

NTEP Technical Policy and Test Procedure Additions to 2021 Edition of Publication 14 Digital Electronic Scales:

Amend NCWM Publication 14 Weighing DES Technical policy Section 8 to add for Single Draft Weigh-in-Motion Scales

Page DES-10 Rename 8.4 to Weigh-in-Motion Vehicle Scales (WIM) and renumber the remaining sub sections

Add the following

8.4 Weigh-in-Motion Vehicle Scales (WIM)

A CC will apply to all models that comply with the following criteria based on the device tested:

- a. Minimum Data Acquisition Time (DAT). Higher values may be applied to individual scales of the type.
- b. Minimum Vehicle Speed. Higher values may be applied to individual scales of the type. A minimum speed greater than zero is required for an in-motion weighment.
- c. Maximum Vehicle Speed. Lower values may be applied to individual scales of the type.
- d. Maximum Speed Changes. Lower values may be applied to individual scales of the type.
- e. Foundation Type. For a weighing/load receiving element that can be installed “at grade” or “above grade” (colloquially referred to as a “pit installation” or an “above ground installation”), without modification to the elements design, the CC will list any limitation related to installation type as follows:
 - If a single WLRE design can be installed in either installation type, NTEP has the option to test both installation types or determine a “worst-case condition”, testing only that installation type with no restriction listed on the CC.
 - If a single WLRE design can be installed in either installation type, and both installation types cannot be tested; in the event that the worst-case installation is not tested, only the tested installation type will be listed on the CC as valid.
- f. Matching approach configuration of the tested device. If the approach configuration varies from the requirements in Handbook 44 (e.g., an amount greater than 10 feet in-plane or an amount greater than ½ the scale length straight, etc.), this is considered a limitation and the variation will be listed as a restriction on the CC.
- g. Vehicle direction of travel. If only designed to be used in one direction of travel or if only a single direction is evaluated during the NTEP testing, this is considered a limitation and will be listed as a restriction on the CC.
- h. Description of method required to ensure the vehicle’s path of travel stays within the lateral side edges of the load-receiving element. The need for physical barriers (e.g., curbs, guardrails, bollards, etc.) along the lateral side edges of the load-receiving element must be listed on the CC. If other methods besides physical barriers have been tested to ensure the vehicle’s path of travel stays within the lateral side edges of the load-receiving element, a description of the device type allowed (e.g., photo eye, pressure sensor, inductive loop, etc.) for this purpose must also be included. If an additional device description is not included, physical barriers must be used.
- i. Restriction on the US Federal Highway Administration vehicle class to only the vehicle classes tested if testing on the three required vehicle classes cannot be fulfilled.

Amend NCWM Publication 14 Weighing DES Checklist and Test Procedures Section 5 add 5.6 after 5.5. page DES-26

Code Reference: S.6.3.b. Notes for Table S.6.3.a. Marking Requirements

5.6 Weigh-In-Motion Vehicle Scales have the following additional marking requirements.

- 5.6.1. Weigh-In-Motion Vehicle Scales shall be marked with the minimum and maximum vehicle speed limitations for the scale as declared by the manufacturer and verified by the NTEP evaluator. Yes No N/A
- 5.6.2. Weigh-In-Motion Vehicle Scales shall be marked with the maximum speed change allowed during the weighment for the scale as declared by the manufacturer and verified by the NTEP evaluator. Yes No N/A
- 5.6.3. Unidirectional Weigh-In-Motion Vehicle Scales shall be marked with the vehicle direction limitation for the scale. Yes No N/A

Amend NCWM Publication 14 Weighing DES Checklist and Test Procedures Section 13 add 13.9 after 13.8. page DES-44

Code Reference: S.1.14.2 Information to be Recorded

13.9. Weigh-in-Motion Vehicle Scales have the following additional recording requirements.

- 13.9.1. If the installation site has more than one weigh-in-motion vehicle scale lane, the recorded representation must include a scale identification. The manufacturer must show the recorded representation after a weighment with the scale lane identification. Yes No N/A
- 13.9.2. If the weigh-in-motion vehicle scale is bi-directional, the recorded representation must clearly identify the vehicle direction of travel. The manufacturer must show the recorded representation after a weighment with the vehicle direction of travel. Yes No N/A

Amend NCWM Publication 14 Weighing DES Checklist and Test Procedures rename section 69 page DES 111 and renumber all remaining sub sections

69. Additional Tests for Weigh-in Motion Vehicle Scale

Code Reference: N.7. Weigh-in-Motion Vehicle Scale, S.1.14.1. Identification of a Fault

69.1 Static Performance and Permanence Test

The scale must comply with all static performance and permanence testing. If the model provided by the manufacturer already has an active CC for compliance with the above requirements, then

this evaluation does not need to be repeated. For new models, not having an active CC, the dynamic testing may be completed prior to the permanence test.

69.2 Dynamic Performance Test

- Verify the DUT provides accurate weighments in normal use conditions with multiple truck types and loading conditions over the specified speed range, AND
- Verify minimum DAT, maximum vehicle speed, and minimum vehicle speed parameters provided by the manufacturer.

69.2.1. Reference Scale

Using the criteria from NIST Handbook 44, section N.7.1, establish a Reference Scale that will be used to create test objects to use during testing. The Reference Scale shall be verified prior to the start of the dynamic performance tests.

69.2.2. Reference Vehicles

Select the Reference Vehicles that will be established as test objects. The criteria for choosing the Reference Vehicles include:

1. At least three (3) different vehicle types representing US Federal Highway Administration Class 9 (typical semi-tractor trailer), Class 6 (typical dump truck) and Class 5 (typical box truck) are required. Multiple vehicles representing the same truck class may be used to avoid having to load/unload vehicles during the test. A heavy-duty test truck normally used for vehicle scale testing may be used for its corresponding class.
2. Each of the three (3) different vehicle types must be loaded to three (3) different load conditions:
 - an empty load condition,
 - a fully loaded condition (>90% of the scale capacity or >90% of the maximum capacity of the vehicle, whichever is less), and
 - a half loaded condition approximately between the empty and fully loaded condition.
3. Ensure each vehicle can be weighed in a single draft on the scale.

69.2.3. Reference Vehicles Weights

The Reference Vehicles (including driver and load) must be weighed statically on the Reference Scale immediately before and after completing the dynamic tests. The Reference Scale division may be smaller than the Weigh-In-Motion Vehicle Scale under test. The initial Reference Vehicle weights must be adjusted using error weights to a whole scale division of the Weigh-In-Motion Vehicle Scale or the WIM dynamic tests must be done in an expanded mode to minimize rounding errors. If the Reference Vehicle weight changes during the test (e.g., driver change, refueling, etc.), the Reference Vehicle must be reweighed. Weather conditions that affect the Reference Vehicle's weight may require testing to be delayed.

69.2.4. Measuring Vehicle Speed

When conducting the dynamic tests, the average vehicle speed may be determined by one or more of the following methods.

1. Determine vehicle speed based on distance traveled during a time period.
 - a. Measure the scale length using a traceable measurement.
 - b. As the vehicle drives across the scale, a timer is started to measure the time required for the first axle to cross the scale length. The time should start when the first axle enters the scale and stop when the first axle leaves the scale.
 - c. The timer may be a manual traceable stopwatch, or another traceable timer started and stopped by timing triggers. The timing triggers may be light curtains, pressure sensors, inductive loops, or other mechanisms that can start and stop a timer. The timing triggers are supplied by the applicant. It may be helpful to record a video to more accurately determine the timing from the video.
 - d. Divide the scale length (e.g., feet) by time (e.g., seconds) to determine the average speed. Use dimensional analysis to convert the speed into the appropriate speed units.
2. Determine vehicle speed based on tire RPM and tire circumference.
 - a. Measure the circumference of one of the vehicle's tires using a traceable measurement.
 - b. As the vehicle drives across the scale, use a traceable tachometer to measure the RPM of the tire. The tachometer is supplied by the applicant. If a tachometer is not available, place a mark on the tire and use a traceable timer to measure how long it takes the tire to make a number of revolutions.
 - c. Divide the tire circumference (e.g., feet) by the average time for one tire revolution (e.g., seconds). Use dimensional analysis to convert the speed into the appropriate speed units.
3. Determine vehicle speed based on GPS signal.
 - a. This method is not traceable and must be validated by either method 1 or 2 above in order to be used.
 - b. A vehicle passenger downloads a free speed app that uses GPS signals on their smart phone. For example, Speedometer by mikrasya.com.
 - c. The passenger starts the app and presses the start record stop/start button to capture the vehicle speed only when the vehicle is on the scale. The passenger must operate the app to maintain site safety. The passenger must be weighed with the vehicle on the reference scale if this method is to be used.
 - d. As the vehicle drives across the scale, the app will display the instantaneous vehicle speed. This will help the driver to maintain a constant speed when the vehicle's speedometer does not register slow speeds.
 - e. A plot of the speed for the recorded run can be used to determine top speed, average speed and speed change. Only use the time period from the plot when the vehicle was actually on the scale.

If the system is capable to display vehicle speed and this capability has been verified during dynamic testing using one of the above methods, then this speed value can be used without further speed measurements.

The expected accuracy error of vehicle speed is +/- 1 mph or less.

69.2.5. Testing Reference Vehicles

Conduct dynamic testing of Reference Vehicles on the Weigh-In-Motion Vehicle Scale.

Weigh each Reference Vehicle and load combination dynamically ten (10) times. If the direction of operation is not restricted by design to one direction, half of the runs are to be conducted from one direction and the other half are to be conducted from the other direction. The average speed of each weighment must be within the speed range and DAT specified by the manufacturer. The driver should vary the speed for each weighment to create weighments at the low, mid, and high end of the speed range. The driver should strive to maintain a constant speed during each weighment to the best of their ability.

The average vehicle speed and DAT must be measured for each of the weighments. Various methods for measuring vehicle speed are provided in the section "69.2.4. Measuring Vehicle Speed". The formula for calculating DAT is provided below.

$$DAT (s) = \frac{(scale\ length\ (ft) - vehicle\ wheelbase\ (ft)) * \frac{1\ mile}{5280\ feet}}{vehicle\ speed\ (mph) * \frac{1\ hour}{3600\ seconds}}$$

It is also possible to measure the DAT by using a traceable timer to measure the amount of time all the vehicle axles are simultaneously on the scale. If the system is capable to display average vehicle speed and DAT for each run, then these values can be used without further measurement provided they are verified.

The maximum speed and minimum DAT capability of the Weigh-In-Motion Vehicle Scale may differ based on the truck type. Not all truck types will be able to travel at the maximum speed and still meet the minimum DAT requirement of the scale.

If a fault condition is triggered during the test, this data shall not be included in the test results for the normal, as used, weighments.

69.2.6. Determine Dynamic Testing Results

At the conclusion of the dynamic testing, there will be a total of at least 90 (=10 runs each x 3 truck types x 3 load conditions) weighments without any fault conditions triggered. Record and compare each of the Reference Vehicle dynamic weighments with the associated Reference Vehicle static weighment. The difference must be within the NIST HB44 Class III L acceptance tolerance limit for the gross weight for all the weighments.

Yes No N/A

The maximum speed, minimum speed and minimum DAT provided by the manufacturer are also verified based on the above results.

Yes No N/A

69.3. Fault Condition Testing

The purpose of fault condition testing is to:

- verify that operation outside the normal operating parameters of the device (i.e., a fault condition) is properly detected by the device,
- verify that no weight value is indicated or recorded when a fault condition is detected,

- verify fault conditions are presented to the consumer and the operator in a clear and unambiguous manner, and
- verify maximum speed change parameter provided by the manufacturer.
- When verifying fault conditions, multiple fault conditions may be triggered simultaneously.

69.3.1. A maximum speed fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure:

Using one of the Reference Vehicles, instruct the driver to exceed the maximum vehicle speed limit specified by the manufacturer as close to the maximum speed limit as the driver can achieve. It is recommended to use the Reference Vehicle with the shortest wheelbase to reduce the possibility of triggering the DAT fault in addition to the maximum vehicle speed fault. The driver should strive to maintain a constant speed to the best of their ability. The vehicle speed must be measured to ensure the vehicle speed slightly exceeded the maximum speed limit specified. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed". If the system is capable to display vehicle speed and this capability has been verified during dynamic testing, then this speed value can be used without further speed measurements.

Alternate test procedure:

This alternate test procedure may be used if the maximum speed limit setting of the system can be adjusted. Instruct the driver to drive the vehicle across the scale at idle speed and record the vehicle speed measured. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed". If the system is capable to display vehicle speed and this capability has been verified during dynamic testing, then this speed value can be used without further speed measurements. Driving at idle speed provides the most consistent and repeatable vehicle speed. Change the system maximum speed limit to slightly below the idle speed value. Instruct the driver to drive the vehicle across the scale at idle speed again. For example:

- a) At idle speed, the vehicle speed is measured as 3 mph.
- b) The maximum speed limit is changed to 2 mph.
- c) The vehicle crosses the scale again at the idle speed (3 mph) and triggers the fault condition because the vehicle speed (3 mph) is now greater than the maximum speed limit (2 mph).

69.3.2. A minimum speed fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure:

Using one of the Reference Vehicles, instruct the driver to drive below the minimum vehicle speed limit specified by the manufacturer as close to the minimum speed limit as the driver can achieve. A Reference Vehicle with an automatic transmission may be best suited for this purpose. The driver should strive to maintain a constant speed to the best of their ability. The vehicle speed must be measured to ensure the vehicle speed was slightly below the minimum speed limit specified. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed". If the system is capable to display vehicle speed and this capability has been verified during dynamic testing, then this speed value can be used without further speed measurements.

Alternate test procedure:

This alternate test procedure may be used if the minimum speed limit setting of the system can be adjusted. Instruct the driver to drive the vehicle across the scale at idle speed and record the vehicle speed measured. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed". If the system is capable to display vehicle speed and this capability has been verified during dynamic testing, then this speed value can be used without further speed measurements. Driving at idle speed provides the most consistent and repeatable vehicle speed. Change the system minimum speed limit to slightly above the idle speed value. Instruct the driver to drive the vehicle across the scale at idle speed again. For example:

- a) At idle speed, the vehicle speed is measured as 3 mph.
- b) The minimum speed limit is changed to 4 mph.
- c) The vehicle crosses the scale again at the idle speed (3 mph) and triggers the fault condition because the vehicle speed (3 mph) is now lower than the minimum speed limit (4 mph).

69.3.3. The vehicle speed change parameter is verified.

Yes No N/A

Recommended test procedure:

Using one of the Reference Vehicles, instruct the driver not to maintain a constant speed while driving the vehicle across the scale. The driver should intentionally vary the vehicle speed within the speed change limit specified by the manufacturer to the best of their ability. Repeat this test at least five (5) times for each of the two test conditions below (10 total runs):

- a) Enter the scale at a fast speed, decrease the vehicle speed while crossing the scale, and exit the scale at a slower speed within the speed change limit. The driver should maintain a constant deceleration to the best of their ability over the length of the scale.
- b) Enter the scale at a slow speed, increase the vehicle speed while crossing the scale, and exit the scale at a faster speed within the speed change limit. The driver should maintain a constant acceleration to the best of their ability over the length of the scale.

The vehicle speed for each run must be measured at the entrance and exit of the scale and compared to determine the speed change was within the limit. Various

methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed", but instead of using the full-scale length, use the first and last portions of the scale length. The Reference Vehicle with the shortest wheelbase may be best suited for this purpose as it will be easiest to measure speed changes. If the system is capable to display vehicle speed change for each run, then these values can be used without further measurement provided they are verified.

Record and compare each of the Reference Vehicle dynamic weighments with the associated Reference Vehicle static weighment. The difference must be within the NIST HB44 Class III L acceptance tolerance limit for the gross weight for all the weighments. The speed changes from these weighments are used to validate the speed change limit of the weigh-in-motion scale.

69.3.4. A vehicle speed change fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure for speed change fault condition:

Using one of the Reference Vehicles, instruct the driver not to maintain a constant speed while driving the vehicle across the scale. The driver should intentionally vary the vehicle speed by more than the speed change limit specified by the manufacturer to the best of their ability. Complete at least one test run for each of the two test conditions below (2 total runs):

- a) Enter the scale at a fast speed, decrease the vehicle speed while crossing the scale, and exit the scale at a slower speed exceeding the speed change limit. The driver should maintain a constant deceleration to the best of their ability over the length of the scale.
- b) Enter the scale at a slow speed, increase the vehicle speed while crossing the scale, and exit the scale at a faster speed exceeding the speed change limit. The driver should maintain a constant acceleration to the best of their ability over the length of the scale.

The vehicle speed for each run must be measured at the entrance and exit of the scale and compared to ensure the speed change limit was exceeded. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed", but instead of using the full-scale length, use the first and last portions of the scale length. The Reference Vehicle with the shortest wheelbase may be best suited for this purpose as it will be easiest to measure speed changes. If the system is capable to display vehicle speed change for each run, then these values can be used without further measurement provided they are verified.

69.3.5. The vehicle direction fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure:

The vehicle direction of travel may be limited to one direction by design or by selection based on an installation. If the scale used for testing is bi-directional,

adjust the settings to unidirectional before completing this test. Using one of the Reference Vehicles, instruct the driver to drive the vehicle across the scale in the incorrect direction while the operation is restricted to the other direction. The vehicle speed must be within the speed range and DAT specified by the manufacturer. The driver should strive to maintain a constant speed to the best of their ability.

69.3.6. The minimum DAT fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure:

Using one of the Reference Vehicles, instruct the driver to drive at such a speed that will cause the DAT to be below the minimum DAT specified by the manufacturer. It is recommended to use the Reference Vehicle with the longest wheelbase because this vehicle will have the shortest time on the scale. The target speed that will result in the minimum DAT can be calculated from the formula provided below based on the vehicle's wheelbase and scale length.

$$vehicle\ speed\ (mph) = \frac{(scale\ length\ (ft) - vehicle\ wheelbase\ (ft)) * \frac{1\ mile}{5280\ feet}}{DAT(s) * \frac{1\ hour}{3600\ seconds}}$$

The driver should strive to maintain a constant speed slightly above the target speed to the best of their ability. The DAT must be determined to ensure it is slightly below the minimum specified by one of the following methods:

- a) The vehicle speed may be measured and the DAT calculated using the formula above. Various methods for measuring vehicle speed are provided in section "69.2.4. Measuring Vehicle Speed".
- b) The DAT measured directly as the total time the vehicle is completely on the scale platform.
- c) If the system is capable to display vehicle speed or DAT and this capability has been verified during dynamic testing, then these values can be used without further measurement.

Alternate test procedure:

This alternate test procedure may be used if the minimum DAT setting of the system can be adjusted. Instruct the driver to drive the vehicle across the scale at idle speed and record the DAT determined/measured. If the system is capable to display vehicle speed or DAT and this capability has been verified during dynamic testing, then these values can be used without further speed or DAT measurements. Driving at idle speed provides the most consistent and repeatable vehicle speed. Change the system minimum DAT to slightly above the DAT obtained at idle speed. Instruct the driver to drive the vehicle across the scale at idle speed again. For example:

- a) At idle speed, the vehicle speed is displayed as 3 mph which corresponds to a verified DAT of 1 second for the specific vehicle.
- b) The minimum DAT is changed to 1.5 seconds.
- c) The vehicle crosses the scale at 3 mph again as the idle speed and triggers the fault condition because the vehicle DAT (1 second) is now lower than the DAT limit (1.5 seconds).

69.3.7. The vehicle outside the lateral side edges of the load-receiving element fault is detected, no weight is displayed/recorded, and the fault is clearly presented to the consumer/operator. Yes No N/A

Recommended test procedure:

Using one of the Reference Vehicles, instruct the driver to drive outside the lateral side edges of the load-receiving element if not restricted by physical barriers. The vehicle speed must be within the speed range and DAT specified by the manufacturer. The driver should strive to maintain a constant speed to the best of their ability.

70. Performance and Permanence Tests for Portable Axle-Load Weighers.....