United States Department of Agriculture

Marketing and Regulatory Programs

Agricultural Marketing Service

Specialty Crops Program

Specialty Crops Inspection Division

United States Standards for Inspection by Variables

Effective May 29, 1973

Reprinted October 18, 2019

This is a reprint of the United States Standards for Inspection by Variables which have been in effect since May 29, 1973 and were updated to modify the format and update obsolete contact information.

Voluntary U.S. grade standards are issued under the authority of the Agricultural Marketing Act of 1946, which provides for the development of official U.S. grades to designate different levels of quality. These grade standards are available for use by producers, suppliers, buyers, and consumers. As in the case of other standards for grades of fresh and processed fruits, vegetables, and specialty crops these standards are designed to facilitate orderly marketing by providing a convenient basis for buying and selling, for establishing quality control programs, and for determining loan values.

The U.S. grade standards and inspection instructions for all fresh and processed fruits, vegetables, and specialty crops are available on the internet and upon request at the address below. These documents provide detailed interpretations of the grade standards and provide step-by-step procedures for grading the product.

Grade standards are issued by the U.S. Department of Agriculture (USDA) after careful consideration of all data and views submitted during rulemaking. The Department welcomes suggestions for improving the standards in future revisions. Comments may be submitted to, and copies of standards and inspection instructions obtained from:

Director, Specialty Crops Inspection Division
Specialty Crops Program,
USDA, Agricultural Marketing Service
1400 Independence Avenue, SW, STOP 0240
Washington, D.C. 20250

Authority: 7 U.S.C. 1621-1627.

Note: Compliance with the provisions of these standards shall not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act, or with applicable State laws and regulations.

United States Standards for Inspection by Variables

Purpose, Options, Requirements

§52.201 Purpose.

The purpose of these standards is to:

(a) Designate and define symbols and terminology associated with statistical quality control;

(b) Prescribe a procedure for collecting and recording data that is adaptable to use for statistical quality control; and

(c) Provide a statistical procedure for determining compliance of a variable, which may be any measurable product characteristic, with a specified requirement.

§52.202 Options.

These standards provide for three operations, any of which may be applied to determine compliance of a variable. These options are based on procedures employing the use of:

(a) Conventional averages;

(b) The median; or

(c) Moving averages.

§52.203 Requirements for application.

These standards are written in general terms to be applied to any variable. Therefore, in order to use these standards it will be necessary to predetermine:

(a) The sampling allowance code;

(b) The sampling frequency;

(c) The values for:

(1) Specified averages;

(2) Warning limits;

(3) Reject limits; and

(4) Maximum range, when requested.

Definitions
§52.204 Definitions.

Statistical and inspection symbols and terms and their respective definitions which are pertinent to the understanding and application of these standards follow.

(a) Symbols defined.

LRL—The lower reject limit for individual measurements. The lowest value an individual measurement may have without causing the production to be rejected for failure to meet prescribed requirements for individual measurements.

LRL$\overline{x}$—The lower reject limit for subgroup averages or medians. The lowest value the average or median of a subgroup may have without causing the production to be rejected for failure to meet prescribed requirements for subgroup averages.

LWL—The lower warning limit for individual measurements. This value serves as a warning point that the production may have reached a level where the chances of subsequently finding an individual measurement that will fall below the LRL have increased to a degree that the production may be in danger of rejection.

LWL$\overline{x}$—The lower warning limit for subgroup averages or medians. This value serves as a warning point that the quality of the production may have reached a level where the chances of subsequently finding a subgroup average or median that will fall below the LRL$\overline{x}$ have increased to a degree that the production may be in danger of rejection.

m—The number of subgroups in a sample.

Mi—The median of all the individual measurements in a subgroup.

$\overline{\overline{M}}$i—The median of all the individual measurements or subgroup medians (Mi) in a sample.

n—The total number of sample units or measurements in a sample. n= (m)(n_s).

n_s—The number of sample units or measurements in a subgroup.

R—A range of measurements, the difference between the highest measurement and the lowest measurement within a subgroup.

$\overline{R}$—The average range of all the subgroup ranges.

$\overline{R}$'—A specified average range value.

R_{max}—A specified maximum range for a subgroup.

s—The standard deviation of the individual measurements.

$s_{\bar{x}}$—The standard deviation of the averages.

URL—The upper reject limit for individual measurements. The highest value an individual measurement may have without causing the production to be rejected for failure to meet prescribed requirements for individual measurements.

URL$_{\bar{x}}$—The upper reject limit for subgroup averages or medians. The highest value the average or median of a subgroup may have without causing the production to be rejected for failure to meet prescribed requirements for subgroup averages.

UWL—The upper warning limit for individual measurements. This value serves as a warning point that the quality of the production may have reached a level where the chances of subsequently finding an individual measurement that will exceed the URL have increased to a degree that the production may be in danger of rejection.

UWL$_{\bar{x}}$—The upper warning limit for subgroup averages or medians. This value serves as a warning point that the quality of production may have reached a level where the chances of subsequently finding a subgroup average or median that will exceed the URL$_{\bar{x}}$—have increased to a degree that the production may be in danger of rejection.

X—The value of an individual measurement for a variable.

$\bar{X}$—The average of all individual measurements in a subgroup.

$\bar{X}'_{max}$—A specified maximum lot average value.

$\bar{X}'_{max}$ adjusted—$\bar{X}'_{max}$ plus a sampling allowance.

$\bar{X}'_{min}$—A specified minimum lot average value.

$\bar{X}'_{min}$ adjusted—$\bar{X}'_{min}$ minus a sampling allowance.

$\bar{\bar{X}}$—The arithmetic mean of all the individual measurements in a sample. When the average is calculated for each subgroup in a sample for conventional averages, $\bar{\bar{X}}$ is also the average of the subgroup averages.

(b) Terms defined.

Average.—The arithmetic mean of two or more values; the sum of all measurements divided by the number of measurements.

Median.—The median is the middle value with respect to magnitude of all the individual measurements when the number of individual measurements is odd. When the number of individual measurements is even and arranged according to magnitude, the median is the arithmetic mean of the two middle values.

Moving average.—A scheme under which a series of consecutive measurements are made until such number equals the subgroup size; the average is then determined and recorded; as new data is collected from continuing production, the first measurement of the subgroup is dropped, the next new value is added, and a new average is calculated; this process of adding new measurements, dropping the oldest measurement in the subgroup, and calculating the average on the new data is continued throughout the production.

Example:

$\overline{X}_1 = \frac{5+7+3}{3} = 5.00$

$\overline{X}_2 = \frac{7+3+4}{3} = 4.67$

$\overline{X}_3 = \frac{3+4+6}{3} = 4.33$

Moving range.—The difference between the highest measurement and lowest measurement within a subgroup from which a moving average is obtained.

One-sided specification.—A specification with rejection limits applicable to only one side of the specified lot average. When only lower reject limits apply, the term “low—sided specification” may be used. When only upper reject limits apply, the term “high—sided specification” may be used.

Two- sided specification.—A specification with both upper and lower rejection limits applicable.

Sample.—Any number of sample units to be used for inspection of a lot.

Sample unit.—A container, the entire contents of a container, a portion of the contents of a container, a composite mixture of a product, or any other unit of container or commodity to be used for inspection.

Sampling allowance.—The amount that the sample quality may deviate from the lot quality due solely to the fact that only a portion has been taken from the whole lot.

Subgroup.—Generally a small group of sample units representing a portion of a sample. The term “subgroup” is synonymous with the term “sample” when the sample contains only one subgroup.

Variable.—Any measurable product characteristic.

Records
§52.205 Records.

(a) General. Records required for use in the implementation of these standards consist of a data sheet, referred to as an “ $\overline{X}$ and R data sheet,” on which numerical values are recorded, and/or a control chart on which certain numerical values are recorded in the form of plottings. It is desirable to use both forms. The control chart may be incorporated on the same sheet with the $\overline{X}$ and R data sheet. However, one of these forms may be used in lieu of both as desired at the option of the packer.

(b) $\overline{X}$ and R data sheets. A separate data sheet shall be maintained for each item. When a single item is simultaneously produced on more than one processing line, it is desirable to maintain one data sheet for the item. In such instances, the processing line designation shall be recorded with the corresponding data.

The $\overline{X}$ and R data sheets shall provide for recording the following information:

(1) The time a sample unit or subgroup has been drawn;

(2) The X values;

(3) The total values of all the X values in the subgroups when conventional averages are used;

(4) The values for $\overline{\overline{M}}$, R, $\overline{R}$, Mi, $\overline{X}$, and $\overline{\overline{X}}$

(c) $\overline{X}$ and R control charts. Control charts consist of an $\overline{X}$ chart and may consist of an R chart. When both are used they are contained on the same sheet with the limits for the $\overline{X}$ chart on the top portion and the limits for the R chart on the lower portion with a space separating the two such that plottings from one does not overlap those of the other.

Separate control charts shall be maintained for each item. More than one day's production of an item may be plotted on a single control chart.

(1) $\overline{X}$ charts.

(i) The $\overline{X}$ charts for two-sided specifications shall consist of lines and values properly representing both the upper and lower reject and warning limit(s), and may require the use of minimum and maximum specification lot averages.

(2) R charts. When the R chart is used, it shall consist of lines and values properly representing $\overline{R}$', R_{max}, and the lower limit for R. For subgroup sizes of 6 or less the value of the lower limit for R will always be zero.

Procedure

§52.206 Sampling.

(a) General. In order to obtain the most reliable results, sampling should be performed at a point where no further change in the variable can occur.

Sample units or subgroups shall be drawn separately for each code, container size, and style.

(b) Subgroup Sampling. Sampling by subgroups consists of drawing more than one sample unit at approximately the same time. This type of sampling is required in the use of the conventional $\overline{X}$ and R determinations for variables.

When a single code is processed on more than one line simultaneously, it is desirable to obtain a subgroup representing a single line, alternating the lines each time a subgroup is drawn for that code. If the processing procedure prohibits obtaining a subgroup representing a single line, it shall be necessary to sample by code only, omitting line identity. Each subgroup thus obtained will generally represent more than one line and consequently reflect variations in the code as a whole but not variations for a single line.

(c) Sample unit sampling. This procedure consists of drawing a single sample unit at random at specified intervals from a production. This type of sampling may employ the use of a moving average and is applicable to a variable or a process when subgroup sampling is not feasible.

§52.207 Measurements, calculations, and recording data.

(a) General. Immediately after the sample unit or subgroup has been taken, measurements and calculations shall be made and recorded on the appropriate form as required.

(b) Recording data on the $\overline{X}$ and R data sheet. The data to be recorded on the $\overline{X}$ and R data sheet is as follows:

(1) The time the sample unit or subgroup is taken;

(2) The value for each individual measurement (X value);

(3) The total value for all the X values in the subgroup, when applicable;

(4) The average value ($\overline{X}$) for each subgroup, when applicable;

(5) The Mi value for each subgroup, when applicable;

(6) The range value (R) for each subgroup, when applicable;

(7) The sample median value ($\overline{\overline{M}}$i) when the median is used;

(8) The sample average value ($\overline{\overline{X}}$) when required; and

(9) The average range value ($\overline{R}$) when applicable.

(c) Recording data on the $\overline{X}$ and R control chart. The data to be recorded on the $\overline{X}$ and R control chart is as follows:

(1) Individual measurements (X values). The values representing the individual measurements of each subgroup (X value) shall be plotted on the $\overline{X}$ chart. The distance between the smallest and largest values of the individual measurements in the subgroup may be used for R in lieu of plotting the range on the R chart. It is desirable to plot all the values for a subgroup on the same linear segment of the chart. Identical values are plotted adjacently in such a manner as to associate such values with the subgroup in which they occur.

(2) The median. When the median option is used, the median for each subgroup shall be identified on the $\overline{X}$ chart in such a manner as to make it readily distinguishable from the rest of the values in the subgroup. When a subgroup consists of an even number of individual measurements, the median represented by the arithmetic mean of the two middle values shall also be plotted on the $\overline{X}$ chart in such a manner as to associate it with the subgroup from which it was calculated.

When the median option is used for a particular production, it is not permissible to change to the option for conventional averages during the same shift.

(3) Subgroup averages ($\overline{X}$ values). When the option for conventional averages is used, the average of each subgroup is calculated and recorded on the $\overline{X}$ and R data sheet. The subgroup average is then plotted on the $\overline{X}$ chart in such a manner as to associate it with the subgroup from which it was calculated. When this option is used, it is not permissible to change to the median option during the same shift.

(4) The range (R value). The range of each subgroup, when required, shall be plotted on the R chart.

(5) The average median ($\overline{\overline{M}}$i value) and sample average ($\overline{\overline{X}}$ value). When the plotted values obviously indicate the acceptability of the lot, $\overline{\overline{M}}$i or $\overline{\overline{X}}$ need not be obtained. When the plotted values for Mi or $\overline{\overline{X}}$ or both indicate the acceptability of a lot may be questionable, $\overline{\overline{M}}$i in the case of the median option, or $\overline{\overline{X}}$ in the case of the option for conventional averages must be obtained and recorded. Acceptability of the lot with respect to the sample median or sample average may then be determined in accordance with acceptance criteria as prescribed under § 52.209(a) of these standards.

§52.208 Application of sampling allowance.

The amount of sampling allowance is obtained from the sampling allowance chart in these standards. The actual value for the sampling allowance is obtained from the point of intersection of a horizontal line drawn from a point on the vertical axis representing the sample size to the diagonal line for the item involved. The value on the horizontal axis corresponding to the vertical line nearest to this point of intersection is the sampling allowance.

The sampling allowances are applied to the specified lot averages to allow for deviations from these averages that are inherent in any sampling procedure. These allowances are applied to the specified lot averages only when the sample average ($\overline{\overline{X}}$ or $\overline{\overline{M}}i$) is less than $\overline{X}'_{min}$ or greater than $\overline{X}'_{max}$. When this occurs; the specification average is adjusted by subtracting the allowance from $\overline{X}'_{min}$ or adding to $\overline{X}'_{max}$ whichever is applicable.

§52.209 Acceptance and rejection criteria.

(a) Conventional averages and the median.

(1) Acceptance. A lot shall be accepted as meeting specified requirements for a variable provided that:

(i) All X values are equal to or greater than LRL and equal to or less than URL;

(ii) All Mi or $\overline{X}$ values are equal to or greater than LRL$\overline{x}$ and equal to or less than URL$\overline{x}$;

(iii) $\overline{\overline{M}}i$ or $\overline{\overline{X}}$ is equal to or less than $\overline{X}'_{max}$ adjusted and equal to or greater than $\overline{X}'_{min}$ adjusted; and

(iv) The condition under paragraph (a) (2) (ii) of this section does not exist.

(2) Rejection. A lot shall be rejected for failure to meet specified requirements for a variable under the following conditions:

(i) Failure to meet any of the requirements under paragraph (a) (1), (i), (ii), or (iii) of this section; or

(ii) All Mi or $\overline{X}$ values are less than $\overline{X}'_{min}$ or greater than $\overline{X}'_{max}$.

(b) Moving averages.

(1) Acceptance. A lot shall be accepted as meeting specified requirements for a variable provided that:

(i) All X values are equal to or greater than LRL and equal to or less than URL;

(ii) All $\overline{X}$ values are equal to or greater than LRL$\overline{x}$ and equal to or less than URL$\overline{x}$;

(iii) $\overline{\overline{X}}$ is equal to or less than $\overline{X}'_{max}$ adjusted and equal to or greater than $\overline{X}'$ adjusted; and

(iv) The condition under paragraph (b) (2) (ii) of this section does not exist.

(2) Rejection. A lot shall be rejected for failure to meet specified requirements for a variable under the following conditions:

(i) Failure to meet any of the conditions under paragraph (b) (1) (i), (ii), and (iii) of this section; or

(ii) All $\overline{X}$ values are less than $\overline{X}'_{min}$ or greater than $\overline{X}'_{max}$.

Sampling Allowance Chart
§52.210 Sampling allowance chart