Improving Weighing Practices for Lab Scales

ISSUE:

FGIS is seeking input, from the Grain Inspection Advisory Committee, regarding its (FGIS) policy on the precision of laboratory scales and possible need to harmonize with the National Institute of Standards and Technology (NIST) weighing standards.

BACKGROUND:

FGIS currently has the authority to provide for the testing of all equipment used in the sampling, grading, inspection, and weighing for official inspection. FGIS also may establish performance criteria for commercial grain instruments.

FGIS regulations at Part § 801 and § 802 set forth official performance and procedural requirements for grain weighing equipment including scales and test weights used to checktest and calibrate scales. These regulations do not currently align with current NIST metrology standards. These regulations reference older versions of the NIST Handbook 44 and Handbook 105-1 that are out of date and no longer recommended by NIST. In addition, FGIS' Weighing and Equipment Handbooks conflict with FGIS regulations because they provide guidance that is contrary to current and past NIST standards. Lack of clarity in the FGIS regulations and handbooks has resulted in different checktest procedures being used within FGIS and Official Agencies.

The current FGIS Equipment handbook states that for a scale to be used in the FGIS official system, it must be marked or classified to specify the required performance of the scale, have a certificate of conformance from the National Institute of Standards and Technology (NIST) National Type Evaluation Program (NTEP), and then receive approval by FGIS. NTEP uses NIST Handbook 44 and National Conference of Weights and Measures (NCWM) Publication 14 as the standards for providing a scale a classification and certificate of conformance.

The scale manufacturer marks the scale with the precision for which it is intended to be used. This is labeled 'e'. Upon request by the manufacturer, this is the value that NIST/NTEP tests the scale's accuracy and repeatability for multiple weighings of the same object. Based on NIST/NTEP's testing, a certificate of conformance is issued for use of the scale. The 'e' value is also the value to which the scale is to be calibrated using certified American Society for Testing and Materials (ASTM) weights during initial installation and then tested for accuracy on a routine basis.

The following are examples of how the 'e' value impacts measurement precision. Suppose we have a scale with a designed precision where the e-value is 0.1g and it has been NTEP-certified at that precision level. Suppose we also have a 50g test weight. This means that this test weight could be displayed by this scale with measurement variations anywhere between 49.9g and 50.1g and still be within the limits of NTEP certification. If we have a designed precision of a scale with an e-value of 0.01g and the same test weight as above, this test weight displayed by this scale could vary anywhere between 49.99g and 50.01g, and still be within the limits of NTEP certification.

Once a scale is in the field, it is regularly checktested with known weights to ensure it is still accurate at the designed precision. Manufacturers design scales with an additional digit on the scale display to simplify checktesting. This digit is clearly marked to be a different style from the rest of the displayed

digits, and it informs the viewer that no rounding occurred when presenting the results. NIST does not allow this additional digit to be used in commercial transactions. FGIS' Weighing Handbook allows FGIS to use lab scales with an e-value of 0.1g with an extra digit displaying to the hundredth (0.01g). FGIS uses this extra digit to determine grades and issue certificates, which is contrary to NIST standards. These grades are also used to assess inspector's grading performance.

Impacts to Grading

FGIS' lab scales with an e-value of 0.1g are used by licensed graders to inspect small portions and separations of grain, commodities, and rice, usually weighing between 0.01 grams and 2,000 grams (for example, a kernel of a small grain like wheat weighs approximately 0.03 grams). Now consider we have collected (through normal FGIS procedures) a wheat sample that needs to be inspected for heat damage and we have verified that the true weight of that sample is 60.00g.

Next, FGIS performs an inspection and identifies a 0.1g portion of the sample above (called a separation) that is classified as heat damage. When that separation is weighed, the scale could display anywhere between 0.0g and 0.2g. Therefore, the final proportion could be anywhere between 0.0g/60.0g = 0.0% and 0.2g/60.0g = 0.3%. This is significant because the limit for heat damage in U.S. No.1 grade wheat is 0.2%. This scale could cause the grader to classify that wheat lot as either U.S. No.1 (0% - 0.2%) or U.S. No. 3 (0.2% - 0.5%) and still be operating within the limits for which it was NTEP-certified.

If we had measured the same wheat sample on an NTEP-certified scale with an e-value of 0.01g, then that 0.1g portion separation could vary anywhere between 0.09g and 0.11g within the limits of the scale. This then corresponds to a proportion range of 0.09g/60.00g = 0.15% and 0.11g/60.00g = 0.18%. In this case, the final proportion is definitively U.S. No.1 wheat because both extremes are under 0.2%.

Table 1, below, shows the upper and lower limits of what a scale could display when checktested, according to NIST procedures, with work portions and separations that are representative of actual work product. When using a scale with an e-value of 0.1g, the difference between the upper and lower limits is much greater than using a scale with an e-value of 0.01g. The difference in percent error becomes more significant the smaller the work portion and the smaller the size of the separation. For example, a 15g work portion with a 0.1g separation on a scale with an 'e' value of 0.1g, can have a final proportion difference of up to 1.3%, while only a 0.13% difference on a scale with an 'e' value of 0.01g. When inspecting large grains like corn and soybeans, using a less precise scale (e.g., 0.1g) will probably not be an issue because the work portions are large, and the grade limits are also wide enough that even small separations (e.g., 0.1g) would be unlikely to push the grain to another grade. However, when we are working with portions of 50g or less and separations under 1g using a less precise scale, this is likely to have a large effect. The results below show the importance of using a precision scale ('e' value of 0.01g or less) when measuring small weights, which is very common in FGIS when dealing with portion separations.

TABLE 1: Upper and Lower Limit Scale Displays (Checktested with NIST Procedures)

		Scale e-value = 0.1g					Scale e-value = 0.01g				
Work Portion (g)	**True Separation (g)**	**Min Sep (g)**	**Max Sep (g)**	**Min Prop (%)**	**Max Prop (%)**	**Diff Prop (%)**	**Min Sep (g)**	**Max Sep (g)**	**Min Prop (%)**	**Max Prop (%)**	**Diff Prop (%)**
15	**0.05**	0.00	0.15	0.00	1.00	1.00	0.04	0.06	0.27	0.40	0.13
15	**0.1**	0.00	0.20	0.00	1.33	1.33	0.09	0.11	0.60	0.73	0.13
15	**1**	0.90	1.10	6.00	7.33	1.33	0.99	1.01	6.60	6.73	0.13
60	**0.1**	0.00	0.20	0.00	0.33	0.33	0.09	0.11	0.15	0.18	0.03
60	**0.5**	0.40	0.60	0.67	1.00	0.33	0.49	0.51	0.82	0.85	0.03
60	**1**	0.90	1.10	1.50	1.83	0.33	0.99	1.01	1.65	1.68	0.03
60	**10**	9.90	10.10	16.50	16.83	0.33	9.99	10.01	16.65	16.68	0.03
125	**0.1**	0.00	0.20	0.00	0.16	0.16	0.09	0.11	0.07	0.09	0.02
125	**1**	0.90	1.10	0.72	0.88	0.16	0.99	1.01	0.79	0.81	0.02
125	**10**	9.90	10.10	7.92	8.08	0.16	9.99	10.01	7.99	8.01	0.02

Impacts to Inspector and System Performance

FGIS inspectors are monitored by Quality Assurance Specialists (QAS') who review the separations from samples they had graded. Like official grades, a QAS could mis-grade an inspector's work due to error between the two scales used. This could negatively impact the inspector's performance. In addition, the aggregate error across these measurements creates challenges in establishing statistical confidence in the overall grading performance of the official system.

Checktesting Procedures and Weight Sets

An adequate quality control program requires that lab scales pass biannual checktests using certified weights to ensure accurate weighing results to keep their certification and remain in service. FGIS' current checktest policy requires the use of NIST Class F weights for assessing the accuracy of all laboratory scale types, however these weights lack the precision to checktest grading scales currently in use ('e' value of 0.01g) within FGIS and the Official Agencies. Per NIST Handbook 105-1 (2019 Edition), as of January 1, 2020, NIST has moved to stop using class F weights and instead adopt the industry standard ASTM weights. ASTM Class 4 weights would improve the precision of the testing to match the required precision of the scales. Additionally, checktesting procedures can be updated to only require 4 points instead of 13. This may provide a financial benefit if weights need to be purchased and decrease the time needed to checktest scales.

OPTIONS:

A. FGIS adopts NIST weighing standards to provide a common language and systematic methodology for managing scales and reducing risk. *(The average cost per agency would be under $10,000. Many agencies would not see any costs.)*

Option A would simplify FGIS standards by deferring to NIST and bring the lab weights and scales into compliance with NIST, state agencies, and industry practices. Current customers performing commercial transactions already have this correct equipment in their own labs to follow NIST/NTEP standards and comply with their state weights and measures bodies. Deferring to NIST would reduce the need to reestablish a Weighing Group within FGIS and promote a uniform and technically sound system of weights and measures. The new checktest procedure would be quicker and require fewer weights. Many of the scales in use today already meet the proposed standard because some markets require this precision even if FGIS doesn't. Additionally, since the current checktest standards are not well matched to how FGIS scales are used, there are scales that are failing checktests, and thus cannot be used. These scales would be able to be used under the new standard. This update would also prevent Official Service Providers (OSPs) from being written up for non-compliance when following the more stringent guidelines of their state agencies instead of the substandard FGIS guidelines.

This option would involve the following:

1. Update regulations 800.801 and 800.802 to align with current NIST standards for weighing.
2. Ensure current FGIS scale approval procedures are updated.
    a. Update NCWM Publication 14.
    b. Approve new scale models for the application(s) in which they will be used per table below.

FGIS Classification	Range	e value / Reporting value
Precision	Less than or equal to 120g	0.01g
Intermediate	120g < x ≤ 500g	0.1g
General	Above 500g	1g

    c. Update procedures in the Weighing, Equipment, and Inspection Handbooks to align with current NIST weighing standards.
    d. Provide training to FGIS and Official Agency personnel who use scales in an official capacity to gain an understanding of application types and what type of scale can be used for each application.

3. Update and simplify checktest procedures to ensure checktest results are accurate at the precision in which the scale is classified per the table below.

E value / Reporting value	Range
0.01g	Less than or equal to 120g
0.1g	120g < x ≤ 500g
1g	Above 500g

a. Require that FGIS and State Agencies replace Class F weight sets with ASTM Class 4 (or better) weights to provide a more accurate assessment of scales at different levels of precision.
b. Update checktest procedures in FGIS Weighing and Equipment to include the use of only four test weights instead of 13.
c. Add "meet or exceed" language on checktest requirements to address facilities that have higher precision devices. Without this, many facilities will be out of compliance for following state and NIST guidelines which exceed FGIS requirements.
d. Update forms related to checktest procedure to align with new standards.
e. Update FGIS' Equipment Capability Testing (ECT) application to accept the appropriate checktest results.
f. Provide training to FGIS and Official Agency personnel on new check test criteria.

4. Establish implementation date to allow official agencies to purchase new scales and weight sets.
    a. Allow a 3 to 5-year transition window so cost can be spread out and scales can be replaced when they normally would be.
    b. Require that starting from day 1 of implementation, new scales and weights must meet the new standard.
    c. Grandfather existing equipment for 3 to 5 years.

5. Identify position in FGIS that would liaison with NIST to keep abreast of updates to NIST weighing standards.

6. Develop communication plan to effectively communicate the impact to official service providers and other stakeholders.

B. Continue with FGIS current standard for lab scales but update our checktest requirements. *(Estimated cost is $700 per official agency.)*

Option B would provide for precise weights to be used for checktesting scales by NIST standards and would simplify the checktest procedure. However, FGIS' current use of the scales would still not meet NIST standards and could call into question the validity of how FGIS uses it scales because they will continue to be used beyond their design and testing specifications.

1. Update and simplify checktest procedures to ensure checktest results are accurate at the precision in which the scale is classified.
    a. Require that FGIS and State Agencies replace Class F weight sets with ASTM Class 4 (or better) weights to provide a more accurate assessment of scales at different levels of precision.
    b. Update checktest procedures in FGIS Weighing and Equipment Handbooks to include the use of only four test weights instead of 13.
    c. Add "meet or exceed" language on checktest requirements to address facilities that have higher precision devices. Without this, many facilities will be out of compliance for following state and NIST guidelines which exceed FGIS requirements.
    d. Update checktest forms to align with new standards.
    e. Update ECT to accept the appropriate check-test results.
    f. Provide training to FGIS and Official Agency personnel on new check test criteria.

2. Update Regulations to **not** follow NIST standards.
3. Consider reestablishing the FGIS Weighing Group to address questions and discrepancies regarding FGIS weighing policy and to keep abreast of updates to NIST weighing standards.
4. Develop communication plan to effectively communicate the impact to official service providers and other stakeholders.
5. Establish implementation date to allow official agencies to purchase weight sets.
    a. 1 to 3-year transition window.
    b. Starting from day 1 of implementation, new weights must meet the new standard.
6. Ensure FGIS is compliant with the new weight standard.

C. Status quo *(No additional cost to industry.)*

Option C is keeping the current system, but it is not a zero-effort option. To keep our current directives and regulations aligned, the regulations will need to be updated to not follow NIST standards. The regulation update, combined with the difficulty of justifying the use of substandard (class F) weights, would best be addressed by reestablishing the FGIS Weighing Group to clarify the existing handbooks and address questions from industry and OSPs. However, FGIS' current use of the scales would still not meet NIST standards and could call into question the validity of how FGIS uses it scales because they will continue to be used beyond their design and testing specifications.

This option would involve the following:

1. Update Regulations to **not** follow NIST standards.
2. Update Handbooks to clarify checktest procedure – proper adoption will reduce the tested precision of some scales.
3. Consider reestablishing the FGIS Weighing Group to address questions and discrepancies regarding FGIS weighing policy.
4. Recommend allowing checktests and scale requirements to include an "or better" option. Without this, many facilities will be out of compliance for following state and NIST guidelines which exceed FGIS requirements.

Perspective: FGIS believes **Option A** could best position the industry for achieving greater accuracy.