EPO No. 16

Appendix B (Supplement 1)

Applying the High-Level Steps of the Substitution and Alternative Substitution Test Method

This supplement to Appendix B provides detailed instructions on how to apply each of the high level steps necessary to perform a proper increasing-load test on a scale with digital indication using the substitution or alternative substitution test method. The procedures contained in this supplement are intended to be applied in the order that they appear.

Establishing a proper reference at no-load (high-level step 1)

a. At no load, apply error weights to the load-receiving element in increments equal to 0.1 d until the displayed indication just begins to flicker to the next higher increment. If the displayed indication is already flickering before adding any error weights, it will be necessary to add enough error weights in increments equal to 0.1 d to go beyond the existing zone of uncertainty to a point just above the lower edge of the next higher one.
b. Remove an error weight equal to 0.1 d from the load-receiving element to confirm that the indication returns to a constant display of the lower increment. If the indication returns to a constant display of the lower increment when the 0.1 d is removed, add back 0.1 d to cause the indication to once again flicker to the next higher increment. **A proper reference is established when the indication is flickering between two consecutive increments and removal of an error weight equal to 0.1 d from the load-receiving element causes the constant display of the lower increment.** Thus, the proper reference to establish is a point just above the lower edge of the zone of uncertainty between two consecutive scale increments. The illustration on the next page depicts the area within the zone of uncertainty where the proper reference should be established.
c. Once a proper reference at no-load has been established, record the values of the two increments that are flickering and the total value of error weights on the load-receiving element of the scale; then remove the error weights.

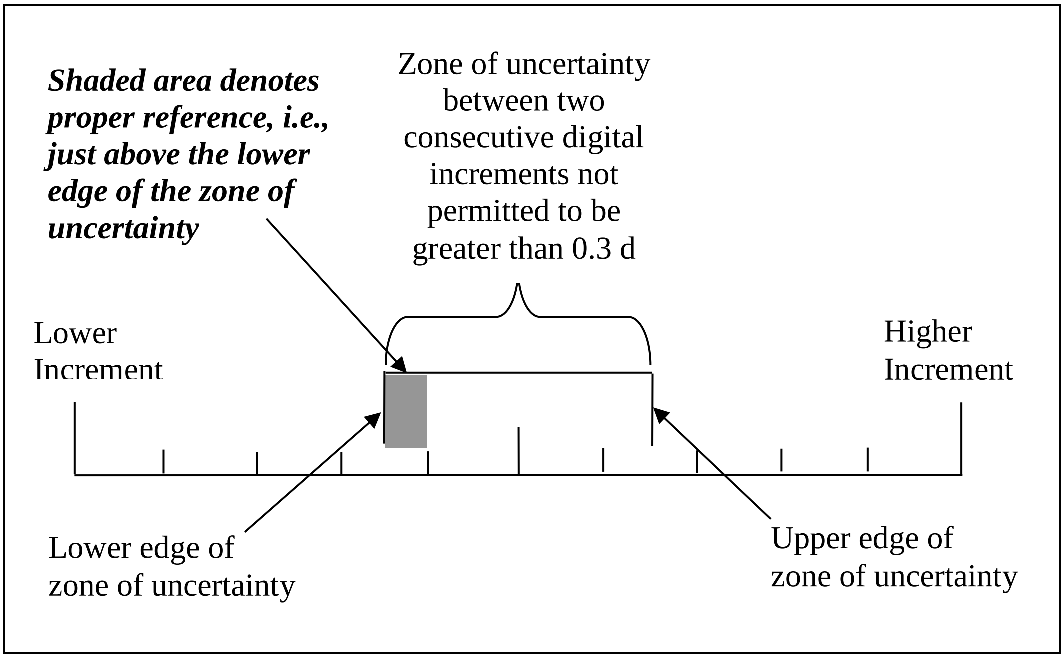

Illustration Depicting Proper Reference

Applying the test weight and establishing proper reference (high-level step 2)

d. Apply the first test load consisting entirely of test weight to the load-receiving element and observe the displayed indication.
e. Add error weights to the load-receiving element in increments equal to 0.1 d to establish a proper reference with the test load applied. For example, if the scale is indicating a constant 3 000 lb after the test weight has been applied, add error weights in increments equal to 0.1 d to establish proper reference at a point just above the lower edge of the zone of uncertainty between 3 000 lb and the next higher increment. Record the total value of the error weights on the scale; then remove the error weights.

Determining the amount of error in the scale at first test load (high-level step 3)

f. Determine the amount of "step" error in the scale at the first test load by inserting the appropriate corresponding values obtained from testing into the following error formula and solving the equation:

$$E_n = I_e - I_s - L + R_s - R_e$$

Where:

"E_n" *(Error)* represents the amount of error in the scale relative to the applied test weight portion of the total applied test load;

"I_e" *(Indication ending)* represents the scale indication after the test weight has been applied and proper reference established;

"I_s" *(Indication start)* represents the scale indication before the test weight was applied;

"L" *(Load)* represents the value of the applied test weight excluding any substituted load;

"R_s" *(Reference start)* represents the value of the error weights on the load-receiving element that established proper reference prior to the test weight being applied; and

"R_e" *(Reference ending)* represents the value of the error weights on the load-receiving element that established proper reference after the test weight had been applied.

Determining appropriate values for "I_e" and "I_s" in the error formula: Because the scale indication flickers between two consecutive increments when proper reference has been established, an average of the two increments should be inserted in the error formula for each of the two components "I_e" and"I_s." For example, if the scale indication at no load is flickering between 10 lb and 20 lb after a proper reference has been established, the average of 10 lb and 20 lb should be determined and inserted in the error formula. The average of 10 and 20 is calculated as follows:

$$\frac{(10+20)}{2}=\frac{30}{2}=15$$

Thus, the value to be applied in the formula for I_s is 15 lb.

If the scale indication, with a 3 000 lb test load applied, is flickering between 3 010 lb and 3 020 lb after a proper reference has been established, the average of 3 010 and 3 020 is calculated as follows:

$$\frac{(3\,010+3\,020)}{2}=\frac{6\,030}{2}=3\,015$$

Thus, the value to be applied in the formula for "I_e" should be 3 015 lb.

Applying the Error Formula:
The following example test results, which include references to the different variables in the error formula, are provided to show how error is to be calculated from results of having applied an initial test weight load of 3000 lb to an ABWS equipped with a scale division value equal to 10 lb:

Scale indication at start of the test with no load applied: 10 lb (this value is not used in the error formula but represents the no-load indication of the scale at the start of the test)

Amount of error weight added at no load to achieve proper reference: 6 lb (R_s)

Scale indication at no load and proper reference established: 10 lb flickering 20 lb (I_s = 15 lb and is determined by averaging the two alternating values as explained above in "Determining appropriate values for "I_e" and "I_s" in the error formula")

Amount of test weight applied: 3 000 lb (L)

Scale indication with test load applied: 3 010 lb (this value also is not used in the formula and represents the scale indication after the test weight has first been applied)

Amount of error weight added with test weight applied to achieve proper reference: 9 lb (R_e)

Scale indication with first test load applied and proper reference established: 3 010 lb flickering 3 020 lb (I_e = 3 015 lb and is also determined by averaging the two alternating values as explained above in "Determining appropriate values for "I_e" and "I_s" in the error formula")

To determine the amount of error in the scale at the first test weight load insert the appropriate values from the example steps above into their proper position in the formula and solve as follows:

Error formula: $E_n = I_e – I_s – L + R_s – R_e$

Corresponding values inserted from the example steps:

$$E_n = 3\,015 – 15 \text{ lb} – 3\,000 \text{ lb} + 6 \text{ lb} – 9 \text{ lb}$$

Solve equation to determine amount and direction of scale error at the first test weight load:

$$E_n = - 3 \text{ lb}$$

Note: The first two tables included in Appendix B (Supplements 2 and 3) provide indication of how an official might record each of these steps.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Verifying return to no-load reference (high-level step 4)

g. Remove the first test load and add error weights on the load-receiving element to reach the no-load reference between the same two consecutive increments made note of in step b. Then subtract the total value of error weights needed to reach the no-load reference from the total value required to establish the initial no-load reference (i.e., the amount made note of in step b.). The result provides the direction and the amount of change in the return to no-load condition. If the amount of change exceeds applicable tolerance, testing should not proceed until the cause of the change has been determined and corrected.

   If no change has occurred or the amount of change does not exceed applicable tolerance, testing may continue. However, in the latter case it will be necessary to make note of the value of the error weights needed to re-establish proper no-load reference. If no change has occurred, the value of the error weights made note of in step b. establishes the no-load reference. Once you've recorded the total value of the error weights that establishes the no-load reference, remove the error weights from the scale.

Creating the first substitution test load (high-level step 5)

h.

Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in an amount to cause the indicator to display as nearly as possible, but not to exceed, the value that was displayed after the first test load was applied in step d.

At a location on the load-receiving element separate from the error weights, apply trim weights as needed, and in whatever amount necessary, to increase the displayed indication to that which was first indicated when the test weight was applied in step d. Then add error weights to the load-receiving element in increments equal to 0.1 d to establish proper reference between the same two increments as was established in step e. (i.e., the indication flickering between the same two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established between the same two consecutive increments, it can be assumed that the weight of the applied load (i.e., the first substitution test load) is the same as that of the field standard test weight for which it now substitutes. Thus, it can also be assumed that the error in the scale with either load (i.e., the test weight or first substitution load) applied is also the same.

Record the total value of the error weights on the scale; then remove them.

Alternative Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element

in the amount necessary to cause the scale to indicate a value that is within five scale divisions of the value that was displayed after the first test load was applied in step d. **To qualify as a substitution test load, the weight of the bulk material must provide a displayed indication that is slightly less, but in no case more than five divisions less, than the indicated weight of the test load for which it is intended to substitute (i.e., the value indicated in step d.).**

Note: Depending upon how close an operator is able to stop the flow of material onto the load-receiving element relative to the weight targeted (i.e., the value indicated in step d), it may be necessary to add trim weights to increase the weight of the bulk material so that its displayed indication is within five divisions of the target weight.

Add error weights in increments equal to 0.1 d to establish a proper reference (i.e., the indication flickering between two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established, record the values of the two increments that are flickering, as well as the total value of the error weights on the scale; then remove the error weights.

Applying the test weight to the first substitution test load, establishing proper reference, and determining scale error (high-level steps 6 and 7)

i. Reapply the test weight to the load-receiving element of the scale and observe the displayed indication.
j. With the test weight and first substitution test load now applied, add error weights in increments equal to 0.1 d to re-establish a proper reference.
k. Determine the amount of error in the scale with the test weight and first substitution test load applied by inserting the appropriate corresponding values obtained from testing into the following error formula and solving the equation:

$$E_n = I_e - I_s - L + R_s - R_e$$

Note: As per the instructions in step f., an average of the two increments that are flickering should be inserted in the error formula for each of the two components "I_e" and"I_s."

Once the total amount of error has been determined, remove from the load-receiving element the test weight portion of the test load, all error weights, and any trim weights that were previously added.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Creating the second substitution test load (high-level step 8)

l.

Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in an amount to cause the indicator to display as nearly as possible, but not to exceed, the value that was displayed after the test weight was applied in step i.

At a location on the load-receiving element separate from the error weights, apply trim weights as needed, and in whatever amount necessary, to increase the displayed indication to that which was first indicated when the test weight was applied in step i. Then add error weights to the load-receiving element in increments equal to 0.1 d to establish proper reference between the same two increments as was established in step j. (i.e., the indication flickering between the same two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established between the same two consecutive increments, it can be assumed that the weight of the applied load (i.e., the second substitution test load) is the same as that of the combination of test weight and first substitution test load for which it now substitutes. Thus, it can also be assumed that the error in the scale with either test load (i.e., the second substitution test load or the combination of the first substitution test load and test weight) applied is also the same.

Record the total value of the error weights on the scale; then remove them.

Alternative Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in the amount necessary to cause the scale to indicate a value that is within five scale divisions of the value that was displayed after the first test load was applied in step i. **To qualify as a substitution test load, the weight of the bulk material must provide a displayed indication that is slightly less, but in no case more than five divisions less, than the indicated weight of the test load for which it is intended to substitute (i.e., the value indicated in step i.).**

Note: Depending upon how close an operator is able to stop the flow of material onto the load-receiving element relative to the weight targeted (i.e., the value indicated in step i), it may be necessary to add trim weights to increase the weight of the bulk material so that its displayed indication is within five divisions of the target weight.

Add error weights in increments equal to 0.1 d to establish a proper reference (i.e., the indication flickering between two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established, record the values of the two increments that are flickering, as well as the total value of the error weights on the scale; then remove the error weights.

Applying the test weight to the second substitution test load, establishing proper reference, and determining scale error (high-level steps 9 and 10)

n. Reapply the test weight to the load-receiving element of the scale and observe the displayed indication.
o. With the test weight and second substitution test load now applied, add error weights in increments equal to 0.1 d to re-establish a proper reference.
p. Determine the amount of error in the scale with the test weight and second substitution test load applied by inserting the appropriate corresponding values obtained from testing into the same error formula provided in the previous steps and solving the equation.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Once the amount of error has been determined, remove from the load-receiving element the test weight portion of the test load, all error weights, and any trim weights that were previously added.

Creating the third substitution test load (high-level step 11)

q. Apply the same procedures that were used to create the second substitution test load to create the third substitution test load except that the weight to be targeted for substitution is that which was first indicated when the test weight was applied in step n.

Applying the test weight to the third substitution test load, establishing proper reference, and determining scale error (high-level steps 12 and 13)

r. Repeat steps n. through step p. replacing the term "second substitution test load" with the term "third substitution test load" to complete the third substitution test and determine the amount of error in the scale using the error formula.

Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional test loads are still needed to make possible a test to at least used capacity, it will be necessary to use a strain load to increase the loading of the scale to the appropriate area where additional testing is needed. Once the strain load has been created and proper reference established for the load, up to three substitution test loads can be created from that strain load using the same procedures outlined in this appendix.

Alternative Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional

test loads are still needed to make possible a test to at least used capacity, continue applying these same procedures, using as many additional substitution test loads as are needed, to complete the test.