

Chapter 4

Pre-Test Determinations Vehicle & Axle-Load Scales

Objectives

- Complete a tolerance worksheet
- Determine maximum test load for the “Test”
- Apply tolerances to be conducted in the “Test”
 - Increasing- and Decreasing-Load Tests
 - Shift Test
 - Repeatability
 - Strain-load Test and Substitution Test
 - Zero-load Balance Change

Terms to Know

- Acceptance Tolerance
- Decreasing-Load Test
- Discrimination Test
- Increasing Load Test
- Maintenance Tolerance
- Sensitivity Requirement (SR)
- Repeatability
- Shift Test
- Strain-Load Test and Substitution Test
- Tolerance

Tolerances

- “A value fixing the limit of allowable error or departure from true performance or value.”
- Recognizes that devices cannot be perfect
- What is a reasonable amount of error to allow?
 - Not so large as to cause economic harm
 - To the buyer
 - To the seller
 - Not so small that the cost of manufacturing and maintaining the device is unreasonable

Applying Tolerances

- Apply equally to overregistration and underregistration
- Overregistration
 - Scale indicates “over” or more than the actual weight
- Underregistration
 - Scale indicators “under” or less than the actual weight
- Tolerances are for the device, not for owner or service person

Marked Scales vs. Unmarked Scales

- Table T.1.1. applies to scales not marked with an accuracy class
- Table T.1.1. specifies that tolerances for unmarked and marked vehicle and axle-load scales are the same
 - Tolerances in “T.N.” section apply

T.N.2. Tolerance Application

- T.N.2.1. General
 - Tolerances are “+” and “-”
- T.N.2.3. Subsequent Verification Examination
 - Tolerances apply regardless of influence factors in effect during examination
- T.N.2.4. Multi-Interval and Multiple Range
 - Tolerances are based on value of scale division of the range in use

G.T.1. Acceptance Tolerances

- Equipment to be put into commercial use for the first time
- Equipment placed into commercial service within the last 30 days and is being officially tested for the first time
- Equipment that has been returned commercial service following official rejection for performance and is being tested within 30 days
- Equipment being tested for first time within 30 days after major overhaul or repair
- Equipment undergoing type evaluation

G-T.2. Maintenance Tolerances

- Applies to equipment in actual use
- Applies in applications not covered under G-T.1. Acceptance Tolerances
- *Generally* acceptance tolerance is half of maintenance tolerance
 - Acceptance is tighter because devices are in new or “like new” (recently repaired or adjusted) condition
 - Maintenance recognizes devices in use are subject to wear

Maintenance Tolerances for Scales

- T.N.3.1. Maintenance Tolerances
 - specified in table 6
- Table 6
 - Outlines tolerances in scale divisions
 - Based upon accuracy class
 - Applied based upon test load
- T.N.3.2. Acceptance Tolerances
 - Acceptance tolerances are one-half maintenance

Table 6 – Maintenance Tolerances

Table 6.
Maintenance Tolerances
(All values in this table are in scale divisions)

Tolerance in scale divisions				
	1	2	3	5
Class	Test Load			
I	0 - 50 000	50 001 - 200 000	200 001 +	
II	0 - 5 000	5 001 - 20 000	20 001 +	
III	0 - 500	501 - 2 000	2 001 - 4 000	4 001 +
IIII	0 - 50	51 - 200	201 - 400	401 +
III L	0 - 500	501 - 1 000	(Add 1d for each additional 500 d or fraction thereof)	

Example of Calculating Tolerances

- Example:
 - Vehicle scale
 - Scale division, “d” = 20 lb
 - Accuracy Class III
 - Scale in service for more than thirty days with no repairs/adjustments
 - Maintenance tolerances apply
- Convert test load in “d” to test load in “pounds”
 - Example:
 - Test load of 500 d
 - $500 \times 20 \text{ lb division (d)} = 10\,000 \text{ lb}$

Example of Calculating Tolerances (continued)

- Convert tolerance in “d” to tolerance in “pounds”
 - Example
 - Tolerance of 1 d
 - 1 x 20 lb division (d) = 20 lb

Test Load in “d”	Maintenance Tolerance in “d”	Test Load in pounds	Maintenance Tolerance in pounds
0 - 500d	1	0 – 10,000 lb	20
501 - 1,000 d	2	10,020 – 20,000 lb	40
1,001 – 1500 d	3	20,020 – 30,000 lb	60
1,501 - 2,000 d	4	30,020 – 40,000 lb	80
2,001 - 2,500 d	5	40,020 – 50,000 lb	100
2,501 - 3,000 d	6	50,020 – 60,000 lb	120
and so on			

Agreement of Indications

- T.N.4.1. Multiple Indicating/Recording Elements
 - Multiple indicators that are intended to be used independently
 - For example, scale with digital indicator and a “stand-by” dial and printer to be used during power failure
 - Tolerances shall apply independently to each indicator

Agreement of Indications (cont.)

- T.N.4.2. Single Indicating/Recording Element
 - Single indicator with component parts that can be used in combination
 - Components can be used to indicate the weight of the same load
 - For example, a weighbeam with counterpoise weights
 - Difference in weight value cannot be greater than absolute value of applicable tolerance
 - Each indication must be within tolerances

Agreement of Indications (cont.)

- T.N.4.3. Single Indicating/Multiple Indications
 - Analog indicating element with two or more indicating means
 - Used to indicate the same load
 - Example, dial with two faces
 - Difference in indications (for loads greater than zero) not greater than one-half the value of the scale division
 - Each indication must be within tolerances

T.N.4.4. Shift Test – Tolerances

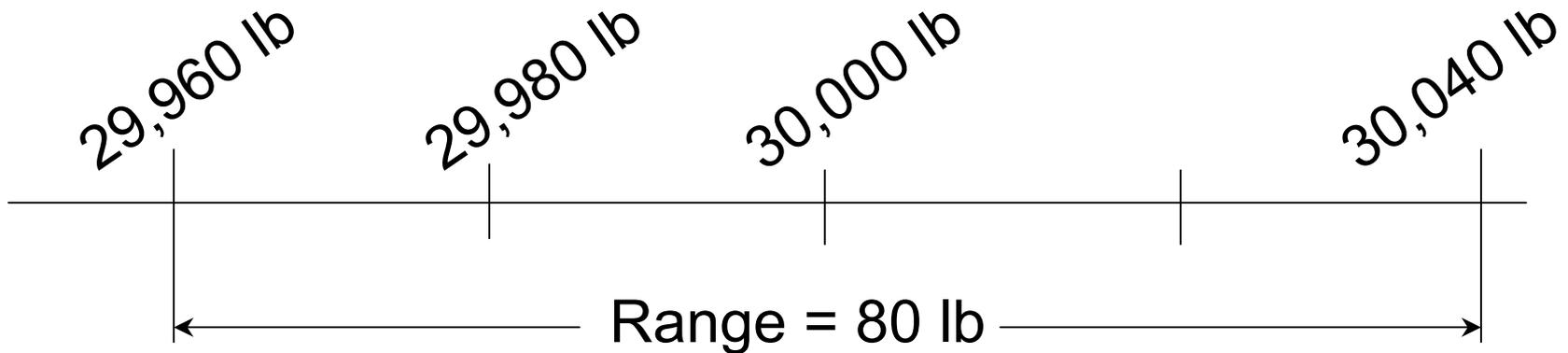
- T.N.4.4. Shift or Section Tests
 - Range of results obtained shall not exceed the absolute value of maintenance tolerance
 - Absolute value is the number without any “+” or “-” signs
 - For example, the absolute value of a tolerance of +/- 20 lb is “20”
 - Each test result shall be within applicable tolerance

Shift Test Tolerances: Example

- Class III L Vehicle Scale, $d = 20$ lb, Maintenance Tolerances apply
- Tolerance on 30,000 lb is ± 60 lb
- Absolute value of maintenance tolerance is absolute value of ± 60 lb or 60 lb
- Test Results:
 - Section 1: 30,040 lb
 - Section 2: 29,980 lb
 - Section 3: 30,000 lb
 - Section 4: 29,960 lb

Shift Test Tolerances: Example

- Section 1: 30,040 lb Meets +/- 60 lb tolerance
- Section 2: 29,980 lb Meets +/- 60 lb tolerance
- Section 3: 30,000 lb Meets +/- 60 lb tolerance
- Section 4: 29,960 lb Meets +/- 60 lb tolerance



- Individual results meet applicable tolerance
- BUT, range of results (80 lb) exceeds permissible range (60 lb)

T.N.5. Repeatability

- Results obtained from repeated weighings of the same load
- Weighings must be done under reasonably static conditions
 - i.e., don't vary the test conditions
- Placement and distribution of weights must be as closely duplicated as possible for each weighing
- Results must agree within absolute value of maintenance tolerances
- Each test result must be within applicable tolerance

Sensitivity Requirement (SR)

- Applies to nonautomatic indicating scales
 - e.g., Weighbeams
- Change in position of indicating element in response to a load that is applied or removed
- T.2.7. SR for Unmarked Scales
- T.N.6.1 SR for Marked Scales
- Test load is the same for both marked and unmarked scales
 - With Balance Indicator: 1 d
 - No Balance Indicator: Lesser of 2 d or 0.2 % of capacity

SR Required Response - Summary

	Test Load— Marked and Unmarked	Equilibrium Change Unmarked Scales	Equilibrium Change Marked Scales
With Balance Indicator	1d	Greater of 0.25 inch change in position or 1 graduation or width of target area	Same as unmarked <u>except 0.20</u> inch change in position
With Trig Loop but no Balance Indicator	Lesser of 2d or 0.2% of scale capacity (whichever, is less)	Tip of beam moves from center of trig loop to the top or bottom	Same as unmarked
With neither Trig Loop nor Balance Indicator	Lesser of 2d or 0.2% of scale capacity (whichever, is less)	Position of weighbeam or lever system moves from midway between stops to either limit of motion	Same as unmarked

Discrimination Test

- Applies to automatic indicating scales
 - Analogous to SR for non-automatic indicating
- Addition or subtraction of a load must produce a minimum change in indication
- Procedure for conducting test will be reviewed in Chapter 6

T.N.7. Discrimination

- T.N.7.1. Analog Automatic Indicating Scales
 - e.g., dial scale
 - Test load of 1.4 d
 - Indication must change at least 1.0 d
- T.N.7.1. Digital Automatic Indicating Scales
 - Test load of 1.4 d
 - Indicated or recorded value must change at least 2 d
 - Requires the zone of uncertainty to be 0.3 d or smaller
 - Zone of uncertainty is point within division where indications flash between two graduations
 - Zone of uncertainty will be discussed further in Chapter 6

Minimum Test Loads Required

- N.3. Minimum Test Weights and Test Loads
 - For in-service tests
 - Minimums specified in Table 4
 - For scales with capacities of more than 40 000 lb:
 - Test weights equal to at least 12.5% of scale capacity
 - Test loads equal to at least 25% of scale capacity
 - “Test loads” means the combination of known test weights and other applied loads used in conduct of substitution test
 - When practical, a strain-load test to used capacity should be conducted
 - For dial scales, test weights to dial face capacity, 1 000 d, or test load to used capacity, if greater than minimums specified

Table 4. Minimum Test Weights and Test Loads

Table 4. Minimum Test Weights and Test Loads ¹			
Device capacity	Minimums (in terms of device capacity)		(where practicable)
	Test weights (greater of)	Test loads ²	
0 to 150 kg (0 to 300 lb)	100 %		
151 to 1 500 kg (301 to 3 000 lb)	25 % or 150 kg (300 lb)	75 %	Test weights to dial face capacity, 1 000 d, or test load to used capacity, if greater than minimums specified
1 501 to 20 000 kg (3 001 to 40 000 lb)	12.5 % or 500 kg (1 000 lb)	50 %	
20 001 kg+ (40 001 lb+)	12.5 % or 5 000 kg (10 000 lb)	25 % ³	During initial verification, a scale should be tested to capacity.

¹ If the amount of test weight in Table 4 combined with the load on the scale would result in an unsafe condition, then the appropriate load will be determined by the official with statutory authority.

² The term "test load" means the sum of the combination of field standard test weights and any other applied load used in the conduct of a test using substitution test methods. Not more than three substitutions shall be used during substitution testing, after which the tolerances for strain-load tests shall be applied to each set of test loads.

³ The scale shall be tested from zero to at least 12.5 % of scale capacity using known test weights and then to at least 25 % of scale capacity using either a substitution or strain-load test that utilizes known test weights of at least 12.5 % of scale capacity. Whenever practical, a strain-load test should be conducted to the used capacity of the scale. When a strain-load test is conducted, the tolerances apply only to the known test weights or substitution test load.
(Amended 1988, 1989 and 1994)

N.1.11. Substitution Test

- Process in which unknown materials or objects are substituted *exactly* for known test weights
 - Additional test weights or other known test loads may be added to the known test load to evaluate higher weight ranges on the scale
- Scale is used as a comparator
- No more than three substitutions are permitted to keep errors to a minimum
 - Each substitution process has the potential to introduce small errors into the test process
- Tolerances applied based on entire substitution load (TN.3.11.)

Substitution Test Process (Overview)

- Known test weights are placed on the scale
- Scale reading is taken
 - Error weights are used to determine scale indication within 0.1d
- The known test weights are removed
- Unknown material or objects are added to the scale until the scale indication reads the same as when the known test weights were on the scale
 - Error weights are again used to duplicate reading
- Process represents one substitution of the known test weights
- Process discussed in more detail in Chapter 6

N.1.12. Strain-Load Test

- Process in which an unknown quantity of material or objects are used to establish a reference load or tare to which test weights or substitution test loads are added.
- Process is used when available test weights are less than the maximum capacity of the scale
 - Enables testing to be conducted in the upper portion of the scale's capacity.
- Process can be combined with substitution testing
- The process for conducting a strain-load test is discussed in more detail in Chapter 6.
- Tolerances applied only to test weights or substitution test load (TN.3.12.)

Strain-Load Test Process (Overview)

- Remove all loads from the scale
- Zero the scale
- Place an unknown load on the scale
 - Use error weights to establish a beginning reference load point
- Known test weights are then applied to the scale
 - Error weights are used to determine the resulting scale reading
- The resulting scale reading is compared with the beginning reference load point and the difference determined
- The error is determined by comparing this difference with the known test load that was applied to the scale

Determining Scale Error

- Some jurisdictions use “error testing”
 - Small test weights used to determine the exact amount of error at each test load
- Most jurisdictions just “tolerance testing”
 - Determine error by direct reading the scale
 - Preferred method
 - Less time consuming than error testing
 - Officials actions not typically based on exact amount of error
 - Less difficulty created by external influences such as wind
- Note that the use of error weights are still employed in some specific tests such as the strain load and substitution test

Acceptable Range of Indications

- Used as part of tolerance testing
- For each test load, determine the acceptable range of scale indications
 - Part of “Pre-Test Determinations”
- For example, if a 10 000 lb load is placed on the scale and the tolerance is +/- 20 lb acceptable indications:
 - $10\ 000\ \text{lb} - 20\ \text{lb} = 9\ 980\ \text{lb}$
 - $10\ 000\ \text{lb} + 20\ \text{lb} = 10\ 020\ \text{lb}$
 - Any indication from 9 980 lb to 10 020 lb is acceptable
 - Any value outside that range exceeds the tolerance

Tolerance Worksheets

- Course material includes templates for:
 - Full capacity weighbeams
 - Mechanical dials
 - Electronic scales
- Calculate tolerances before beginning test
 - Helps to plan the test
 - Make the best use of available test weights
 - Identify additional loads needed for test
 - Includes determination of acceptable range of scale indications

