THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Procedure 7 of Section 11 of ICAR Guidelines - Computerized Solutions for Periodic Checking of Recording and Sampling Devices

Section 11 – Computerized Solutions for Periodic Checking of Recording and Sampling Devices

Version February 2023

Network. Guidelines. Certification.

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Change Summary

Date of Change	Nature of Change
June 2020	Creation of document.
November 2022	Decision rule of 3% confirmed as agreed by SC.
July 2023	Approved by General Assembly and published.

1 Introduction

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, they may replace the annual routine accuracy test. The requirement is to run these statistical checks at least once per year. However, for best practices in quality assurance, it is recommended to run these checks more frequently throughout the year, for instance at each milk recording visits.

b. These methods must be used for routine test only and do not replace nor are suitable for the installation test.

c. While the computerized method will identify deviating meters, it does not replace other aspects 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.

2 Several milking stand installations

2.1 Use of expected milk yield

2.1.1 Principles

A comparison between expected milk yield and the milk yield measured by the milk meter is used to estimate whether a milk meter is out of calibration or operating within tolerances. The expected milk yield may be estimated from various calculations (Table 1). When the calculation uses a "herd factor" (calculations n°2 and n°4 as demonstrated in Table 1), it increases the accuracy of expected yield estimation (Table 2). There are no significant differences between calculations using a herd factor. Further, there are no significant differences between 5 to 10 milkings (or days) for one type of calculation.

Thus, the best compromise between accuracy and data amount is the calculation from last 5 milkings at M_n (n^{th} milking of the day) corrected by a herd factor (i.e. calculation n°4 in Table 1**).**

Step 1: Calculation of expected milk yield

Table 1. Expected milk yield calculations.

	Expected milk yield calculations
1	**Yields average on the last X days and time elapsed since last milking:** $\left(\frac{\sum_{i=1}^{x}(y_1+y_2)_i}{X}\right) \times \text{time elapsed from last milking}$
2	**Yields average on the last X days and time elapsed since last milking * "herd factor":** $\left(\frac{\sum_{i=1}^{x}(y_1+y_2)_i}{X}\right) \times \text{time elapsed from last milking} \times \left[\frac{h_n(\text{current milking})}{\left(\frac{\sum_{i=1}^{x}(h_1+h_2)_i}{X}\right) \times \text{time elapsed from last milking}}\right]$
3	**Yields average on the last X milkings at M_n** $\frac{\sum_{i=1}^{x} y_{ni}}{X}$
4	**Yields average on the last X milkings at M_n x "herd factor"** $\frac{\sum_{i=1}^{x} y_{ni}}{X} \times \frac{h_n(\text{current milking})}{\left(\frac{\sum_{i=1}^{x} h_{ni}}{X}\right)}$

with:

y_1 and y_2	: milk yield of a cow at milking M_1 (first milking) or M_2 (second milking).
y_n	: milk yield of cow n at milking M_n (n=1 or 2)
h_1 and h_2	: milk yield average of the herd at milking M_1 or M_2
h_n	: milk yield average of the herd at milking M_n (n=1 or 2)
X	: number of previous days / milkings

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

Table 2. Concordance correlations between measured milk yield and expected milk yield for different calculations (Rouzaut & Allain, 2011).

	Concordance correlation			
Expected milk yield calculation	**X=5**	**X=7**	**X=10**	**Data amount**
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 2: Calculation of cow deviation

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

Equation 1. Cow deviation.

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

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 (%).

$$\text{Deviation (\%)} = \frac{\sum \text{(cow deviations (kg) for this milk meter)}}{\sum \text{(expected yields (kg) of these cows for this milk meter)}} \times 100$$

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.

2.1.2 Decision rule

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

If the average deviation exceeds these limits, the milk meter calibration shall be confirmed with the manufacturer manual calibration test, a procedure described in Procedure 6 here or with a milking test, whose procedure is also described in Procedure 6 here.

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 milk meters.

2.1.3 Use conditions/requirements

The use of this method requires reliable electronic cow identification. There must be 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 there are less than 8 stands in the parlour then the method and results can only be used as a qualitative tool to indicate to the technician the meters that require attention.

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

During the first 30 days of the lactation, milk yields are not stable to estimate a reliable expected yield (Pérochon *et al.*, 1996). These data must be excluded prior to the calculation. As a consequence, it is not recommended to use this method in the calving period (in the case of grouped calvings).

Milk yields equal to zero (0) are considered as being unusual and should be excluded prior to the calculations.

In step 3, prior to the calculation of 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 excluded prior to the calculations.

Equation 3. Relative cow deviation (%).

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

2.2 Application example of the expected milk yield method

Step 1: Calculation of expected milk yield

Table 3. Example for calculation of expected milk yield using 5 last milkings at M1 for cow n°4044.

Date *(DD/MM/YYYY)*	**Time**	**Measured milk yield (kg)** y_i	**Herd yields average (kg)** h_i	
04/06/20xx	M_1	y_1=20.2	h_1=14.7	
	M_2	y_2=12.2	h_2=9.5	
05/06/20xx	M_1	y_1=18.8	h_1=14.4	
	M_2	y_2=10.2	h_2=8.6	5 days back
06/06/20xx	M_1	y_1=19.2	h_1=14.4	
	M_2	y_2=10.8	h_2=9.1	
07/06/20xx	M_1	y_1=16.3	h_1=14.2	
	M_2	y_2=10.3	h_2=9.1	
08/06/20xx	M_1	y_1=17.2	h_1=14.4	Current milking
	M_2	y_2=10.2	h_2=8.6	
09/06/20xx	M_1	y_1=18.4	h_1=14.4	
	M_2	y_2=10	h_2=8.4	

Therefore, expected milk yield estimation for current milking is given using formula of Table 1.

$$\textbf{Expected milk yield} = \frac{\sum_{i=1}^{5} y_{1i}}{5} \times \frac{h_1(\text{current milking})}{\left(\frac{\sum_{i=1}^{5} h_{1i}}{5}\right)} = \left(\frac{20.2+18.8+19.2+16.3+17.2}{5}\right) \times \frac{14.4}{\left(\frac{14.7+14.4+14.4+14.2+14.4}{5}\right)} = 18.3 \text{ kg}$$

Step 2: Calculation of cow deviation

The cow deviation can be calculated using Equation 1.

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 20xx-06-09, milking M_1, milk meter n°5 (from a 28 stands rotary milking parlour).

Table 4. 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
8541	13.0	2.1	13.9

The milk deviation can be calculated using Equation 2.

Deviation (%) =

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

Table 5. Deviation calculation of milk meter no. 5 in June 20xx.

Date (DD/MM/YYYY)	Milking	Deviation (%)	Smoothing on 10 milkings (%)	Smoothing on 20 milkings (%)
01/06/20xx	M1	0.8		
01/06/20xx	M2	-2.1		
02/06/20xx	M1	-2.3		
02/06/20xx	M2	-2.6		
03/06/20xx	M1	-0.2		
03/06/20xx	M2	0.2		
04/06/20xx	M1	-0.2		
04/06/20xx	M2	2.5		
05/06/20xx	M1	-3.5		
05/06/20xx	M2	-0.6	-0.8	
06/06/20xx	M1	-0.5	-0.9	
06/06/20xx	M2	-0.6	-0.8	
07/06/20xx	M1	2.3	-0.3	
07/06/20xx	M2	-4.3	-0.5	
08/06/20xx	M1	-0.3	-0.5	
08/06/20xx	M2	0.9	-0.4	
09/06/20xx	M1	2.6	-0.2	
09/06/20xx	M2	-2.2	-0.6	
10/06/20xx	M1	-0.3	-0.3	
10/06/20xx	M2	-1.6	-0.4	-0.6
11/06/20xx	M1	5.9	0.2	-0.3
11/06/20xx	M2	6.3	0.9	0.1
12/06/20xx	M1	1.1	0.8	0.2
12/06/20xx	M2	4.5	1.7	0.6
13/06/20xx	M1	4.9	2.2	0.9
13/06/20xx	M2	4.3	2.6	1.1
14/06/20xx	M1	0.3	2.3	1.1
14/06/20xx	M2	-2.9	2.3	0.8
15/06/20xx	M1	-1.5	2.1	0.9
15/06/20xx	M2	-4.3	1.9	0.7
16/06/20xx	M1	-3.7	0.9	0.6
16/06/20xx	M2	3.6	0.6	0.8
17/06/20xx	M1	2.4	0.8	0.8
17/06/20xx	M2	-1.9	0.1	0.9
18/06/20xx	M1	0.3	-0.3	0.9
18/06/20xx	M2	-2.5	-1.0	0.8
19/06/20xx	M1	-0.1	-1.1	0.6
19/06/20xx	M2	-3.5	-1.1	0.6
20/06/20xx	M1	1.4	-0.8	0.7
20/06/20xx	M2	-0.5	-0.5	0.7
21/06/20xx	M1	0.3	-0.1	0.4
21/06/20xx	M2	-1.3	-0.5	0.0
22/06/20xx	M1	1.8	-0.6	0.1
22/06/20xx	M2	-2.1	-0.6	-0.3
23/06/20xx	M1	-0.1	-0.7	-0.5
23/06/20xx	M2	-1.5	-0.6	-0.8
24/06/20xx	M1	-1.4	-0.7	-0.9
24/06/20xx	M2	-4.6	-0.8	-1.0
25/06/20xx	M1	-1.7	-1.1	-1.0
25/06/20xx	M2	-2.9	-1.4	-0.9
26/06/20xx	M1	2.5	-1.1	-0.6
26/06/20xx	M2	-4.8	-1.5	-1.0
27/06/20xx	M1	3.3	-1.3	-1.0
27/06/20xx	M2	1.6	-1.0	-0.8
28/06/20xx	M1	-1.9	-1.1	-0.9
28/06/20xx	M2	3.3	-0.7	-0.6
29/06/20xx	M1	-2.2	-0.7	-0.7

Date *(DD/MM/YYYY)*	Milking	Deviation (%)	Smoothing on 10 milkings (%)	Smoothing on 20 milkings (%)
29/06/20xx	M2	0.9	-0.2	-0.5
30/06/20xx	M1	1.5	0.1	-0.5
30/06/20xx	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 5):

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

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

Example for the last 20 milkings (21th to 30th of June from Table 5):

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

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

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 during the previous 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:

a. no smoothing,
b. smoothing on 10 milkings, and
c. smoothing on 20 milkings.

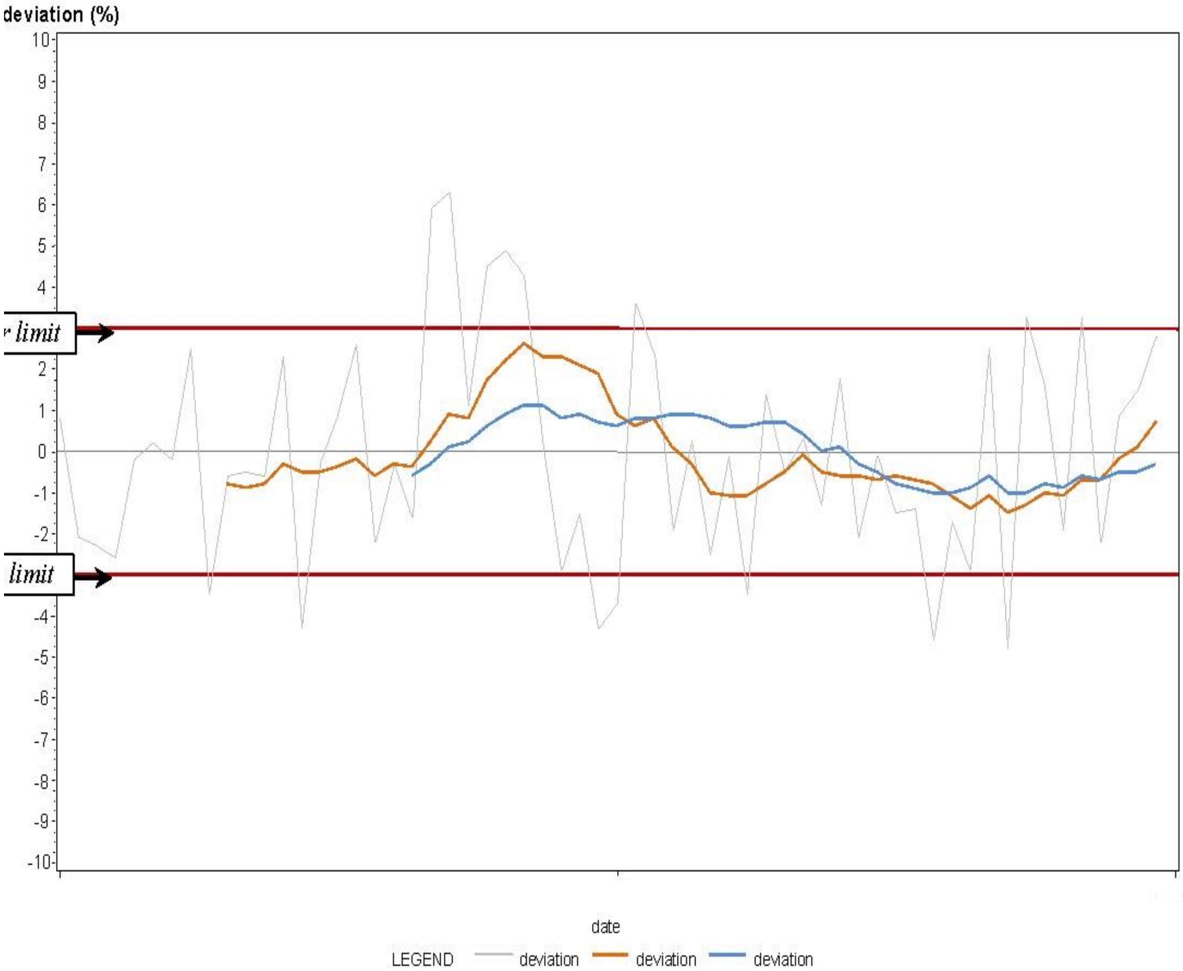

Figure 1. Graphical presentation of results of the average deviation of a milk meter.

2.3 Model of De Mol and André (2009)

2.3.1 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 (DLM).

$$\mathbf{Deviation_{ms} = AveYield_{ms} - AveYield_{m}}$$

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.

$$\mathbf{Deviation_{ms} = \mu_{ms} \times AveYield_{m}}$$

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 is given by Equation 6.

Equation 6. Observation equation for DLM.

$$\mathbf{Y_t = F_t'\theta_t + v_t, \; v_t \sim N[0, V_t]}$$

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.

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

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 and milking session m (t ≡ m) with the following implementation:

Y_m = $Deviation_{ms}$: the observed deviation for stand s and milking session m (kg)
$\theta_m = \theta_{ms}$: 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 (Equation 6) states that the stand deviation factor of the overall average is observed. The system equation (Equation 7) 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.

2.3.2 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, a test described in Procedure 6 here or with a milking test, whose procedure is also described in Procedure 6 here.

Note: 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.

2.3.3 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.

2.4 Model of Trinderup (2009)

2.4.1 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.

$$\mathbf{Y_i = \alpha_1(Date_i) + \alpha_2(Milking_i) + \beta_1 \times DIM_i + \beta_2 \times DIM_i^2 + \beta_3 \times DIM_i^3 + \beta_4 \times \left(\frac{1}{DIM_i}\right) + \beta_5(Milking_i) \times DIM_i + \beta_6(Milking_i) \times DIM_i^2 + \beta_7(Milking_i) \times DIM_i^3 + \beta_8(Milking_i) \times \left(\frac{1}{DIM_i}\right) + a(Cow_i) + \varepsilon_i}$$

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.

2.4.2 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, a test described in Procedure 6 here or with a milking test, whose procedure is also described in Procedure 6 here.

Note: 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.

2.4.3 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 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.

Note: 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.

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

3 Automatic Milking Systems (AMS)

3.1 Comparison between robot milk meter and the tank

3.1.1 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.

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

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, it is recommended to calculate the average deviation by Equation 10 (rather than an average of deviations calculated in step 1):

Equation 10. Model for computing deviation (%).

$$\text{Average deviation (\%)} = \frac{\sum_{i=1}^{X}(\text{milk weighed by AMS milk meter})_i \,|\, \sum_{i=1}^{X}(\text{Collected milk})_i}{\sum_{i=1}^{X}(\text{Collected milk})_i} \times 100$$

with:
X: milk collection number (= 3 to 5)

3.1.2 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, a test described in Procedure 6 here or with a milking test, whose procedure is also described in Procedure 6 here.

3.1.3 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).

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

3.2 Application example of the comparison between AMS and tank

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

Table 6. Example of data recorded by an AMS between 2 milk collections.

Milking start *(DD/MM/YYYY HH:MM)*	**Milking end** *(DD/MM/YYYY HH:MM)*	**Cow id**	**Milk yield (kg)**	**Milk Destination**
16/04/20xx 12:08	16/04/20xx 12:15	51	9.7	Tank
16/04/20xx 12:16	16/04/20xx 12:23	58	14.0	Tank
16/04/20xx 12:23	16/04/20xx 12:31	45	7.5	Tank
16/04/20xx 12:31	16/04/20xx 12:40	4	13.8	Tank
16/04/20xx 12:40	16/04/20xx 12:53	19	11.8	Tank
16/04/20xx 13:29	16/04/20xx 13:44	33	19.5	Tank
16/04/20xx 13:44	16/04/20xx 13:50	50	16.9	Drain
16/04/20xx 13:51	16/04/20xx 14:08	60	10.9	Tank
16/04/20xx 14:08	16/04/20xx 14:19	53	9.9	Tank
16/04/20xx 14:19	16/04/20xx 14:30	37	8.1	Tank
16/04/20xx 14:31	16/04/20xx 14:37	11	6.2	Tank
16/04/20xx 18:14	16/04/20xx 18:27	26	10.2	Tank
16/04/20xx 18:28	16/04/20xx 18:38	24	11.3	Tank
16/04/20xx 18:38	16/04/20xx 18:47	16	17.2	Tank
16/04/20xx 18:48	16/04/20xx 18:57	42	11.6	Tank
16/04/20xx 18:58	16/04/20xx 19:06	15	10.2	Tank
16/04/20xx 19:07	16/04/20xx 19:15	38	7.1	Tank
16/04/20xx 19:15	16/04/20xx 19:22	47	13.2	Tank
16/04/20xx 19:22	16/04/20xx 19:27	30	8.6	Tank
16/04/20xx 19:28	16/04/20xx 19:36	32	12.5	Tank
16/04/20xx 19:37	16/04/20xx 19:44	56	16.2	Tank
16/04/20xx 19:44	16/04/20xx 19:50	5	15.5	Tank
16/04/20xx 19:51	16/04/20xx 19:58	20	11.9	Tank
⋮	⋮	⋮	⋮	⋮
18/04/20xx 11:11	17/04/20xx 11:21	28	14.1	Tank
18/04/20xx 11:21	17/04/20xx 11:28	27	16.3	Tank
18/04/20xx 11:28	17/04/20xx 11:40	19	9.9	Tank
18/04/20xx 11:40	17/04/20xx 11:46	59	16.7	Tank
18/04/20xx 11:46	17/04/20xx 11:53	48	14.5	Tank
18/04/20xx 11:53	17/04/20xx 12:00	9	11.1	Drain
18/04/20xx 12:21	17/04/20xx 12:31	20	11.6	Tank
18/04/20xx 12:31	17/04/20xx 12:43	33	13.9	Tank
18/04/20xx 13:25	17/04/20xx 13:31	39	7.9	Tank
18/04/20xx 13:31	17/04/20xx 13:39	49	11.7	Tank
18/04/20xx 13:39	17/04/20xx 13:49	31	10.1	Tank
18/04/20xx 13:49	17/04/20xx 13:55	47	8.1	Tank
18/04/20xx 13:55	17/04/20xx 14:14	60	16.8	Tank
18/04/20xx 14:15	17/04/20xx 14:26	41	19.2	Tank

Milk collection on 16/04/20xx 13:05

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

Milk collection on 18/04/20xx

Table 7. Deviation calculation of the milk meter on several milk collections.

Collection date *(DD/MM/YYYY)*	Collection time *(HH:MM)*	Tank volume (l)	Milk weight in the tank (kg)	Sum of milk yields measured by the milk meter (kg)	Deviation (%)
16/04/20xx	13:05	/	/	/	/
18/04/20xx	13:05	2400	2481.6	2475.0	-0.3
20/04/20xx	13:05	2494	2578.8	2575.0	-0.2
22/04/20xx	13:05	2434	2516.8	2509.6	-0.3
24/04/20xx	13:05	2321	2399.9	2389.1	-0.5
26/04/20xx	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 7):

Average deviation (%) =

$$\frac{\sum_{i=1}^{3}(\text{milk weighed by AMS milk meter})_i \mid \sum_{i=1}^{3}(\text{Collected milk})_i}{\sum_{i=1}^{3}(\text{Collected milk})_i} \times 100 =$$

$$\frac{(2429.9+2389.1+2509.6) \mid (2444.4+2399.9+2516.8)}{2444.4+2399.9+2516.8} \times 100 = 0.5\%$$

Average deviation for the last 5 collections (18 to 26 April from Table 7):

Average deviation (%) =

$$\frac{\sum_{i=1}^{5}(\text{milk weighed by AMS milk meter})_i \mid \sum_{i=1}^{5}(\text{Collected milk})_i}{\sum_{i=1}^{5}(\text{Collected milk})_i} \times 100 =$$

$$\frac{(2429.9+2389.1+2509.6+2575+2475) \mid (2444.4+2399.9+2516.8+2578.8+2481.6)}{2444.4+2399.9+2516.8+2578.8+2481.6} \times 100 = 0.4\%$$

A graphic representation (Figure 2) of the results allows visualizing the deviation evolution.

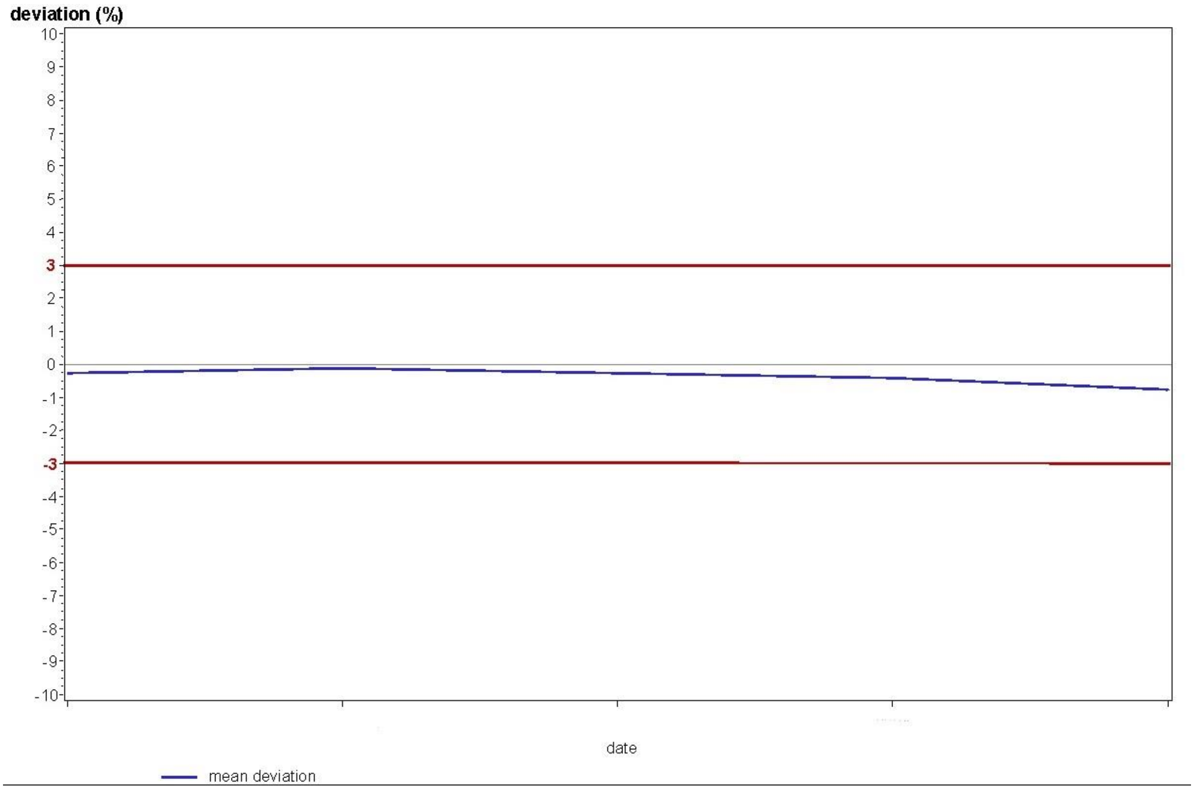

Figure 2. Graphical presentation of the average deviation between AMS and bulk tank.