Instrument Grading Systems for Beef Carcasses

Performance Requirements for Instrument Marbling Evaluation (PRIME)
I. Demonstration of Repeatability, Accuracy, and Precision

BACKGROUND:

The Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Livestock and Seed (LS) Program will utilize beef carcass marbling scores made by approved instruments to assist in determining the official quality grade of beef carcasses. The LS Program will approve instrument systems that meet specific performance requirements for accuracy, precision, and repeatability in the prediction of the marbling scores for beef carcasses. The performance requirements outlined in this document were established after consultation with an Industry Working Group that was convened by the LS Program and the National Cattlemen's Beef Association (NCBA). The Industry Working Group was comprised of representatives of USDA, NCBA, beef processing companies, cattle producers, technology providers, and academia.

PURPOSE:

The purpose of this document is to provide a performance standard to determine if instrument systems can objectively predict marbling scores accurately and precisely for use in the evaluation of beef carcasses for quality grade, certification programs, and carcass data information programs. An instrument must be tested and must meet the following requirements to gain approval from the LS Program. The approval process consists of two phases:

   Phase I   Demonstration of the repeatability of marbling score prediction on stationary beef carcasses, and

   Phase II   Demonstration of the accuracy and precision of marbling score prediction at line speeds.

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METHODOLOGY:

Phase I Protocol

A minimum of 200 stationary carcass sides shall each be measured three times to provide a minimum of 600 observations for the evaluation of repeatability. Instrument systems can be evaluated for repeatability at any of the four trials of the test (see the Phase II Protocol section below for an explanation of the four trials). Repeatability will be estimated from carcasses that adequately represent the U.S. fed beef population and are distributed over the full range of degrees of marbling (Table 1).

Table 1

Degree of Marbling	Number for Stationary Repeatability (Phase I)	Number for On-line Grading per Establishment Trial (Phase II)
Traces or less	10	50
Slight	60	300
Small	60	300
Modest	40	200
Moderate	20	100
Slightly Abundant or higher	10	50
Total	200	1000

The Triple Placement method shall be used for collecting images (data) from stationary carcasses for Phase I testing. The Triple Placement method is defined as:

Triple Placement: Place the camera head unit over the 12th-l3th rib interface on one side of each carcass and obtain one image; remove the camera head unit; return the camera head unit to the ribeye interface and obtain a second image; remove the camera head unit again; return the camera head unit to the ribeye interface, and obtain a third image, and

The AMS, LS Program, Standardization Branch (STDZ) may determine for certain conditions that a Triple Trigger method may be used as an alternative. The Triple Trigger method is defined as:

Triple Trigger: Place the camera head unit over the 12th-l3th rib interface of one side of each carcass, and obtain three sequential but separate images without moving the camera head unit.

Phase II Protocol
An instrument system must be tested in four separate trials at locations determined by STDZ to ensure variation due to environmental conditions (e.g., bloom time/chain speed, carcass temperature, sawing and ribbing) is considered. During each of the four trials, 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 (i.e., each instrument presented for approval must be tested on a minimum of 4,000 carcasses). If a company-specific user of an instrument system seeks approval for use only within their organization, the instrument system must also be tested as specified above.

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. An AMS representative will select the side of the carcass to be evaluated by the instrument and the official panel. No more than 80 percent of the images shall derive from one side (left or right). Following carcass evaluation by the instrument, an AMS representative will select carcasses to be included in the study and those carcasses will be segregated onto a stationary rail for determination of the *expert panel marbling score* as described below.

Establishing the Expert Degree of Marbling
In order to validate the accuracy and precision of an instrument system, an *expert panel marbling score* must be established for each carcass from the side selected for evaluation. Marbling score must be evaluated by a panel of five officials designated by STDZ or otherwise evaluated by a method approved by STDZ. Following the on-line evaluation by the instrument, carcasses will be placed on an adequately illuminated (a minimum of 100 foot candle power) stationary rail for evaluation by the official panel. The evaluation of marbling score by the official panel must be completed within 30 minutes of image capture. The official panel will independently evaluate the marbling score in accordance with the *Official United States Standards for Grades of Carcass Beef* (January 1997). Marbling score shall be recorded to the nearest 10 marbling score units. 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 *mean expert panel marbling score* (MEPMS) will be computed from the independent observations for each carcass. Carcasses will be excluded from the test if the difference of any one of the independent observations from the MEPMS exceeds a range of three (3) times the root mean square of the differences between all independent observations and their corresponding MEPMS over all the carcasses. The root mean square error will be calculated after all data has been collected.

AMS will compute the MEPMS, the range of *expert panel marbling scores* (REPMS), and the standard deviation (SD) for each carcass. Carcasses will be ranked by MEPMS in ascending order by day and then every other carcass will be assigned to a calibration data 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 AMS and the results reconciled before release of information to the technology provider. AMS will provide the MEPMS, REPMS and SD to the technology provider for the carcasses assigned to the calibration data set. The technology provider may use the calibration data to develop or refine their marbling score prediction equation.

Submission of Predicted Marbling Score and Prediction Equation
At the completion of the four trials, the technology provider will submit the instrument predicted marbling scores to AMS for comparison with the MEPMS of the test data set. AMS will then compute the necessary statistics to determine if the instrument system meets the requirements below. The technology provider will provide AMS 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 AMS will use to validate the information collected and outputs computed.

Exclusion of Images Captured and Data Collected
In order for the test to provide the best results possible, STDZ 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 STDZ 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.

PERFORMANCE REQUIREMENTS:

SCOPE:
Approval will be granted in accordance with the following performance requirements to an instrument system that predicts marbling scores accurately and precisely using instruments and devices that utilize a validated prediction equation. The scope of an instrument's approval is determined by STDZ and will be based on the intended use of the instrument system. The scope will be set forth in the final approval.

Phase I: Stationary measurement of repeatability:

- Ninety five percent 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.

Phase II: On-line measurement of accuracy and precision:

- Average residual = 0 ± 10 marbling score units where the residual is the difference between the instrument marbling score and MEPMS;

- The standard deviation of the residuals (rSD) from the MEPMS ≤ 35 marbling score units; and,

- Slope of 0.000 ± 0.075, using the residual from the MEPMS as the dependent variable (y-axis) and the average of the instrument marbling score and MEPMS as the independent variable (x-axis).
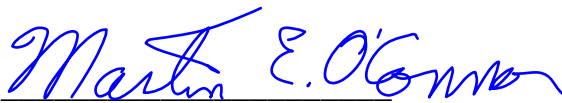
ESTABLISHMENT IMPLEMENTATION APPROVAL PROCESS

Procedures for the implementation and verification of operational accuracy will be established and approved on a plant-by-plant basis once the instrument has met the performance requirements above. For the minimum criteria that must be addressed, please review the LS Program document titled *Implementation and Verification of Operational Procedures* (http://www.ams.usda.gov/lsg/stand/instrument.htm).

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

Requests for approval shall be submitted to:

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