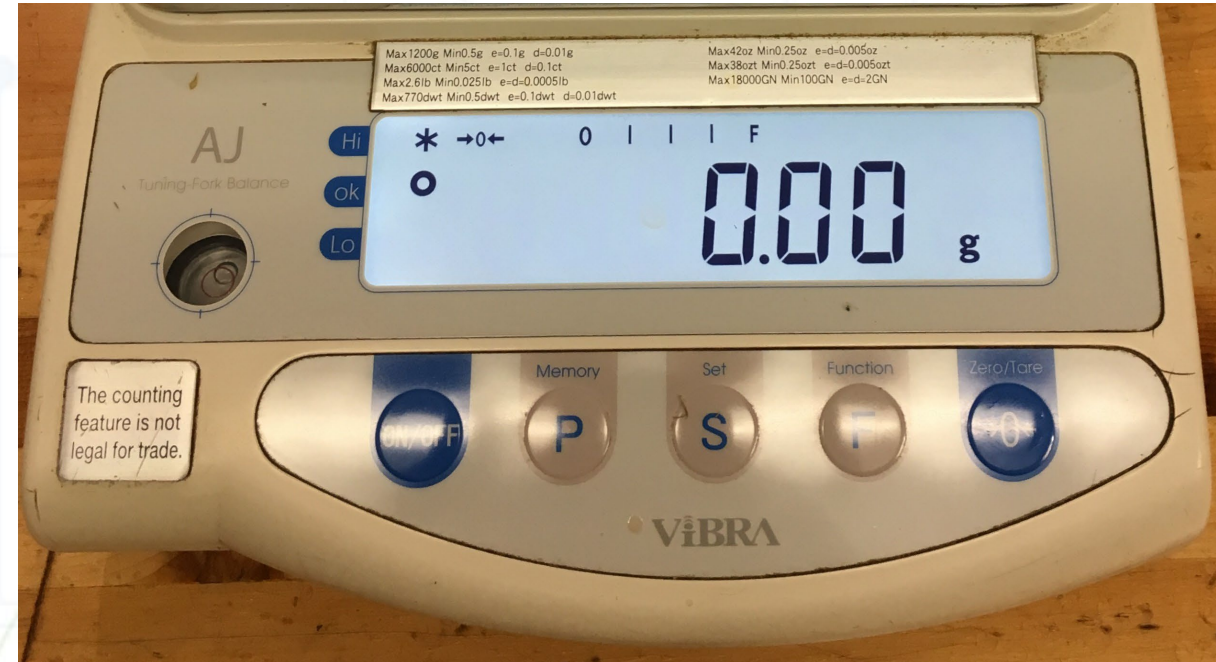
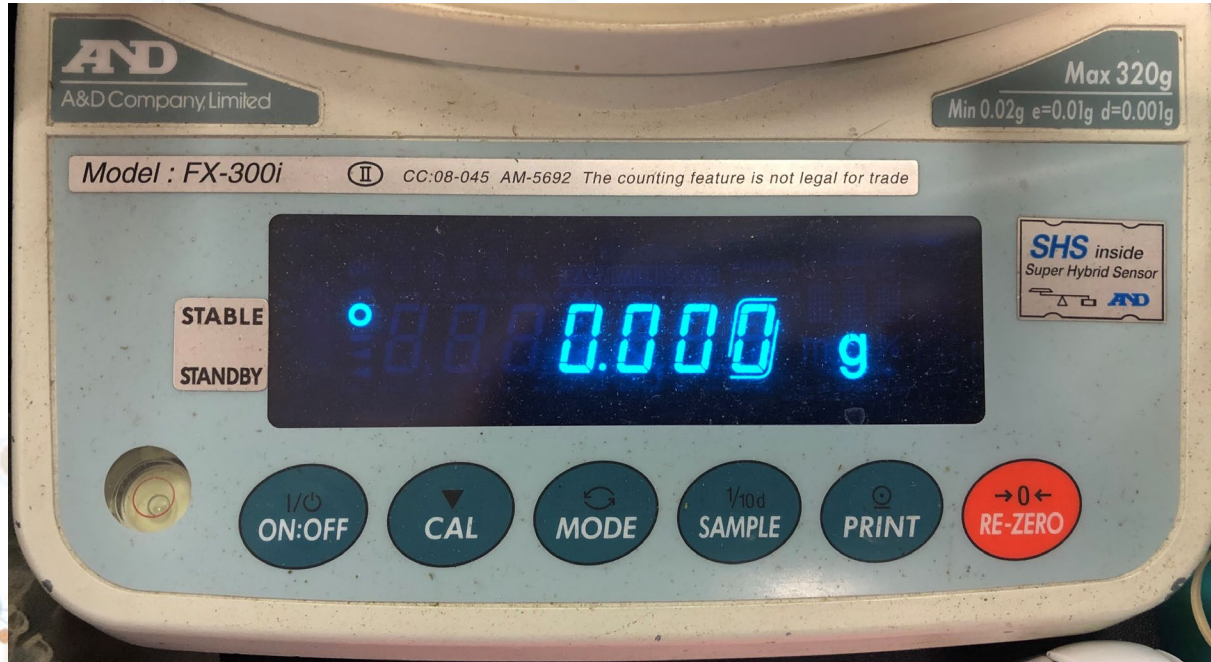


# Precision Scale Overview



Photos courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards



# Module 1

## Introduction

Certain commercial equipment or instruments are identified in this **presentation** for illustration purposes only. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the equipment **or instruments** identified are necessarily the best available for the purpose."



# Course Objective

- Properly interpret and apply NIST Handbook 44 requirements applicable to Class I & II scales





# Learning Objectives

- Differentiate between the Verification Scale Division (e) and the Scale Division (d)
- Identify how e & d are marked and recognize how they must be displayed
- Identify which classification of field standards are appropriate and recognize how to use them correctly



# Learning Objectives

- Properly apply Class I & II tolerances and,
- Explain suitability criteria and be able to apply them to determine proper scale selection



# Class I & II Scale - Applications



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# Class I & II Scale - Applications



ground chili



oregano



mix of peppers



parsley



poppy seeds



paprika

# Poll Question

What application for Class I or Class II scales are you most familiar with?

- a. Determining dockage/test weight
- b. Used to determine the value of jewelry for “scrap”, sale, trade-in, or loan
- c. Prescription Scales (compounding or counting)
- d. Loose leaf herbs, loose leaf teas, and bulk spices
- e. Cannabis
- f. Other applications





## Module 2

### Verification Scale Division (e)

### Scale Division (d)



# Learning Objectives

- Differentiate between the Verification Scale Division (e) and the Scale Division (d)
- Identify how e & d are marked and recognize how they must be displayed



# Verification Scale Division (e)/Scale Division (d)

Most scales encountered in commerce have an e that is equal to d

- Retail Computing Scales
- Vehicle Scales
- Floor Scales

Exceptions

- Class I & II Scales
- Dynamic Monorail Scales
- Weight Classifiers





## Verification Scale Division (e)/Scale Division (d)

Many Class I and Class II scales are marked with a verification scale division (e) that differs from the actual scale division value (d).

How does this affect the application of NIST Handbook codes?

To begin to understand this we need to know what each represents and the relationship between them.



# Verification Scale Division (e)/Scale Division (d)

## HB 44 Definition: Verification Scale Division (e):

A value, expressed in units of weight and specified by the manufacturer of a device, by which the tolerance values and accuracy class applicable to the device are determined.



# Verification Scale Division (e)/Scale Division (d)

## HB 44 Definition: Scale Division (d):

The value of the scale division, expressed in units of mass, is the smallest subdivision of the scale for analog indication or the difference between two consecutively indicated or printed values for digital indication or printing.





# Verification Scale Division (e)/Scale Division (d)

## S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

- When (e) does not equal (d) they must conform to the expression

$$d < e \leq 10 d$$

- the value of (e) must satisfy the relationship  $e=10^k$  of the unit of measure
  - k can be a positive or negative whole number or zero
- the value of (d) must be a decimal submultiple of (e) and the ratio must be  $\leq 10:1$



# Verification Scale Division (e)

## S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

What does “the value of (e) must satisfy the relationship  $e=10^k$  of the unit of measure” mean? It means e must be a whole or decimal unit of 1

<u>When k equals</u>	<u>e is displayed as:</u>
<b>-3</b> is expressed as: $(10^{-3})$	<b>0.001</b>
<b>-2</b> is expressed as: $(10^{-2})$	<b>0.01</b>
<b>-1</b> is expressed as: $(10^{-1})$	<b>0.1</b>
<b>0</b> is expressed as: $(10^0)$	<b>1</b>
<b>1</b> is expressed as: $(10^1)$	<b>10</b>
<b>2</b> is expressed as: $(10^2)$	<b>100</b>
<b>3</b> is expressed as: $(10^3)$	<b>1 000</b>



# Scale Division (d)

## S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

When e is a whole or decimal unit of 1, what are acceptable values of d?

$$d < e \leq 10 d$$

<b>When e is:</b>	<b><u>d can be</u></b>		
<b>0.001</b>	<b>0.0001</b>	<b>0.0002</b>	<b>0.0005</b>
<b>0.01</b>	<b>0.001</b>	<b>0.002</b>	<b>0.005</b>
<b>0.1</b>	<b>0.01</b>	<b>0.02</b>	<b>0.05</b>
<b>1</b>	<b>0.1</b>	<b>0.2</b>	<b>0.5</b>
<b>10</b>	<b>1</b>	<b>2</b>	<b>5</b>
<b>100</b>	<b>10</b>	<b>20</b>	<b>50</b>
<b>1 000</b>	<b>100</b>	<b>200</b>	<b>500</b>





# Verification Scale Division (e)/Scale Division (d)

## S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

### Exceptions

- The value of (e) and (d) must be equal on multi-interval and multiple range scales
- A Class I device with  $e = 1 \text{ mg}$  ( $0.001 \text{ g}$ ) can have a  $d < 1 \text{ mg}$  and can exceed the 10:1 ratio of d to e, for example a Class I scale could be configured with an  $e = 0.001 \text{ g}$  and  $d = 0.00002 \text{ g}$ , a 50:1 ratio



## Verification Scale Division (e)/Scale Division (d)

### S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

For Class I & II scales where  $e \neq d$

When both values are continuously displayed during normal operation:

- “d” resolution must be differentiated from the “e” value by size, shape, color, etc. throughout the range of “d”

The “d” resolution makes possible the reading of a scale between increments of “e”



# Verification Scale Division (e)/Scale Division (d)

## S.1.2.2.1. Class I and II Scales and Dynamic Monorail Scales.

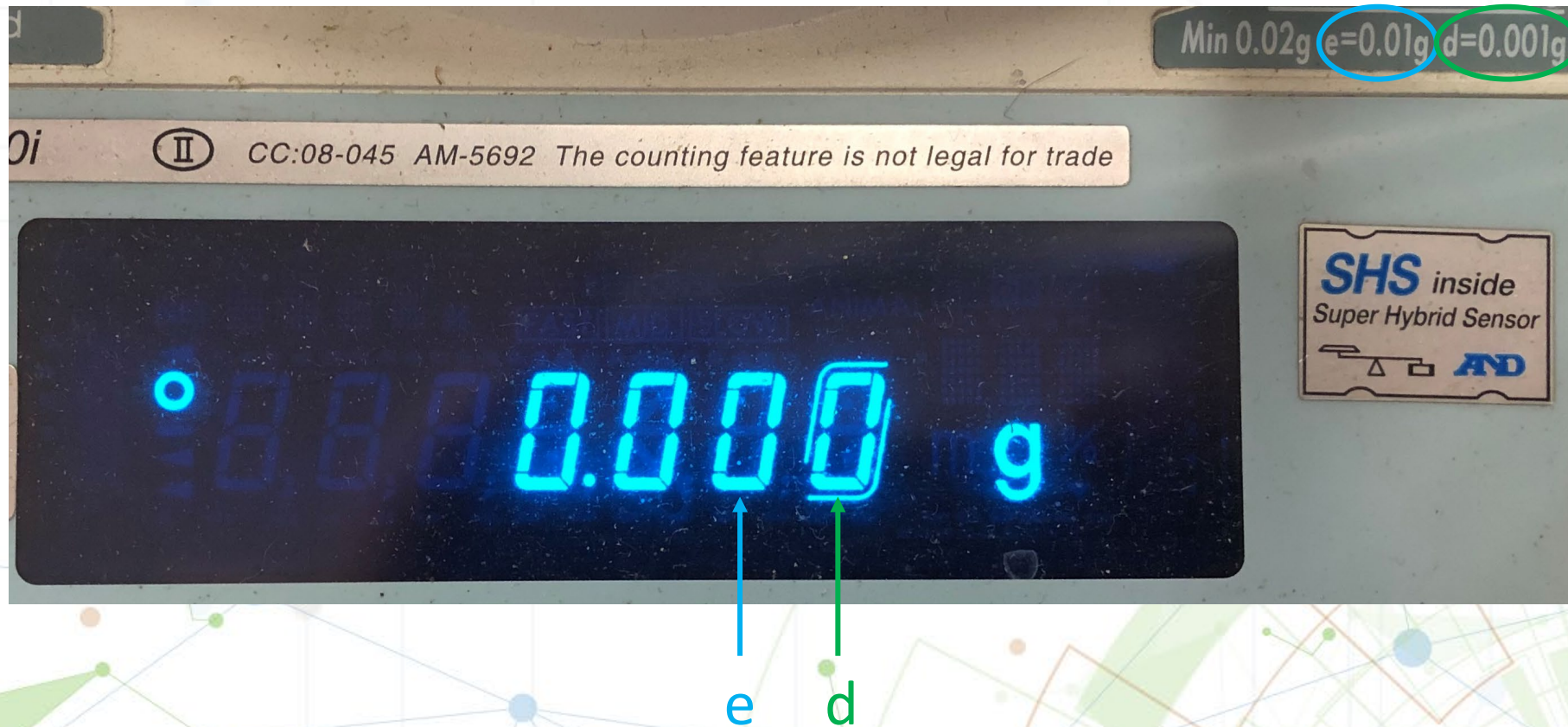


Photos courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards

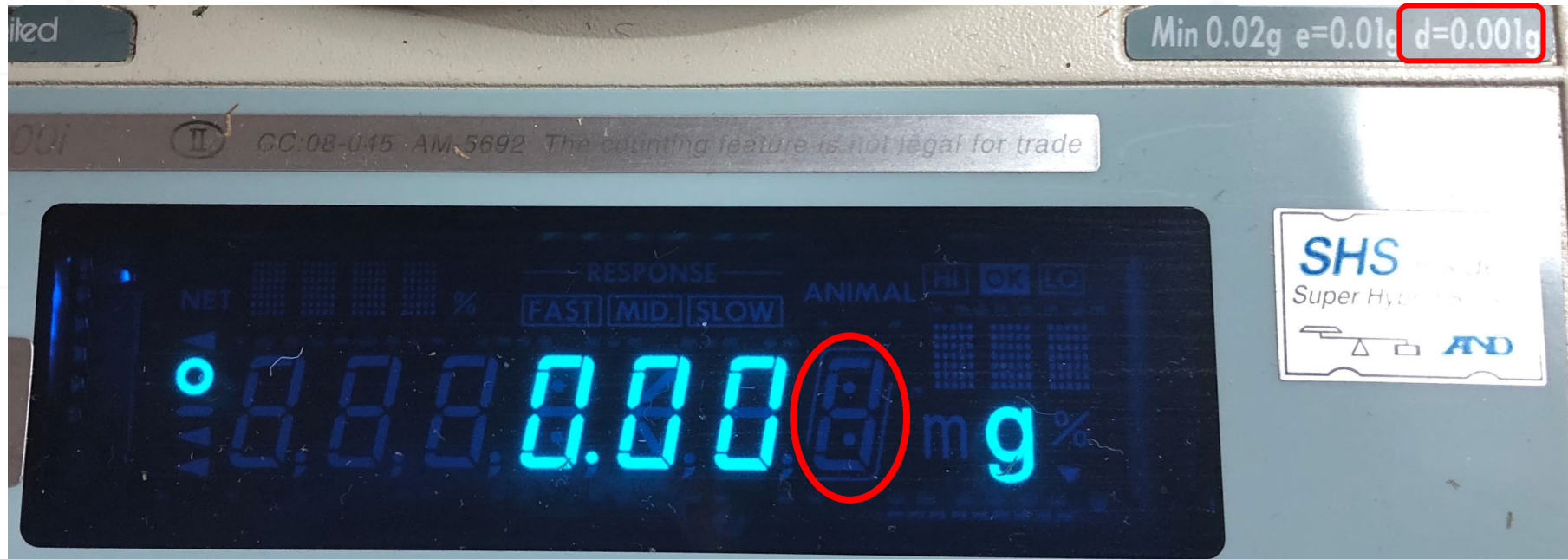




# Verification Scale Division (e)/Scale Division (d)



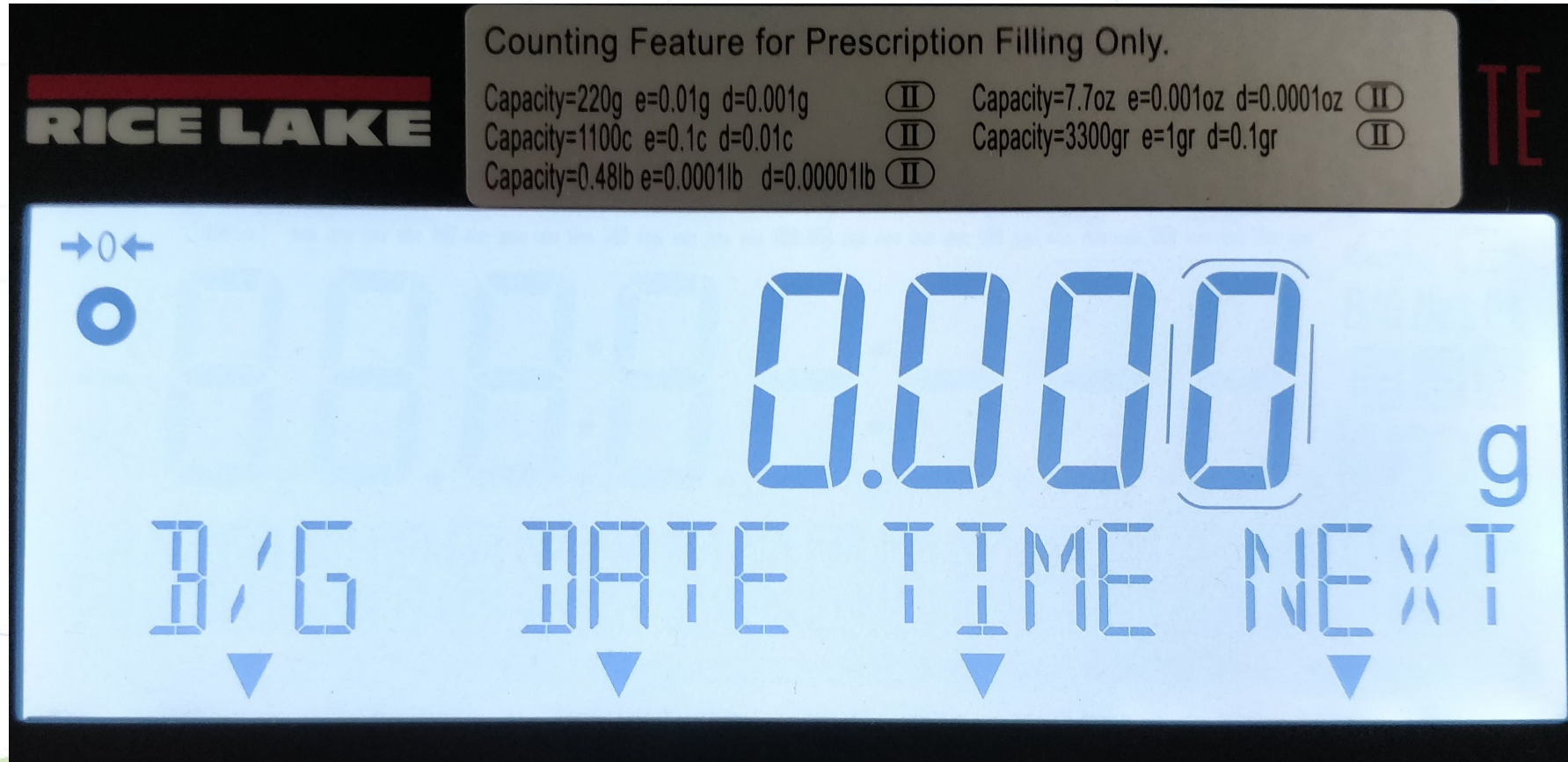
## Verification Scale Division (e)/Scale Division (d)



G-S.5.2.2. Digital Indication and Representation. – Digital elements shall be so designed that:  
*(d) A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left.*  
[Nonretroactive as of January 1, 1986]

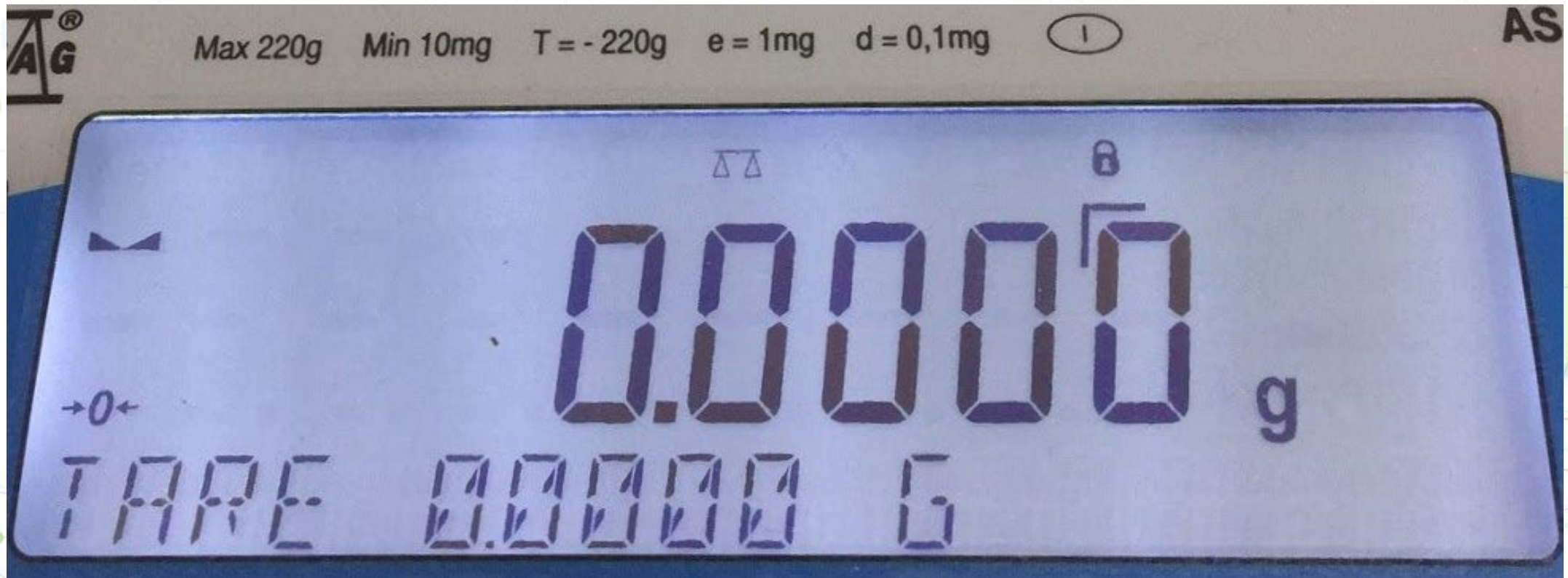


# Verification Scale Division (e)/Scale Division (d)





# Verification Scale Division (e)/Scale Division (d)



Photos courtesy of the Oregon Dept. of Ag., Div. of Weights & Measures



## Module 2 Summary

When  $e \neq d$ :

- $e=10^k$  means  $e$  must be a whole or decimal unit of 1 (100, 10, 1, 0.1, 0.001, etc.)
- $d < e$  and can't have a ratio of more than 10:1\*
- $d$  must be differentiated when displayed with  $e$

\*Class I scales with an  $e = 1$  mg are the exception.



# Poll Question

On a class II scale, which of these configurations is acceptable (select all that apply):

- a.  $e = 1 \text{ g}$   $d = 0.01 \text{ g}$
- b.  $e = 0.2 \text{ g}$   $d = 0.02 \text{ g}$
- c.  $e = 10 \text{ g}$   $d = 2 \text{ g}$
- d.  $e = 0.01 \text{ g}$   $d = 0.005 \text{ g}$





## Module 3

### Field Standard Test Weights

### Classification and Handling

### Class I and Class II Scales



# Learning Objectives

- Recognize the different field standard test weight classifications
- Identify the appropriate field standard test weight classification for testing Class I & II scales in compliance with NIST HB 44 Scales Code paragraph N.2. Verification (Testing) Standards.
- Describe how to properly handle standards used to test Accuracy Class I & II scales to ensure accuracy
- Describe some variables that can affect the accuracy of your test weights



## N.2. Verification (Testing) Standards.

- Requires field standard weights to comply with:
  - NIST Handbook 105-1 Series standards
  - other suitable and designated standards
  - or the tolerances expressed in Appendix A, Fundamental Considerations, paragraph 3.2. Tolerances for Standards





# NIST Handbook 105-1

## Specifications and Tolerances for Field Standard Weights

- Updated in 2019 due to increased use of Class I and II scales in commerce
  - Tolerances for NIST Class F test weights too great to use on Class I and II scales
  - Directs the user to a much broader choice of mass standards with appropriate tolerances
  - Proper selection ensures compliance with NIST Handbook 44 Appendix A Fundamental Considerations



# NIST Handbook 105-1

- It is the responsibility of the field official or service agent to verify that the maximum permissible errors of weights used for a specific test comply with the requirements of the Fundamental Considerations as published in NIST Handbook 44.
- The suitability evaluation of field standards is typically performed for loads at the top of each tolerance window (tolerance breakpoints) as those test loads have the most stringent requirement.
- The specifications and tolerances identified herein are intended to permit the use of the equipment in normal field-testing operations as standards having nominal values.



# Field Standard Weight Classifications

- NIST HB 105-1
  - Class F-standards placed in service prior to 1/1/20 can still be calibrated
- ASTM E617
  - 1, 2, 3, 4, 5, & 6
- OIML R 111
  - $E_1$ ,  $E_2$ ,  $F_1$ ,  $F_2$ ,  $M_1$ ,  $M_{1-2}$ ,  $M_2$ ,  $M_{2-3}$  and  $M_3$





# Proper Selection

Accuracy Class Scale to be Tested	Mass Standards Required
Class I Scales	OIML E <sub>2</sub> , ASTM 1, or standards of greater accuracy
Class II Scales	OIML F <sub>2</sub> , ASTM 2, or standards of greater accuracy
Class III Scales	NIST Class F, ASTM 6, or OIML M <sub>2</sub> , or standards of greater accuracy
Unmarked scales	Use standards of the proper level of accuracy that comply with NIST Handbook 44 Fundamental Consideration



# Field Standard Weight Classifications

- For example, when testing a Class II scale with an  $e=0.01$  g a test load of 5 000 e is 50 g
- Maintenance tolerance is  $\pm 1 e$  or  $\pm 0.01$  g (10 mg) and acceptance tolerance is  $\pm 0.5 e$  or  $\pm 0.005$  g (5 mg).
- A 50 g test weight would need to have an error and uncertainty of less than
  - 3.333 mg when applying maintenance tolerance
  - 1.667 mg when applying acceptance tolerance

ASTM	MPE	OIML	MPE
50 g Class 1	0.12 mg	50 g Class E <sub>2</sub>	0.10 mg
50 g Class 2	0.25 mg	50 g Class F <sub>1</sub>	0.30 mg
50 g Class 3	0.60 mg	50 g Class F <sub>2</sub>	1.0 mg
50 g Class 4	1.2 mg	50 g Class M <sub>1</sub>	3.0 mg

MPE stands for Maximum Permissible Error



# Field Standard Weight Classifications

- Continuing the example, when testing a Class II scale with an  $e=0.01$  g a test load of 20 000 e is 200 g
- Maintenance tolerance is  $\pm 2 e$  or  $\pm 0.02$  g (20 mg) and acceptance tolerance is  $\pm 1 e$  or  $\pm 0.01$  g (10 mg).
- A 200 g test weight would need to have an error and uncertainty of less than
  - 6.667 mg when applying maintenance tolerance
  - 3.333 mg when applying acceptance tolerance

ASTM	MPE	OIML	MPE
200 g Class 1	0.5 mg	200 g Class E <sub>2</sub>	0.3 mg
200 g Class 2	1.0 mg	200 g Class F <sub>1</sub>	1.0 mg
200 g Class 3	2.0 mg	200 g Class F <sub>2</sub>	3.0 mg
<b>200 g Class 4</b>	<b>4.0 mg</b>	<b>200 g Class M<sub>1</sub></b>	<b>10 mg</b>





## Field Standard Test Weights Classification Summary

- NIST Class F test weights are not suitable to test Class I and II scales
- ASTM E617 & OIML R-111 have classifications that are appropriate
- MPE and uncertainty of test weights must be less than  $1/3$  applicable device tolerance



# Calibration Certificates

- Issued by the lab that calibrated the weights
- Those who use these standards should be familiar with the information on the certificate
- Should be kept with field standards for reference
- Can be referenced to ensure proper selection for a particular device



# Handling of Field Standard Test Weights

- MPE is very small (tenths of a mg)
- Small amounts of oil (hands), spilled product, dust, or moisture can affect test results as well as environmental factors
- Special care is required when handling precision standards





## Handling of Field Standard Test Weights

- Wear gloves and use special tools and materials when handling precision standards.



# Handling of Field Standard Test Weights

- Always wear gloves
  - Even with tools, forceps and lifting equipment
  - Reduces chance of touching weight

- Gloves
  - Lint Free
  - Powder Free



## Handling of Field Standard Test Weights

- Never contaminate the standards by placing them on dirty surfaces.





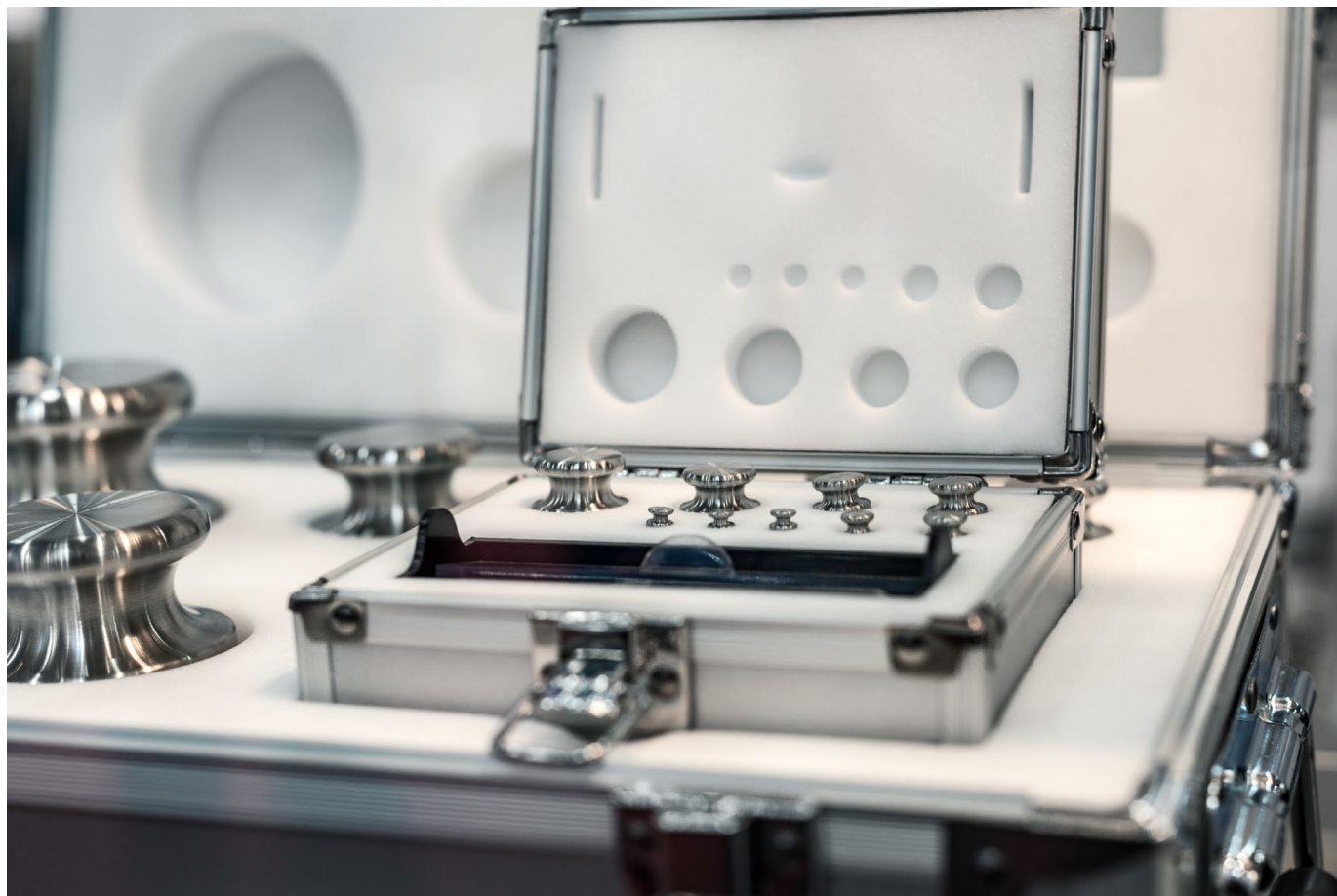
# Handling of Field Standard Test Weights

- Temperature
  - Do not store in vehicle when not in use (overnight/weekends)
  - Allow to acclimate with environment were used when possible



# Handling of Field Standard Test Weights

- Cases
  - Well sealed to prevent dust & moisture
  - Weights should fit securely in case



# Handling of Field Standard Test Weights

- Avoid stacking if possible
- If weights must be stacked:
  - Use extra caution when placing and removing
  - Distribute weight as evenly as possible while centering on platter





# Handling of Field Standard Test Weights Summary

- Equipment

- Gloves
- Handling tools
- Filter paper

- Storage

- Proper case
- Climate controlled

- Use

- Acclimation
- Avoid stacking





# Poll Question

NIST Class F test weights are suitable for which of the following class of scale? (select all that apply):

- a. Class I
- b. Class II
- c. Class III
- d. Class III L
- e. Class IIII



# Module 4

## Tolerance Application

### Verification Scale Division (e)

### Scale Division (d)



# Learning Objectives

- Recognize how to:
  - interpret Table 6 and
  - apply tolerance when  $e \neq d$



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

In the Scales Code, Table 6 specifies the Maintenance tolerance applied to scales. The table uses the term scale division in two places.

Table 6. Maintenance Tolerances (All values in this table are in <b>scale divisions</b> )				
Tolerance in <b>Scale Divisions</b>				
	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 1 d for each additional 500 d or fraction thereof)	





# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

HB 44 Definitions:

scale division, value of (d). – The value of the scale division, expressed in units of mass, is the smallest subdivision of the scale for analog indication or the difference between two consecutively indicated or printed values for digital indication or printing. (Also see “verification scale division.”)

verification scale division (e): a value, expressed in units of weight and specified by the manufacturer of a device, by which the **tolerance values** and accuracy class applicable to the device are determined.



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

Based on these definitions, when  $e \neq d$ , the values in Table 6 are verification scales divisions.

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

**Tolerance in Scale Divisions**

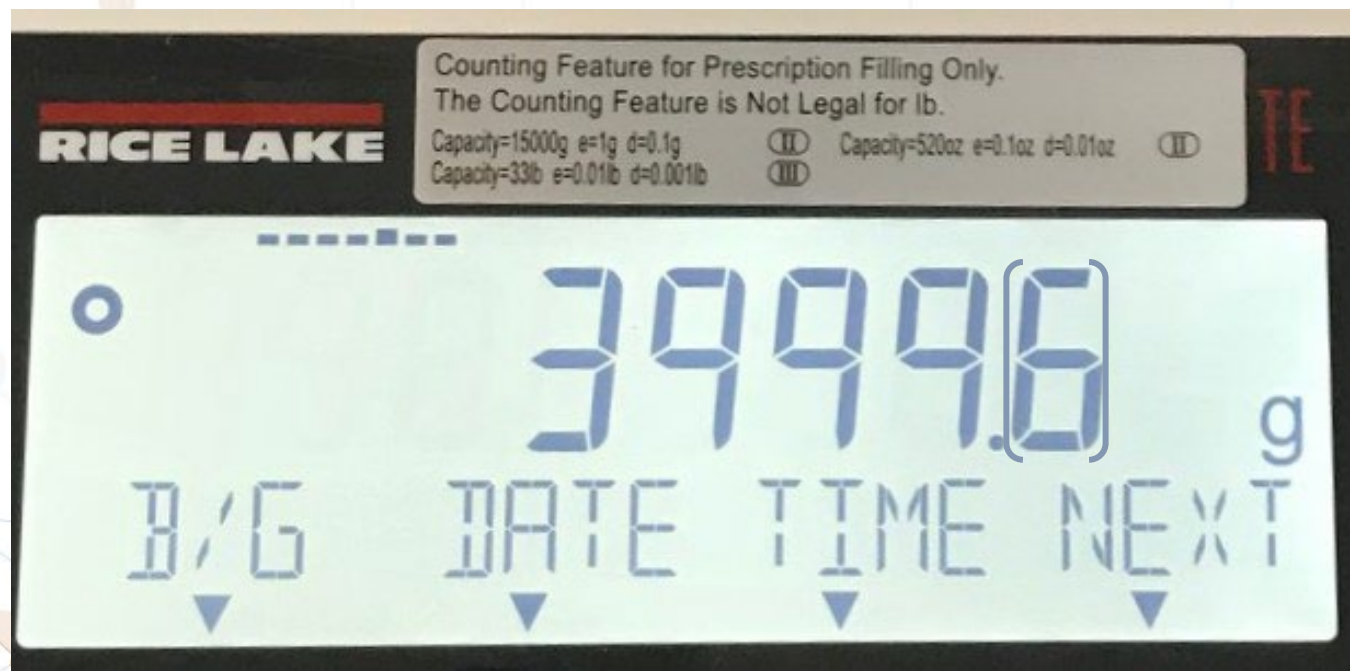
	1	2	3	5
Class	Test Load			
I	0 - 50 000	50 001 - 200 000	200 001 +	
II	0 - 5 000	5 001 - 20 000	20 001 +	
III	0 - 500	501 - 2 000	2 001 - 4 000	4 001 +
IIII	0 - 50	51 - 200	201 - 400	401 +
III L	0 - 500	501 - 1 000	(Add 1 d for each additional 500 d or fraction thereof)	



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



Think of  $d$  as a decimal of  $e$ . In this case  $e=1$  g and  $d=0.1$  g.

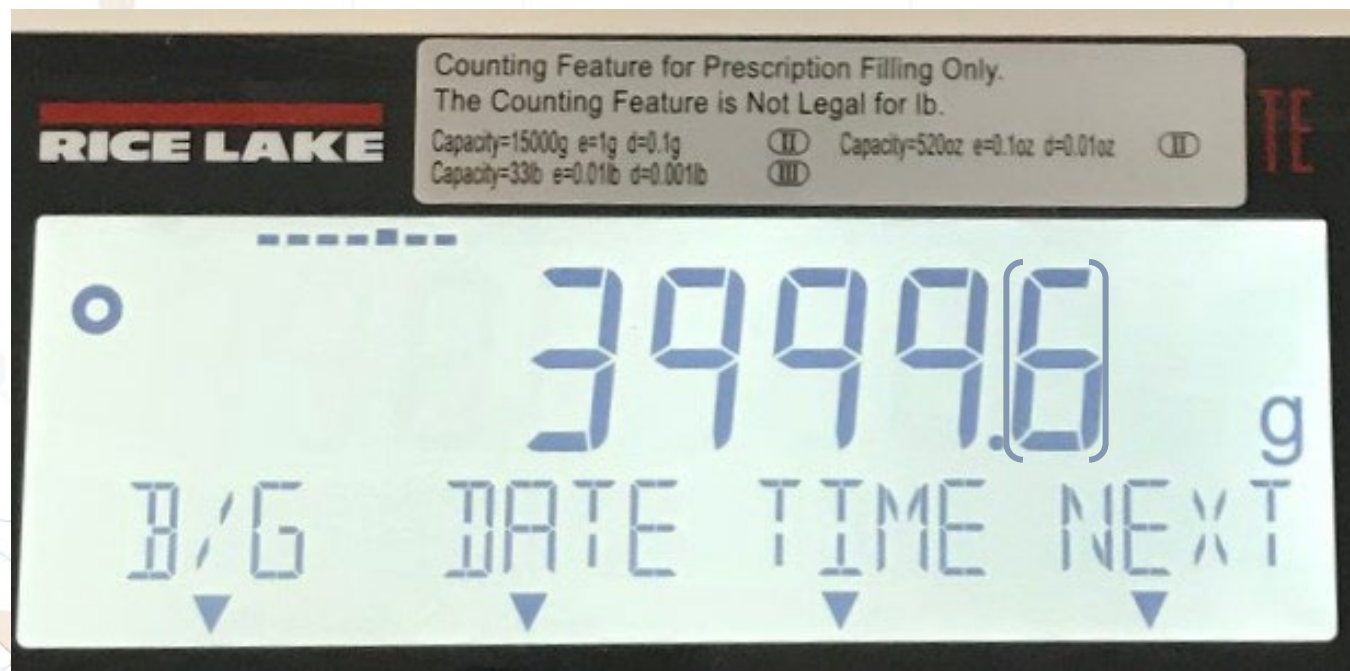
Assuming a test load of 4000 g is applied, the error is -0.4 g



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



A test load of 4000 g equates to 4000 e ( $4000 \text{ g} \div 1 \text{ g}$ ).

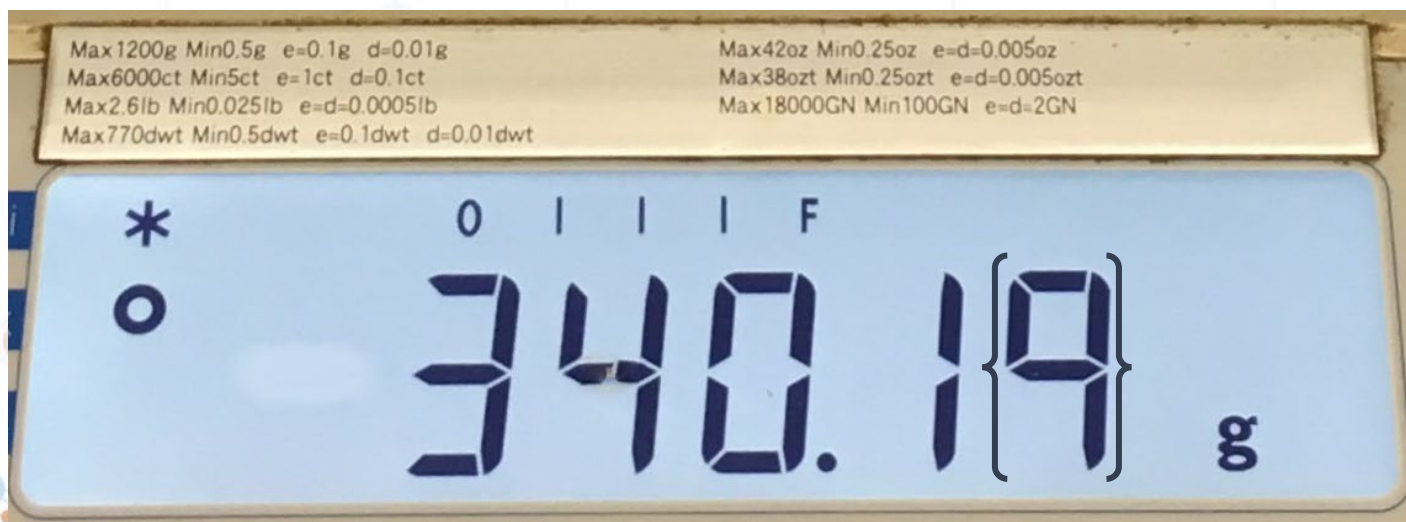
The error is -0.4 g or -0.4 e ( $0.4 \text{ g} \div 1 \text{ g}$ )

For a Class II scale, maintenance tolerance is +/- 1.0 e and acceptance tolerance is 0.5 e.

# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



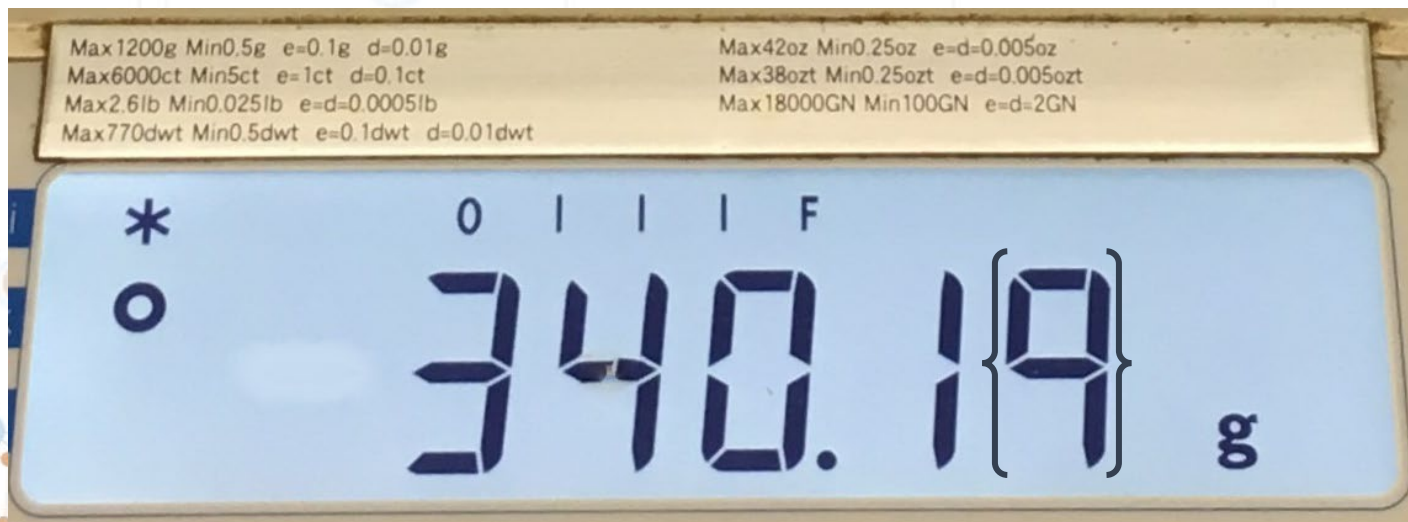
Here's another example.

In this case  $e=0.1$  g and  $d=0.01$  g.  
Assuming a test load of 340 g is applied, the error is +0.19 g

# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



A test load of 340 g equates to 3400 e ( $340 \text{ g} \div 0.1 \text{ g}$ ).

The error is +0.19 g or +1.9 e ( $0.19 \text{ g} \div 0.1 \text{ g}$ )

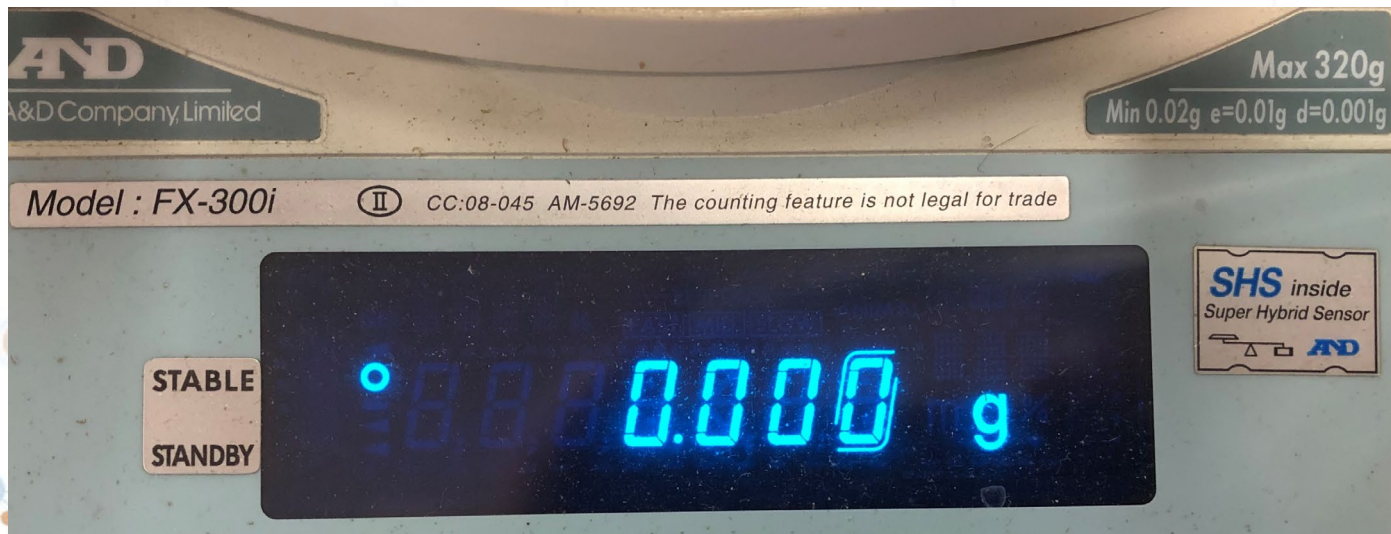
For a Class II scale, maintenance tolerance is +/- 1.0 e and acceptance tolerance is 0.5 e.



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



Here's another example.

Here  $e=0.01$  g and  $d=0.001$  g.

If a test load of 200 g is applied, how many verification scale divisions does that represent?

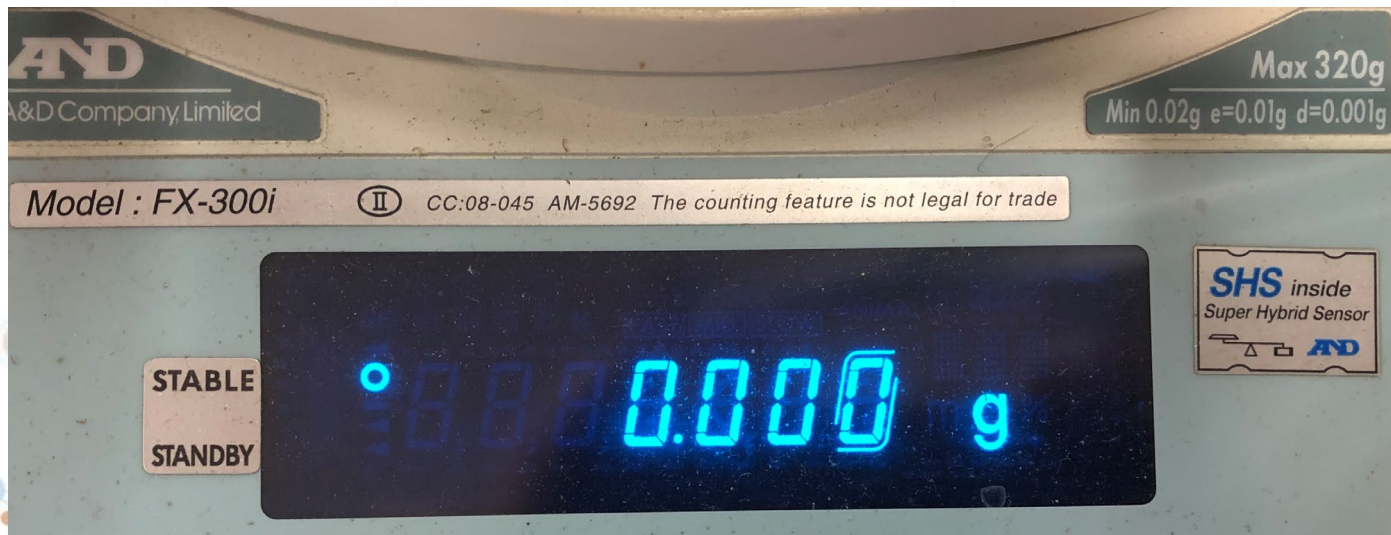
$$200 \text{ g} \div 0.01 \text{ g} = 20\,000 \text{ e}$$



# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



If the scale displays 200.022 g with a test load of 200 g applied, what is the error in e?

$$0.022 \text{ g} \div 0.01 \text{ g} = 2.2 \text{ e}$$

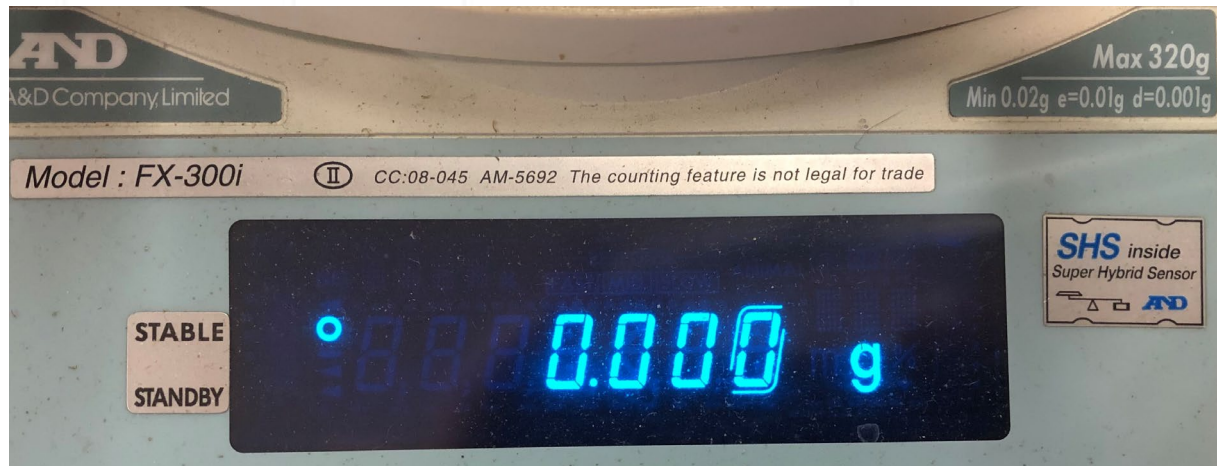




# Tolerance Application

## Verification Scale Division (e) Scale Division (d)

How are indications interpreted when  $e \neq d$ ?



If the scale displays 200.022 g with a test load of 200 g applied, is the scale in tolerance?

$$200 \text{ g} \div 0.01 \text{ g} = 20\,000 \text{ e}$$

$$0.022 \text{ g} \div 0.01 \text{ g} = 2.2 \text{ e}$$

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 +	



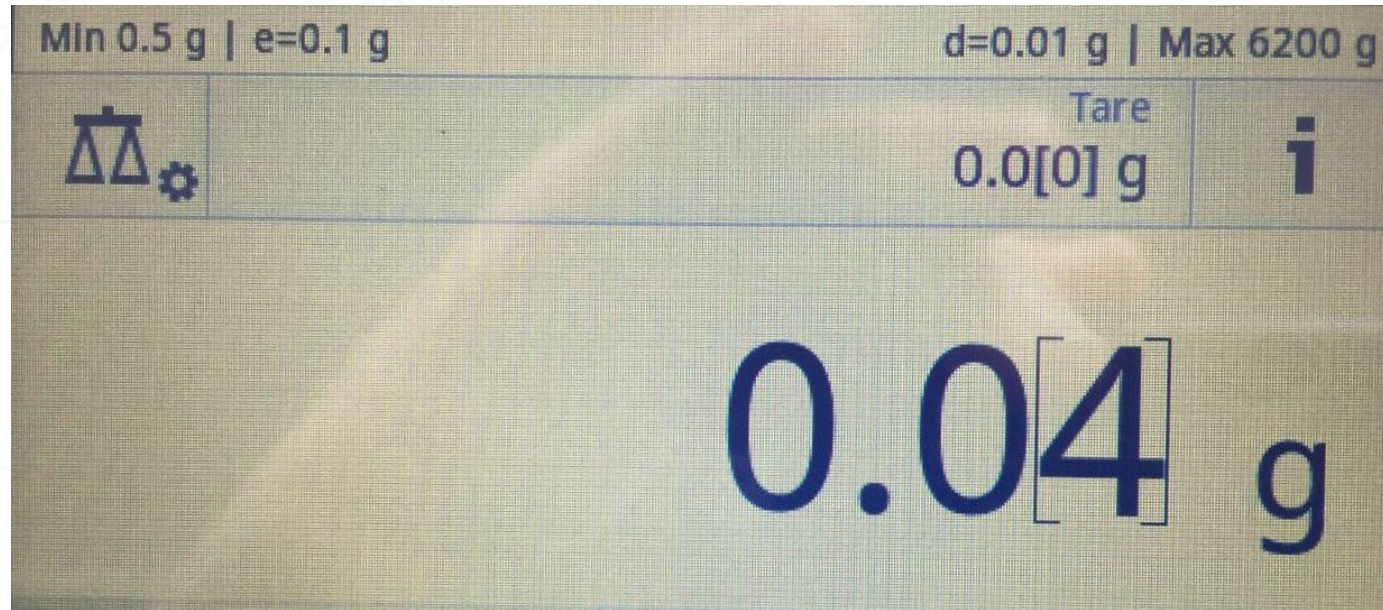
## Module 4 Summary

- Tolerance is based on the value of  $e$
- When interpreting errors,  $d$  is a subpart of  $e$





# Poll Question



The weight indication pictured above is equivalent to?

- a. 40 e
- b. 4 e
- c. 0.4 e
- d. 0.04 e



# Module 5

## Testing

### Verification Scale Division (e)

### Scale Division (d)



# Learning Objectives

- Recognize the minimum test specified in the Scales Code
- Determine the correct test load to apply when  $e \neq d$





# Tests and Compliance Verification

- Minimum Tests
  - Increasing Load Test (N.1.1.)
  - Decreasing Load Test (N.1.2.)
  - Shift Test (N.1.3.7.)
  - Zero-Load Balance Change (N.1.9.)
  - **Discrimination Test (N.1.5.)\***
  - **RFI Susceptibility Tests (N.1.6.)\*\***

\*Conducted under controlled conditions, typically not done in the field.

\*\*Conducted when RFI is present in the environment.





# Tests and Compliance Verification

- Other “Tests”
  - Capacity Indication (S.1.7.)
    - (a) 105 %
    - *(b) 9 d - electronic computing scales only (NR 1/1/1993)*
  - Repeatability (G-S.5.4. & T.N.5.)
    - May be verified during each inspection
    - Must be verified when an issue is suspected



# Test Load Application

- Tolerance is based on the value of  $e$
- Test Loads are based on  $e$



# Test Load Application-Increasing Load Test (N.1.1.)

- N.1.1. specifies that the increasing load test:
  - Shall be conducted on all scales
  - Test loads are approximately centered on the load-receiving element
  - Does not specify value of test loads
- Table 4 specifies testing to capacity ( $\leq 300$  lb or 150 kg)



# Test Load Application-Increasing Load Test (N.1.1.)

- Begin the test at the Recommended Minimum Load

UR.3.1. Recommended Minimum Load. – A recommended minimum load is specified in Table 8. Recommended Minimum Load since **the use of a device to weigh light loads** is likely to **result in relatively large errors**.

**Table 8**  
**Recommended Minimum Load**

Class	Value of Scale Division (d or e*)	Recommended Minimum Load (d or e*)
I	$\geq 0.001$ g	100
II	0.001 g to 0.05 g	20
II	$\geq 0.1$ g	50

\*For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape or color), the value of the verification scale division “e” is the value of the scale division immediately preceding the auxiliary means.





# Test Load Application-Increasing Load Test (N.1.1.)

- Test at several points in each tolerance range and at each “tolerance breakpoint”
- For Class I:
  - Consider increasing by 10 000 e increments
  - Include test loads at:
    - 100 d ( $e = d$ ) or 100 e ( $e \neq d$ )
    - 50 000 e
    - 200 000 e
    - Capacity



# Test Load Application-Increasing Load Test (N.1.1.)

- Test at several points in each tolerance range and at each “tolerance breakpoint”
- For Class II were  $e = d$  between 0.001 g and 0.05 g :
  - Consider increasing by 1 000 e increments
  - Include test loads at:
    - 20 d
    - 5 000 e
    - 20 000 e
    - Capacity



## Test Load Application-Increasing Load Test (N.1.1.)

- Test at several points in each tolerance range and at each “tolerance breakpoint”
- For Class II where  $e \neq d$  and  $e$  between 0.001 g and 0.05 g :
  - Consider increasing by 1 000  $e$  increments
  - Include test loads at:
    - 20  $e$
    - 5 000  $e$
    - 20 000  $e$
    - Capacity



## Test Load Application-Increasing Load Test (N.1.1.)

- Test at several points in each tolerance range and at each “tolerance breakpoint”
- For Class II where  $e = d$  and are  $\geq 0.1$  g :
  - Consider increasing by 1 000 e increments
  - Include test loads at:
    - 50 d
    - 5 000 e
    - 20 000 e
    - Capacity





# Test Load Application-Increasing Load Test (N.1.1.)

- Test at several points in each tolerance range and at each “tolerance breakpoint”
- For Class II where  $e \neq d$  and  $e \geq 0.1 \text{ g}$  :
  - Consider increasing by 1 000 e increments
  - Include test loads at:
    - 50 e
    - 5 000 e
    - 20 000 e
    - Capacity



# Compliance Verification-Capacity Indication (S.1.7.)

## S.1.7. Capacity Indication, Weight Ranges, and Unit Weights.

- (a) **Gross Capacity.** – An indicating or recording element shall not display nor record any values when the gross load (not counting the initial dead load that has been canceled by an initial zero-setting mechanism) is in excess of 105 % of scale capacity.
- (b) **Capacity Indication.** – **Electronic computing scales** (excluding postal scales and weight classifiers) shall record a gross or net weight in excess of scale capacity plus 9 d.

*[Nonretroactive as of January 1, 1993]*



# Compliance Verification-Capacity Indication (S.1.7.)

- To verify compliance with S.1.7. (a)
  - Calculate 105% of Capacity (Capacity x 1.05)
  - Add 1 d to the calculated value

For example, for a scale with a capacity of 620 g and  $e=0.1$  g/ $d=0.01$  g

$$620 \times 1.05 = 651 \text{ g}$$

$$651 \text{ g} + 0.01 \text{ g} = 651.01 \text{ g}$$

The scale should “blank out” or display an overload indication, e.g., - - - -, >>>>, etc. when the indication exceeds 651.01 g



# Compliance Verification-Capacity Indication (S.1.7.)

- To verify compliance with S.1.7. (b)
  - Multiply  $d$  by 9 and add to the capacity

For example, for a scale with a capacity of 620 g and  $e=0.1$  g/ $d=0.01$  g

$$9 \times 0.01 \text{ g} = 0.09 \text{ g}$$

$$620 \text{ g} + 0.09 \text{ g} = 620.09 \text{ g}$$

The scale should “blank out” or display an overload indication, e.g., - - - -, >>>>, etc. when the indication exceeds 620.09 g





# Test Load Application-Decreasing Load Test (N.1.2.)

- For scales with  $n < 1000$ , test at half capacity
- For scales with  $n \geq 1000$ , test at each “tolerance breakpoint”
  - For Class I at:
    - 200 000 e
    - 50 000 e
    - Zero
  - For Class II at:
    - 20 000 e
    - 5 000 e
    - Zero



## N.1.9. Zero-Load Balance Change.

N.1.9. Zero-Load Balance Change. – A zero-load balance change test shall be conducted on all scales after the removal of any test load. The zero-load balance should not change by more than the minimum tolerance applicable. (Also see G-UR.4.2. Abnormal Performance.)

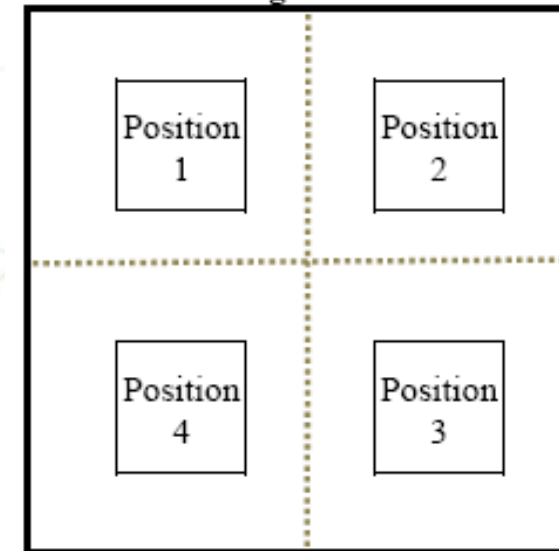
- Per Table 6, for both Class I and II scales maintenance tolerance is  $\pm 1 e$  at 0 (no test load applied)
- When the test load is removed, the scale must return to within :
  - $1 e$  of zero when applying maintenance tolerance
  - $0.5 e$  of zero when applying acceptance tolerance



# Test Load Application-Shift Test (N.1.3.7.)

- N.1.3.7. (a) - For scales with a capacity  $\leq 1000$  lb (500 kg)
  - Test at 1/3 capacity (30% - 35%)
  - Centered as nearly as possible at the center of each quadrant

Figure 1

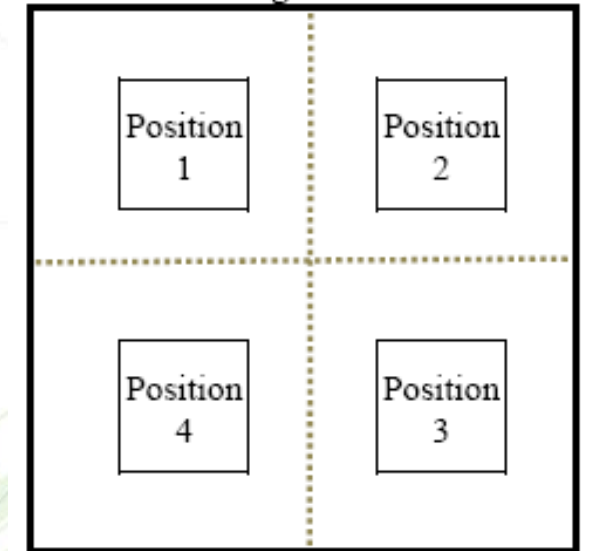


# Test Load Application-Shift Test Tolerance (T.N.4.4.)

**T.N.4.4. Shift or Section Tests.** – The range of the results obtained during the conduct of a shift test or a section test shall not exceed the absolute value of the maintenance tolerance applicable and each test result shall be within applicable tolerances.

- The range of results is always evaluated using maintenance tolerances
- The result from each position is evaluated using applicable tolerances

Figure 1





# Test Load Application-Shift Test Tolerance (T.N.4.4.)

- For example, on a Class II 620 g capacity scale with  $e=0.01$  g &  $d=0.001$  g installed within the last 10 days, the following results are obtained:

200.009, 200.002, 199.995, 199.992

- $200\text{ g}=20\,000\text{ e}$  ( $\pm 2\text{ e}$  maintenance tolerance)
- What are the individual errors in  $e$ ?

+0.9, +0.2, -0.5, -0.8

- What is the range?

$|+0.9 - (-0.8)| = 1.7$

- Does the scale pass the shift test?

Yes



# Compliance Verification-Repeatability (G-S.5.4. & T.N.5.)

- G-S.5.4. –Requires a device to be capable of repeating within specified tolerances
- T.N.5. –Specifies tolerance application similar to the shift test
- Conducting a Repeatability Test
  - The repeatability test can be conducted with any test load normally applied during testing.
  - When conducting the test, the same test load is applied a minimum of two times under reasonably static test conditions and the results must comply with T.N.5.



## Compliance Verification-Repeatability (G-S.5.4. & T.N.5.)

- For example: On a Class II scale with a 210 g capacity and  $e=0.01$  g and  $d=0.001$  g, a test load of 50 g is applied three times with the following results:

50.007, 50.002, 49.995.

What are the individual errors in  $e$ ?

+0.7  $e$ , +0.2  $e$ , -0.5  $e$

If applying maintenance tolerance, are the test results acceptable?

Each individual results is in compliance ( $\pm 1 e$ )

But the range of 1.2  $e$  ( $|+0.7 - (-0.5)| = 1.2$ ) exceeds maintenance tolerance

# Module 5 Summary

- Minimum Tests
  - Increasing Load Test (N.1.1.)
  - Decreasing Load Test (N.1.2.)
  - Shift Test (N.1.3.7.)
  - Zero-Load Balance Change (N.1.9.)
  - **Discrimination Test (N.1.5.)\***
  - **RFI Susceptibility Tests (N.1.6.)\*\***

\*Conducted under controlled conditions, typically not done in the field.

\*\*Conducted when RFI is present in the environment.





# Module 5 Summary

- Other “Tests”
  - Capacity Indication (S.1.7.)
    - (a) 105 %
    - *(b) 9 d - electronic computing scales only (NR 1/1/1993)*
  - Repeatability (G-S.5.4. & T.N.5.)
    - May be verified during each inspection
    - Must be verified when an issue is suspected



# Module 6

## Suitability

### Verification Scale Division (e)

### Scale Division (d)



# Suitability

- Not explicitly defined by HB-44
- Must be considered for each particular application
- The buyer, the seller, and the weights and measures official must agree that a device is suitable for a particular application



Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards



# Suitability

- Factors to be considered:
  - Weight of the smallest and largest loads to be weighed
  - Unit prices (cost) of commodities to be weighed
  - Will there be a need to take tare?
  - Physical characteristics of products to be weighed
  - Will the scale be used for direct sales?



Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards



# Suitability-Selection

**UR.1. Selection Requirements.** – Equipment shall be suitable for the service in which it is used with respect to elements of its design, including but not limited to, its **capacity, number of scale divisions, value of the scale division or verification scale division, minimum capacity, and computing capability.**

- **Capacity - UR.3.2. Maximum Load.** – A scale shall not be used to weigh a load of more than the nominal capacity of the scale.
- **Number of Scale Divisions** – Unmarked or marked, the consideration is what accuracy and precision is required, see next bullet
- **Value of the verification scale division (e) or the scale division (d)** – How precise must the measurement be?
- **Minimum Capacity - UR.3.1. Recommended Minimum Load.** – A recommended minimum load is specified in Table 8. Recommended Minimum Load since the use of a device to weigh light loads is likely to result in relatively large errors.
- **Computing Capability** – Will the scale be interfaced with a POS?



# Suitability-Selection

- **Capacity - UR.3.2. Maximum Load.** – A scale shall not be used to weigh a load of more than the nominal capacity of the scale.
- **Number of Scale Divisions** – Unmarked or marked, the consideration is what precision and accuracy is required
- Ideally, the majority of weighing on a scale should be between one-quarter and three-quarters scale capacity

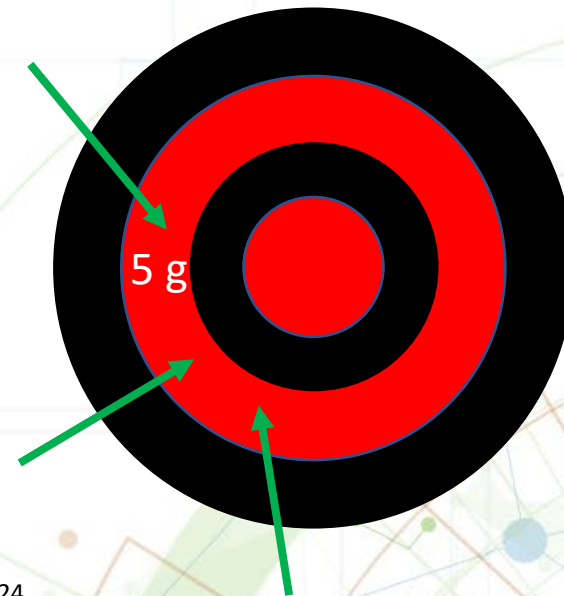
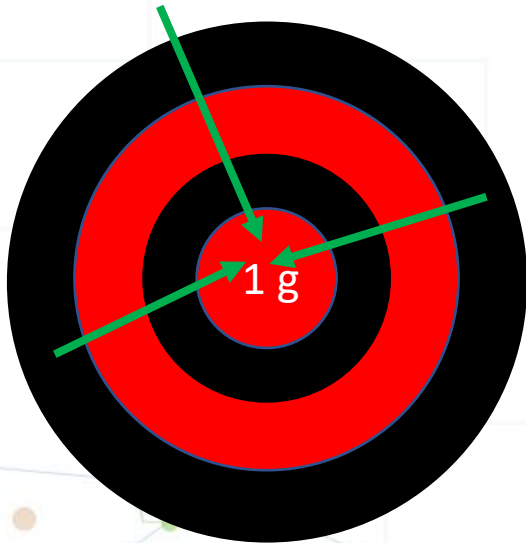
Classification	Capacity	Verification Scale Division (e)	Number of Scale Divisions (n)	Ideal Range
Class II	210 g	0.01 g	21,000	50 g – 160 g
Class II	1000 g	0.01 g	100,000	250 g – 750 g



# Suitability-Selection

- Value of the verification scale division (e) or the scale division (d) – How precise must the measurement be?

**Resolution**<sup>1</sup> (noun) res·o·lu·tion / rezə'lı̄d̄SH(ə)n : the smallest interval measurable by an instrument; the resolving power.



<sup>1</sup>“Resolution.” Google , Oxford Languages, <https://www.google.com/search?q=definition+of+resolution>. Accessed 2 Feb. 2024.

# Suitability-Selection

Accuracy when comparing e & d of the same value on devices configured differently

Class I Tolerance					
	e	d	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
S <sub>1</sub>	0.01 g	0.001 g	<b>+/- 0.01 g</b>	+/- 0.02 g	+/- 0.03 g
S <sub>2</sub>	0.001 g	0.001 g	+/- 0.001 g	+/- 0.002 g	+/- 0.003 g

10 times less accurate

	e	d	Test Load	Error	Result	
	e	d	50 g	Error	Approve	Reject
S <sub>1</sub>	0.01 g	0.001 g	50.005 g	+ 0.5 e	<b>X</b>	
S <sub>2</sub>	0.001 g	0.001 g	50.005 g	+5 e		<b>X</b>

Table 6 Maintenance Tolerances			
Tolerance in Scale Divisions			
	1	2	3
Class	Test Load		
I	0 – 50 000	50 001 – 200 000	200 001 +
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>





# Suitability-Selection

Accuracy when comparing e & d of the same value on devices configured differently

Class II Tolerance					
	e	d	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>
S <sub>1</sub>	0.1 g	0.01 g	<b>+/- 0.1 g</b>	+/- 0.2 g	+/- 0.3 g
S <sub>2</sub>	0.01 g	0.01 g	+/- 0.01 g	+/- 0.02 g	+/- 0.03 g

10 times less accurate

	e	d	Test Load	Error	Result	
	e	d	50 g	Error	Approve	Reject
S <sub>1</sub>	0.1 g	0.01 g	50.05 g	+ 0.5 e	<b>X</b>	
S <sub>2</sub>	0.01 g	0.01 g	50.05 g	+5 e		<b>X</b>

Table 6 Maintenance Tolerances			
Tolerance in Scale Divisions			
	1	2	3
Class	Test Load		
I	0 – 5 000	5 001 – 20 000	20 001 +
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>



# Suitability-Selection

UR.3.1. Recommended Minimum Load. – A recommended minimum load is specified in Table 8. Recommended Minimum Load since **the use of a device to weigh light loads** is likely to **result in relatively large errors**.

**Table 8**  
**Recommended Minimum Load**

Class	Value of Scale Division (d or e*)	Recommended Minimum Load (d or e*)
I	$\geq 0.001$ g	100
II	0.001 g to 0.05 g	20
II	$\geq 0.1$ g	50

\*For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape or color), the value of the verification scale division “e” is the value of the scale division immediately preceding the auxiliary means. For Class III and IIII devices the value of “e” is specified by the manufacturer as marked on the device; “e” must be less than or equal to “d.”



# Suitability-Selection Price per Scale Division

Commodity	\$	d	\$ per d	Rounding Error	Maintenance Tolerance Error Allowed in \$ per d			
					500 d	2000 d	4000 d	4001 d +
					5.00 lb	20.00 lb	40.00 lb	40.01 lb +
Ground Turkey	\$6.89/lb	0.01 lb	\$0.07	\$0.03	\$0.07	\$0.14	\$0.21	\$0.35

- Things to consider
  - Value of the commodity
  - Size of the scale division
  - Rounding error
  - Accuracy of scale and how that relates to the max \$ error allowed



# Suitability-Selection Price per Scale Division (III) Common Commodities

Commodity	\$	d	\$ per d	Rounding Error	Maintenance Tolerance Error Allowed in \$ per d			
					500 d	2000 d	4000 d	4001+ d
					5.00 lb	20.00 lb	40.00 lb	40.01 lb +
Russet potato	\$0.99/lb	0.01 lb	\$0.01	\$0.005	\$0.01	\$0.02	\$0.03	\$0.05
Anaheim pepper	\$2.49/lb	0.01 lb	\$0.02	\$0.012	\$0.02	\$0.04	\$0.06	\$0.10
Potato salad	\$4.99/lb	0.01 lb	\$0.05	\$0.025	\$0.05	\$0.10	\$0.15	\$0.25
Ground turkey	\$6.89/lb	0.01 lb	\$0.07	\$0.03	\$0.07	\$0.14	\$0.21	\$0.35
Roast beef deli meat	\$11.99/lb	0.01 lb	\$0.12	\$0.06	\$0.12	\$0.24	\$0.36	\$0.60
Alaska snow crab	\$19.99/lb	0.01 lb	\$0.20	\$0.10	\$0.20	\$0.40	\$0.60	\$1.00





## Suitability-Price per Scale Division (II)

Commodity	Price (\$)	d	\$ per d	Rounding Error	Maintenance Tolerance Error Allowed in \$ per d		
					5000 d	20000 d	20001+ d
					50 g	200 g	201 g +
White Winter Truffles	\$15/g	0.01 g	\$0.15	\$0.075	\$0.15	\$0.30	\$0.45
Cannabis	\$10/g	0.01 g	\$0.10	\$0.05	\$0.10	\$0.20	\$0.30
Persian Saffron	\$5/g	0.01 g	\$0.05	\$0.025	\$0.05	\$0.10	\$0.15
Dry-Aged USDA Prime Filet Mignon	\$1.00/g	0.01 g	\$0.01	\$0.01	\$0.01	\$0.02	\$0.03
					500 g	2000 g	2001 g +
Green Tea Leaf	\$0.50/g	0.1 g	\$0.05	\$0.025	\$0.05	\$0.10	\$0.15
Lobster Tail	\$0.10/g	0.1 g	\$0.01	\$0.005	\$0.01	\$0.02	\$0.03
					5000 g	20000 g	20001 g +
Jelly Belly Bulk Jellybeans	\$0.02/g	1 g	\$0.02	\$0.01	\$0.02	\$0.04	\$0.06
Asparagus	\$0.01/g	1 g	\$0.01	\$0.005	\$0.01	\$0.02	\$0.03



# Suitability-Net Load and \$ per d

Commodity	Price \$	Class	d	\$ per d	Rounding Error	Max Error
White Winter Truffles	\$15/g	II	0.01 g	\$0.15	\$0.075	3 d

The net load being weighed compared to the price per division must also be considered. The heavier the load, the less effect the price per division has on the transaction. The lighter the load the more effect it has.

For example, if a restaurant purchases 500 g (50000 d) of truffles the total price of the transaction is \$7500.00. In this case, the price per scale division represents 0.002% of the total transaction.

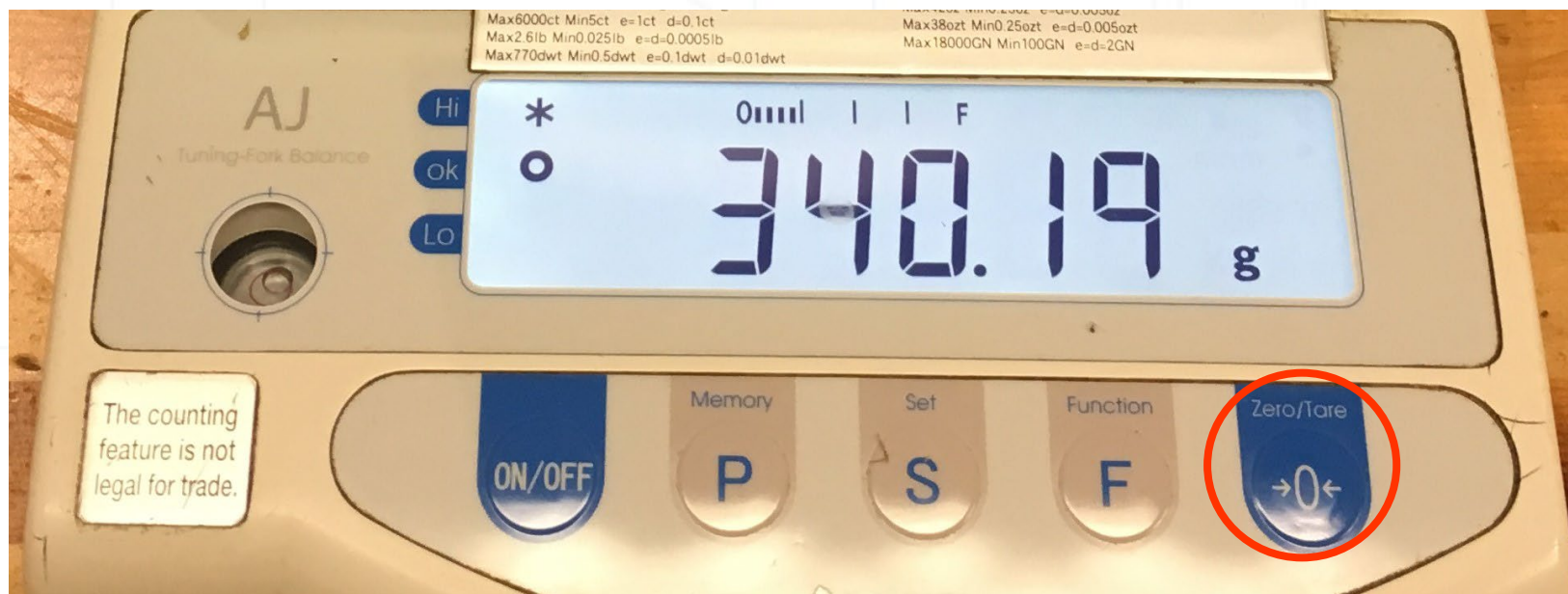
In contrast, if a consumer purchases 0.5 g (50 d) of truffles the total price of the transaction is \$7.50. In this case, the price per scale division represents 2% of the total transaction.



## Suitability-Selection

### Tare Capability

- Programmable Tare
- Push Button Tare key
- Zero Key



**S.2.1.6. Combined Zero-Tare (“0/T”) Key.** – Scales not intended to be used in direct sales applications may be equipped with a combined zero and tare function key, provided that the device is clearly marked as to how the key functions. The device must also be clearly marked on or adjacent to the weight display with the statement “Not for Direct Sales.”

Photo courtesy of the Colorado Dept. of Ag.,  
Div. of ICS, Measurement Standards



# Suitability-Selection

## Indicating Elements

- G-UR.3.3. requires a device to be positioned so the indications can be observed from some reasonable “customer” and “operator” position.



Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards





# Suitability-Selection

## Indicating Elements

- G-UR.3.3. requires a device to be positioned so the indications can be observed from some reasonable “customer” and “operator” position.



Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards

# Suitability-Selection

## Computing Capability

- Retail Computing Scale????
- Point-of-Sale (POS) System

**point-of-sale system.** – An assembly of elements including a weighing or measuring element, an indicating element, and a recording element (and may also be equipped with a “scanner”) used to complete a direct sales transaction. The system components, when operated together, must be capable of the following:

1. determining the weight or measure of a product or service offered;
2. calculating a charge for the product or service based on the weight or measure and an established price/rate structure;
3. determining a total cost that includes all associated charges involved with the transaction; and
4. providing a sales receipt.





# Suitability-Selection

## Computing Capability

- Will the scale be interfaced with a POS?

If the answer is yes:

- Does the software have an NTEP CC
- Is it compatible with the scale division/unit of measure
- Verify that the system complies with NIST HB 44 requirements, specifically:
  - S.1.8.5. Recorded Representations, Point-of-Sale Systems
  - S.1.12. Manual Weight Entries



# Suitability-Selection

## Computing Capability

- Will the scale be interfaced with a POS? **Yes**
  - S.1.8.5. Recorded Representations, Point-of-Sale Systems
    - Receipt includes
      - the net weight;
      - the unit price;
      - the total price;
      - the product class or, in a system equipped with price look-up capability, the product name or code number; and
      - ***the tare weight.***

***[Nonretroactive as of January 1, 2025]***





# Suitability-Selection

## Computing Capability

- Will the scale be interfaced with a POS? **Yes**
  - S.1.12. Manual Weight Entries
    - only allows an entry when the device is at zero
    - requires recorded representations to “identify the weight value as a manual weight entry by one of the following terms: “Manual Weight,” “Manual Wt,” or “MAN WT.”
  - UR.3.9. Use of Manual Weight Entries. limits manual entries to the following:
    - a point-of-sale system interfaced with a scale is giving credit for a weighed item;
    - **an item is pre-weighed on a legal for trade scale and marked with the correct net weight;**
    - a device or system is generating labels for standard weight packages;



# Suitability-Selection

What if the scale isn't interfaced with the device that is the POS?

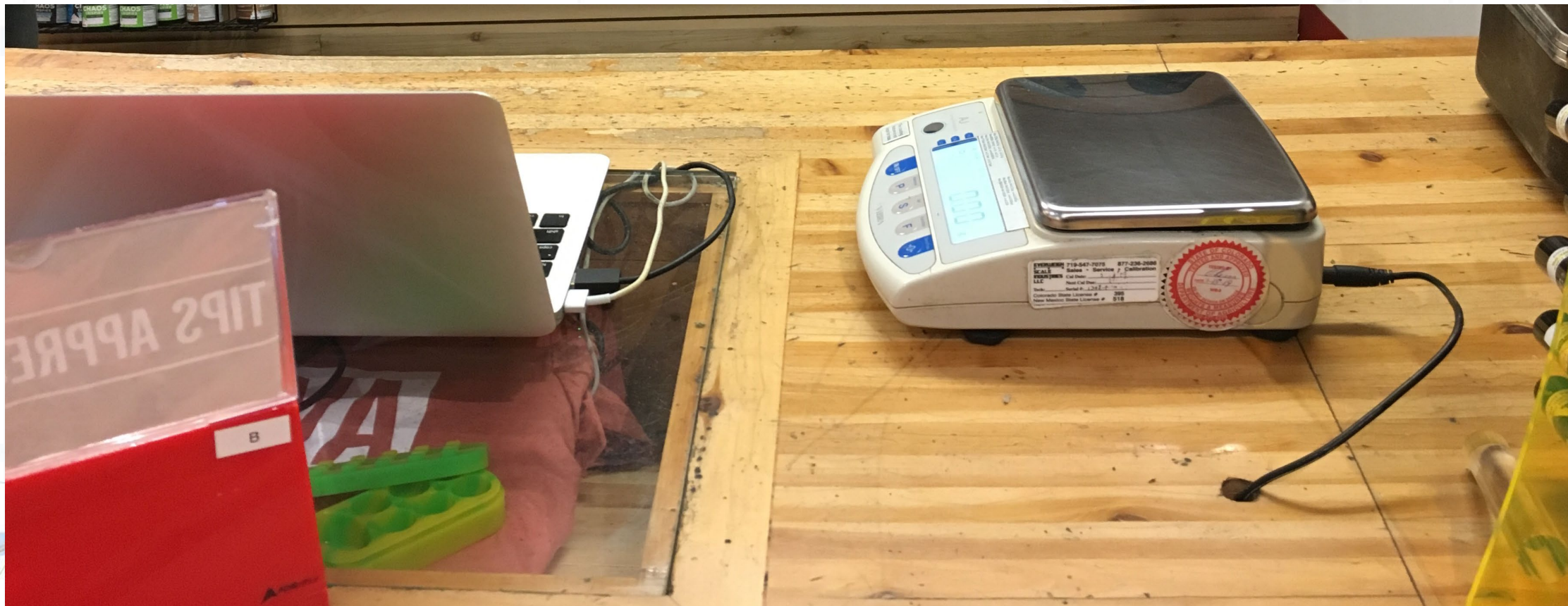


Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards

# Suitability-Selection

## Computing Capability

- When there is no POS System
  - How is the transaction completed?
    - Total price entered into the system
    - Net weight entered into system
  - Are both these methods allowed?





# Suitability-Selection

## Computing Capability

- When there is no POS System
- Can the Total price be entered into system
  - Yes (if the net weight and total price are calculated correctly)
  - May be entered using SKU, UPC, etc., or manually
  - This is how most items are processed in retail transactions





# Suitability-Selection

## Computing Capability

When there is no POS System

- Net weight entered into system-????

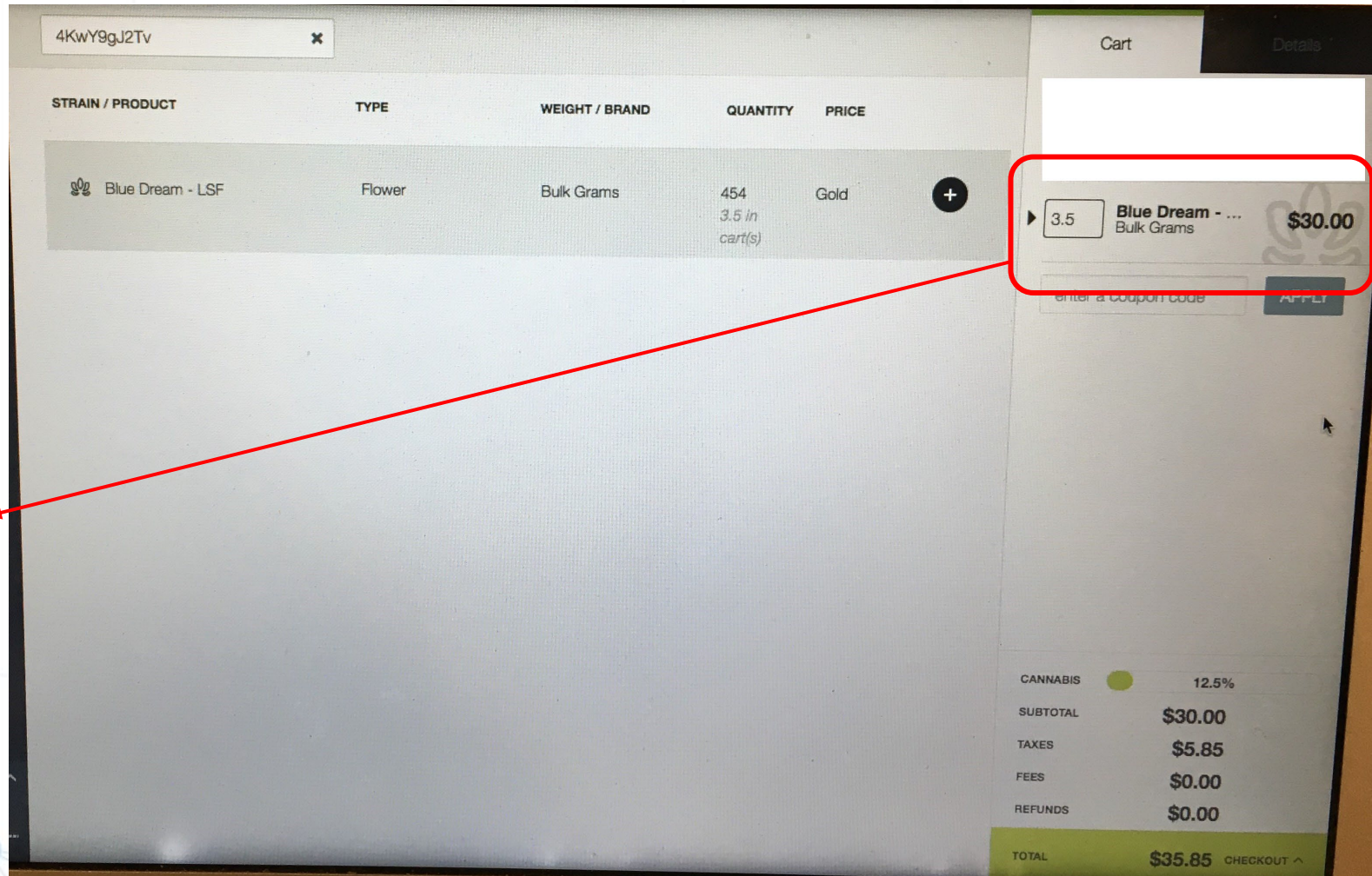


Photo courtesy of the Colorado Dept. of Ag., Div. of ICS, Measurement Standards

# Suitability-Selection

## Computing Capability

When there is no POS System

- Net weight entered into system-????
  - What standards apply?
    - NIST Handbook 44 No
    - NIST Handbook 130 Yes-Uniform Weights & Measures Law, Section 14
    - State W & M Laws Yes



# Suitability-Selection

## Computing Capability

When there is no POS System

- Net weight entered into system-????
- What standards apply?
  - NIST Handbook 130      Yes-Uniform Weights & Measures Law

### Section 14. Misrepresentation of Quantity

No person shall:

- (a) sell, offer, or expose for sale a quantity less than the quantity represented; nor**
- (b) take more than the represented quantity when, as buyer, he/she furnishes the weight or measure by means of which the quantity is determined; nor**
- (c) represent the quantity in any manner calculated or tending to mislead or in any way deceive another person.**





# Suitability-Installation Environmental Factors UR.2.1.

- Weighing Location

- Stable/Sturdy (bench, table, stone bench). The weighing bench should not sag when work is carried out on it and should transfer as few vibrations as possible.
  - Antimagnetic (no steel plate).\*
  - Protected against electrostatic charges (no plastic or glass).\*
  - Wall or floor installation: The weighing bench should be fixed either to the floor or on the wall. \*
  - Preferably reserved for the balance.\*
- Positioned away from doors, vents, fans,

\*Effect more pronounced for Class I scales





# Suitability-Installation

## Environmental Factors UR.2.3.

- Temperature-Weighing results can be influenced by temperature!
  - The temperature of the room should be as constant as possible.
  - Avoid locating the scale near HVAC vents, incandescent/halogen bulbs, or windows.
  - Class I scales have automated self-calibration that can compensate for temperature drift.
- Atmospheric humidity
  - Ideally, the relative humidity (% RH) should be between 45% and 60%. Balances should never be operated above or below the measuring range of 20% to 80% RH. Review owner's manual for proper operating conditions.\*

\*Effect more pronounced for Class I scales



## Suitability-Sealing

- Per S.1.11.2., an exception to sealing is made for Class I scales
- Does that mean a Class I scale that is used in a commercial application isn't required to be sealable?

**No, G-S.2. Facilitation of Fraud**

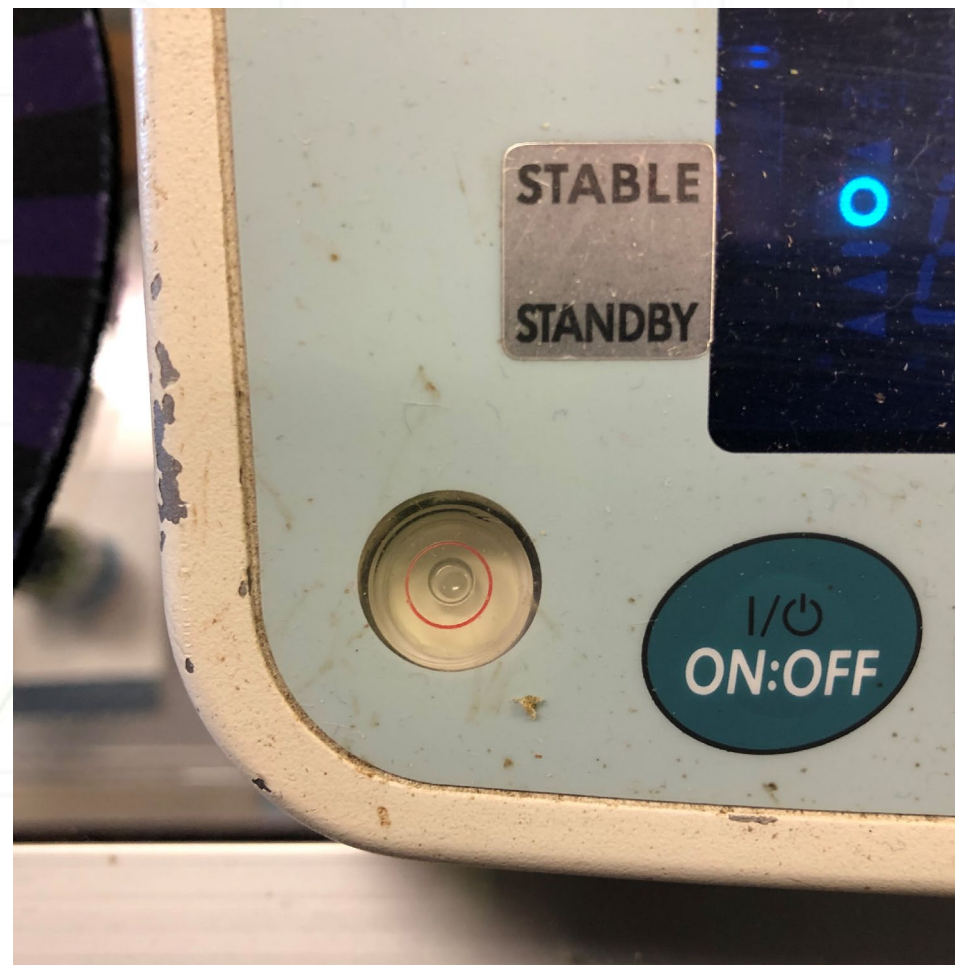
- Exception added in 1983 with no explanation
- Table 7 provides a clue—"Precision laboratory weighing"



## Suitability-Installation

- Maintain  
Level  
Condition

- Last but not least!





# Suitability-Summary

- Not explicitly defined by HB-44
- Must be considered for each particular application
- The buyer, the seller, and the weights and measures official must agree that a device is suitable for a particular application





# Suitability-Summary

## UR.1. Selection Requirements. including:

- Capacity - UR.3.2. Maximum Load.
- Number of Scale Divisions
- Value of the verification scale division (e) or the scale division (d)
- Minimum Capacity - UR.3.1. Recommended Minimum Load.
- Computing Capability



# Suitability-Summary

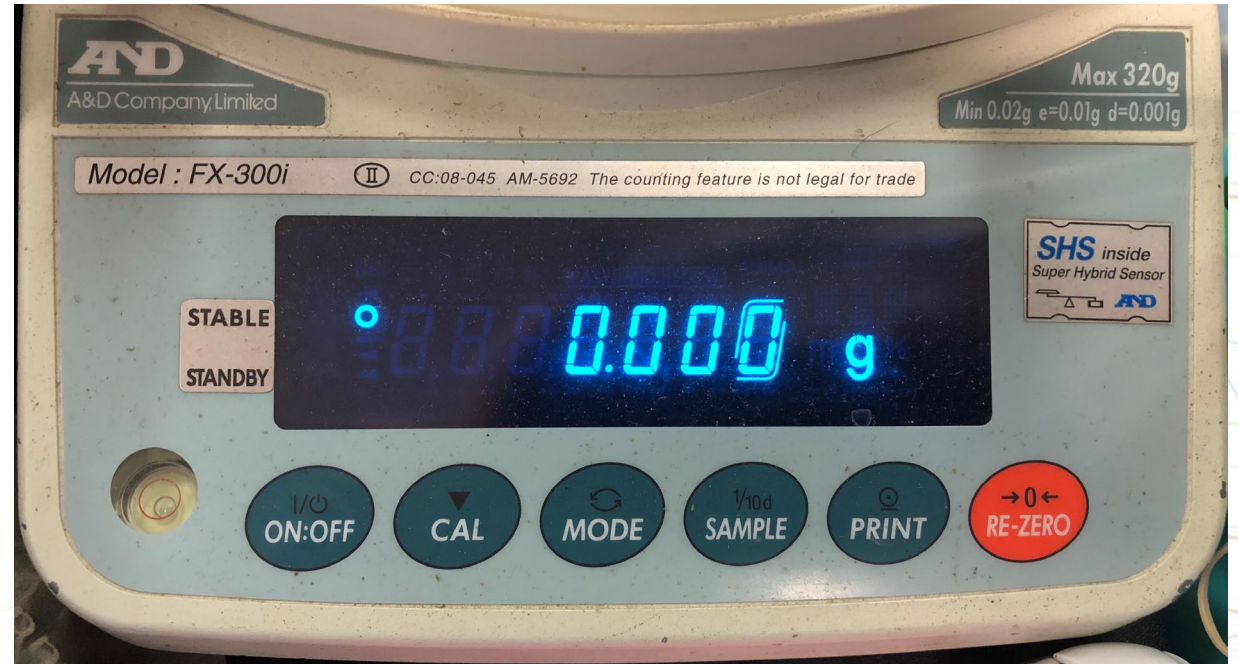
## Installation and Environment

- Scale should be:
  - Properly supported
  - Located in a stable environment
  - Properly sealed
  - Kept level!



# Precision Scale Overview

What questions do you have?



# Contacts

● Loren Minnich [loren.minnich@nist.gov](mailto:loren.minnich@nist.gov) 202-430-0435

Jan Konijnenburg [jan.konijnenburg@nist.gov](mailto:jan.konijnenburg@nist.gov)

**Office of Weights and Measures**

[OWM@nist.gov](mailto:OWM@nist.gov) or (301) 975-4004

