THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Procedure 8 of Section 11 of ICAR Guidelines – Procedure for Validation of Sensor Systems

Procedure for Validation of Sensor Systems

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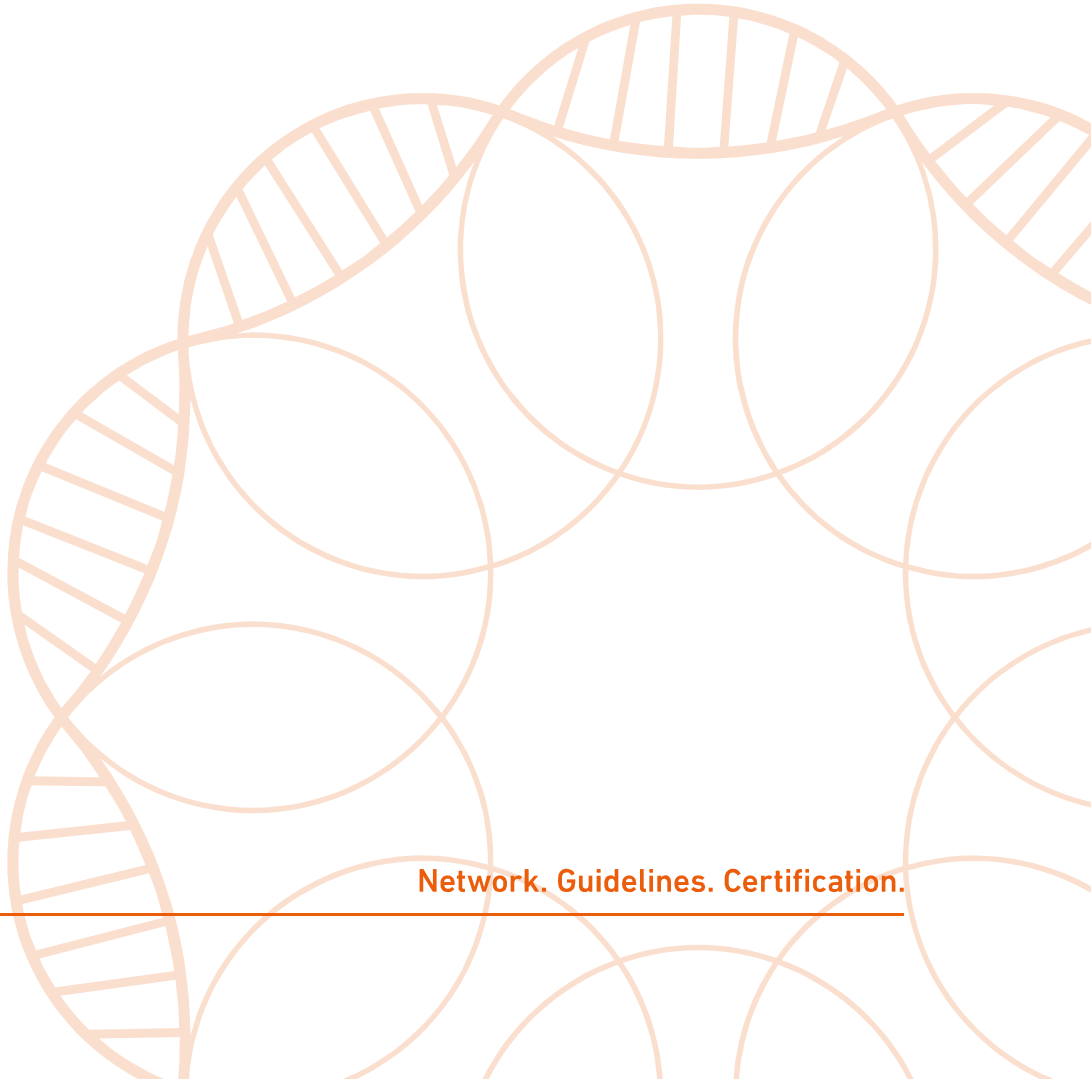

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Change Summary

Date of Change	Nature of Change
August 2021	Creation of new procedure.
July 2023	Approved by General Assembly and published.

1 Introduction

Sensor system validation is the final stage of the ICAR testing and validation process for sensor systems as illustrated in Procedure 1 of Section 11 of the ICAR Guidelines. ICAR-validated sensor systems have demonstrated, through ICAR testing and evaluation, that the system delivers data for the purpose as described in the test report. Further, the manufacturer of the system meets the conditions for validation outlined in Procedure 1, Procedure 2, Procedure 9, Procedure 10 (where applicable) and this procedure of Section 11 of the ICAR Guidelines.

When a new or modified sensor system is to be submitted for ICAR validation, the applicant must provide to ICAR several documents as described in Procedure 1. ICAR validation for sensor systems consists of several steps. The different steps are described in general in this document.

The validation of any new or modified sensor system is based on the test plan developed by the assigned ICAR test centre. The test plan will identify the purpose and the specifics of the test as applicable for the system.

The test plan may describe the following:

- Field test or review,
- Evaluation of the installation and routine calibration procedures for the system as described in Procedure 9 and Procedure 10 (where applicable),
- Data review for system,
- Desk review for a modified system,
- Modified test plan 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 system. In addition, the assigned test centre may engage additional expertise from other ICAR sub-committee or working group members to ensure the test plan is comprehensive and designed to meet the needs of the manufacturer/applicant.

After internal review, the test plan is presented to the manufacturer/applicant and agreed upon by all parties. All contracts associated with the test of the sensor system are administered by ICAR with the test centre acting as an agent of ICAR.

Note: It is known that the ICAR test centres may be part of, or associated with, research institutions and they may be involved in the preliminary/early stages of the development of a sensor system. These systems may be initially developed for research purposes and subsequently adapted for or installed on commercial farm operations. In these cases, there is no contractual involvement with ICAR during these development phase(s). Further, these sensor systems may be mentioned in peer-reviewed scientific publications with that information available to the institution when assuming the role as an ICAR test centre.

1.1 Category of sensor system

ICAR distinguishes distinct categories of sensor systems to aid in development of test plans. If a sensor system in use delivers data in multiple categories and the purpose of the review or evaluation is as such, a manufacturer may select multiple categories as part of the application process. For example, a sensor system provides milk yield, milking speed, and milk

composition and the manufacturer identifies the purpose of the system validation test to include all these parameters, it is feasible to select multiple categories.

ICAR offers validation testing services for systems in these categories.

1. Milk yield and flow,
2. Milk composition,
3. Live body measurements,
4. Live activity measurements,
5. Feed efficiency measurements, and
6. Greenhouse gas measurements.

In the case of a sensor system that provides measurements of a parameter in one category based on internal estimates of a parameter using principles defined in another category, the test centre will determine the appropriate approach for the evaluation of the system in the test plan. For example, a sensor system may provide yields of milk, milkfat, and protein but does not provide the actual milk composition for these components. In this case, the system may be evaluated using the ICAR guidelines for milk composition based on calculated estimates of composition for the components to be evaluated as part of the sensor system test.

2 Definitions

Definitions and terminology used in this document can be found in the Overview Procedure.

3 Purpose

The core principle of sensor system validation is an evaluation that the data provided by the system meets the purpose defined by the manufacturer/applicant. In defining the purpose of the system test, the manufacturer, as part of the application process, should define:

1. Species,
2. Life stage, if applicable (i.e. lactating cows, breeding stock, etc.),
3. Level of reporting such as individual animal, group of animals, or other level as defined by the manufacturer,
4. Parameter(s) to be included in the system test (i.e. body condition score, milk fat & true protein, etc.),
5. Use of data for the parameter(s) measured by the system (i.e. general management data, alarm/actionable data, genetic evaluations or predictions, research).

The number of installations, sensors and/or data measurements required are dependent on the type of system, the purpose of the evaluation, and will be determined during the development of the test plan.

4 Evaluation of sensor systems

The ICAR validation of a sensor system involves an evaluation of eight key areas described below that are identified as critical to the accuracy, performance and ongoing delivery of validated data from the system. The evaluation will include:

1. Definition of the measurement principle,
2. Evaluation of the accuracy/repeatability/reproducibility of measuring component(s) of the sensor system,

3. Evaluation of the animal ID system and linkage to measurements,
4. Evaluation of the data handling – estimates, rounding, missing data points, and outliers,
5. Evaluation of the data interface & transfer procedures to MRO and databases,
6. Evaluation of the system installation parameters and procedures,
7. Evaluation of the routine or periodic checking procedures,
8. Evaluation of the effect of the system on animal well-being.

4.1 Definition of measurement & principle – direct & indirect

The objective of this test is to understand the measurement for parameter(s) as estimated by the system, and to be able to determine use, usability and usefulness of data generated for the parameter(s) as part of the test. The measurements may be direct measurements of a parameter or indirect measurements using a proxy for the parameter.

The key components of this test will quantify the following:

1. Description of the parameter measured and the parameter reported by the system
2. The units reported for (or definition of) the parameter in the system output.
3. If data for the parameter is measured on a scale, either linear or categorical, a description of the scale used by the system and its equivalence to other scales for the same parameter that may exist in practice should be described.
4. If the data reported for a single parameter is the combination of direct and/or indirect measurements of the multiple parameters by the sensor system, the details of this measurement should be described.

The test report will include this information and a summary of the data generated by the system for those parameters requested as part of the application process. ICAR and the test centre will use discretion in the confidentiality of the manufacturer's intellectual property where desired when providing a summary of the system measurement(s) and principle(s).

4.2 Evaluation of accuracy/repeatability/reproducibility of measuring component(s) of the sensor system

The objective of this test is to assess the range, accuracy and precision of the measurement of the parameter(s) estimated by the sensor system. The precision (contained within total accuracy) will be evaluated by studying the repeatability and reproducibility of the sensor system. Accuracy, which includes other error sources than just the repeatability and reproducibility errors. For an illustration of the breakdown of the accuracy errors, please refer to Annex A in ISO 8196-1|IDF 128-1.

Where ICAR guidelines exist for the parameter(s) requested to be included in the test, those guidelines will be referenced as the standard. For measurement of other parameter(s), where an ICAR guideline does not exist, the following considerations may be made to assess the accuracy and precision of the sensor system. These include:

1. Accepted industry standards for biological range, accuracy and precision such as IDF or ISO standards,
2. Peer-reviewed journal articles demonstrating these values,
3. Direct comparison of the measurements to a known assessment of the measurement as it may exist in industry practice,
4. Internal validation studies on the repeatability and reproducibility of measurements. If the precision indicator is provided by the manufacturer from internal research, ICAR and the test centre will review if the study(ies) are adequate to describe the

range of measurement along with the accuracy and precision of the measurements for the parameter(s) that are part of the ICAR system test.

On request of, and at the cost of the manufacturer, ICAR could assess the accuracy, repeatability and reproducibility of the sensor system by carrying out a validation study at one of the ICAR test centres or an institution under the supervision of the test centre personnel.

The test report will include a summary and conclusion if the accuracy and precision of the data generated by the system for those parameters requested as part of the application process meets the standards identified above. This information will be part of the assessment of the use and usability of the data.

4.3 Evaluation of the animal ID system and linkage to measurements

The objective of this test is to evaluate the linkage of the animal ID to the measurement. Therefore, several checks will be carried out (where applicable):

1. Which ID is linked to the measurements (i.e. the official animal ID or external sensor ID),
2. Point of measurement and location of animal ID system used by the sensor system,
3. Sensor identification as part of the sensor system (i.e. transponder ID in the sensor component) or reliance on linkage to existing ID system (i.e. RFID tag or other system transponder ID),
4. List of animal ID system(s) that are suitable for use with the sensor system,
5. Availability of protocols for ID cross-referencing and validation in the database of the sensor system (i.e. duplicate IDs related to both official animal ID and sensor ID),
6. The use of the ID system of the sensor system with other devices/sensor systems,
7. Availability of a protocol for validation of the ID system and linkage to sensor measurement(s) for the parameter(s) prior to data transfer.

The test report will include a summary of the ID system and linkage to measurements as determined by the test, noting limitations and best practices to be employed when using data from the sensor system for the purpose noted in the test.

4.4 Evaluation of the data handling – estimates, rounding, missing data points, and outliers

The objective of this test is to evaluate how the sensor system software delivers the values reported for the parameter(s) described in the test plan. This will be evaluated by quantifying data handling exceptions that include:

1. Outlier determination principles, if applicable, and the value reported by the system in the case of outlier exclusion,
2. Rounding of the data and precision of data reporting (i.e. milk fat 4.1% vs 4.14%),
3. Data handling of missing observations,
4. Recording period of the data for the parameter(s) such as a single measurement, actual or extrapolated 24-hour measurement, multi-day average(s), or rolling mean average for the parameter(s) included in the test.

The test report will provide a summary of the sensor system values for the parameter(s) included in the test with respect to considerations on data handling. This assessment, along with test report findings described in 4.1 and 4.2 of this procedure contribute to the use and usability assessment of the system data by recording organisations, external databases, and other interested parties.

4.5 Evaluation of the data interface & transfer procedures to MRO and databases

The objective of this test is to evaluate the interface and data transfer possibilities of the device. This will be evaluated by investigating if the device includes the following:

1. Software to exchange data with external parties like milk recording organisations and external databases,
2. Requirements of the sensor system software to use of other data sources or software program(s) before data is transferred,
3. While not mandatory, agreement with the ICAR Animal Data Exchange (ADE) format(s) if represented as such by the manufacturer,
4. Other data exchange format(s) used or available with the sensor system software.

The test report will provide a summary of the considerations for successful data exchange with recording organisations, external databases, and other interested parties.

4.6 Evaluation of the system installation parameters and procedures

The objective of this test is to evaluate the installation or commissioning procedure of the device as described in Procedure 9 of Section 11. This test is carried out in agreement with the member organization and/or in collaboration with the technician of the manufacturer or an authorized dealer.

The test report will provide a copy of the installation or commissioning procedure as provided by the manufacturer/applicant. The test report may also include specific considerations on the installation of the sensor system that include software version(s), physical installation requirements (i.e. in-line milk analyser should be installed after the milk meter at a level mount), or other items identified during the ICAR test.

4.7 Evaluation of the routine or periodic checking procedures

The objective of this test is to evaluate the routine or periodic checking procedures to assure ongoing data quality from the sensor system for the parameter(s) included in the test. The guidelines for the routine or periodic checking procedures are described in Procedure 9 of Section 11.

The manufacturer may also propose a new or novel approach for a routine computerized solution for period checking of the sensor system. Procedure 10 of Section 11 provides guidelines for computerized solutions and guidelines to propose and validate new solutions.

This test is carried out in agreement with the member organization and/or in collaboration with the technician of the manufacturer or an authorized dealer. These procedures will be evaluated based on the procedure provided by the manufacturer/applicant. The appropriateness of the suggested frequency of checking will be consider to assess the extent that the procedure will provide an assurance of quality data.

The test report will provide a copy of the routine or periodic checking procedure as provided by the manufacturer/applicant.

4.8 Evaluation of the effect of the system on animal well-being

The objective of this evaluation is objectively assess the impact of the system on the well-being of the animal using available current criteria such as IDF guidelines or industry principles/standards. It will give information about the following (where applicable):

a. Physical impact of the sensor as attached to the animal,

b. Impact of the sensor system on milking system performance as it relates to impact on milk quality measures,

c. Disturbance of normal/traditional cow routines for sensor systems that require changes to eating, mobility, resting or other movements,

d. Potential benefit of the sensor on animal well-being (i.e. early identification of mobility issues, health issues, or milk quality issues).

The test report will provide a summary of the observed effects of the sensor or sensor system on animal well-being based on assessment during the ICAR test.

Upon completion of the evaluation of these eight key areas, where applicable, the ICAR test centre will provide a report of the sensor system. This confidential report will be reviewed as outlined in Procedure 3.1 of Section 11. Further, as the areas of review described are identified as critical to the accuracy, performance and ongoing delivery of validated data from the system, the ICAR test centre will prepare summary document with non-confidential information that will be accessible by ICAR members and other parties (upon request). This document will include the purpose of the system evaluation, parameter(s) reviewed, and the summary information from each area of the evaluation. This document is designed to aid milk recording organisations, external databases, and other interested parties in the decision on the use and usability of data from the sensor system for the parameter(s) described.