Scale Manufacturers Association

(SMA)

Standard

Shock and Overload Protection of Scales

(SMA SOP 04-99)

Provisional First Edition
Approved By SMA
Pending Final Comment

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Standard for Shock and Overload Protection of Scales

1. Introduction

1.1 Purpose

This standard is intended to provide criteria for the design and suitability of weighing devices (scales). Scales are subject to shock loading and overload during normal use. This document quantifies the abuse a scale meeting this standard will withstand. This knowledge can be used by potential scale owners and operators to properly size a scale for the application.

1.2 Applicability

These requirements cover all scales used in the determination of mass by the measurement of the force exerted on an object by gravity (including mass comparison).

The standard can be applied to mechanical or electronic devices.

The standard applies to complete scales or scale platforms and does not include consideration of individual scale components (such as load cells).

This standard applies to scales used in applications where shock and overload conditions are expected.

Emphasis is placed on scales of sufficiently low capacity that manual load introduction is normal: this specification applies to all scales of capacity less than 30kg unless specified by the manufacturer to the contrary.

A manufacturer may declare exceptions for a specific device. Special application scales, for example scales of very high capacity for the platform size may meet reduced requirements. Scales designed for special shock or overload conditions may meet declared conditions exceeding those of this specification.

1.3 Scope

This standard covers test methods, test criteria and quantitative load tolerance expectations. Scales meeting this standard will pass test criteria after being subjected to the specified shock and overload conditions. Scales of all capacities and types are covered. Two categories, one covering devices typically subjected to severe shock and overload conditions and another covering devices subject to more benign applications (such as laboratory devices), are defined.

The tests outlined in this standard can be used to determine the suitability of a device when subjected to the specified conditions. Conditions of vertical and horizontally applied loads are covered. Both the physical and metrological integrity of the device are covered by this standard.

2. Definitions

2.1 Shock

A shock load is defined as a dynamic or transient force applied to the equipment under test (EUT). Typically, shock loads are caused by dropped loads or side impacts from the load or load-transporting device. Forces imparted by shock loads can easily exceed the scale nominal capacity.

2.2 Overload

An overload condition is defined as any static load applied to the scale platform in excess of the rated scale capacity or in excess of a specified load per unit area (*e.g.*, concentrated load capacity).

2.3 Side impact

For the purpose of this standard a side impact is a shock load applied in any direction perpendicular to the direction of the force of normally applied loads. Side impact loads usually are horizontally applied. The source of test side impact loads for this standard include:

a) A freely swinging pendulum of construction defined in §4.4.1.
b) Vehicular traffic impacting the scale or scale platform.

2.4 Controlled Environment

A scale in a controlled environment is operated under benign conditions by trained operators. The likelihood of misapplication and abuse is minimized. Examples include laboratory scales and analytical balances.

2.5 Uncontrolled environment

A scale in an uncontrolled environment is operated by untrained operators or unsympathetic users. The likelihood for abuse is increased. Examples include all types of scales used in legal for trade applications, mail scales, parts counting, and household use scales.

2.6 Scales loaded vertically

The category of scales loaded vertically includes all devices where loads are applied to a load receiving platform. This category includes scales ranging from analytical balances to hanging scales and floor scales.

2.7 Scales not loaded vertically

Scales not loaded vertically include those in which loads are rolled onto the platform (*e.g*., vehicle and railroad track) and scales over which loads are conveyed (*e.g*., checkweighers).

3. Evaluation of conformance to standard

The following outlines tests that scales meeting this specification must pass. Scales are tested before and after the prescribed test.

A device meeting this specification remains within applicable limits of error after the test.

3.1.1 Initial Evaluation

Perform a metrological evaluation of the device to confirm the EUT meets specifications. Evaluation will typically include an increasing and decreasing load test and an eccentric load test. For legal-for-trade devices, procedures are as specified by the National Conference on Weights and Measures (NCWM) Publication 14, or the Organisation Internationale de Métrologie Légale (OIML) R76 for example. For the purpose of this standard, it is the intent that the EUT remain within tolerance as specified for the device: the EUT must remain within specifications. It may be convenient to state specifications in terms of compliance with NIST Handbook 44 or OIML R76 requirements.

3.1.2 Final Evaluation

Repeat the metrological evaluation performed in §3.1.1. Note any deviations from the initial findings.

3.1.3 Test load design

A shock load is a transient force as defined in §2.1. A mass gains velocity in free fall. Upon impact with the scale, the mass decelerates (*dv/dt*) until at rest (generally after a number of oscillations). The shock load (F_s) seen by the reacting scale platform is given by the expression:

$$F_s = m \times \frac{dv}{dt}$$

The more rigid the mass, the greater the deceleration and consequently the larger the applied force. To create a standard, therefore, a controlled test weight design is necessary.

Test weight design is a function of the scale, the scale accuracy, and environment. The following designs are recommended:

a) Controlled environment

For precision scales and balances, the test weight employed should be a cloth (linen) bag filled with lead shot. Individual shot diameter is less than 2 mm (0.080"). The bag is sized in such a way that, upon coming to rest on the platter, up to 50 % of the platter area is covered.

b) Uncontrolled environment

For general purpose and legal-for-trade scales, the test weight employed by this standard is a cardboard box of cross-sectional area up to one-half the area as the platter of the EUT. The box is filled to the test load with steel, lead shot or sand depending on size constraints. Individual shot diameter is less than 2 mm (0.080"). The box is of suitable height so that it can be completely filled and sealed closed with no remaining headroom. If the box is not filled, there is a possibility that a load shifting will produce varying results.

The mass of the test weight is determined as follows:

The shock load F_s imparted is given by the expression:

$$F_s = \sqrt{2mghk}$$

Where:

m is the mass of the test weight,
g is the acceleration due to gravity,
h is the height from which the weight is dropped, and
k is the composite spring constant of the weight and scale system.

The shock load force for a given mass/scale system will be a constant value if the product *m.h* is kept constant. Doubling the height and halving the mass will maintain a constant shock load. The mass of the test weight can be expressed as:

$m_{test} \,.\, h = K_v \,.\, Scale\_capacity$

The units of mass for m_{test} and *Scale_capacity* must be the same and *h* is either the drop-height in inches or millimeters as indicated by K_v given in Table 1.

Table 1

Scale category	K_v (in)	K_v (mm)
Controlled environment	1	25
Uncontrolled environment	3	75

The terms "controlled" and "uncontrolled" environments are defined above (§2.4, §2.5).

For example, a 15 kg nominal capacity scale is used in an "uncontrolled" environment. A convenient drop height is 150 mm. The test load is therefore:

$$m_{test} = K_v.Scale\_capacity/h = 75.15\ kg/150 = 7.5\ kg$$

4. Testing of vertically loaded scales

4.1 Overload

45.1.1 Test

Load the EUT to the load indicated in Table 2. Shock loads must be minimized. This can be accomplished by incrementally increasing the applied load while maintaining the center of gravity of the applied load generally at the intended center of load.

Table 2

Scale category	Overload value (x capacity)
Controlled environment	2
Uncontrolled environment	4

4.1.2 Results

4.1.2.1 Controlled environments

For precision scales and balances, the scale indication at zero-load shall not change more than 1% of scale nominal capacity. After re-zeroing the weight indication, devices meeting this standard remain within specified tolerances.

4.1.2.2 Uncontrolled environments

The scale indication at zero-load shall not change more than 2 display increments. After re-zeroing the weight indication, devices meeting this standard remain within specified tolerances.

4.2 Shock

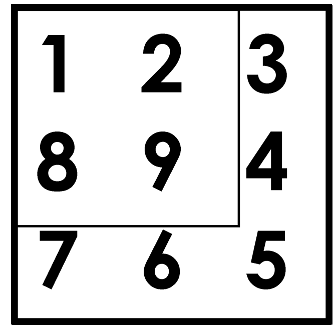

Figure 1. Shock load locations

4.3 Vertical impact

This test is to be applied to the scale platform and is an evaluation of metrological response to impact.

4.3.1 Test procedure

Test the EUT for compliance to specification. The shock test load is dropped once at each of nine locations from the height used to compute the test load (§3.1.3). The approximate locations are shown in Figure 1. The test load should not extend beyond the edge of the platform.

4.3.2 Results

After completion of the nine loads in §4.3.1, the displayed value indicated at zero load should not change more than 2% of scale capacity. After re-zeroing the weight indication, devices meeting this standard remain within specified tolerances. Minor component deformation should not affect the scale performance in any way.

4.4 Horizontal impact to platter/platform

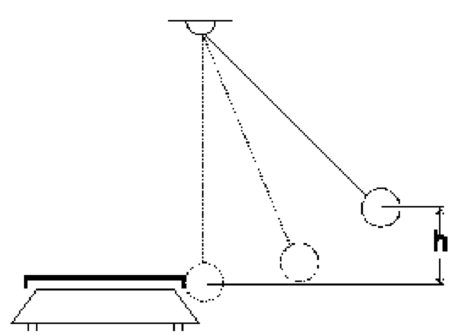

Figure 2. Horizontal impact

The horizontal loads applied in this test impact the platter or platform. This test is an evaluation of metrological response to side load impact.

4.4.1 Test load design

Shock is generated by the impact of a swinging pendulum. The pendulum mass is preferably a steel ball. For larger capacities, a standard steel weight may be practicable. The mass of the pendulum is given by the expression:

$$m_{pendulum} \cdot h = K_h \cdot Scale\_capacity$$

Where K_h is given in Table 3 and $m_{pendulum}$ and the scale capacity are in the same units of mass.

Table 3

Scale category	K_h (in)	K_h (mm)
Controlled environment	0.2	5
Uncontrolled environment	0.6	15

The pendulum is dropped from a height *h* (Figure 2) determined in combination with $m_{pendulum}$ from the above expression. For example if the scale capacity is 30 kg and the value of *h* is 150 mm, then the pendulum mass should be 3 kg in an "uncontrolled environment" test.

4.4.2 Test procedure

The results derived from this test depend to varying extent on the installation conditions. Set the scale on a surface typical of normal use. The scale should be secured and/or restrained if this is typical of normal installations.

Confirm that the EUT meets specifications. Release the pendulum weight once at each location shown in Figure 3.

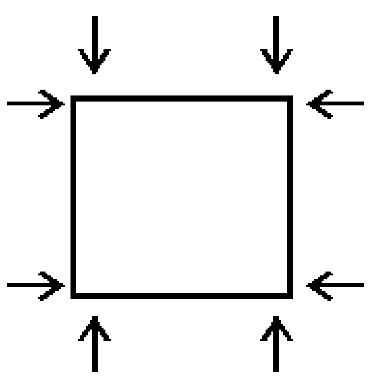

Figure 3. Impact locations

4.4.3 Results

After completion of the procedures of §4.4.2, the displayed value indicated a zero load should not have changed more than 2% of scale capacity. After re-zeroing the weight indication, devices meeting this standard remain within specified tolerances. Specifically the platter/platform shall not have moved to a degree that binding and scale malfunction occurs. Any overload stop settings for the protection of the scale under vertical shock loads shall not be affected to the extent they are no longer operative.

5. Evaluation of scales not loaded vertically

5.1 Vehicle scales

Shock and overload conditions do not usually control vehicle scale suitability. Vehicle scales meeting this specification are designed for at least one million weighments of vehicles for which the scale was designed.

Design guidelines are derived from the Bridge Gross Weight Formula, published by the US Department of Transportation, Federal Highway Administration[1], augmented by the factor r as defined in NIST Handbook 44[2].

The modified FHA formula is given by:

$$W' = r \times 500 \times \left[\frac{L \times N}{(N-1)} + (12 \times N) + 36 \right]$$

W' = the maximum weight in pounds that can be carried on any group of two or more consecutive axles.

r = CLC / 34,000 lb.

CLC = the concentrated load capacity specification for the scale in pounds.

L = the spacing in feet between the outer axles of any two or more consecutive axles in feet.

N = the number of axles being considered.

5.1.1 Overload

A vehicle scale shall be designed in order to withstand one million weighments of vehicles loaded according to the most stringent limits of the formula for W' without structural failure.

Scales meeting this specification must withstand at least ten load cycles of a vehicle overloaded to 150% of the most stringent limits of the formula for W'. The scale structure will undergo no measurable permanent deformation and will perform within applicable tolerances after the test.

5.1.2 Shock

5.1.2.1 Test

Ensure that the EUT meets specification. When fully on the scale platform, rapidly apply the brakes of a vehicle suitable for weighing on the EUT, initially travelling at 3 mph. Perform this test three times, at least once in each available direction of traffic flow.

5.1.2.2 Test results

The displayed value indicated a zero load shall not change more than 2 display increments. After re-zeroing the weight indication, devices meeting this standard remain within specified tolerances.

5.2 Railroad track scales

Railroad authorities tightly control conservative scale specifications using the Cooper rating system. The suitability of a railroad track scale can be determined by its Copper rating. For the majority of legal-for-trade applications, a minimum rating of Cooper E-80 is required.

5.3 Checkweighers

Checkweighers often are designed in such a way that they will not readily convey loads greater than rated capacity. Checkweighers meeting this standard have passed the requirements as outlined in NCWM Publication 14, Section 2 - Chapter 2: Automatic Weighing Systems Checklist, §3.3 "Permanence Tests for Automatic Weighing Systems". Scales meeting this requirement meet or exceed the requirements of this test.

6. Housing impact

The horizontal loads in this test are applied to the scale housing. This test is an evaluation of the structural integrity of the housing and is not intended to evaluate metrological response to side load impact.

Where applicable, scales meeting this standard pass the requirements of UL 1950 §4.2. This standard requires that "enclosures shall have adequate mechanical strength and shall be constructed as to withstand such rough handling as may be expected in normal use". This standard details mechanical tests to determine this suitability. This requirement applies to self-contained scales typically of bench and portable capacity and size and to the indicator or terminal elements of larger scales.

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[1] U.S. Department of Transportation, Federal Highway Administration Publication No. FHWA-MC-89-048: Federal Highway Administration Office of Motor Carrier Information, Management and Analysis, HIA-10, 400 7th St., S.W., Rm. 3140 Washington, DC 20590, (202) 366-4023.

[2] This formulation is covered by H-44 UR.3.2.1 in a slightly different format.

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