

SOP 27
Standard Operating Procedure
for

Railroad Test Cars Using a Master Track Scale

1 Introduction

1.1 Purpose.

This Standard Operation Procedure (SOP) describes the procedure to be followed for the calibration of railroad test cars on master track scales calibrated (certified) by the U.S. Department of Agriculture (USDA). By necessity, the SOP has been generalized to accommodate the variety of designs of master scales in the United States. The maximum railroad test car load is determined by the scale capacity and available length of track on each master track scale. The accuracy and precision of the calibration is determined by the reported values for each master track scale as part of the USDA railroad scale testing program, the proficiency and experience of the operator, and any additional control information maintained.

1.2 Detailed measurement ranges, standards, equipment, and uncertainties for this SOP are generally compiled in a separate document in the laboratory.

1.3 Limitations: The maximum railroad test car load shall not exceed the maximum calibration point listed on the master track scale calibration certificate or the nominal capacity of the master track scale.

1.4 Prerequisites

1.4.1 The master scale must have an up-to-date calibration along with a scale correction for the load being tested. The calibration must have demonstrated metrological traceability to the international system of units (SI), which may be to the SI through a National Metrology Institute such as NIST.

1.4.2 Access to the scale must be limited to authorized personnel only. If the master scale is owned by the railroad or other private entity, security must be maintained and controlled; registered keys to the facility must be provided.

1.4.3 Regularly scheduled calibration of all railway track scales is required because the scale is used as a secondary standard. If a jurisdiction can supply certified test weights and appropriate delivery systems to conduct a substitution test, then the scale may be used as a comparison scale.

- 1.4.4 The scale, process, and standards must be evaluated to ensure that the combined standard uncertainties for the intended level of calibration are sufficiently small.
- 1.4.5 When mass standards are used with substitution methods, ensure the availability of suitable working standards or recently calibrated (and unused) field standards (e.g., NIST Class F, OIML Class M₁) in quantities up to the capacity of the railroad test car that will be calibrated. All standards must have known conventional mass values with valid metrological traceability to the SI, which may be through laboratory working standards to the National Institute of Standards and Technology. In the case of substitution measurements, refer to NISTIR 6969¹, SOP 4, Double Substitution.
- 1.4.6 The metrologist or specialist must be experienced in the operation of the master scale and have adequate means to deliver the test car to and from the scale. The metrologist is reminded of the importance of evaluating potential safety hazards prior to a calibration and taking adequate precautions to avoid personal injury or damage to the scale or the railroad test car. If the master scale is under the control of the railroad and/or located on railroad property, the work will need to be coordinated with railroad personnel.
- 1.4.7 Environmental conditions must be suitable for mass calibrations and within the recommended limits noted in Table 1. Equilibration times for railroad test cars are noted in Table 2. Deviation from these limits is permissible but may need to include additional corrections and uncertainty components due to possible convection currents. Railroad test cars that do not completely fit within the enclosed structure, allowing the doors to be closed, must be calibrated only when external environmental conditions are acceptable. The scale should be protected from the effects of wind and adverse weather. In some installations, drafts may still be prevalent, applying force to the scale. Every effort should be taken to eliminate the effects of air movement.

Table 1. Recommended environmental conditions.

Temperature	Relative Humidity
18 °C to 27 °C	20 % to 80 %

- 1.4.8 Railroad test cars must be properly cleaned and painted and all repairs completed (as needed) prior to calibration. See section 2.3.3. for inspection requirements.

¹ NISTIR 6969, Selected Laboratory and Measurement Practices, and Procedures to Support Basic Mass Calibrations.

1.4.9 Railroad test cars must be completely dry, with no ice or moisture on the surface or under carriage of the car.

Experience has shown that a light coating of frost can cause errors in excess of the tolerance for the car. In heated facilities, the test car must be allowed sufficient time to warm to prevent condensation.

Table 2. Recommended stabilization times.

Temperature Range 22 °C (facility)	Temperature Range 72 °F (facility)	Minimum Equilibration Time*
± 5 °C, 17 °C to 28 °C	± 10 °F, 62 °F to 82 °F	4 hours
< 17 °C and > 28 °C	< 62 °F and > 82 °F	24 hours/overnight
* deviation is allowed if the known railroad test car temperature is at the facility temperature ± 2.5 °C (5 °F).		

1.4.10 Railroad test cars that repetitively demonstrate excessive “as found” out-of-tolerance conditions from the previous calibration date, may be required to be submitted on a more frequent basis; with every consideration being given to determine the cause of the variability.

1.4.11 Railroad test cars with unacceptable ballast; i.e., cement, pulverized lead, or other materials that absorb water or oxidize excessively, should be documented as to their instability. Repetitive tests demonstrating instability will warrant removal of the test car from service until the problem is corrected.

1.4.12 Stenciled weight of railroad test cars under USDA jurisdiction are required to be in 1,000 lb increments. Decals may be used for non-USDA railroad test cars, which may also be set to the nearest 100 lb increments.

2 Methodology

2.1 Summary

A railroad test car is calibrated by taking direct readings from the USDA calibrated railroad master track scale. The master track scale is calibrated by using calibrated 10 000 lb mass standards and 10 000 lb weight cart that are maintained with traceability to the SI, and calibrated in a recognized² facility in Clearing, Illinois.

² NIST Office of Weights and Measures, Handbook 143, Program Handbook provides recognition of compliance to program requirements associated with ISO/IEC 17025 and suitable evidence of metrological traceability.

2.2 Equipment / Apparatus

- 2.2.1 A track scale in good operating condition, with a current calibration certificate as noted in prerequisites.
- 2.2.2 Barometer (if available), thermometer, and hygrometer with sufficiently small resolution, stability, and uncertainty (See NISTIR 6969³, SOP 2) to record the monitored environmental conditions at the 1 % of air density level. Buoyancy corrections are not performed in this procedure; however, environmental data is critical to demonstrate environmental stability during the calibration.⁴
- 2.2.3 Correction or error weights adjusted to within NIST Class F⁵ tolerances with current calibration certificate(s).
- 2.2.4 Hand tools:
 - 2.2.4.1 Wrenches;
 - 2.2.4.2 Screw driver;
 - 2.2.4.3 Wire cutters; and
 - 2.2.4.4 Solvent to free rusty locks, as needed.
- 2.2.5 Means to safely move the railroad test car.
- 2.2.6 Operational knowledge of railroad test cars including the braking system and operating controls is required. Only qualified personnel should operate and inspect the test car. Verification that the brakes are operative prior to movement of the vehicle is imperative.
- 2.2.7 Suitable adjustment material must be available for placement in the adjusting compartments.
- 2.2.8 Check list or inspection work sheet.
- 2.2.9 For reasons of safety and the observance of unstable operations, two people are recommended for performing the calibration.

³ NISTIR 6969, Selected Laboratory and Measurement Practices, and Procedures to Support Basic Mass Calibrations.

⁴For most mass calibrations, the barometer, thermometer, and hygrometer are used to determine the air density at the time of the measurement. The air density is used to make an air buoyancy correction. The limits specified are recommended for high precision calibration. For this calibration, buoyancy corrections are not performed.

⁵ NIST Handbook 105-1, 1990, Specifications and Tolerances for Field Standard Weights (NIST Class F).

2.3 Pre-calibration Inspections

2.3.1 Inspect the Master Scale

2.3.1.1 Inspect the scale deck for wear and check for binds between the weigh rail and the approach rail.

2.3.1.2 Measure the gap between the weigh rail and the approach rail. If this distance is less than 1/8 in or more than 3/8 in based on requirements in the American Association of Railroads Handbook, a service technician must make adjustments prior to the calibration.

2.3.1.3 Inspect the scale pit for cleanliness and dryness.

2.3.1.4 Inspect the weigh beam, poise, butt connections, and counterpoise tip loop connections. While performing this inspection, put the blade edge of a screwdriver between the weigh beam and the side of the clevis at the pivot point, adjusting as necessary so there is equal distance on both sides between the clevis and the beam.

2.3.1.5 If using ratio weights, butt weights, or tip weights, confirm the ratio of the beam. This procedure can be useful to establish the as-found error. Railroad test cars that have been recently reconditioned may require several hundred pounds of adjustment material and correction to return them to nominal mass. Using ratio kits can reduce the amount of weight handling.

2.3.2 Inspect the Master Scale House

2.3.2.1 Note the following conditions and take action as warranted:

- Accumulated dirt or debris;
- Environmental conditions that may adversely affect performance;
- No load sensitivity: out of specification condition, look for physical bind, rodent or snake activity;
- “As found” balance condition;
- Evidence of tampering or unauthorized entrance; and
- Unstable electronic indications.

2.3.3 Inspect the Railroad Test Car

2.3.3.1 Determine the type of railroad test car (see Appendix A).

2.3.3.2 Note and record the stenciled mass value.

2.3.3.3 Visually inspect the railroad test car.

Check for damage, obvious loose parts; or, have a qualified railroad employee inspect the railroad test car. Assess the cleanliness of the railroad test car and determine if steam cleaning or painting is required prior to calibration. Note any major leaks or accumulation of oil, grease, dirt, trash, or unnecessary cargo.

2.3.3.4 Check any available operation and maintenance records; note recent derailments, repairs or incidents that could affect the calibration of the railroad test car.

Note in particular:

- Brake shoes;
- Spring hangers;
- Grab irons;
- Padlocks in place;
- Air hoses in place;
- Hand brake working status;
- Pedestal bolts;
- Retaining blocks;
- Spring condition; and
- General condition.

2.3.3.5 For, self-propelled cars, inspect the following:

- Oil level in engine;
- Fluid level in hydraulic oil reservoir, assuring that the level is within operational range;
- Motor fuel levels, removing extra gas tanks not tagged or marked as being part of the car's calibrated weight; and
- All fluid systems for leaks.

2.3.3.6 Check security seals, if present, for tampering or unauthorized entry to sealed compartments.

2.3.3.7 An inventory list should be securely posted in a conspicuous place to identify extraneous equipment that is to remain in the test car as part of the calibrated value. Items not on the list must be removed prior to calibration. Note: If there is a history of unauthorized repairs, permanently stamp or color code couplers, drawbars or other replaceable equipment, and note these conditions on the calibration certificate.

2.4 Calibration Procedure (Refer to NISTIR 6969, GMP 1, Reading Turning Points on an Equal Arm Balance if needed for beam scale readings.)

2.4.1 Zero balance the railroad track scale.

Set the scale with no load, no drop-weights or counterpoise weights, and the sliding poise set at 50.0 lb. If there is no poise, a 50 lb calibrated weight may be balanced on the deck of the scale. (If the test car has been recently reconditioned, a larger amount of test weight may be balanced in.) This is the reference indication, R_I , for all measurements on the scale during the calibration. Arrest the beam, release and repeat the reading to show repeatability and evidence of correct scale operation prior to use in calibrating the railroad test car.

2.4.2 Apply the drop-weights or counterpoise weights to the beam in an amount appropriate for the size of the test car to be calibrated. (i.e., 100 000 lb, 80 000 lb). Adjust the amount of drop or counterpoise weights until equilibrium is reached.

2.4.3 Position the test car on the center of the scale, taking note of the position markings on the rail if so provided. These markings are noted on the Master Scale calibration report and provide for corrected values at the various markings. Record scale indication as the railroad test car observation, S_I .

2.4.4 Arrest the beam. Release and repeat reading. Record observations.

2.4.5 Adjust the test car by adding or removing stable, metal adjusting material (as needed).

2.4.6 Remove the test car, recheck the reference indication, noting any drift. Arrest, release and repeat. Record observations.

2.4.7 Reposition the test car on the center of the scale and move the sliding poise to attain equilibrium of the beam. This scale indication, S_I , determines the “as left” error. Arrest, release, and repeat. Record observations.

2.4.8 Remove the test car and recheck the reference indication and record observations, again, noting any drift. Arrest, release, and repeat. Record observation.

2.5 Marking

2.5.1 Stencil the nominal value of the railroad test car and the date and location of calibration. Test cars under USDA jurisdiction are stenciled in 1,000 lb increments.

2.5.2 The metrologist may exercise discretion in marking or stamping removable or replacement components, such as drawbars or couplers.

3 Calculations (Measurement Equations)

Calculations. The calibrated scale is used as a secondary standard and the average of replicate mass values is used to assign the mass to the railroad test car. The scale indications, S_I , and the reference point indications, R_I provide the observed conventional mass difference. The scale corrections, S_{corr} , is subtracted from the observed difference to provide “as found” and/or “as left” conventional mass values. Where replicate measurements are made, the mean conventional mass is calculated and reported.

3.1 Calculate the conventional mass, CM_x .

$$CM_x = (S_I - R_I) - S_{corr} \quad \text{Eqn. (1)}$$

3.2 Calculate the mean conventional mass, \overline{CM}_x .

$$\overline{CM}_x = \frac{CM_{x1} + CM_{x2}}{2} \quad \text{Eqn. (2)}$$

NOTE: The S_{corr} needs to be subtracted whether the scale correction is positive or negative. For example, if the master scale reports lists a correction that is positive, this indicates that the scale is weighing heavy, and when negative it indicates that the scale is weighing light – as a negative scale reading correction. That means when you have a positive value for the scale correction it needs to be subtracted from the reading to determine the actual conventional mass value.

4 Measurement Assurance

It is not practical to duplicate this calibration process with a check standard. Replicating the measurement process is encouraged. The procedure calls for repeated measurements, in which case a standard deviation chart may be used for measurement assurance. Measurement assurance of the scale operation is obtained through scale arrestments and verification of repeated scale reference readings for each weighing. If SOP 4 is used, replicate measurements will provide estimates of standard deviation that may be pooled if appropriate following techniques in NISTIR 6969, Section 8.

5 Assignment of Uncertainty

The limits of expanded uncertainty, U , include estimates of the standard uncertainty of the mass standards used, u_s , estimates of the standard deviation of the measurement process, s_p , and estimates of the effect of other components associated with this procedure. These estimates should be combined using the root-sum-squared method (RSS), and the expanded uncertainty, U , reported with a coverage factor to be determined based on the degrees of freedom, which if large enough will be 2, ($k = 2$), to give an approximate 95 percent level of confidence. See NISTIR 6969⁶, SOP 29 for the complete standard operating procedure for calculating the uncertainty.

5.1 Uncertainty for the master track scale, u_{MS} .

Calculate the average uncertainty for the master scale at the calibrated nominal mass to be used for the calibration of the railroad test car from the USDA calibration certificate. The USDA calibration certificates give errors for positions at each nominal value (and for sensitivity response) to be used during the calibration; however each point does not contain uncertainties as the average value is considered for applications.

5.2 Uncertainty for correction weights, tip or butt weights, or tare weights, u_s .

Obtain uncertainties for any correction or tare weights from their respective calibration certificates.

5.3 Uncertainties for the measurement process and master track scale in use.

5.3.1 Standard deviation of the process

Calculate the standard deviation of replicate measurements or use the values for repeatability from the sensitivity response and zero shift observations.

5.3.2 Sensitivity Response (or Repeatability)

Obtain the sensitivity response value from the USDA calibration certificate for the master track scale.

5.3.3 Zero Shift

Record observations during the calibration to determine the average shift from the established reference point.

⁶ NISTIR 6969, Selected Laboratory and Measurement Practices, and Procedures to Support Basic Mass Calibrations.

Table 3. Example Uncertainty Budget Table.

Uncertainty Component Description	Symbol	Source	Typical Distribution
Uncertainty of the master scale calibration	u_{MS}	USDA calibration certificate	Normal divided by the coverage factor
Uncertainty of correction and tare weights	u_s	Calibration certificate	Normal divided by the coverage factor
Standard deviation of the process	s_p	Calculated from repeated measurements	Normal
Sensitivity response	s_r	One half of the USDA calibration certificate reported value	Rectangular
Zero shift	u_z	Observed data	Rectangular

- 5.4 Calculate the combined uncertainty using standard root sum square methods and expand the uncertainty with a coverage factor that is associated with appropriate degrees of freedom. Values for repeatability of similar size railroad test cars may be pooled using techniques provided in NISTIR 6969, Section 8.
- 5.5 Evaluation, Adjustment to Nominal, and Conformity Assessment

According to the Association of American Railroads Handbook, All test weight railroad cars are required to be maintained accurately to their designed or nominal weight values. For this purpose, each car weight shall be corrected as close to zero error and practical and certified within Class F tolerances as often as may be required. Railroad test cars should be adjusted to nominal conventional mass values (zero error) during calibration and must be maintained for use within 0.02 % of the nominal mass. The expanded ($k = 2$) combined uncertainty of the calibration must be less than one-third of the tolerance (0.0067 % of the nominal mass).

- 5.6 Draft an Appropriate Uncertainty Statement

The uncertainty reported is the root sum square of the standard uncertainty of the standard, the standard deviation of the process, and the uncertainty associated with the buoyancy corrections, multiplied by a coverage factor of 2 ($k = 2$) for an approximate 95 % confidence interval. Factors not considered in the evaluation: air buoyancy, magnetism, environmental variation.

Note: Where inadequate degrees of freedom are available, k , is determined using the appropriate degrees of freedom and the 95.45 % column in the table from Appendix A of NISTIR 6969, SOP 29.

6 Certificate

Report results as described in SOP No. 1, Preparation of Calibration Certificates. Report the Conventional Mass, environmental conditions during the calibrations, and calculated

uncertainties. No correction for the effect of air buoyancy is to be assumed unless stated on the calibration certificate. In addition to requirements of SOP 1, the following information is included on the calibration certificate:

- Master Scale identity and its calibration date;
- Railroad test car identification;
- Stenciled conventional mass value;
- “As found” mass value (with explanation of adjustments, if appropriate);
- “As left” mass value (railroad test cars that have demonstrated excessive wear from year to year may be left on the higher side of the tolerance to compensate for wear); and
- Signature of witnesses to the calibration, if appropriate and desired.

Appendix A – Types of Railroad Test Cars

- 6.1 Monitor car. Essentially a modified freight car with approved lading to which field calibration has been performed. These cars cannot be verified on a railroad master scale. They are used only in emergency situations such as returning a scale to service pending the arrival of a certified test car.
- 6.2 Composite car. Each composite car is provided by design with a tool and/or cargo compartment, usually runs transversely through the car body which can be secured by lock or wire seal. Wheel base lengths (center of front axle to center of rear axle) shall not exceed 7 ft. Composite cars are calibrated on railroad track master scales. Standard composite car values range from 30 000 lb to 110 000 lb in multiples of 10 000 lb.
- 6.3 Self-contained car. The self-contained type of test weight car has a metal body made up of either one or two castings mounted on a 7 ft wheel base with a space provided to contain a small number of 50 lb or smaller test weights. This compartment is called the adjustment cavity and is secured by lock or seal.
- 6.4 Compartment car. The compartment car is constructed of one or more casting or fabricated steel plates mounted on a 7 ft wheel base forming a shell that can be loaded with 50 lb or 100 lb weights to a value at least equal to the weight of the empty car. The compartment is secured by lock or seal.
- 6.5 Long wheel base car. The self-propelled hydraulic jack design is of average freight car length and employs four hydraulic jacks spaced 7 ft apart (to simulate a 7 ft wheel base for section testing) which are lowered to the scale section which is to be tested (repeated per number of sections). The self-propelled design allows the car to move autonomously onto the scale.

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