INSTRUMENT APPROVAL PROCESS

INSTRUMENT GRADING SYSTEMS FOR BEEF CARCASSES

BACKGROUND:

In 2020 and 2021, AMS worked with members of the American Meat Science Association's (AMSA) Instrument Grading Committee to update these requirements as technology had evolved and changed since the original document was drafted. Members of the AMSA instrument grading committee was comprised of members of academia, beef processing companies, NCBA, and representatives of USDA.

1. PURPOSE

The U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Livestock and Poultry (LP) Program has implemented a program to predict beef carcass quality and yield factors made by approved instrument systems. The purpose of this document is to provide the performance standard by which the instruments will be evaluated for the ability to accurately and precisely measure USDA grade factors **used to predict final yield and quality grades**. **For a technology provider that wants their instrument approved, t**wo **like** instrument**s** must be tested, and each instrument must meet the following requirements to gain approval from the LP Program. The approval process consists of four phases:

Phase I   Submission of approval request and determination of designation as either a "New" instrument, which includes both previously unapproved instruments or currently approved instruments that have undergone significant upgrades.   A currently approved instrument that has undergone non-significant upgrades will be considered an "Upgrade", see section 9.

Phase II   Demonstration of the repeatability of marbling score, ribeye area, fat thickness and final yield grade predictions on stationary beef carcasses

Phase III Demonstration of the accuracy and precision of marbling score, ribeye area, fat thickness and final yield grade predictions at line speeds consistent with intended use.

2. SCOPE

The intent of utilizing beef carcass instrument grading augmentation is to improve the accuracy and uniformity of grade application nationwide. LP reserves the right to confirm if changes have been made to the software by utilizing existing monitoring and quality control tools.

3. REFERENCES

QAD 500 - Beef, Bullock, and Bull Grading Methods and Procedures | Agricultural Marketing Service (usda.gov)

QAD 515 - Beef Carcass Instrument Grading Procedures | Agricultural Marketing Service (usda.gov)

Carcass Beef Standard December 2017 (usda.gov)

Standard Practice for User Requirements for Livestock, Meat, and Poultry Evaluation Devices or Systems. American Society of Testing Materials (ASTM) International Standard F 2341-05.

Standard Specification for Developing and Validating Prediction Equation(s) or Model(s) Used in Connection with Livestock, Meat, and Poultry Evaluation Device(s) or System(s) to Determine Value. ASTM International Standard F 2340-05.

4. DEFINITIONS

- A "New" instrument is described as either a new instrument or a currently approved instrument that has undergone significant upgrades.

    o Significant upgrades can be described to include, but are not limited to:
        ▪ Any change that can affect at least one of the predicted independent variables, to include both hardware and/or software changes

5. APPROVAL PROCESS

5.1 Phase I - Submission of approval request and determination of designation as either a "New" instrument or an "Upgrade" to an already approved instrument

    5.1.1 The applying technology provider will send a request for approval to the Standards and Specifications Division (SSD). Details in this request should include:

- Both a basic and an in-depth summary of how their instrument works.
- Whether this is a:
    o "New" instrument
        ▪ An instrument not previously approved for use

- A significant "Upgrade" to a currently approved instrument
  - List all upgrades to the instrument if utilizing a previously approved device as the base for the upgrade.
  - a Non-significant "Upgrade" to a currently approved instrument
- A signed affidavit acknowledging that LP requires that no additional changes to an instrument will be made without prior knowledge of AMS after the initial sample collection has begun.

5.1.2 LP will make the final determination if the instrument is a new instrument or an upgrade approval.

5.2 Phase II **-** Demonstration of the repeatability of marbling score, ribeye area, fat thickness and final yield grade predictions on stationary beef carcasses

5.2.1 Marbling - A minimum of 200 stationary carcass sides shall be measured three times[1] to provide a minimum of 600 observations for the evaluation of repeatability. Instruments can be evaluated for repeatability at any of the two approval trials or prior to the approval trials (see 4.3 Phase III). Repeatability will be estimated from carcasses that represent the U.S. fed beef population[2] and are distributed over the full range of degrees of marbling (Table 1).

Table 1

Marbling Scores	Minimum required for Phase II	Minimum required for Phase III
Traces or less	5	50
Slight 0-49	20	200
Slight 50-99	30	200
Small	60	600
Modest	40	400

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[1] The Triple Placement method shall be used for collecting images (data) from stationary carcasses for marbling, REA, and fat thickness. LP may determine, for certain conditions, that a Triple Trigger method may be used as an alternative.

[2] Estimates of the distribution of the U.S. fed beef population was provided by the AMSA Beef Grading Committee.

Moderate	25	300
Slightly Abundant	15	200
Moderately Abundant or higher	5	50
Totals per location	200	2000

5.3 Phase III **-** Demonstration of the accuracy and precision of marbling score, ribeye area, fat thickness and final yield grade predictions at typical line speeds

5.3.1 - Marbling - A "New" instrument must be tested in at least two separate trial locations to ensure that any carcass variation due to environmental conditions (e.g., bloom time/chain speed,carcass temperature, sawing and ribbing) is considered. The locations shall be regionally diverse and be approved by LP. The technology provider will be responsible for contacting the location and obtaining approval to collect samples.

During each trial, a minimum of 1,000 carcasses shall be included to adequately represent the U.S. fed beef population and the full range of marbling scores, resulting in a minimum of 2000 carcasses for each instrument approval. Of the 2,000 carcasses coming from each of the trial locations, no more than two-thirds (2/3) of the samples in any one of the marbling categories can come from a single plant

For the development and refinement of any prediction equations, an additional 1,000 carcasses will be collected at each location. The official marbling calls for these carcasses will be provided to the applicant.

Sample collection shall occur in each of the two locations for a minimum of 1 full production shift per location. If the total number of carcasses per marbling category cannot be collected during these two shifts, collection over a third shift may be necessary. At least 90% of samples within each marbling score must be fulfilled before the sample collection for an approval trial may be completed. It will be at the discretion of USDA AMS as to whether additional production shifts and/or additional plant/facility will be utilized.

Carcasses must be presented for image capture and analysis at a continuous normal operating chain speed. The degree of marbling matrix shown in Table 1 will serve as the template in guiding carcass selection. LP personnel will select the side of the carcass to be evaluated by the instrument and the Gold Standard Committee as outlined

in 5.3.1.1. No more than 80 percent of the images shall derive from one side (left or right).

5.3.1.1 – The Gold Standard Committee is responsible for establishing the Official Marbling Score. The Official Marbling Score will be determined by a panel of three LP experts. The Gold Standard Committee will include three LP experts from the following: National Meat Supervisor, Assistant National Meat Supervisor and Meat Supervisors from the Gold Standard Team. Once the instrument trial has started, the Gold Standard Committee will remain unchanged until the completion of the instrument trial.

5.3.1.2 – Procedure for determining the Official Marbling Score - Prior to or immediately following the on-line evaluation by the instrument, carcasses will be evaluated by the Gold Standard Committee in an adequately illuminated (a minimum of 100-foot candle power) area. The Gold Standard Committee will independently evaluate the marbling score in accordance with the *Official United States Standards for Grades of Carcass Beef* (January 2017) and shall be recorded to the nearest 10 degrees of marbling. The marbling score will be numerically coded as follows:

Table 2

Degree of Marbling	Marbling Score
Practically Devoid	100
Traces	200
Slight	300
Small	400
Modest	500
Moderate	600
Slightly Abundant	700
Moderately Abundant	800
Abundant	900

A final Official Marbling Score will be computed from the independent observations for each carcass. Carcass data will be excluded from the test if the difference of any one of the independent observations exceeds a range of three (3) times the root mean square of the differences between all independent observations and their corresponding average for that carcass. The root mean square error will be calculated after all data has been collected.

The Gold Standard Committee will compute the final Official Marbling Score and the standard deviation (SD) for each carcass. Carcasses will be ranked by the final Official Marbling Score in ascending order by trial location and then every other carcass will be assigned to a calibrationdata set. The other half of the data will become the test data set. Data entry, data checking, and assignment to calibration and test data sets shall be conducted in duplicate by the Gold Standard Committee and the results reconciled before release of information to the technology provider. The Gold Standard Committee will provide all data parameters to the technology provider for the carcasses assigned to the calibration data set. The technology providermay use the calibration data to develop or refine their marbling score prediction equation.

5.3.1.3 – Submission of Predicted Marbling Score and Prediction Equation

At the completion of the two trials, the technology provider will submit the instrument predicted marbling scores to LP for comparison with the Official Marbling Scores of the test data set. LP experts will then compute the necessary statistics to determine if the instrument system meets the requirements outline in section 5. The technology provider will provide LP with a copy of the prediction equation used as well as the values for each variable in the prediction equation for each of the predicted marbling scores, which LP will use to validate the information collected and outputs computed.

5.3.1.4 – Quality control of images and *data collected*

For the test to provide the best results possible, LP will review all data and images to determine if the data and images from the selected carcasses were accurately obtained. Technology providers must submit to LP the original image and the processed display screen image or thumbnail for each carcass in the test so that images can be reviewed to determine if proper image capture occurred.

6. PERFORMANCE REQUIREMENTS for MARBLING

Approval will be granted in accordance with the following performance requirements. Approval of the instrument will be determined by LP and will be based on the intended use of the instrument system. The scope will be set forth in the final approval.

6.1 Stationary measurement of repeatability: Phase II:

- 95% of the carcasses shall have all three of the predicted marbling score observations within 20 marbling score units of the mean predicted marbling score for that carcass.

6.2 On-line measurement of accuracy and precision: Phase III:

- Average residual = 0 ± 10 marbling score units where the residual is the difference between the predicted instrument marbling score and mean expert panel marbling score;

- The standard deviation of the residuals (rSD) from the mean expert panel marbling score < or + 35 marbling score units; and,

- Slope of 0 ± 0.075, using the residual from the MEPMS as the dependent variable (y-axis) and the average of the instrument marbling score and mean expert panel marbling score as the independent variable (x-axis).

7. PERFORMANCE REQUIREMENTS for RIBEYE AREA

Approval will be granted in accordance with the requirements listed below. Accuracy of ribeye measurement will be evaluated by comparing (correlation and regression) the ribeye area observation to the actual ribeye area.

7.1 Phase II: Stationary measurement of repeatability

- <u>Stationary Accuracy</u>

  o 95% of the carcasses shall have all three of the predicted ribeye area observations within 1.0 square inches of the *predicted mean ribeye area* for that carcass.

- <u>Stationary Repeatability</u>

  o 95% of predicted ribeye area observations within 0.5 square inches of the mean of the three ribeye area observations for that carcass

7.2 Phase III: On-line measurement of accuracy and precision

A minimum of 200 carcasses (representing a range of at least 3.0 square inches from the smallest ribeye are to the largest ribeye area sampled) must be presented for image analysis under normal beef carcass grading conditions. Freshly ribbed carcasses must be presented to the instrument on a line where chain speeds are more than 300 head per hour. Following collection of images, carcasses should be placed on a stationary rail for determination of *actual mean ribeye area* as described in the Phase II.

- $R^2 = 0.85$ or greater

- 95% of ribeye area observations within 1.0 square inches of the *actual mean ribeye area*

- Residual standard deviation (RSD) shall not exceed 1.0 square inches

8. PERFORMANCE REQUIREMENTS for FAT THICKNESS

Approval will be granted in accordance with the requirements listed below. Accuracy of fat measurement will be evaluated by comparing (correlation and regression) the fat thickness observation to the *actual mean fat thickness of that carcass side.*

A minimum of 200 carcasses must be presented for image capture and analysis under normal beef carcass grading conditions. Freshly ribbed carcasses must be moving at a minimum chain speed of 300 head per hour. Following collection of images, carcasses should be placed on a stationary rail for determination of *actual fat thickness* as described above (Phase II).

8.1 Phase II: Stationary measurement of repeatability

- Stationary Accuracy

  o 95% of the carcasses shall have all three predicted fat thickness observations within 0.2 inches *predicted mean fat thickness* for that carcass.

8.2 Phase III: On-line measurement of accuracy and precision

- 95% of predicted fat thickness observations within 0.1 inches of the *calculated actual fat thickness*

- The average of the residuals (between applicant fat thickness and *calculated actual fat thickness) shall equal* 0 ± 0.05 inches

9. PERFORMANCE REQUIREMENTS for YIELD GRADE

Approval will be granted in accordance with the requirements listed below. Accuracy of yield grade will be evaluated by comparing (correlation and regression) the yield grade observation to the *actual expert calculated yield grade.*

9.1 Phase II: Stationary measurement of repeatability

- Stationary Accuracy

o $R^2 = 0.90$ or greater

9.2 Phase III: On-line measurement of accuracy and precision

- 95% of predicted yield grade observations within 0.5 yield grade units of the *actual expert calculated yield grade*

Note: (Preliminary yield grade observations and adjusted fat thickness predictions will not be evaluated separately from the final yield grade.)

10. Performance Requirements for a Non-Significant Upgrade of an already approved instrument.

Approval will be granted in accordance with the requirements listed below. A non-significant upgrade is an upgrade that does not potentially influence or practically affect at least one independent variable being measured.

10.1 The manufacturer will have the option to choose between expert panel to prototype testing or approved device to prototype testing. The manufacturer will notify LP of its choice before initiation of testing.

The prototype instruments will be required to fulfill all requirements listed for *Phase III* measurements. If the manufacturer choses the approved device to prototype testing method, the measurement values given by the approved device will be used in place of the mean expert scores.

11. PREVIOUS DOCUMENTS

This document replaces:

- USDA AMS Prime I (Instrument Grading Systems for Beef Carcasses), June 2006

- USDA AMS Prime I Addendum A (Instrument Grading Systems for Beef Carcasses), December 2012

- USDA AMS Procedures for approval and use of instrument systems for beef carcass ribeye measurement, February 2003

- USDA AMS Procedures for approval and use of vision-based instrument systems for beef carcass yield grade measurement, March 2005

- USDA AMS Procedures for approval and use of vision-based instrument systems for beef carcass yield grade measurement Addendum A, March 2007

12. ADDITIONAL REQUIREMENTS

12.1 VERIFICATION OF APPROVED EQUATIONS

The LP Program must be notified prior to implementing any modifications of the device, system, or process that would affect one or more independent variables of a LP Program approved equation (see Section 5.2 ASTM International Standard F 2340-05; and Section 5.3.3. ASTM International Standard F 2341-05). The instrument manufacturer must allow LP personnel access to the unencrypted software coding for an instrument immediately upon request by LP. Immediate view of a specific instrument's coding will be required (no generalized coding will be accepted.)

The manufacturer will keep an electronic log within the instrument system that tracks any updates or modifications to the software coding. This electronic log will be provided to LP staff immediately upon request.

12.2 CONDITIONAL APPROVAL

Approval of an instrument will be granted on a conditional basis of performance in the field setting for a minimum of one year from date of approval. During this conditional period, USDA AMS may require additional testing of the instruments if field data suggests that the instruments are not performing to the levels achieved in the approval process.

12.3 USE OF A REFERENCE DEVICE

The device manufacturer will provide LP with an instrument to be used as a reference device. LP will possess this device and will utilize it as a reference device when testing instruments in the production setting.

This standard is subject to revision at any time by the LP Program.

Requests for approval shall be submitted to:

Standards and Specifications Division

USDA, AMS, LP   Phone: (202) 841-2974

Room 2628, South Building   FAX: (202) 720-1112

1400 Independence Avenue, S.W.   Email: willy.horne@usda.gov

Washington, DC 20250-0254   chad.nelson2@usda.gov