Section 2 - Guidelines for Dairy Cattle Milk Recording

Section 2 – Cattle Milk Recording

Version May, 2022

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Change Summary

Date of Change	Nature of Change
April 2017	Complete rewrite of Section 2.1 including separation out of procedures for calculating 24 hour and lactation yields.
June 2017	Minor edits based on feedback from ICAR members.
July 2017	Reformatted according to new ICAR template for ICAR Guidelines.
July 2017	Edits of headings, add number to tables, and insertion of cross references to tables.
August 2017	Add index of Tables and index of Figures to Table of Contents.
August 2017	Update version to August, 2017. Highlight links to other sections to be inserted when guidelines are available on ICAR website.
October 2017	Recreated links to the other Sections of the Guidelines that were renamed.
May 2022	Update of Liu-method and adding the Kyntäjä method to Procedure 1 of Section 2.

1   Introduction

Information about milk production traits is very important for managing and breeding dairy herds. The milk recording process starts with the collection of animal identification, a calving date of milking cows, the amount of milk given and the date with time or time frame of a day. A milk sample may be taken. The obtained milk sample is analysed for milk constituents. The results of the analysis plus the data about milk yield and time of milking are stored in a database. Subsequently a number of parameters, cumulative yields and indices are calculated and stored in the database and, finally, reported to the farmer.

This section (2) of the ICAR Guidelines focuses on the milk recording process for dairy cattle.

2   Definitions and terminology

A list of important definitions for terms and abbreviations used in these guidelines is provided by Table 1.

Table 1. Definitions of Terms used in these guidelines.

Term	Definition
24-hour yield	The amounts of milk, fat and protein produced by the individual cow over 24 hours.
Accumulated yield	The amounts of milk, fat and protein produced by the individual cow during an appointed period of time, e.g. a calendar year.
Average yield	The amounts of milk, fat and protein produced by all cows in the herd in average during the appointed time period.
Lactation	The period from an individual cow's calving to her dry off or culling (lactation can be incomplete)
Milk recording	The system that contains the whole process described in paragraph 1 of this guideline. This is also known as Dairy Herd Improvement (DHI).
Recorded cow	Any cow in a recorded herd.
Recorded herd	Any herd that is enrolled in milk recording.
Recording	The action of measuring a cow's milk yield by collecting the data and processing it (e. g. by use of a database). This is also known as testing or test day.
Sampling	The action of taking a representative sample of a cow's milk. Sampling is generally attached to a recording.
Standard lactation	The period from an individual cow's calving until her dry off or 305th day since her calving.
Vial	The vessel containing a milk sample, also known as bottle etc.

3   Scope

Figure 1 gives a pictorial summary of the main elements of this guideline.

In summary, this section of the ICAR Guidelines covers the milk recording process from the enrolment of a herd for milk recording, through to the delivery of information which a herd owner can use to assist in a range of decisions.

Figure 1. Scope of Section 2 - Dairy cattle milk recording.
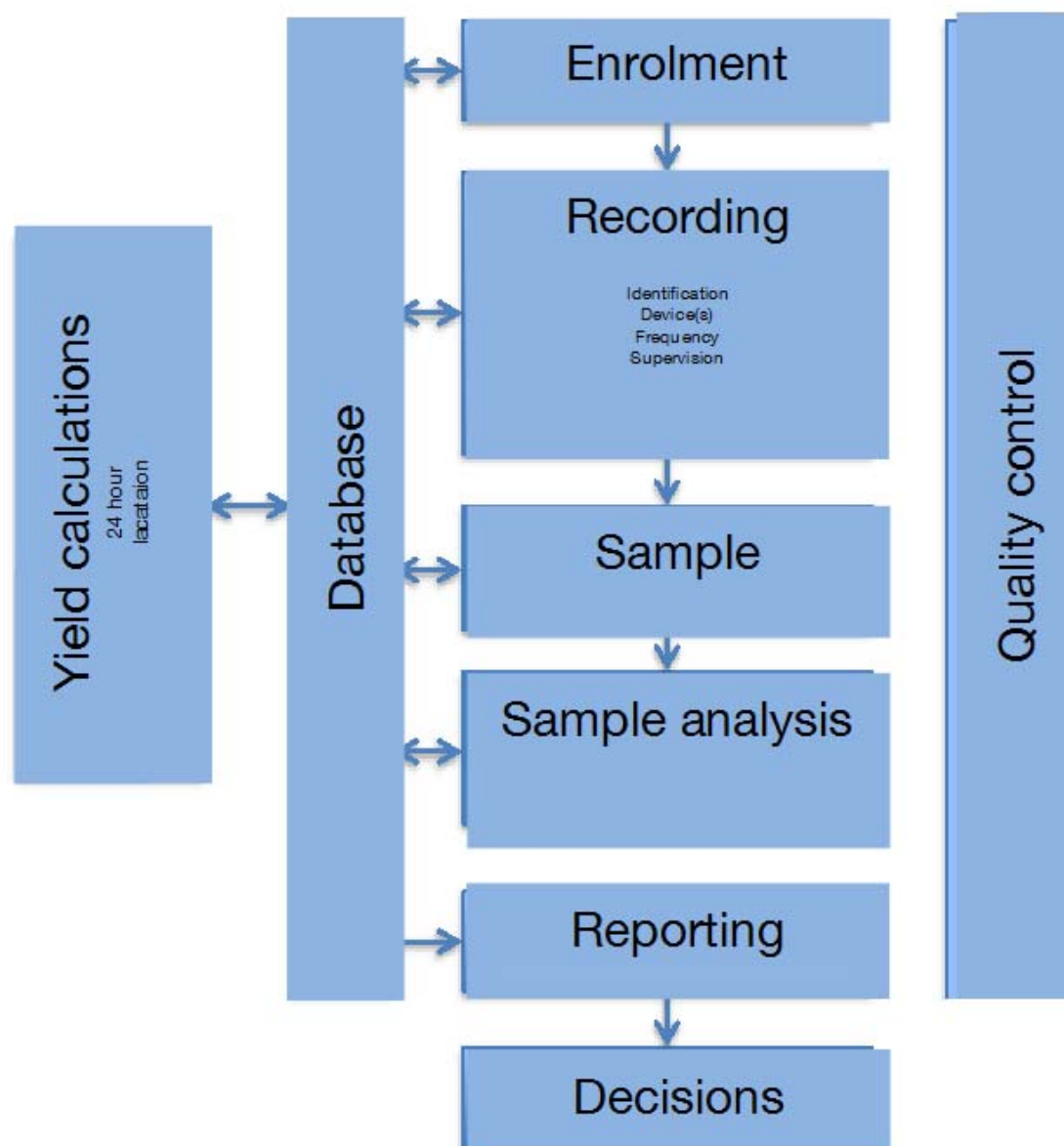
Not covered in this section are:

a. Standards and guidelines for ICAR approval of milk recording devices. Please consult Section 11 for this subject.

b. Standards and guidelines for ICAR approval of ID devices. Please consult Section 10 for this subject.

c. Standards and guidelines for preparation of milk samples and for quality assurance of milk analysis. Please consult Section 12 for this subject.

d. Standards and guidelines for in-line milk analysis on the farm. Please consult Section 13 for this subject.

4   Enrolment

Enrolment of new herds in the recording process should involve an agreement between the farmer and the recording organisation regarding technical and financial questions such as:

a. General information about the recording programme itself, i.e.

- Herd and cow identification.

- Scope of recorded data, including database setup as required by the user.

- Scheduling recording.

- Data capture and processing.

- Recording methods and intervals.

- Milk measuring and meters.

- Sampling and sample transport.

- Reports (outcomes) and supporting decisions.

b. Definition of supervision scheme and other quality assurance and plausibility checking steps.

c. Fee structure and invoicing.

d. Approval of technicians by milk recording organisations (MROs) so as to give them free access to farms for all recording and supervision actions.

In cases where the owner of the recorded cows or his employees carry out the recording itself, it is up to the organisation to decide upon, and provide for, any necessary training.

The most important links to other parts of the Guidelines are:

a. Section 10: Testing and Certification of Devices Used in Animal Identification

b. Section 13: Guidelines for In-line Milk Analysis

5   Database

Storing the recorded data in a milk recording database is an indispensable part of the recording. It is recommended to use the quickest possible means to store the data in the database in order to ensure up-to-date breeding values and management applications. Where computerised data capture is possible, it should not take more than five days after the recording to have the complete recording data set in the database.

The application of the Guidelines in Section 2 Procedure 1, together with other parts of the Guidelines, ensure that data from particular animals are linked with the relevant phenotypes, genomic information and environments to the required accuracy and using the best methods. There is a distinction, however, between the accuracy required for official milk recording and breeding value estimations and other relevant official results and data used for managerial purposes.

The guidelines on storage of data collected by the milk recording process are:

a. For every recording, cow identification (ID), 24-hour milk yield or individual milk yields with a minimum of 0.2 kg (or the equivalent thereof) milk accuracy and recording date have to be stored.

b. Where possible, it is advisable to store each milking separately. The data stored can include milk yield, time and date of milking, and milking scheme.

c. Analysed results of the milk sample are stored, namely: sample ID, fat content (or percentage), sample status, sample type. Optional data can be stored on protein and/or lactose content, somatic cell count and additional analyses.

d. Analysis results can be linked to one or more milkings of the cow.

e. In case of storage or performance problems it might be necessary to remove old data of individual cow milkings from the database.

f. Recording day information is the yield over 24 hours and should at least be kept in the database for the current lactation and the previous lactation.

g. If recording day information is changed after batch processing it should be marked with a user-ID and time stamp.

h. Yields are stored in kg or lbs or, in the case of fat and protein contents, in percent units.

The necessary additional information about how the results have been obtained include:

a. Who did the recording (certified technician, farmer etc.).

b. Herd and/or cow milking frequency.

c. How many milkings were measured.

d. How many milkings were sampled.

e. Sampling scheme when sampling.

f. Daily yield calculation method used.

g. Recording and sampling intervals.

h. Basic checks for recording data

i. Farm (herd): identified by a unique key.

j. Animal ID: has to be unique in database.

k. Format of animal ID: compliant to international standards of identification and registration.

l. Recording date: less than or equal to today, greater than last recording date.

m. Milk yield: stored with one decimal.

n. 24 hour milk yield: range 3.0 - 99.9 kg.

o. Fat and protein content: e.g. within a range of +/- 3 standard deviation of population average (range of the daily recorded values in Chapter 6.6).

p. Calving date: greater than birthday of cow (e.g. greater than birthday of cow + 20 months).

q. Calving date: less than or equal to today.

6 Recording

6.1 General Standards and Guidelines

a. Milk yields should be recorded and milk samples collected using equipment approved or provisionally approved by ICAR.

b. The list of approved and provisionally approved equipment is included in the ICAR Standards and Guidelines for Approval and Checking of Devices and Equipment and is monitored and updated by the Secretariat and made available online on the ICAR web page.

c. The equipment, materials and methods used for analysing the composition of recorded milk are discussed in Section 12 and the appendices to that Section.

d. The accuracy of the equipment used for milk recording and sampling must be checked by an agency approved by the member organisations, on a regular and systematic basis using methods approved by ICAR. The list of methods is given in the ICAR Standards and Guidelines for Approval and Checking of Devices and Equipment.

e. All analyses of the composition of a milk sample shall be carried out on the same milk sample.

f. These samples should ideally represent the 24-hour milking period.

g. If milk samples do not represent a 24-hour period, the results of milk analyses should be corrected to a 24-hour period by a method approved by ICAR, as described in 6.6 Missing results and/or abnormal intervals on page 16.

h. In cases where the duration of recording deviates from 24 hours, the results must be converted into 24-hour yields. Only approved 24-hour yield calculation methods can be used. The appropriate methodology is described in Chapter 9 in this section of the ICAR Guidelines.

i. Calculation methods

- The quantities of milk and milk constituents shall be calculated according to one of the methods outlined in this section of the ICAR Guidelines.

- Member organisations should keep the ICAR Secretariat informed about the calculation methods being used by the records processing operations in their organisation or country and shall be responsible for ensuring that the records are corrected and calculated as specified in this section of the ICAR Guidelines.

6.2 Identification (ID)

6.2.1 Animal ID

An official milk recording system must be based on a clearly identifiable and unique animal ID. It is recommended that a single scheme for the whole country be used. Animal identification must also be in accordance with national and international regulation (e.g. EU member countries with EU legislation - 1760/2000 for cattle),

and with relevant parts of currently valid ICAR Guidelines. The animal must be marked with an ICAR approved identification device or system. If the ID of imported animals is changed, the connection to the original ID must be maintained. Management numbers for cows can be used aside the official ID.

6.2.2   Herd ID

Each herd in milk recording must be allocated a unique permanent identification number.

6.2.3   Electronic ear tags and boluses

For the electronic identification of cows in milk recording, both official RFID (radio frequency animal identification) devices and management RFID transponders can be used. In the latter case, the management ID must be cross-referenced to the official ID, either on farm level or in the central database. When electronic devices are used, an electronic reader provides a means to connect the cow ID with the right milk data and sample.

6.2.4   Identification of the sample vial

The sample, the milk weight and the cow ID must be linked at the milking.

Vials can be identified according to:

   a. Vial placement in the rack.

   b. Cow or sample ID written on the vials.

   c. Barcoded vial with printed cow ID.

   d. Barcoded vial with cow ID registered at the milking.

   e. RFID vial with cow ID registered at the milking.

6.2.4.1 Sample identification without electronic equipment

Samples are identified according to their placement in the sample rack. Additionally, sample or cow numbers can be written on the vials with a waterproof marker. If this marking is not done, there must be a sure and efficient way to identify sample No. 1 (e.g. different colour) and the sequence of other samples.

Each sample rack must be connected to a list of samples where cow ID is given for each sample. Each transportation box also has to carry the relevant herd ID's and, preferably, the sampling dates.

6.2.4.2 Barcoded vials

Samples are identified according to the barcode on the vial label.

If the label contains cow and/or herd ID, no electronic equipment is needed at the recording. The samples can be sent to the laboratory without accompanying sample lists or herd ID markings on the box.

If the label contains a random sample ID number, the cow ID must be connected with it on the farm. This is done with a barcode reader and computer programmes making the connection possible.

6.2.4.3 Vials with RFID

Samples are identified according to the RFID chip in the vial. This system requires the use of RFID readers and specific computer programmes creating a file where the cow and vial ID's are connected.

6.2.4.4 Automatic sampling systems

In automatic milking systems (AMS), ICAR approved automatic samplers has to be used. Sample identification in these systems can be based on vial placement, barcode or RFID. The file with corresponding cow ID is in the management programme of the milking system. Data transfer is carried out with specific software and via a specific interface from the milking robot to the milk recording organisation.

6.2.4.5 Sample ID in the laboratory

For impartiality and better quality, it is recommended that the samples are identified without cow ID and sent to the laboratory anonymously and the analysis results are merged afterwards in the data processing centre.

6.2.5   Connection of the sample to milking and 24 h yield

6.2.5.1 Sample and milk weight from the same milking

The ideal situation is that the sample and milk weight represent the same milking. This occurs without further corrections in sampling schemes P, E, T and C. With sampling scheme M it is also possible if additional milk weights are not considered (See 6.4 Recording Method on page 12 for method descriptions).

6.2.5.2 Sample from one milking, milk weight from two

Sampling scheme Z, in most cases, combines a 24-hour-yield with a one-milking sample. A corrected analysis is routinely attached to the 24-hour yield.

6.2.5.3 Sample from one milking, milk weight from two or more, corrected by intervals

In this case, a 24-hour-yield is also combined with a one-milking sample, but the 24-hour yield is obtained by correcting the recorded milkings according to the length of the preceding milking intervals. For example, if a cow has produced 20 kg milk in two milkings and the preceding intervals total 20 hours, her 24-hour yield is calculated as 20 kg * (24 h/20 h) = 24 kg. A corrected analysis is attached to this 24-hour yield.

6.2.5.4 Sample from one milking or day, milk weight from several days

With stationary milk meters, it is possible to use the milk production from several days. This gives better accuracy of milk yield estimation; the highest accuracy with uncorrected milk weights is reached using a 4-day average. The problem is that the sample results become disconnected from the milk yield and a loss in fat and protein yield accuracy will occur. Ideally, fat and protein production should be connected to the recording day even in robotic systems.

In this case, there are three options to connect samples to the 24-hour yield:

a.   Milk weight is estimated from a longer measurement period but for fat and protein yield estimation only the milk yield on sampling day is used.

b. Information only from the recording day for contents in milk and milk yield estimation.

c. Combination of multiple day milk yield with contents from sampling. See ICAR procedures for using data from more than one day (Lazenby *et al.*, 2002), estimation of fat and protein yield (Galesloot and Peeters , 2000).

The analysis data are merged with milk weights in the laboratory or data processing centre and the date of the analysis must be known.

6.3 Traits to be recorded

In official milk recording, the following data have to be recorded, wherever available:

a. Identification of each cow in the herd, even if they remain in the herd for a very short time.

b. Birth date, sex, breed and parents of each animal when known.

c. All services and embryo flushings and transfers: date, recipient, sire, dam of the embryo.

d. All animal deaths and movements between farms and owners.

e. Recording dates and locations.

f. Milk yields for each cow and recording date.

g. Fat content in milk for each cow and sampling date.

It is recommended to record also the following:

a. Protein content in milk for each cow and sampling date.

b. Milk somatic cell count for each cow and sampling date.

c. Other results obtained from milk analysis.

d. Milking duration and milking speed where possible.

e. Milking times during recording.

f. Recording methods and respective symbols used in records.

g. Information about cow during the rearing period.

6.4 Recording Method

The recording method for the herd consists of using five different symbols for:

a. Responsibility for the practical recording.

b. Sampling method.

c. Recording interval.

d. Sampling interval (if different from the above).

e. Number of milkings per day (especially any deviation from 2x milking).

The symbols in Table 2 should be used:

Table 2. Symbols for milk recording schemes.

Responsibility for recording	Sampling scheme	Recording frequency	Sampling frequency	Number of milkings per day
A	P	1	1	1 x
B	E	2	2	2 x
C	Z	3	3	3 x
	T	4	4	4 x
	M	5	5	R x
	etc.	etc.	etc.	1.4x
				S x

As an example: Recording method is CP36, 2x means that this is a recording where records/ samples are taken partly by the owner (farmer), and partly by a technician from the milk recording organisation, where the recording frequency is every 3 weeks, where the sampling frequency is every 6 weeks, and where the number of milkings per day is 2. If national system is used, it should be possible to transfer this system into ICAR nomenclature.

The reference milk recording method is by a representative of the recording organisation, measuring and sampling every four weeks, with proportional sampling and two milkings per day (AP44, 2x).

Recording other than by the reference method must be indicated using the appropriate symbols.

In the next sections the symbols are explained:

6.4.1 Responsibility for the recording

This symbol indicates who is responsible for measuring the milk yields and taking samples in the herd.

a. Representative of the milk recording organisation (Method A; see Section 1.3)

b. Farmer or his/her representative (Method B; see Section 1.3)

c. Mixed responsibility (Method C; see Section 1.3)

6.4.2 ICAR Standards for sampling schemes

6.4.2.1 Proportional sampling (P)

Samples and milk weights are taken at each milking during the recording day. The sampled amount corresponds to the milk yield of each milking. This is achieved by the use of a pipette in equal number of pipetting at each milking or of a specially designed tool which ensures proportional sampling to create one mixed sample. This is the default sampling scheme with no necessary correction to the analysis results, all other schemes must be reported.

6.4.2.2 Equal measure sampling (E)

Samples and milk weights are taken at each milking during the recording day. The amount of the sample is measured to be equal at each milking and mixed into one sample. The analysis results for fat should be corrected if one of the milking intervals is shorter than 10 or longer than 14 hours.

6.4.2.3 Multiple sampling (M)

Samples are taken at more than one milking during the recording day while milk weights are taken at each milking or over several days. Samples from different milkings are not mixed but they are kept in distinct vials so that each cow has at least two samples. The analysis results must be corrected to correspond to the 24-hour fat and protein yields. For example: a cow is milked 3x during 24 hours and 2 or 3 separate samples are taken, kept and analysed in different vials.

6.4.2.4 One-milking sampling with milk weights from more than one milking (Z)

Samples are taken from one milking during the recording day while milk weights are taken at each milking or over several days. The analysis results should be corrected (Delorenzo and Wiggans 1986 for parlours, Galesloot 2000 for robots)

6.4.2.5 Alternated one-milking recording (T)

Samples and milk weights are taken during one milking, alternating between morning and evening milkings. The milk weights and analysis results must be corrected (Delorenzo and Wiggans 1986 or Liu 2019 or another ICAR approved method).

6.4.2.6 Constant one-milking recording (C)

Samples and milk weights are taken during one milking, constantly during morning or evening milking. The milk weights and analysis results must be corrected (Delorenzo and Wiggans 1986 or another ICAR approved method).

6.4.2.7 In-line analysis recording (I)

Milk is not sampled but its constituents are continuously analysed by a stationary analyser.

6.4.3   ICAR Standards for recording and sampling intervals

Refer to Table 3.

Table 3. Standards for recording and sampling intervals.

	Recording or sampling interval (weeks)	Minimum number of recordings or samplings per year	Interval between recordings or samplings (days)	
			Min	Max
Reference method	1	44	4	10
	2	22	10	18
	3	15	16	26
	4	11	22	37
	5	9	32	46
	6	8	38	53
	7	7	44	60
	8	6	50	70
	9	5	55	75
	Daily	310	1	3

6.4.4   Seasonal production and dry periods

Where a herd is dry for a period of the year, the minimum number of recordings should be adjusted proportionately to the production period.

Minimum number of herd recordings should be at least 85% of the normal number of recordings.

6.4.5 ICAR standards for number of milkings per day

Table 4. Symbols for number of milkings per day.

Number of milkings per day	Symbol
Once per day milking	1 x
Two milkings	2 x
Three milkings	3 x
Four milkings	4 x
Continuous milking (e.g. robotic milking)	R x
Regular milkings not at the same times on each day (e.g. 10 milkings per week) Shown as the average number of milkings per day.	1.4x
Animals that are both milked and suckled. (Number of times milked to prefix the S)	S x

6.4.6 Changing of recording methods

It is recommended that a limit is set for changing the recording method e.g. so that normally it is only possible to change the method twice per year.

It is recommended to store the Recording method ICAR code on event level, which is for every single cow milking stored in the database. The recording method for an accumulated yield is derived from the recording method of the underlying single milkings, in which case the recording method with the highest frequency is used to calculate the accumulated yield.

6.5 The recording

6.5.1 Authorisation to record

It is recommended that professional milk recording technicians be trained and certified before they carry out recordings on their own. Ideally, such training includes a period of supervised work with a certified technician. Where such a certification system is in place, it is not allowed to record without an authorisation.

It is also recommended that frequent training be given to milk recording technicians on new technologies and equipment, safety instructions and data quality issues.

In B and C recording, farmers or their employees doing the practical recording need to be capable of operating the recording equipment correctly (e.g. milk meters, data capture tools) and are familiar with recording techniques.

It is recommended to have an conformation test from a certified recording agency and that frequent training take place.

6.5.2 Cows to be recorded

In a recorded herd, all milk-producing cows must be recorded on each recording day. Acceptable reasons for missing data are discussed below, in 6.6 Missing results and/or abnormal intervals on page 16.

However, if a cow is permanently excluded from milk production, she can also be excluded from milk recording. This may happen through retirement or through use as a suckling cow. In each case it must be certain that the cow will never again produce milk to the bulk tank on the same farm.

6.5.3 Milk weights

Milk weights are recorded for each milking of the recording period. The measurement may be done using any of the ICAR approved recording devices, or by weighing. The minimum accuracy of the measurement is 0.2 kg. Milk meters with electronic data capture are discussed in Chapter 6.7 of these guidelines.

6.6 Missing results and/or abnormal intervals

A recorded daily yield is the best estimate of the yield and the components of the milk weighed, sampled and recorded within 24 hours on the day of recording.

a. When herds are normally milked at intervals such that the recording day is other than 24 hours, the yields shall be adjusted to a 24-hour interval using the following procedure (or other procedures approved by the ICAR):

Divide 24 by the interval, then multiply by the yield. For example:
- For a 25 hour interval   (24/25) x   35 kg = 33.6 kg

- For a 20 hour interval   (24/20) x   35 kg = 42.0 kg

b. A recording is a set of daily test values for a given animal on a given day of recording, one or some or all of them can be missed (missing values).

c. Missing values can be due to:

- Out of range.

- Sickness.

- Disaster.

- No sample analysis results.

d. The number of the official and complete (milk, fat and protein) recordings in the lactation or other accumulated yield should be reported.

e. Permitted range of the daily recorded values is given in Table 5. Outside of these ranges, the daily recorded value will be considered as a missing value.

Table 5. Permitted range of the daily recorded values.

	Milk (kg)		**Fat %**		**Protein %**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Main Dairy Cattle Breeds	3.0	99.9	1.5	9.0	1.0	7.0
High Fat[1] Cattle Breeds	3.0	99.9	2.0	12.0	1.0	9.0

f. The true daily recorded values collected from animals labelled by the farmer as sick, injured or under treatment must be used in the computation of the lactation record unless the milk yield is less than 50% of the previous milk yield or less than 60% of the predicted yield. In such a case, the whole set of daily recorded values may be considered as missing.

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[1] **Note:** High fat breeds have breed average higher than 5.0 for fat %.

g. Estimates of the missing values of a daily recording can be computed by using interpolation procedures or by more sophisticated procedures approved by ICAR.

6.7 Use of data collected by milk meters

This subsection covers data files produced by milk meters in conventional or automatic milking systems.

For official milk recording purposes, the data file obtained from electronic milk meters must contain the following:

a. Cow ID

b. Milking time stamp

c. Milk weight

d. Sampling stamp to mark the milking were the sample comes from

It may also contain:
  a. Vial ID (this is obligatory with M sampling scheme)

  b. Milking duration

  c. Milking speed

  d. Incomplete milking in automatic milking systems

  e. Other relevant data measured or reported by the equipment

The data must be obtained by direct measuring, avoiding any alteration. The computation of the 24-hour yield is done by the Milk Recording Organisation, not by the milking equipment software. This is done in order to guarantee harmonisation of calculation methods between the different brands of equipment and software.

6.8 Fully automatic recording systems

This subsection covers systems where milk weights, milk quality or other traits of the cows are monitored constantly and automatically. This can be done in both automatic and manually operated milking systems.

Use of data from fully automatic systems requires that:

  a. Animal identification is automatic and reliable. Please consult the Animal Identification section of the Guidelines for details. Farm transponders can also be used for automatic identification if they are linked to the cow's official identification in farm software.

  b. Where milk weights are collected automatically, the milk meter used must be ICAR approved and duly tested according to the standards presented in Section 11 of the Guidelines.

  c. Where milk components are analysed, the equipment used must meet ICAR standards for accuracy. Please consult Sections 12 and 13 of the Guidelines for details.

  d. For other traits, the data may be used if it is comparable to similar data from other farms and/or recording equipment.

When using data from fully automatic recording systems, the recording method must state:

  a. Who extracts the data from the automatic system and takes the samples (method A without farmer involvement, otherwise B).

  b. Recording interval in weeks (including daily).

  c. Length of the measurement period in days.

  d. Sampling scheme (Z = one sample, M = multiple samples, I = in-line analysis recording).

  e. Milking scheme (2x, 3x, Rx).

The most important links to other parts of the Guidelines are:

  a. Section 10: Testing and Certification of Devices Used in Animal Identification

  b. Section 12: Guidelines for quality assurance in milk recording laboratories

  c. Section 13: Guidelines for in-line milk analysis

7   Samples

7.1   Representative sample

The milk sample has to represent the complete milking linked to it. This is achieved by mixing the milk thoroughly or pouring it into another vessel right before sampling.

Sampling scheme P requires using a pipette for making the sample proportional between different milkings.

With sampling scheme E, it is advisable to use a measuring cup to make sure the sample parts actually are equal.

Immediately after sampling, the vials have to be preserved, capped, shaken and marked. Samples should be stored cool and dark.

7.2   Transport

Samples should be transported for analysis to a laboratory as soon as possible after sampling.

The samples need to be packed for transport and handled during transport in a manner that guarantees that sample IDs are not compromised or mixed. It is also recommended to protect the packages from external interference.

The packing material must be clean and disposable or easy to clean.

During transportation, it is recommended that the temperature of the samples stays below +10°C.

8   Sample Analysis

This section of the ICAR Guidelines examines how observations are performed on farms and how data are collected, analysed and reported back to farmers. It forms an integral part with other sections of the ICAR Guidelines. It ensures that samples are analysed to the relevant degree of accuracy for the purposes of milk recording, breeding value prediction and other areas of usage. ICAR members operate in a range of situations, ranging from places with almost fully automated recording systems to areas with no roads and electricity. Therefore, the guidelines only demand standards that can be followed, irrespective of production situations and recommend more advanced options, where possible or required. Under the guidelines some practices might not be permitted while other practices are tolerated but not recommended.

The most important links to other parts of the Guidelines are:

a.   Section 12: Guidelines for quality assurance in milk recording laboratories

b.   Section 13: Guidelines for in-line milk analysis

c.   Section 15: Data definition and data transfer

9   Yield calculations

This section covers 24-hour yields and accumulated yields for milk, fat, protein and somatic cells. It also describes the procedure for acceptance of new methods not previously mentioned in the guidelines.

The basic requirements for all calculation methods are that rounding shall only take place at the last step of the computation.

9.1 Lactation period

9.1.1 A lactation Period is considered to commence

a. After the cow calves, or

b. In the absence of a calving date, the best estimate of day that the cow commenced milk production.

A (valid) calving is defined as a parturition taking place:

a. after the mid-point of the gestation period if a service has been recorded, or,

b. after at least 75% of the normal gestation period has elapsed since the previous calving recorded if no service event has been recorded.

Any parturition falling outside the above definition shall be recorded as an abortion and shall not start a new lactation period.

For cows of dairy breeds the normal gestation length shall be deemed to be 280 days unless more specific breed information is available for use.

If the first recording is done on the calving date or within the first 4 days after calving, the milk yield and contents at the first recording should not form part of the official lactation record, especially for automated milking systems (AMS) with multiple recorded days.

9.1.2 A lactation period is considered to end

a. The day that the lactation period, as recorded by the member or according to the ICAR Guidelines, has been completed or

The day that the cow ceases to give milk (goes dry) or
The day the cow gives less than 3.0 kg/day or 1.0 kg/milking in a recording (unless recorded sick).

b. When it is common practice not to record the dry-off date, the day of the midpoint between the last recording with the cow in milk and the first recording day with the animal dry may be assumed to be the dry-off date.

The lactation period ends on whichever date of a. or b. above occurs first.

c. Cows may be recorded as absent or sick on recording day, without lactation period is defined as terminated.

9.2 Production period

In the case where yield records are calculated on the basis of a period of production, usually a year, the record should be expressed as a 'production period record' (symbol PP).

The production period begins the day after the end of the previous production period and ends as defined by the length (in days) of the production period.

9.3 Additional notes

For any ICAR method the interval between two consecutive recordings must routinely fulfil the value for the acceptable range on the herd level.

If the first recording occurs within 14 days from calving, then no adjustment is required to the first recorded value when computing the accumulated record. If the first recording occurs 15 to 95 days from calving, then an adjustment procedure may be applied.

If the 305th day of a lactation falls before the last recording, the interpolation method should be used also for the last period to compute the yields.

9.4   Standard methods for calculating 24 hour yields from AM/PM milkings

The ICAR approved methods are presented in [Procedure 1 of Section 2](). They include:

a. Methods for calculating daily yields from AM/PM milkings:

  - Method of Delorenzo and Wiggans (1986)

  - Method of Liu et al. (2019). Please note that in 2022 the method of Liu et al. (2000) has been updated to the method of Liu et al. (2019). We recommend to organisations that currently have implemented the method of Liu et al. (2000) to update to method of Liu et al. (2019).

  - Method of Kyntäjä et al. (2021)

b. Methods to estimate 24h yield from Automatic Milking Systems

  - Using data on more than one day (Lazenby et al., 2002)

  - Using data on 1 day (Bouloc et al., 2002)

  - Estimation of fat and protein yield (Galesloot and Peeters, 2000)

  - Sampling period (Hand et al., 2004; Bouloc et al., 2004)

c. Standard methods to estimate 24h yield from stationary milk meters

  - Estimation of 24-hour milk yield

  - Using data on more than one day (Hand et al., 2006)

  - Estimation of 24-hour fat and protein yield

9.5   Standard methods for calculating accumulated yields

The ICAR approved methods are presented in [Procedure 2 of Section 2](). They include:

a. Test Interval Method (TIM) (Sargent, 1968)

b. Interpolation using Standard Lactation Curves (ISLC) (Wilmink, 1987)

c. Best prediction (VanRaden, 1997)

d. Multiple-Trait Procedure (MTP) (Schaeffer and Jamrozik, 1996)

9.6   Procedure to approve new methods

a. All parties interested in seeking approval for any new accumulated yield calculation method will notify the ICAR Secretariat and provide a brief description of the proposed method.

b. The ICAR Dairy Cattle Milk Recording Working Group will then consider the proposal and recommend that it be provisionally approved or rejected.

c. If the proposal is accepted, a detailed report will then be prepared to include statistical details, scientific references and other relevant data.

d. The next steps will consist of discussion of these details, final approval or rejection of the method, possible approval by the General Assembly and publication in the guidelines.

10 Reporting

This subsection covers reports, data files, statistics and calculated key figures provided to farmers for breeding and management purposes.

It is recommended that farmers are given reports after each recording and at the end of the recording year or another longer recording period. These reports should contain data on both cow and herd level. In bigger herds, it is also advisable to present results by management groups or otherwise chosen cow groups within the herd. The reporting may be done on paper, through web pages and/or in the form of data files or electronic reports.

Where data files are distributed or direct access given to the results in the database, care must be taken that data ownership is clearly defined. This also includes defining who has access to data and how this access can be authorised.

ICAR members are advised to prepare annual statistics in a reasonable timeframe after closing the recording year. The minimum data requirements are what is needed for the ICAR Dairy Cattle Yearly Enquiry on-line database.

Table 6. Examples of key figures for herd to be used by farmers and other users.

Key figure	Explanation
12-month rolling average yield	Total milk, fat and protein produced during the 365 (366) days preceding the recording divided by the average number of cows for the same period.
Average 305-day yield	Total milk, fat and protein produced within 305-day lactations finished during the reporting period divided with the number of finished 305-day lactations
Average 305-day yield within a period	Total milk, fat and protein produced within 305-day lactations during the reporting period divided with the average number of cows on a 305-day lactation within the reporting period
Average annual yield	Total milk, fat and protein produced during the recording year divided by the average number of cows for the same recording year.
Average calving interval	The average preceding intervals of all calvings second and more during the reporting period
Average fat, protein or lactose contents in milk	Total fat, protein and lactose yields divided by the total milk yield, usually expressed with two decimals
Average lactation yield	Total milk, fat and protein produced within lactations of any length finished during the reporting period divided with the number of finished lactations
Average lactation yield within a period	Total milk, fat and protein produced during the reporting period divided with the average number of cows in milk within the reporting period
Average number of cows	Average number of cows in the herd (or group) on a given day during the reporting period. Usually expressed with one decimal.
Average somatic cell count	Individual cow cell counts weighted into an average by individual milk yields
Daily milk, fat and protein yields	1) Total daily milk, fat and protein yields divided by number of cows, or 2) Total daily milk, fat and protein yields divided by number of cows in milk
Energy Corrected Milk (ECM)	Calculated according to a national standard Example from the Nordic countries: ECM = (fat yield, kg * 38.3 + protein yield, kg * 24.2 + milk yield, kg * 0.7832)/3,14 or, if lactose has been analysed ECM = (fat yield, kg * 38.3 + protein yield, kg * 24.2 + lactose yield *16.54 + milk yield, kg * 0.0207)/3,14 From solids expressed as %: ECM = [(fat content, % * 383 + protein content, % * 242 + 783.2)/3140]* milk yield, kg or, if lactose has been analysed ECM = [(fat content, % * 383 + protein content, % * 242 + lactose content, % * 165.4 + 20.7)/3140]* milk yield, kg
Number of lactations	Total number of finished lactations in the herd (or group) during the reporting period.
Reporting period	The period presented in the given report. The most usual options are: one day, one recording interval, lactation, rolling 365 days, recording or calendar year, and the cow's lifetime

11 Decisions

As a result of the recording process and reports prepared on the basis of its results, decisions can be made on one or more of the following:

11.1 Short term impact: day-to-day management decisions taken on farms

a. Decisions about bulk milk quality.

b. Feeding decisions - daily diet based on group or individual performance.

c.   Pasture management decisions.

d.   Grouping decisions - placing cows in different management or feeding groups.

e.   Culling decisions - decisions on the sale or slaughter of cattle.

f.   Mating decisions.

g.   Decisions regarding programmes of certification for milk and milk products.

h.   Decisions based on data flow from milk recording organisations to farms and vice versa.

11.2 Medium-term impact

Farmers' decisions based on advisory services, veterinarians, independent experts and other services.

Decisions about production planning on farms (herd development).

11.3 Long-term impact

Breeding programme and selection decisions - breeding partners informed by genetic evaluation (Section 9) based on milk recording results.

Decisions based on herd book and breeder association activities and deciding on business actions related to breeding animals, i.e. in some countries animal recording data are required for international trade with breeding animals.

11.4 Strategic decisions

Research programmes concerning management, recording and breeding.

Political decisions about possible subsidies in dairy cattle breeding at the governmental level and implementing measurements according to agriculture policy.

The most important link to other parts of the Guidelines is Section 9: ICAR standard methods of genetic evaluation

12   Quality control / Plausibility checks

This Section together with other parts of the Guidelines ensure that data from particular animals are linked with the relevant phenotypes, genomic information and environments to the required accuracy and using the best methods. There is a distinction, however, between the accuracy required for official milk recording and breeding value estimations and other relevant official results and data used for managerial purposes.

12.1 Bulk tank data comparison

It is a recommended practice to compare milk recording data with dairy deliveries and bulk tank milk contents. This can be done on the recording day or over a longer period of time. The calculation is done as follows:

a.   Comparison ratio = Total recorded milk yield, kg /Total milk produced, kg.

This comparison is used where there is a reliable estimate of the farm use of milk

b. Quick comparison ratio = Total recorded milk yield, kg/ Total milk delivered, kg

This comparison is used where farm use of milk is not estimated

c. Content comparison = Recorded average fat - Bulk tank average fat

d. Comparison ratio for fat = Total recorded fat yield, kg/ Total fat produced, kg

e. Total recorded milk yield, kg = Σ(Individual milk yield, kg)

f. Total milk delivered, kg = Total milk delivered, litres * milk density kg/litre

g. Total milk produced, kg = (Total milk delivered, litres + Milk used or discarded on the farm, litres) * milk density kg/litre

h. Total fat produced, kg = Total milk produced, kg x (Bulk tank fat percent/100)

i. Recorded average fat = Σ[Individual milk yield kg x (Individual fat percent/100)]/Σ(Individual milk yield, kg)

The recommended acceptable range for comparison ratios is 0.95 - 1.05, and for quick comparison ratios 0.90 - 1.00, with due regard to herd size.

12.2 One day bulk tank data comparison

Milk yields and fat yields or contents are compared on the recording day. Comparing the contents is routinely possible where every delivery is sampled or by taking a bulk tank sample (see point 12.1 above for how the comparison is done.)

12.3 Bulk tank data comparison over a longer period

Milk yields and fat yields or contents are compared over a longer period of time, e.g. 4 months or 12 months. This option requires a routine to obtain the applicable data from the dairies or milk buyers. Farm use of milk may be taken into account where applicable.

12.4 Bulk tank sample

Bulk tank samples can be used to verify the milk contents analysis obtained in milk recording. A sample is taken from a well-mixed bulk tank on the recording day. It must represent the milk of the whole 24-hour period. Bulk tank fat and protein contents are then compared to the weighted averages of the fat and protein percent obtained from milk recording. Normally, the difference between the values should not be more than 5%.

12.5 Supervised or repeated recording

Supervised recording is a tool designed to verify that individual cow records are reliable. It is based on repeating the herd recording as soon as possible after the original recording, and the obtained results are compared with the original recording. It is obligatory for

ICAR Certificate of Quality (CoQ) holders to practice regular supervision, irrespective of recording methods used.

It is recommended that the supervised recording will follow immediately after the original recording, but for a good reason it can be postponed for up to 7 days.

The farmer and any other staff doing the original recording must not know that a supervised recording will follow. The technician who performs the supervised recording should not be the same person who did the original recording.

Usually supervised recording is done by recording the whole herd again, using the same sampling scheme and recording method (or a reference method) as in the previous recording. When herd size exceeds 200 cows, it is also allowed to do a supervised recording to selected, or randomised groups of animals in the herd.

Choosing the herds for supervised recording may be random or based on preselection. Traits for this preselection may include high yield, great increase in yield, presence of bull dams in the herd, and general suspicions about the correctness of herd results.

The traits compared in supervised recording must include milk and fat. Comparing protein is also recommended.

12.6 Supervision - example of comparison calculations

a. Milk, fat and protein yields per cow are calculated for both the original and the supervised milking.

b. Individual cow records where results between supervised recording and the original recording differ outside the norms might be excused where a good explanation can be given for exclusion (illness, heat, missed milking)

c. Deviations (%) are calculated for each cow and yield constituent according to the formula: deviation = (supervised yield/unsupervised yield)*100-100

d. Herd averages of the absolute values for each yield constituent are calculated.

e. If the supervised recording occurs within 2 days of the original recording, the acceptable difference in herd averages are 7% for milk and protein and 9% for fat.

f. If the supervised recording occurs between 3 and 7 days after the original recording, the acceptable difference of the aforementioned herd averages are 9% for milk and protein and 12% for fat.

The limits mentioned in these examples are typically applied by some of the member organisations, and are not meant to be understood as exact norms. Such norms should be laid down by each member organisation.

12.7 Evaluation of recording data

It is recommended that data quality is evaluated for each herd recording day. When such an evaluation is applied, the following features of the data have to be included:

a. Person responsible for the recording.

b. ICAR approval and calibration status of the recording equipment if owned by the farmer.

c. Number of herd recordings per time period and/or recording interval.

d. Number of herd samplings per time period and/or sampling interval.

The following features are also recommended to be included if possible:

a. Deviation of milk and fat yields from dairy deliveries.

b. Deviation of milk and fat yields from previous or predicted yields.

c. Standard deviation of individual cow records.

d. Number of recorded and/or sampled milkings within the recording day.

e. Number of cows missed or not recorded in the recording.

The most important link to other parts of the Guidelines is Section 12: Guidelines for quality assurance using DHI analysis

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14 Acknowledgements

14.1 Dairy Cattle Milk Recording Working Group

14.2 Feedback Provided

Cattle Breeders' Association - Israel), Guðmundur Jóhannesson (The Icelandic Agricultural Advisory Centre - Iceland), Charl Hunlun (ICAR Secretariat, Italy/South Africa).