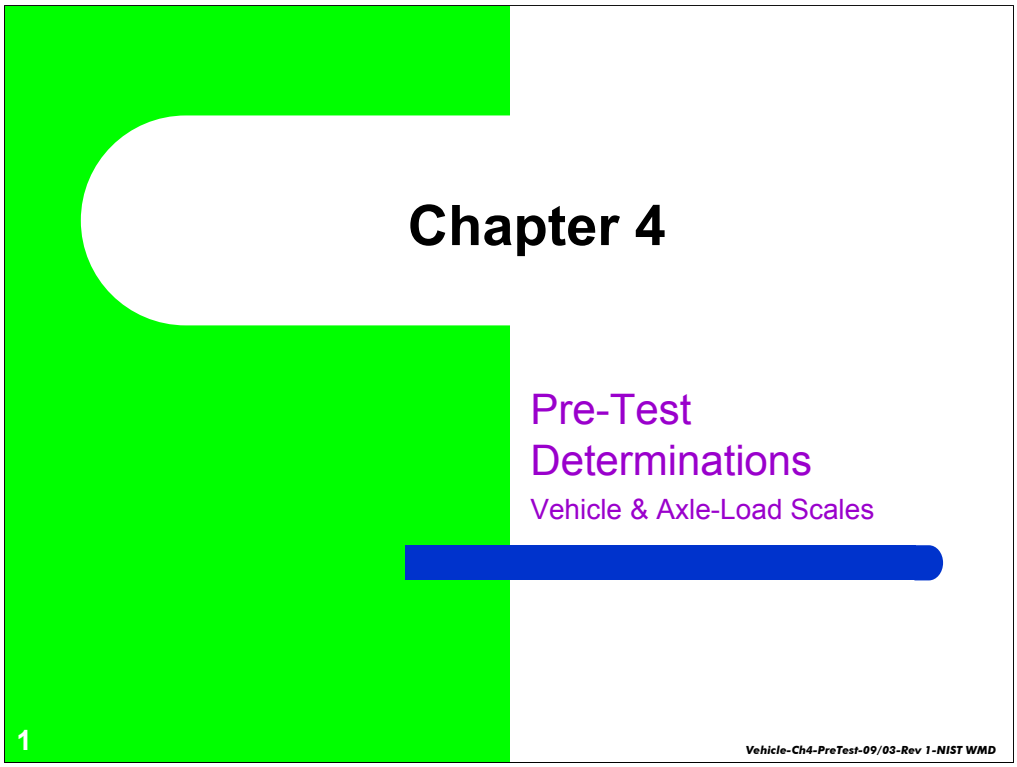
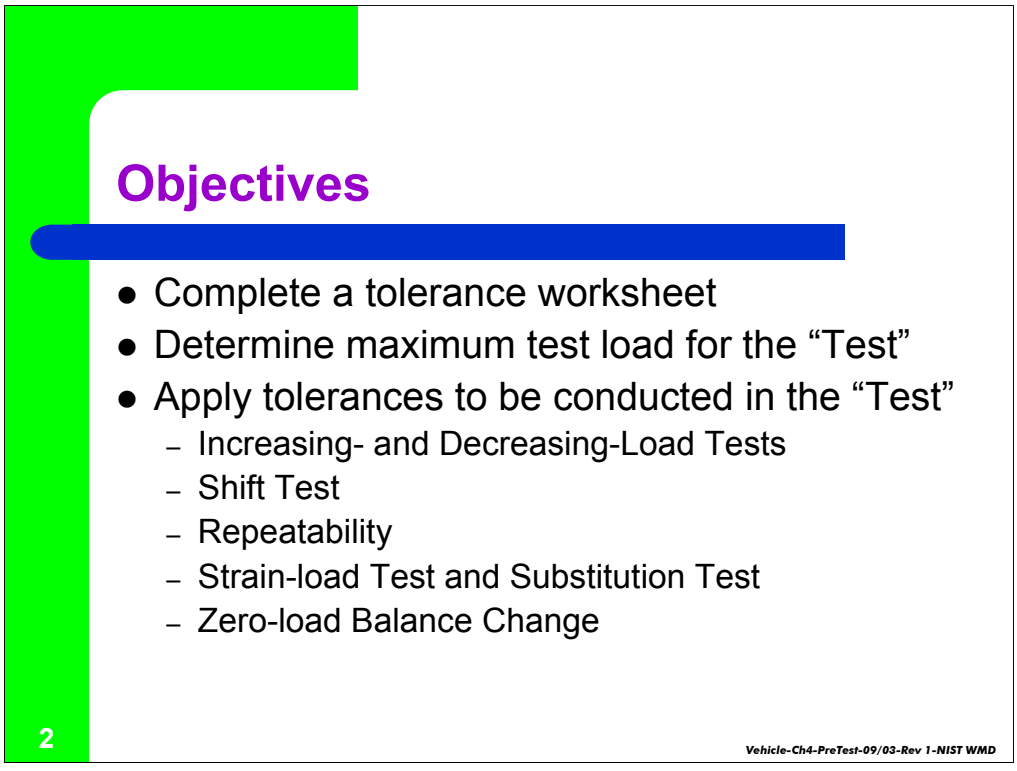


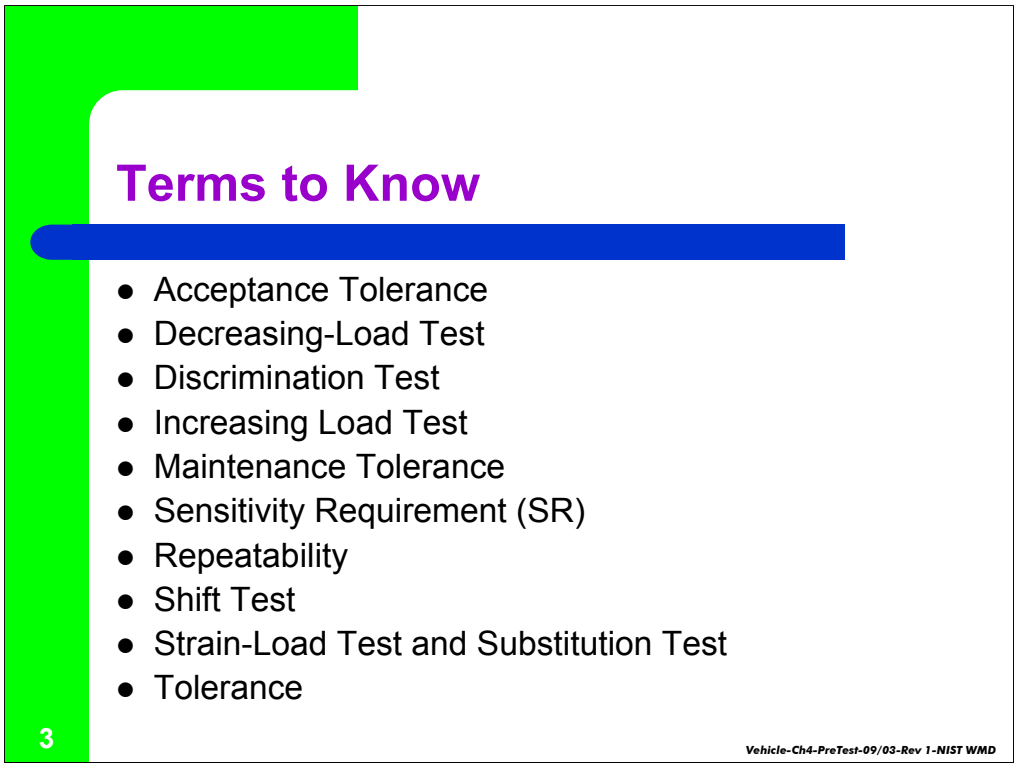

Chapter 4 Objectives

1. Be able to determine tolerances on vehicle and axle-load scales and apply them for tests to be conducted in the test portion of the field examination. These tests are:
    - decreasing-load test
    - increasing-load test
    - repeatability
    - shift test
    - strain-load test
    - substitution test
    - zero-load balance change
2. Complete a tolerance worksheet for vehicle and axle-load scales.
3. Determine the minimum sensitivity requirement on non-automatic indicating type vehicle and axle-load scales and properly conduct the sensitivity tests.
4. Determine the minimum test weights and test loads needed to satisfactorily test vehicle and axle-load scales.
5. Determine the maximum test load to be applied during the test.

**Note: Before introducing the slide presentation for each chapter, it is recommended that the presenter read the course material for the chapter in its entirety and refer to the written material as needed while using the slide presentation to illustrate and explain the text.**




Objectives from slide 1.




Define each of these terms.

## 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



Review Fundamental Considerations 2.1. and 2.2., Tolerances for Commercial Equipment.

## 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





Read and explain G-T.3. And  Fundamental Considerations 2.3.

# 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



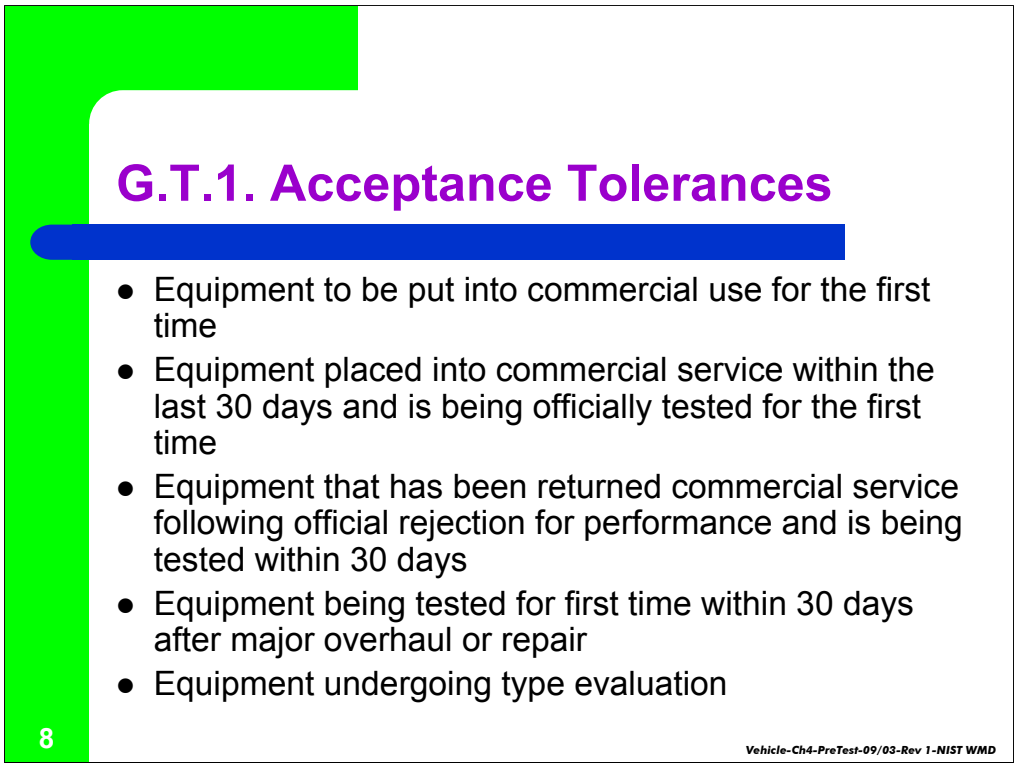
Explain table T.1.1.

# 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



Read and explain each of these tolerance application requirements. Explain how a multi-interval and multiple range scale functions and how tolerances are applied to the different ranges.




Read G.T.1. and then explain each bulleted item. Discuss the need for timely inspections on new devices that are being put into service for the first time. (inspect within 30 days from date first put into commercial service)

Also discuss the need for prompt re-inspections on devices that have been repaired or returned to service following official rejection or condemnation. (also inspect within 30 days following repair or return to service)

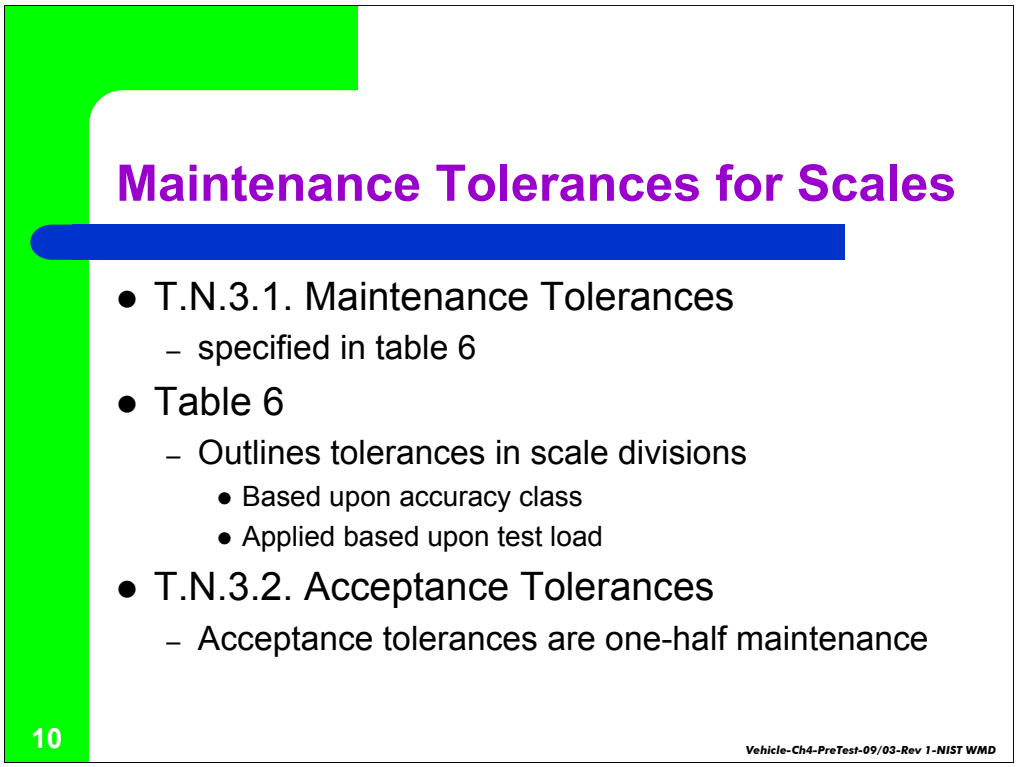
For further discussion: Discuss the criteria to be used for determining a major overhaul or major repair.

## 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



Read and explain G-T.2.




Read T.N.3.1. Identify the appropriate accuracy class and associated tolerance from Table 6. Be certain to explain that vehicle and axle-load scales are Class III L devices. Refer to Table 7a if needed. Read T.N.3.2. and explain how acceptance tolerance is determined.

# 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) | |





Use Table 6 to explain the application of maintenance and acceptance tolerances. Explain how to apply one-half division acceptance tolerance to an electronic device.

For additional discussion: Explain how error weights can be used to read a digital scale finer that the closest whole division.

# Example of Calculating Tolerances

- Example:
  - Vehicle scale
  - Scale division, “d” = 20 lb
  - Accuracy Class IIIL
  - 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 x 20 lb division (d) = 10 000 lb





From the example provided, explain how 500 divisions is converted to test load and how the tolerance is then determined.

# 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 | | | |

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Use the slide to explain how to convert divisions to tolerances.

The following are some additional examples using different division sizes and test loads. Answers are provided in bold type. Calculate the maintenance and acceptance tolerances for the following examples:

Example 1

Vehicle Scale – Class III L

Acceptance Tolerance

Maintenance Tolerance

Scale division: 10 lbs

Test Weights: 17,500 lbs

**2d or 20 lbs**

**4d or 40 lbs**

Example 2

Acceptance Tolerance

Maintenance Tolerance

Vehicle Scale – unmarked

Scale division: .01 ton

Test weights: 22,500 lbs

**1.5d or .015 ton = 30 lbs**

**3d or .03 ton = 60 lbs**

## 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



Read and explain the requirement. Use handout entitled “Agreement of Indications,” to describe the application of the requirement T.N.4.1.

Note: All T.N.4 agreement requirements also appear as part of the chapter 5 presentation but for a different reason. For slides 14 through17 of this chapter, concentrate on teaching the application of each requirement and explain how tolerances are applied. In the next chapter, you will concentrate on teaching how to perform agreement tests.

# 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
  - Each indication must be within tolerances
    - For example, a weighbeam with counterpoise weights
  - Difference in weight value cannot be greater than absolute value of applicable tolerance



Read and explain the requirement. Use handout entitled "Agreement of Indications" to describe the application of T.N.4.2. and to explain how tolerances are applied when enforcing the requirement.

# 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



Read and explain the requirement. Use handout entitled "Agreement of Indications" to describe the application of T.N.4.3. and to explain how tolerances are applied when enforcing this requirement.

# 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





Read and explain the requirement. Use handout entitled "Agreement of Indications" to describe the application of T.N.4.4. and to explain how tolerances are applied when enforcing this requirement.

## 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





Using the example, explain how individual sections are within applicable tolerance yet sections fail agreement range as defined by T.N.4.4.

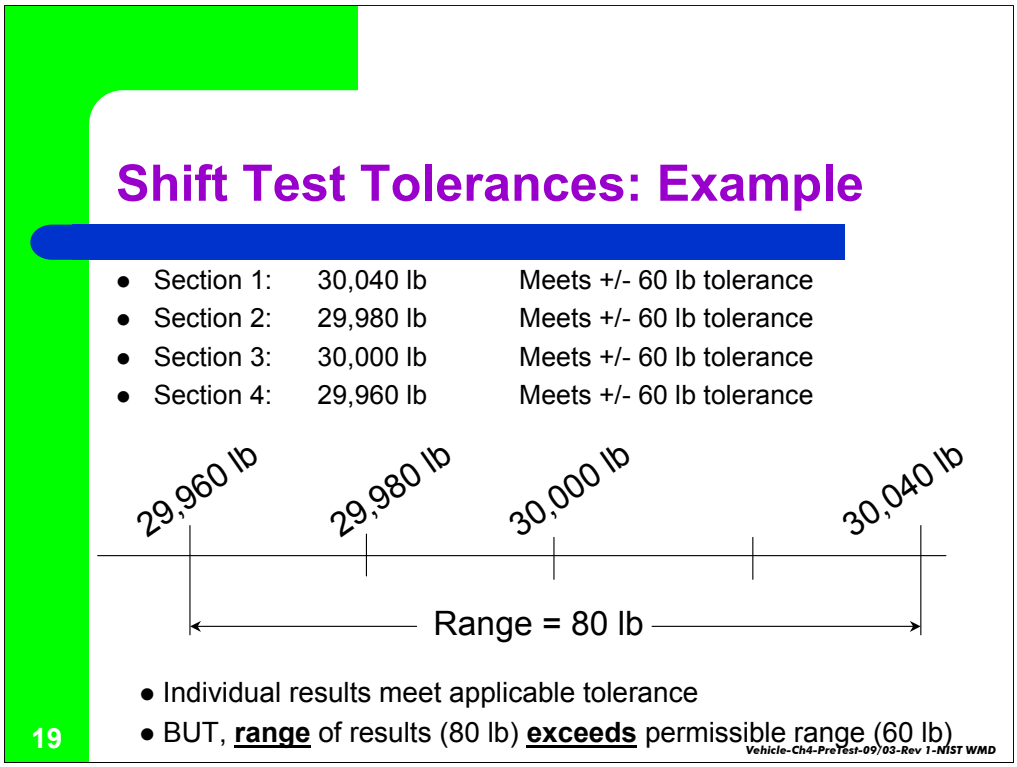



Chart shows all sections within +/- 60 lb tolerance and range exceeding permissible range defined in T.N.4.4.

## 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





Read and explain the requirement. Provide specific instructions on how to conduct the test. Explore and discuss possible causes of poor repeatability on vehicle and axle-load scales.

# 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



Explain the importance of sensitivity on a non-automatic scale. Explain the requirement for sensitivity on a vehicle scale having a balance indicator and one without. Explain how the test is performed in both directions, i.e., observing the change in position of the beam when SR is added and also removed from the platform. Explain some causes of poor sensitivity. Discuss why it is necessary to add or remove weights from the load-receiving element when testing SR rather that just using the poise on the beam.

# 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 except ***0.20*** 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 |



Explain how the chart should be applied.

# 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



Read and explain the requirement. Describe the procedure for calculating the minimum test weights and test loads needed to test vehicle and axle-load scales. Explain why it is important to set minimum test weight and test load requirements for vehicle and axle-load scale tests. Why are these minimums a percentage of the scale's capacity. Describe how a strain load test is conducted and why it's important to conduct a test to used capacity.

Explain why it would be important to have test weights rather than test loads equal to dial face capacity.

## 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<br><br>During initial verification, a scale should be tested to capacity. |
| 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] | |

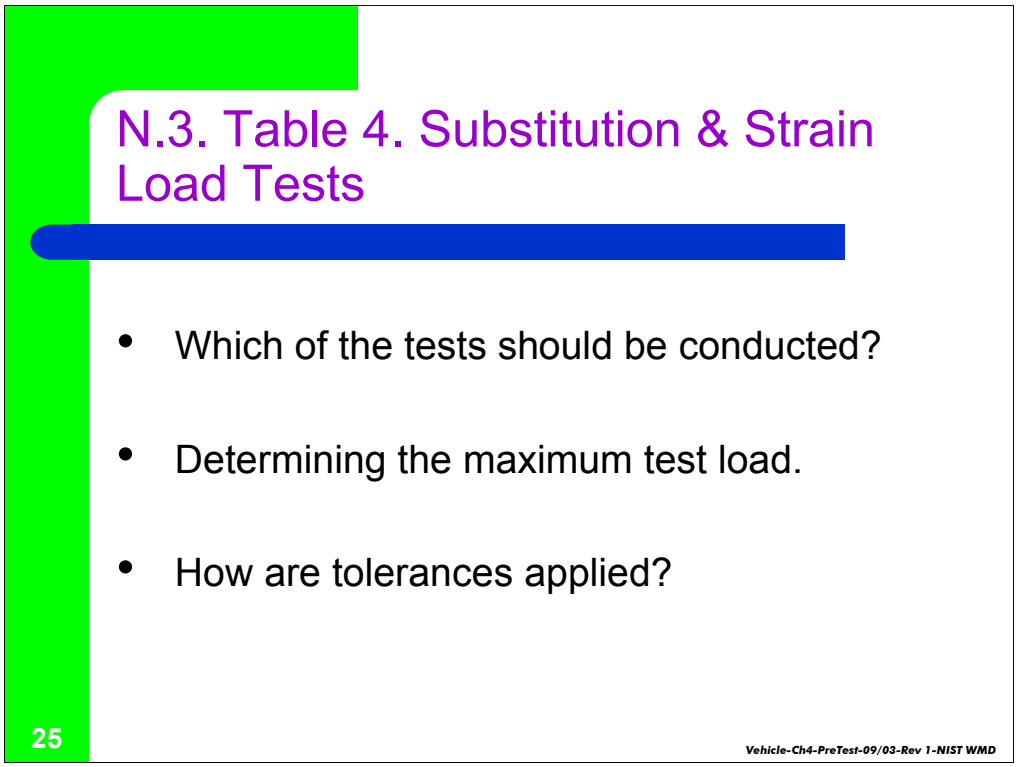
[1] If the amount of test weight in Table 4 combined with the load on the scale would result in an unsafe condition, then the appropriate load will be determined by the official with statutory authority.

[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)



Review the information on the Table. Describe the differences between substitution testing and strain-load testing. Explain why footnote 2 limits the number of substitution tests to three after which the tolerances for strain load tests are applied. (It is because of the inherent error that results from using the scale under test to adjust the weight of substituted material to an accuracy that then enables that material to be used as a known standard. Each time a substitution takes place, more error is built into the test procedure.)




Describe the necessary equipment needed to conduct a substitution and strain load test. Describe the means for determining the used capacity of a vehicle and axle-load scale. Describe how the tolerances are applied differently to a strain load v. substitution test.

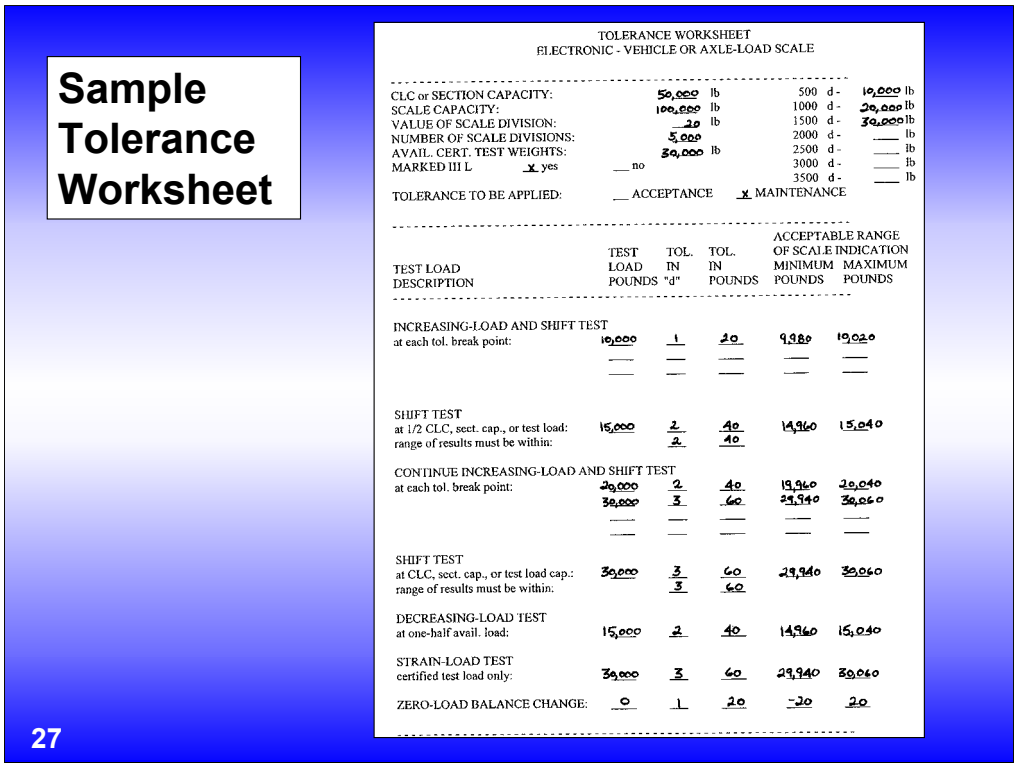
## Tolerance Worksheets

- 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



The use of tolerance worksheets is optional. Explain the benefits of using the worksheets when performing tests on vehicle and axle-load scales.

# Sample Tolerance Worksheet



TOLERANCE WORKSHEET
ELECTRONIC - VEHICLE OR AXLE-LOAD SCALE

| | | | | |
|---|---|---|---|---|
| CLC or SECTION CAPACITY: | 50,000 lb | 500 d - | 10,000 lb |
| SCALE CAPACITY: | 100,000 lb | 1000 d - | 20,000 lb |
| VALUE OF SCALE DIVISION: | 20 lb | 1500 d - | 30,000 lb |
| NUMBER OF SCALE DIVISIONS: | 5,000 | 2000 d - | ____ lb |
| AVAIL. CERT. TEST WEIGHTS: | 30,000 lb | 2500 d - | ____ lb |
| MARKED III L x yes | __ no | 3000 d - | ____ lb |
| | | 3500 d - | ____ lb |

TOLERANCE TO BE APPLIED: __ ACCEPTANCE x MAINTENANCE

| TEST LOAD DESCRIPTION | TEST LOAD POUNDS | TOL. IN "d" | TOL. IN POUNDS | ACCEPTABLE RANGE OF SCALE INDICATION MINIMUM POUNDS | MAXIMUM POUNDS |
|---|---|---|---|---|---|
| INCREASING-LOAD AND SHIFT TEST at each tol. break point: | 10,000 | 1 | 20 | 9,980 | 10,020 |
| | ____ | ____ | ____ | ____ | ____ |
| | ____ | ____ | ____ | ____ | ____ |
| SHIFT TEST at 1/2 CLC, sect. cap., or test load: | 15,000 | 2 | 40 | 14,960 | 15,040 |
| range of results must be within: | | 2 | 40 | | |
| CONTINUE INCREASING-LOAD AND SHIFT TEST at each tol. break point: | 20,000 | 2 | 40 | 19,960 | 20,040 |
| | 30,000 | 3 | 60 | 29,940 | 30,060 |
| | ____ | ____ | ____ | ____ | ____ |
| | ____ | ____ | ____ | ____ | ____ |
| SHIFT TEST at CLC, sect. cap., or test load cap.: | 30,000 | 3 | 60 | 29,940 | 30,060 |
| range of results must be within: | | 3 | 60 | | |
| DECREASING-LOAD TEST at one-half avail. load: | 15,000 | 2 | 40 | 14,960 | 15,040 |
| STRAIN-LOAD TEST certified test load only: | 30,000 | 3 | 60 | 29,940 | 30,060 |
| ZERO-LOAD BALANCE CHANGE: | 0 | 1 | 20 | -20 | 20 |



Handout of tolerance worksheet is a part of course material. Describe how to complete the worksheet for a digital vehicle scale as shown. Describe how to complete the worksheet for a beam vehicle scale. Describe how the worksheet is used when performing a test on the scales.