


Figure 4. Graphic representation of results.

16 Annex 9. Lists of approved meters

16.1 List of approved milk meters

The updated list of ICAR approved milk meters for cattle, sheep and goats is available here on the ICAR website.

16.2 List of approved Jars

The milk jars of the different manufacturers which fulfill the guidelines in 5 (Approval test) above and had a national approval on 1 January 1992 in at least three member countries are considered as approved. New types have to be fully tested.

The updated list of approved jars for cattle by ICAR is available here on the ICAR website.

17 Annex 10. Periodic checking of approved meters. Hints for the sample taker and farmer

Appendix 10, located here on the ICAR website provides hints for the periodic checking of approved meters.