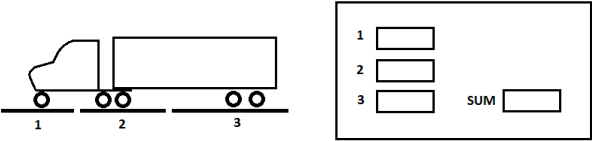


Developing Item
Multiple Scales with Summing Indicator
S&T Items 3200-5 and 3600-2

Submitted by
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Participant in 1990 decision
Revised January 9, 2018



The diagram shows a truck with three axles labeled 1, 2, and 3. To the right of the truck is a box containing three input fields labeled 1, 2, and 3, and a SUM field.

We will be discussing multiple scale array depicted here. The system includes three independent scales and a summing indicator. The discussion will focus on how to apply HB44 to the summing indicator. We have history going back to 1989.

Why am I pushing this issue? There are two reasons.

Although I am retired, I'm still active in W&M. In preparing Certification exams, the SME's and I sometimes find issues with the Codes. When we do, I offer to let one of the SME's write the proposal or volunteer do it myself. I have introduced several issues in the last few years in this way. All of them dealing with technical application of the codes. It is critical to note that while the issue is an direct outgrowth of the Certification Program, I am not representing NCWM in any way in this effort.

I also have a stake in this issue since I was an active part of the discussion that took place back in 1989-90 when this issue first came up. I supported the S&T position then but now think the NCWM made a mistake. The mistake surfaced both during preparation of the large capacity exam and during SMA discussions of the Vmin paragraph (2015-16). I want to set things right.

S&T Positions on Record

- *1990 - Item 320-11 p 157*
“... not only must each independent weighing device meet the requirements of Handbook 44, but the entire weighing system must meet all requirements that would apply if the device were a single scale.”

I will focus on the mistake by showing two current positions of the S&T Committee that contradict each other.

In 1990 the S&T proposed and the NCWM confirmed the array must be considered as three individual scales and one combined scale. The combination is a scale with SUM as the primary display. When we say the SUM must comply we are really saying the combined system of three load receiving elements and the SUM are a scale that must comply.

We've been using this ruling for 27 years.

S&T Positions on Record

- 2016 - Item 320-2 p 333
“Because the summed display is not an additional scale and has no measuring function ... applying the v_{\min} relationship to the total number of load cells in all of the load-receiving elements ... has no metrological basis.”

Yet, in 2016 the SMA proposed changing the V_{\min} paragraph to exempt the SUM from the V_{\min} formula. The S&T moved this forward and the NCWM overwhelmingly approved the change, thus signifying acceptance of the arguments supporting the SMA proposal.

What is critical to see in this decision is the reasoning supporting the exemption. Namely that:

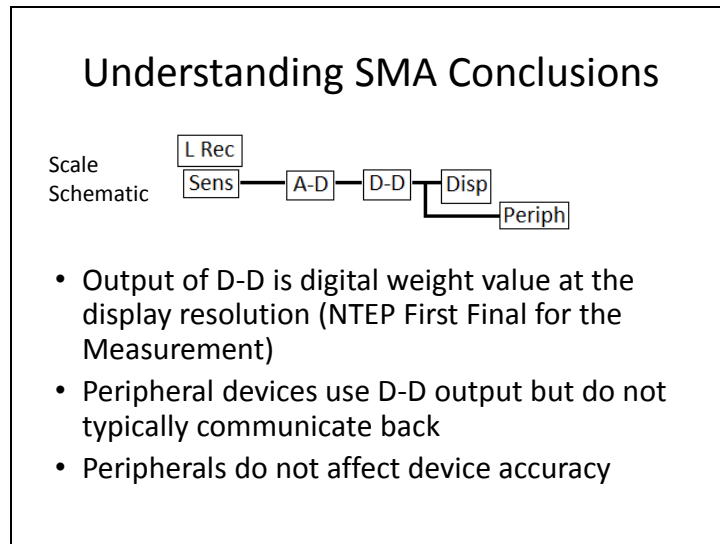
The SUM has no measurement function.

The SUM is not a scale (i.e. the combined system using the SUM as the primary indicator is not a scale)

Actually the SUM is an accounting function. Like the calculator app on your cell phone.

Question, did you ever think it necessary to verify the accuracy of your calculator app? And, if you wanted to verify it, how would you do it?

The question we need to resolve is, Is the combination of multiple load receiving elements with the SUM indicator a scale or isn't it? The 1990 decision says yes but the 2016 decision says no.



The SMA arguments were metrological. They looked at the functions of a scale or weighing device. These are:

Load receiver – isolates the load on the load sensors

Load sensors – produce an analog output proportional to the load applied

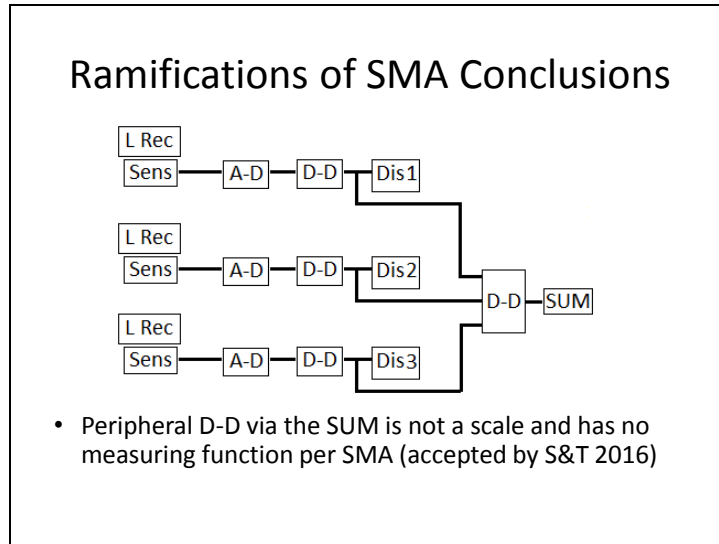
A-D – converts the analog load sensor output to a digital value in counts – a dimensionless unit

Note compliance with the Scales Code requires devices to have multiple counts per displayed scale division

D-D – converts the counts to displayed weight values

Display – Indicates the weight (This is NTEP's first final)

Peripheral output from D-D is typically one directional to printers and computers (such a peripheral has no affect on the measured value)



With the multiple scale array we have three such scales in an array. The SMA showed the Vmin only applicable to the individual scale and not the SUM. It's critical to see that the SUM is the product of a second D-D process. This peripheral D-D processor has only the three rounded, digital weight values to work with. This process is not a measurement according to the 2016 decision. This second D-D processor is an adding machine!

It is the location of the SUM in the same housing that masks this critical separation. If this were three scales with separate indicators interfaced to a separate computer system it might be more visible. This is the difficulty with digital systems. They can be configured in a multitude of ways.

So what does the Code tells to help us answer the is it or isn't it a scale question?

Support for SUM in Scales Code

- **UR.3.3. Single-Draft Vehicle Weighing.** – A vehicle or a coupled-vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However, the weight of:
 - (a) a coupled combination may be determined by uncoupling the various elements (tractor, semitrailer, trailer), weighing each unit separately as a single draft, and adding together the results; or
 - (b) a vehicle or coupled-vehicle combination may be determined by adding together the weights obtained while all individual elements are resting simultaneously on more than one scale platform. (underline added)

The SMA also showed the summing of separate scale readings is expressly recognized in the code. Careful reading of UR.3.3. starts by saying vehicles shall be weighed as single drafts, meaning single measurement.

But then we encounter the word “however” which introduces alternative means of compliance that are multiple draft or multiple measurement.

In part (a) we see that a coupled-vehicle may be uncoupled and weighed in pieces. The total weight is the sum of the pieces.

In part (b) we are still weighing in pieces just doing it simultaneously. The code refers to more than one scale platform, not more than one load-receiving element. Clearly it is describing the multiple scale array.

In both cases the total is obtained by simple addition on our calculator. The Code specifies no additional requirements on the scales in an array such as closer agreement on sections, maximum number of scale divisions, or higher accuracy. Scales used need only by suitable (e.g. loads greater than minimum recommended load and less than capacity) and comply with Scales Code requirements.

Application of the Scales Code

A.1. General. – This code applies to all types of weighing devices other than The code comprises requirements that generally apply to all weighing devices, and specific requirements that are applicable only to certain types of weighing devices.

- If something isn't a scale – NONE of the Scales Code requirements apply!

Now let's expand the argument to make it a legal issue. Scales Code applies to weighing devices. We concluded in 2016 the SUM isn't a scale (weighing device) and doesn't measure anything. First conclusion, if the SUM is not a scale indication, NONE of the scales code requirements apply. Regulations are all or nothing, you can't pick and choose to apply some requirements.

Either it's a scale and all requirements are applied, or it's not a scale and none of the requirements apply.

But, there's more.

Application of HB44

G-A.1. Commercial and Law-Enforcement Equipment. – These specifications, tolerances, and other technical requirements apply as follows:

- (a) To commercial weighing and measuring equipment; that is, to weights and measures and weighing and measuring devices commercially used or employed in measurement of quantities, things, produce, or articles for distribution or consumption, purchased, offered, or submitted for sale, hire, or award
- (b) To any accessory attached to or used in connection with a commercial weighing or measuring device when such accessory is so designed that its operation affects the accuracy of the device.
- **SUM is not a scale and has not affect on accuracy of any of the measuring devices- Can't apply HB44 to the SUM**

This conclusion is further supported in the General Code. Note first that G-A.1. applies to the entire Handbook and not just to the General Code.

If we look at the General Code G-A.1.(a) the operative words are “used or employed inMEASUREMENT of quantities....” here I emphasize measurement as opposed to accounting.

The SMA logic the NCWM accepted concluded the SUM had no measurement function. Clearly a sum relies entirely on the three independent scales to do the measuring and the SUM makes no independent measurement, nor does it alter any of the values from the three scales in any way.

But let's cover all the bases: Maybe the SUM is an accessory? Then we turn to (b) and we find that an accessory is only covered in HB44 when the accessory is designed such that it affects the accuracy of the device. I showed earlier that the peripheral output is one-way and the peripheral devices here have no means to impact the measurements made by the three scales, the three devices.

Second conclusion: NONE of the HB44 requirements apply to the SUM.

Conversely, We agree if the SUM is a scale indication then it must comply with ALL applicable Scales Code requirements as per the 1990 decision. This includes Vmin. Yet the NCWM exempted the SUM from Vmin on the basis it wasn't a scale.

Don't despair, there are other legal codes. Section 15 of UWML prohibits misrepresentation of quantity. A false sum would violate that section so it's actually regulated by our Law.

Summed Indication Not a Scale

- SUM won't comply with:
 - S.2.1.3.2. Automatic Zero Tracking
 - S.2.1.2. Motion Detection Zero
 - S.2.5.1. Motion Detection Printing
- SUM can't comply with:
 - S.1.1.1. Center of Zero
 - T.N.7.2. Discrimination Test
- **Scales Code applies to devices actually doing the measurement.**

If you are still not convinced, I found further proof that the SUM is not a scale indication. In 1990 the S&T identified 5 criteria applicable to the SUM. Yet, I found the combined scale won't or can't conform to several other Scales Code requirements when test loads are equally distributed over the three platforms.

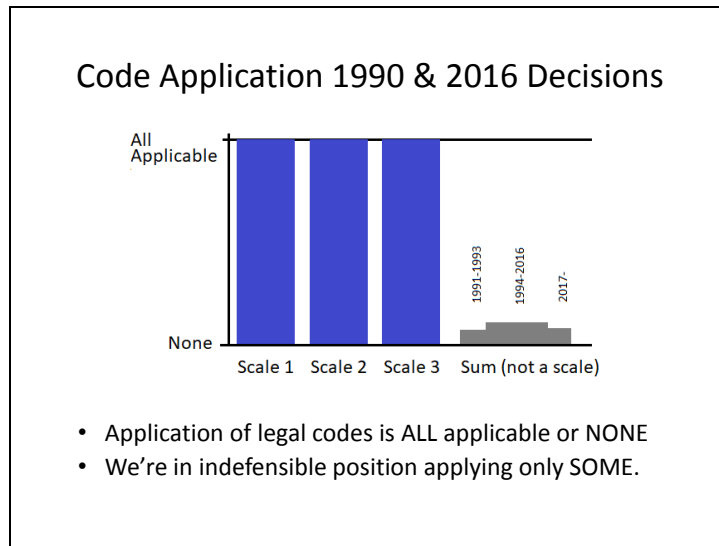
With AZT and motion for Class III L there is a 3d window for the individual scales. This gets added in the second D_D processing. So the SUM has a 9d AZT and motion window which won't comply. Go out to one of these scales and you can add 50 lb all at once to each of the three scales and the SUM remains at zero. That's 7.5 d. Using the same logic, with center zero the individual scales must maintain zero within $\frac{1}{4}$ d and thus the SUM is only accurate to $\frac{3}{4}$ d.

With Discrimination we find the ZU's for the three scales under load will not always line up uniformly. Thus the scale divisions on the SUM may be anywhere from ~2 lb wide to ~58 lb wide. To pass the discrimination test they need to be close to a uniform 20 lb spacing. Random simulations I ran show the scale will only comply about 50% of the time because the ZU's randomly align.

Notice the wording of won't and can't. The won't group of requirements has a possible workaround. The AZT and motion windows could be set to 1d for each of the individual scales resulting in a 3d window for the SUM. However, the workaround may render the device almost unusable in windy conditions.

I can't find any workaround for the can't requirements, center zero accuracy or discrimination. Conclusion, because the SUM is not truly a scale, it can't comply with several of the Scales Code requirements. To comply a "scale" has to have access to the internal resolution (the A-D counts) to comply with the active weighing requirements. It has to be involved in the "measurement."

My purpose here is NOT to suggest we condemn all the scales presently in the marketplace. The scales are suitable, fully compliant, and have a history of acceptable service. Rather I am showing that our decision in 1990 was flawed.



This is really a legal issue. Legal compliance is ALL or NOTHING. If you can't get past the A paragraphs of a code you can't apply any of the requirements in the Code.

If the SUM is a scale indication then ALL the requirements apply to the scale especially Vmin. Vmin is the only proof the load cells comply with influence factors.

Alternatively, if the SUM is not a scale indication, then NONE of the HB44 requirements apply.

In the 1990 decision we picked a subset of 5 criteria to apply to the SUM. In 1993 Vmin got added but subsequently removed from that list in 2016. We held the array to higher standards by inventing our own rules, as opposed to following HB44. Contrary to A.1., we held something that is not a scale to a limited set of Scales Code requirements.

All of that is now clearly exposed. We stand today in no-man's land. The Sum is not a scale and should be subject to NONE of the Scales Code or General Code requirements and I have shown that the sum, as a scale, will not pass ALL the requirements. Now that we are aware, we should have the professional integrity to fix it. To stand here and say nobody is complaining is unacceptable to me as a professional. It should be unacceptable to you as well.

Actions Proposed

- Act on 3200-5 to remove references to multiple scale arrays from Table 3 Footnote 4.
- Revisit 2016 changes to S.5.4. Vmin (recommend returning to pre-2016 language)
- Officially reverse conclusions of 1990 S&T item 320-11. System is three independent axle-load scales not one vehicle scale!
- **Impact, no application of Nmax or Shift test to the SUM. Apply UR.2.6.2. to approaches not UR.2.6.1.**

I believe there is sufficient justification to move forward on the proposals in item 3200-5. Where we are today is not defensible. This requires two code changes.

1. We should remove the two sentences about the summed indicator from footnote 4 of Table 3.

2. In 2016, S.5.4. was changed to exempt the SUM from Vmin compliance. I am recommending we revert back to the original pre-2016 language. It was correct to begin with. Also note the 2016 exemption is moot because the SUM is not a scale. However, we could leave it just to ensure people don't apply Vmin to the SUM.

Most important, we need to formally reverse the 1990 decision from item 320-11. I've provided the code analysis necessary. The NCWM should reverse its position and recognize the array solely as multiple independent scales. This is the alternative position from the Sector in 1989, the one that should have been adopted by the NCWM.

The primary impacts are minor: No longer apply Nmax and Shift Test to the SUM and apply UR.2.6.2. to the approaches since the scales are axle-load scales not vehicle scales.

Also note you can't just add new code to Table 3 and Shift test since the Scales Code doesn't apply in its entirety.

Effect on accuracy is minimal. Critical to see this not as lowering the bar but properly enforcing the law as written.

Actions Proposed

- Continue work on 3600-2
 - Future changes to Fundamental Consideration
 - I support the formation of a Work Group
 - Address gray area of peripheral processing and when it is or is not covered by HB44
 - Peripheral processing may affect other codes e.g. blending or fleet sales)

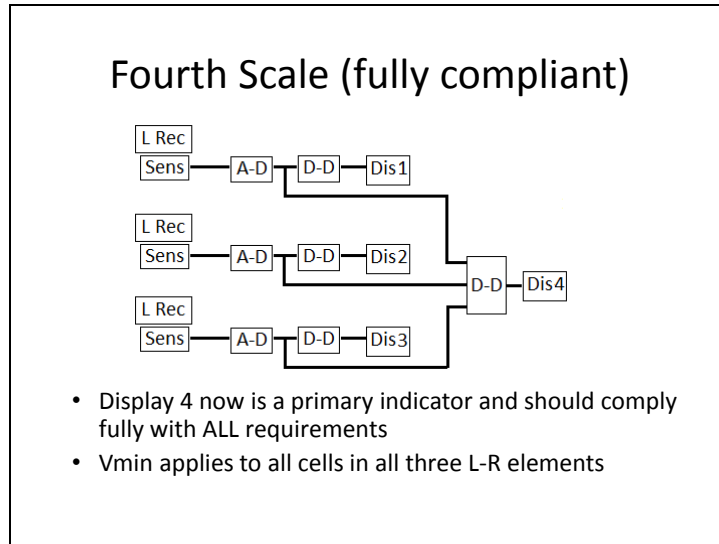
I propose withdrawing the proposal for the General Code change in Item 3100-1. Based on discussions at the NEWMA meeting May 2017 and further study on my part, I find it is already covered in UWML section 15 Misrepresentation of Quantity.

The 3600-2 item addresses possible changes to Fundamental Considerations to better explain application of the codes to peripheral processing. This is not an immediate need but it is needed. Digital devices just keep getting more complicated and sophisticated. We will find it more and more difficult to identify exactly what the measuring device is and where we should draw the line in our inspections.

I support the idea of creating a work group. However, I think the philosophical issues as they impact Fundamental Considerations are bigger than the Scales Code. Good examples are liquid blending using multiple devices or fleet sales on gas pumps. We should invite participation from manufacturers of all device types to participate.

Questions or Comments

- Additional slides to show other HB44 instances involving SUM's and some responses to comments from others on this issue.



Under this scenario the Dis 4 is a primary indicator to a fourth scale, which represents the total load on the three load receiving elements. This is not the case with most arrays we have today. The D-D processor uses internal resolution counts from the A-D of the three scales to measure the total weight. This TOTAL should be easily able to comply with all active scale requirements like AZT, motion, etc.

Problem is that this 4th display may not agree with the sum Dis 1+Dis 2+Dis 3. Random simulations indicate there will be 1 d difference about 33% of the time. While this may appear to some as a superior alternative to a SUM, the Code expressly recognizes a mathematical SUM as a valid way to determine the weight of the truck. Also, having the sum agree with the individual scale readings will eliminate a lot of questions from customers.

Also remember that the weight of a truck is rarely the basis of a commercial transaction. You need a second weight to get to a Net weight which is the basis for the commercial transaction.

Weigh-In Weigh-Out Ticket	
In	66,280 lb
Out	<u>21,720 lb</u>
Net	34,560 lb

The Weigh-in Weigh-out systems also do not measure the net weight. It is calculated by addition (i.e. adding a negative tare weight to the gross weight).

No active scale code requirements such as specifications or tolerances apply to the difference. Only the individual scales have to comply with the code requirements.

The value on which the commercial transaction is based is the net weight. All of the measured weights are presented on the record. (This is the extent of W&M authority, i.e. to require that measured values are validly presented on record produced by the device.)

RMFD Fleet Sales			
Store 208	Pump 2	10.965 gal	12/1
Store 368	Pump 7	12.567 gal	12/4
		9.329 gal	12/9
		11.865 gal	12/21
Store 208	Pump 8	11.476 gal	12/12
		12.048 gal	12/16
Store 275	Pump 3	10.833 gal	12/28
Monthly total		79.083 gal	

The value on which the commercial transaction is based is the total (SUM). Although there may be individual price extensions based on the daily price per gallon under the contract. The contract is outside of W&M jurisdiction. The exemptions in the PPU specifications for fleet sales in HB44 are there to remind you that you have no jurisdiction where an outside contract defines the financial terms of sale.

Again, all measured values are presented on the record.

Commercial transactions have four primary components: 1) advertisement, 2) negotiation of contract, 3) exchange of custody, and 4) exchange of title.

In this case, the seller 1) advertised a fleet purchase option, 2) the buyer and seller signed a contractual agreement before any product was exchanged, 3) after each exchange of product under contract, the buyer has custody and authority to use the commodity, and 4) upon receipt of payment, the buyer has legal title to the fuel that may already be used.

W&M authority may be thought of as one small part of the process of transfer of custody. W&M authority does not extend to the other parts of the Commercial Transaction. Some parts are under the UWML, but the main authority is under the Uniform Commercial Code, which W&M does not enforce.

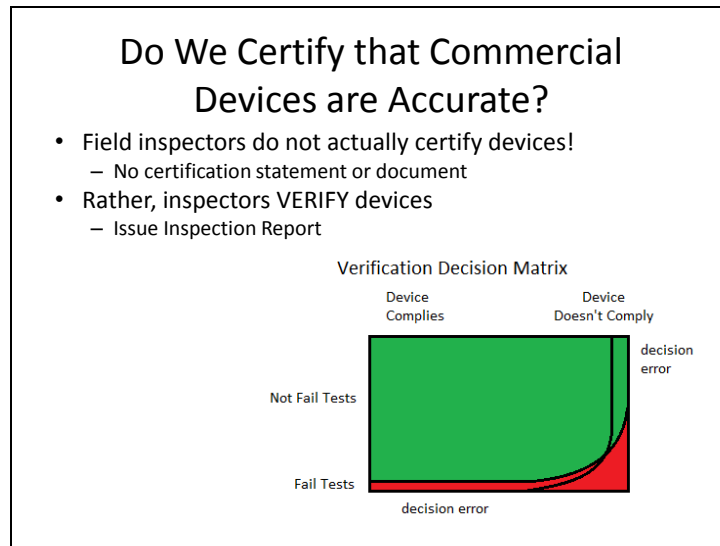
Automatic Bulk Weighing for Grain (scale cap 50,000 x 10 lb)			
	No-Load	Load	Net
Draft 1	0 lb	45020 lb	45020 lb
Draft 2	0 lb	45010 lb	45010 lb
Draft 3	10 lb	45000 lb	44990 lb
Draft 4	10 lb	45030 lb	45020 lb
Draft 5	0 lb	45010 lb	45010 lb
.....			
Draft N	0 lb	10,150 lb	<u>10150 lb</u>
Sum			1,000,020 lb

SUM is the basis for the commercial transaction. This is 100,000+ scale divisions. HB requirements are not applied to the SUM (but to the device, i.e. the hopper)

All of the measured values (in this case both no-load and load) are included on the record.

Only the active weighing device undergoes testing and specifications are applied only to the active weighing device.

Notice that the SUM feature of the ABWS only appears in the A.1. essentially as a definition of the type of scale. There are no specifications, tolerances, or user requirements directed to the SUM. What separates the ABWS system from a hopper scale in the Scales Code is primarily the specifications on the automation. The technology within the hopper scales is essentially identical in both codes except for AZT, which is not permitted on ABWS.



Our field inspectors certify NOTHING! Compare what NTEP does to our field inspectors. NTEP formally examines every specification and performs every possible test, including at extremes of influence factors. Also NTEP issues a Certificate of Conformance that states the type complies. Field tests may not formally evaluate every specification and only a limited set of tests are performed at the ambient conditions. Inspector does not issue a certificate, but rather an inspection report. This is a report of VERIFICATION.

The purpose of HB44 is to fail devices, not to pass them. Read this in HB44 Introduction paragraph (B). Inspectors reject or condemn devices that fail certain tests or fail to comply with technical specifications and user requirements, “without prejudice to apparatus that conforms...”

Consider the decision matrix with device inspection. Let’s say the green area is 90%, i.e. our compliance rate. The red area is the 10% rejections. Yet there are risks as we see some percentage of devices that did not fail (top right) should have. Likewise some percentage of devices that failed (bottom left) should have. With verification it is not feasible to formally evaluate the relative percentages of these two decision errors so we agree to ignore them as both buyer and seller share these risks.

This allows field inspector to make black and white decisions. If device fails one or more tests, it is rejected. If device fails to fail a test, then it is allowed to remain in service without prejudice. Without prejudice is not the same thing as certifying it complies! W&M officials should be keenly aware of this distinction.

Do measurements made by devices have to comply with HB44?

- NO, HB44 requirements apply only to the device (singular), not the product of the device
- Some W&M tests are permitted to be outside tolerance.
 - RFI/EMI and other disturbances (wind)
 - Split-compartment delivery VTM
- “Approved” devices not 100% compliant
 - Approved truck scales often in error by significant amounts, meaning weights produced do not conform

In comments on this issue OWM suggested that the sum of weights produced by an multiple scale array should conform to the HB44 tolerances. While that may be the expectation of people outside W&M, those of us in the field know that statement is unrealistic and built on a false premise.

First, look in HB44 and try to find a single requirement that states the commodity measurement must comply with the Code. You won't find any. The Code requirements are written to the measuring device.

Contrast with package checking. We use HB44 in device testing and apply the requirements to the device, and not the things measured. We use HB133 in package testing and apply the requirements to the lots of packages in commerce, and not the packaging apparatus. We should be careful not to mix our metaphors.

Put another way, we can't reject a scale based on the subsequent test of a commodity measured. The tests don't work that way.