



THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Procedure 5 of Section 11 of ICAR Guidelines - Procedure for Testing of Automatic Milk Recording and Sampling Systems

Section 11 – Testing of Automatic Milk Recording and Sampling Systems
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Change Summary

Date of Change	Nature of Change
April 2022	Creation of separate Procedure.
July 2023	Approved by General Assembly and published.

1 Requirements for automatic milk recording and sampling 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 parlours. Systems for automatic milk recording 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).

Note: ICAR certification for automatic milk recording and sampling systems are based on the combination of the robot and the sampler. The automatic milk recording system must be tested with automatic sampling device(s) to achieve an ICAR certification. The automatic milk recording system cannot be tested by itself for milk yield nor may an automatic sampling device be tested by itself for milk sampling.

Note: Multiple automatic milk samplers may be tested with a single automatic milk recording system and multiple versions of the automatic milk recording system may be tested with one or more automatic milk samplers as part of the same test when requested as part of the application process.

- 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 and ISO: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 the ICAR guidelines and provide written operating instructions.

The combination of the automatic milk recording system and sampler combination 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.

1.1 Yield display

As automatic milking systems are connected to a computer system, and this system 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,
- 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 5 mm in height, which can be read at any level of ambient light.

The display shall indicate the milk yield in kilograms with increments of no more than 0.2 kg, with the preference of increments of 0.1 kg.

1.2 Sampling

The sample shall be:

- a. Representative for all the milk collected during that milking.
- b. Sufficient amount for analysing the milk composition.

A minimum volume of 25 ml shall be taken at the minimum recordable milk yield of 5 kg for cattle.

Note. The sufficient amount for analysing is depending on the country and varies between 25 ml and 50 ml. In the case when multiple samples of multiple milking are combined, 25 ml sample per milking is sufficient in all countries. When samples from milkings are separately analysed, in some countries a higher amount of sample may be prescribed.

The sampler shall be easily accessible, sampling tubes or bottles (when used) shall be easy to place and remove.

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 all local, regional and national health and safety requirements where applicable
- a. It may be included in the automatic milking system washing circuit.
- b. Carry-over of milk between animals is minimized.

1.3 In-line milk analyser in automatic milk recording systems

In the case that the automatic milk recording systems is equipped with an in-line milk analyser, the milk analyser shall:

- a. Give a value for fat and protein at a minimum, representative for all the milk collected during that milking session.
- b. Have no observed or measured effect on the milk flow or quality in any way.

A milk analyser 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 certification test on request of the manufacturer. In the case of request for ICAR certification for additional components, these components have to fulfil the ICAR requirements in addition to fat and protein.

Note. Next to the parameters mentioned above, other parameters such as conductivity, blood and progesterone may be measured in milk. As for these parameters, no accuracy limits are yet defined, they are not a part of the requirements for milk recording devices. However, if these measures are a proxy for another component (i.e. conductivity measurements used to predict SCC), then the ICAR limits for such parameters would apply.

1.4 Limits of error for milk yield and milk composition

The limits of error for both milk yield and fat percentage are presented in Table 2 both for recording on the test day and for daily recording of milk production. Moreover, bias and standard deviation shall have a 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 1. 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).

Species	Milk yield			Fat percentage		
	Range	Standard deviation ¹	Bias ²	Range	Standard deviation	Bias
Cattle	2 - 10 kg	0.50 kg	0.2 kg	2 – 8 %	0.10 % fat	0.05 % fat
	> 10 kg	5 %	2 %			

¹In kg or in percentage of mean reference yield.

²In kg or in percentage of the reference yield.

In case of an automatic milk recording device with an in-line milk analyser, 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 components, which are not obliged. A test and potential certification for these components 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 2. The accuracy limits for on-farm milk analysers in milk recording for fat and protein (compulsory elements for approval of milk analysers).

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

Accuracy	Range	St. Dev.	Bias
Lactose	4.0 - 7.0 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 (x1000)	0-2000	25 %	13 %

2 Procedures for certification

2.1 Submission for testing

When a new automatic milk recording system is to be submitted for a certification test ([Procedure 1](#)), the test applicant must provide to ICAR a list of potential farms with the system in operation to select for the test.

Table 4. Number of automatic milk recording systems with either automatic milk samplers or milk analysers needed for a certification test.

	Robot
Number of AMS for field test	2
Number of farms for the field test	2
Number of reserve devices	NA

Note: The manufacturer/test applicant is responsible for the correct installation and calibration of the automatic milk recording system(s) on the farms. After installation, the test centre will conduct the tests without representatives of the manufacturer/test applicant present.

2.2 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 certification of milk recording devices is adjusted to the situation with automatic milk recording systems on the following points:

- 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 two 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. A test farm, operated and/or owned by the manufacturer, is not eligible as a farm for the ICAR test.
- c. In the case of automatic (voluntary) 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 of the sampling device.

2.3 Modified automatic milk recording or sampling systems

If previously certified automatic milk recording or sampling devices in a system 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 Chair of the Sub-Committee for Measuring, Recording and Sampling Devices (MRSD-SC). The Chair will consult the test centre responsible for the original certification test. Based on the information gathered by the Chair of the MRSD-SC, the manufacturer will be presented the plan of the required desk review or retest that must be completed to extend ICAR certification to the modified device or sampler.

The manufacturer reports the device or sampler modification to ICAR on the [normal test application form](#).

3 Certification test

The test of any new or modified automatic milk recording and/or sampling device is based on the test plan developed by the assigned ICAR test centre. The test plan will identify the specifics of the test as applicable for the device.

The test plan may describe the following:

- Desk review for a modified recording device, sampler, or combination,
- Field test,
- Modified test that may include one or more of the above.

Test plans, while developed by the assigned ICAR test centre, are reviewed internally by all test centres to ensure complete and objective testing of the automatic milk recording and

sampling system. After internal review, the test plan is presented to the manufacturer or applicant and agreed upon by all parties.

3.1 Desk Review

As described in 2.3 of this procedure, if previously-certified milk recording or sampling devices are modified in hardware and/or software, influencing the measurement, sampling or the testing routine, a desk review of the modification(s) may be conducted as determined by the original test centre. A desk review will compare the original device, sampler or system and the reported modifications, referencing the original ICAR test and documentation provided by the manufacturer/applicant.

The test centre will report to the MRSD-SC the findings of the desk review and may recommend extending ICAR-certification to the modified device, sampler or system or may recommend a modified test based on the findings.

3.2 Field test

Field tests have to be carried out to assess the performance of the automatic milk recording and sampling system under field conditions. These tests are to be carried out under normal milking conditions on farms with, for the breed and country, representative levels 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.

For a number of tests (i.e. 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 $30 \pm 2^\circ\text{C}$ until used in the tests. The milk shall be of healthy animals and shall have a normal composition.

3.2.1 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 ± 0.02 kg. The amount of reference milk is corrected for the amount (weight) of the sample taken for reference analysis of fat percentage.

Duplicate samples are taken from the milk collected in the bucket (reference) and duplicate samples are taken from the milk collected by the automatic milk sampler. In all cases, milk in the bucket and sampler has to be mixed thoroughly before taken samples. For any observation where no duplicate sample is available (it is not possible to take two samples), this sample should be analysed twice if possible and the results will be treated as duplicates. Samples are analysed for fat percentage by an accredited laboratory as identified in the test plan.

In case of a milk analyser test, results 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).

In each test run at least 40 readings per device have 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 5.

Table 5. 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 - 8 %	2.5 - 5 %

^aProtein content is only needed for milk analysers.

3.2.2 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 automatic milk recording and sampling system has passed the test if:

- There are no visible residues on milk contact surfaces.
- Bulk milk quality and/or ATP show no raise in number of bacteria/ATP levels.

3.2.3 Faulty automatic milk recording device or sampler in the test

In case that the automatic milk recording system fails due to poor calibration or technical defect, then:

- The test centre may decide to select a different farm from the list provided by the manufacturer.
- The test centre may stop the test, ask the manufacturer to repair and/or calibrate the device, and then retest the combination of the automatic milk recording device and sampler.

In case that the automatic milk sampler fails due to poor operation or technical defect, then:

- The test centre may decide to select a different automatic milk sampler of the same model, when available to use, for the test with automatic milk recording system,
- The test centre may stop the test, ask the manufacturer to repair and/or calibrate the sampler, and then retest with that sampler.

3.3 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 centres and associate members of ICAR.

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.

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. 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 in Figure 1.

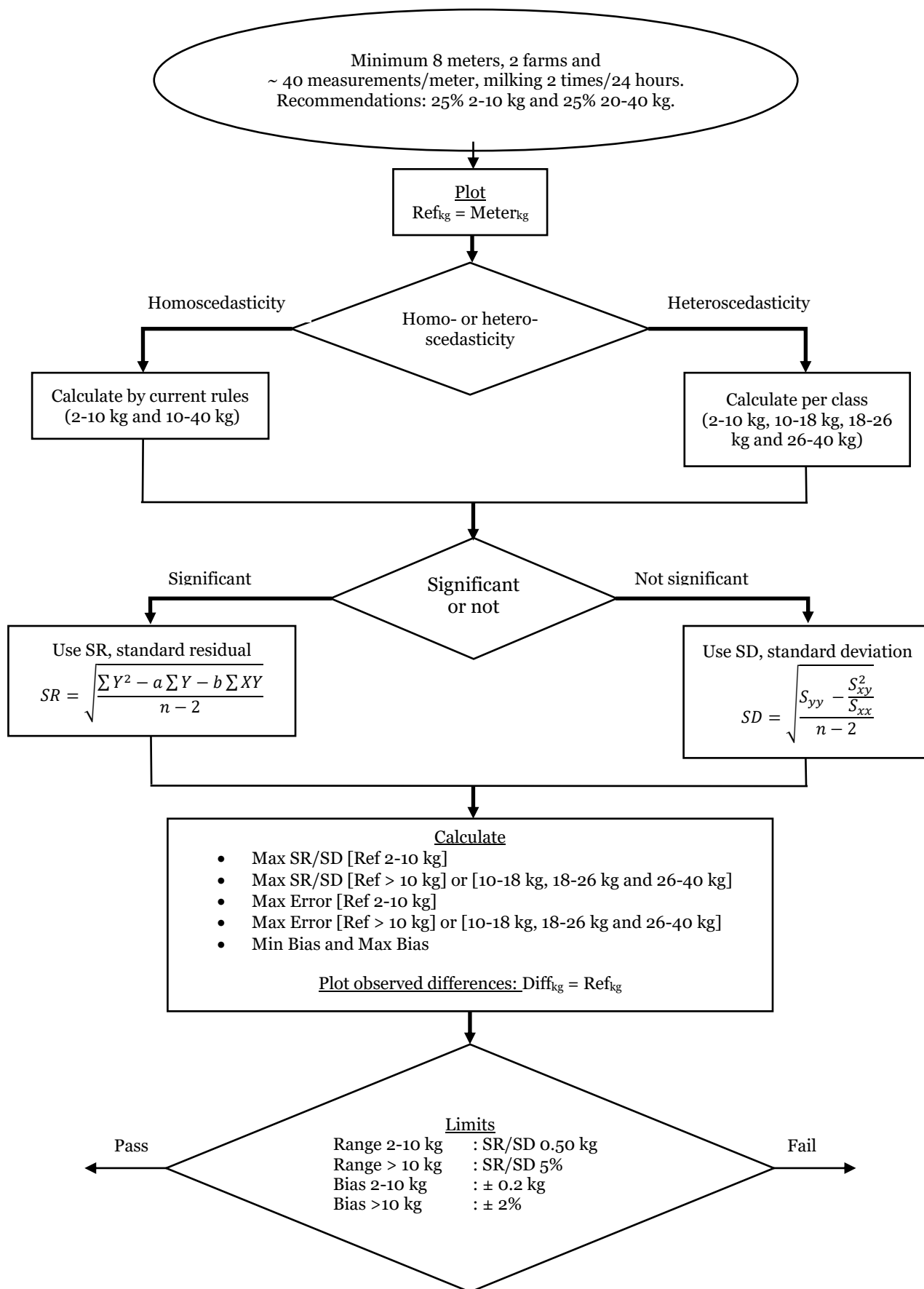


Figure 1. Flow chart statistical analysis for dairy cows.

3.3.1 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.

3.3.2 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.

3.3.3 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. Instead of 5 farms and 100 readings, in the procedure described in this document 2 farms (1 automatic milking system, 1 milking parlour) 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.