Developing a Hydrometer Accuracy Checking Program For Maple Syrup Producer Associations

This information was assembled to assist State and Provincial Maple Producer Associations in developing and offering a simple hydrometer accuracy-checking program for their members.

October 2019

Gary Graham, Ph.D.
Ohio State University Extension

Henry Marckres
Maple Flavor and Grading Consultant

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Developing A Hydrometer Accuracy Checking Program

Every maple producer association can be checking producer hydrometers for accuracy. It is easy to do and a way to ensure association members are producing the highest quality, and a legal density product for the retail market. The following describes how to check hydrometers and the equipment needed.

Why Hydrometer Accuracy Checking is Critical:

Hydrometers are a critical tool for making quality, legal density maple syrup. **A $20 to $30 investment in an accurate hydrometer can make a return of $400 in extra income for every 100 gallons of syrup made.** *Example, accurately lowering the density four points from 70.5 Brix to 66.5 Brix makes eight more gallons of syrup for every 100 gallons made (at $50 per gallon, this equals $400 in extra income)*. Auto-draw offs are a great tool, but their accuracy should be confirmed with an accurate hydrometer. If buying or selling sap with an inaccurate sap hydrometer, either the buyer or seller is losing potential income.

When to Test Hydrometers:

Anytime and often is the best answer. At annual association meetings, maple schools, summer tours. Producers should get into the habit of having hydrometers checked at minimum annually.
A State/Provincial maple association could obtain everything needed for checking hydrometers for approximately $600 to $800 and test members hydrometers at every function they have as a service to members.

Visually Inspect Hydrometers Before Checking:

Many hydrometer issues can be detected by a thorough visual inspection before checking. Hydrometers crusted with calcium scale adds extra weight on the hydrometer causing it to read higher than in should for correct density syrup. If hydrometer is crusted with a calcium scale or niter or syrup residue, it is important to clean thoroughly before placing into the calibration solution. If placed directly into the calibration solution it will turn the solution darker. As the solution darkens over time it becomes harder to read correctly and eventually the solution becomes unusable. The potassium iodide if taken care of should last for many years. Vinegar, alcohol, or the product CLR (Calcium, Lime, Rust Remover) and a Teflon pan cleaning pad will aid in removal of calcium scale and niter. Heavily crusted/scratched hydrometers should be replaced.

Closely inspect the hydrometer tip on the weighted bottom with a magnifying glass to check for cracks or missing glass. Cracked or missing glass on the tip allows moisture to find its way into the bowl adding weight and causing it to read heavy. Do not check a hydrometer with cracked or missing glass on the tip as it needs replacing due to potential glass contamination in syrup.

Using a magnifying glass, inspect if glue dots on the paper have come loose and/or accuracy verification thread or wax dot (if it has one) are intact. Look down the hydrometer stem, a straight line will be observed on the paper. If line is not straight and has a twist to it, then one of the glue dots has loosened and the paper twist makes the hydrometer unusable. Papers with a twist can read slightly inaccurate (½ to ¾ °Brix) to greatly inaccurate (2+ °Brix) depending on the severity of the twist.

If both glue points have loosened paper shift happens (up or down). Hydrometers will read light if paper shifts up or heavy if paper shifts down. ***Note: hydrometers numerical scale ends on the stem where the bowl flare starts, allowing for a quick visual check for paper slippage.***

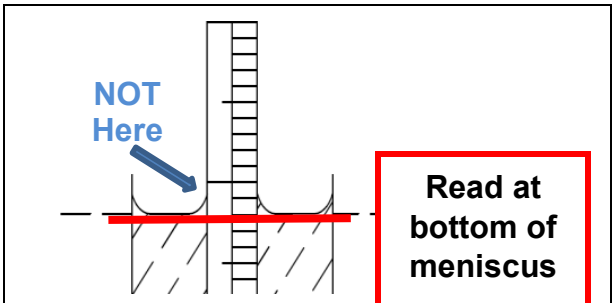
How to Check Hydrometer Accuracy:

Shake density checking solution* before pouring into 500ml measuring cylinder (14”/36cm tall). If calcium and niter particles (floating debris) develop, filter out by pouring solution through several layers of cheesecloth occasionally. Make sure testing solution has reached room temperature before starting to check hydrometers. Stir periodically to prevent temperature gradients in the solution. ****Details on making calibrated density checking solution in the “Equipment Needs” section.***

Checking Hydrometer Accuracy to Certified Master Hydrometer:

Float the certified master hydrometer in the room temperature calibration solution. Leaving master in the solution, float pre-inspected and clean producer hydrometer into solution alongside the master. Once both are stable (not moving), compare certified master hydrometer reading to hydrometer being checked. Just like you would check syrup/sap density, take reading at the bottom of the meniscus or where the liquid cuts through the stem and not the viscosity edge that creeps up on the hydrometer stem. (see graph).

NOTE: Be sure you take reading at the **bottom of the meniscus** like it was syrup or sap, (where fluid crosses through the hydrometer) **NOT where fluid creeps up hydrometer stem**.



Scale Issues Between Long Stem Master and Short Stem Hydrometers

Long stem hydrometers are scaled at 10^{ths} °Brix/Baume. The majority of producers' hydrometers brought in for checking will be short stem units with marks at 1 °Brix/Baume scale. The person checking will need to understand scale differences in comparing where the meniscus crosses the different scales
eg. 1 °Brix/Baume scale (short stem) to a 10^{ths} °Brix/Baume scaled (long stem master).
Degree differences between 10^{ths}° to 1° scales: 2.5/10^{ths} = ¼°; 5/10^{ths} = ½°; 8.5/10^{ths} = ¾°

Recommendations on Checked Hydrometers Compared to Master:

- **Calcium scale** – **scale needs cleaned off before checking**
  - *Calcium scale adds extra weight giving a false reading*
- **Cracked or missing glass** anywhere **– not for use**
  - *If cracked it should not be used due to potential glass contamination in syrup*
- **Twisted paper,** *even if a slight twist* **– not for use, will get worse with time**
  - *Paper twist can give a false reading of several Brix/Baume*
- **¼° Brix (2.5/10^{ths})** or less off master – **can still be used**
- **½° Brix (5/10^{ths})** off master - ***ok for a backup, but not main hydrometer***
- **¾° Brix (8.5/10^{ths})** off master – ***not for use - needs replaced***
- **1° Brix or more** off master – ***not for use - needs replaced***
  - **Never tell a producer how to read the hydrometer with the error built in.**
  - *Factored in wrong, the error would be doubled leading to making light or heavy density syrup.*
    - *Offer to check new purchased hydrometer for accuracy. It is rare, but brand new hydrometers can become inaccurate in shipping.*
- **In accordance with the Maple Products Regulations, hydrometers in Vermont are rejected under the following variances of accuracy:**
  - *More than 2/10° above or 4/10° **Brix** below the master floated reading*
  - *More than 1/10° above or 2/10° **Baume** below the master floated reading*
- **Never check antique hydrometers** *(can ruin them & should never be used as contain lead)*
- **Never check alcohol hydrometers** *(won't float due to difference in °Brix scales)*
- Remind producers they **should always a have minimum of two hydrometers**. One will break when needed the most. Not having a backup hydrometer can lead to off density issues. Floating both at the same time to assure they are reading the same is good practice. If one starts reading off, it is detected right away, not after drums or containers develop problems (fermented or sugar crystals).

Typical Hydrometer Problems Found Through Checking:

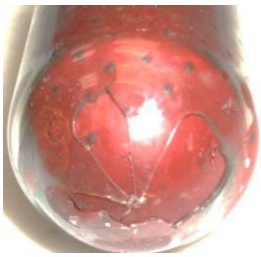
When a hydrometer is off, they typically read heavy, but they can read light too. If syrup is finished heavy, sugar crystals will form on the container bottom. Crystals equal lost sugar, lost flavor, lost income and unhappy customers. If a hydrometer is reading light the syrup is thin and could mold or ferment. ***Due to allergic reactions, skimming mold off low-density syrup for resale should never be done.***

Though rare, a new hydrometer can read off due to damage in shipping. New hydrometers should be checked before use. A hydrometer certified by the State of Vermont Metrology Lab has already gone through an accuracy check but should be rechecked before use in case of shipping damage. Some years the Vermont Lab rejects 20% of the 5,000 to 11,000 units they check due to inaccuracy.

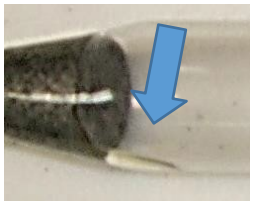
Typical Hydrometer Issues:

Calcium Scale Buildup

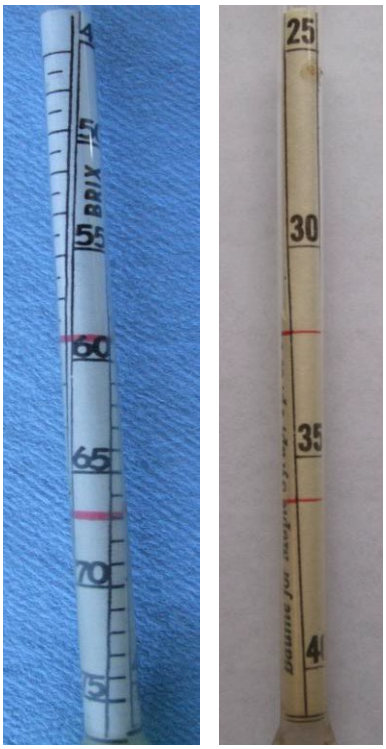
Cracked/Missing Glass



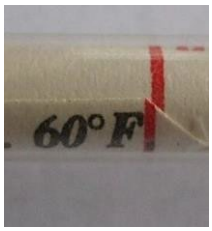
Moisture Buildup



Paper Twist



Paper Problems



Checking Refractometers (Digital or Analog):

Start by cleaning the units reading eye/surface with distilled water. If a digital unit, set unit to zero using distilled water. Place sample of purchased calibration solution on unit like you would syrup. Check unit at minimum three (3) times with the same sample of calibration solution to see if readings vary. Checking one digital unit against another zeroed digital refractometer at the same time is a recommended practice. The solution can be purchased from several equipment dealers. Keep solution sealed when not using as well as stored and protected like a temporary grading kit would be.

Hydrometer Checking Equipment Needs
&
Procedure for Making Calibration Solution

The following equipment is standard laboratory equipment. Be sure bottles have good sealing caps as the iodide solution can evaporate and will stain if spilled. Avoid glass unless laboratory glass storage bottles and do not use syrup bottles/jugs for storage of hydrometer checking solution.

Equipment Needs:

Quantity	Description	*Notes*
1	500 gram bottle of Potassium iodide 99+% for analysis	*1*
1	Bottle of refractometer calibration solution	*2*
2	500ml Clear Plastic or Polypropylene measuring cylinders *(minimum 14" (36cm) tall for long stem hydrometers*)	*3*
3	500ml polypropylene lab storage bottles or laboratory glass storage bottles	*4*
2	Long stem certified master hydrometers for syrup	*5*
2	Long stem certified master hydrometers for sap	*5*
1	Gallon of purchased pure Distilled water *(not permeate or RO water)*	*6*
1	Flashlight	*7*
1	Magnifying glass *(30 power magnification with LED light built in is best)*	*8*
1	Tool box to carry supplies	*9*
	Assorted cloth towels, paper towels, felt tip markers, post-it-notes,	*10*
1	Glass rod	*11*

Notes:

1. *Can find through laboratory equipment sales companies. Do not use syrup as will change density over time from just setting out while checking hydrometers.*
2. *The solution is sold by several equipment dealers.*
3. *Clear plastic is easier to see through, but polypropylene is more durable. Can find either through laboratory equipment sales companies.*
4. *Polypropylene is more durable. Need 3: for syrup hydrometer solution, sap hydrometer solution, and distilled water. Can find through laboratory equipment sales companies. Do not use syrup jugs for this.*
5. *Can get a long stem master certified by Vermont Agency of Agriculture Metrology Lab (approximately $100 + S&H) or from manufacture for an additional cost. Just as with Hydrometers in the sugarhouse you need two of each (Sap/Syrup). Laboratory master hydrometers are more expensive, more delicate and they will break if mishandled. Being able to check two certified masters against each other is another good practice to check for accuracy before testing producer hydrometers.*
6. *Purchase this product. Do not use permeate/RO water or steam collected in sugarhouse or tap water. This can carry sugar or impurities that could lead to a built in error or off readings of instruments testing.*
7. *A flashlight makes it easier to read hydrometers, especially when solution turns darker over time.*
8. *A magnifying glass is needed to check for cracks on the hydrometer tips (from being dropped into empty hydrometer cup) and to check if paper glue spots have let loose, causing paper drop or paper twist and to inspect the verification wax string is not broken at top of hydrometer (if it has one).*
9. *A heavy-duty plastic toolbox works best. A small tray in it is good for small items; flashlight, magnifying glass, pens, post-it-notes, etc.*
10. *The potassium iodide can stain porous items. Clean the residue off hydrometers with paper towels before placing back into producers box/tube. Remind them to wash the hydrometers good with hot water before using it. Lay a cloth towel down to keep from staining the testing area.*
11. *Glass rod is for stirring the density solution periodically to prevent temperature gradients from forming within the solution column. Can find through laboratory equipment sales companies.*

Why it is Important to Use a Certified Master Long Stem Hydrometer for Checking

Using a certified long stem master or a certified laboratory hydrometer is critical. When checking and either passing or rejecting a producers hydrometer, an accurate and certified instrument must be used. You can obtain a verification certificate from the State of Vermont Weights and Measures Metrology Laboratory for a fee. The Vermont Metrology laboratory has the equipment and credentials to perform a master hydrometer verification directly traceable to the National Institute of Standards and Technology (NIST). The Vermont Lab will provide a certificate indicating the statement of tolerance and accuracy for master hydrometers.

Why Use Potassium Iodide Instead of Syrup for Checking Hydrometers

The potassium iodide is easily adjusted to mimic syrup density without the sticky viscosity issues of syrup. Once density is set, the potassium iodide solution will stay close to the set point unless the solution is exposed to heat or excess air movement causing water to evaporate.

When using hydrometer checking solution it is key to:

1. Stir solution periodically to reduce temperature gradients from forming.
2. Check in well-lighted area and not under a heat source or a fan; set up on a steady table to reduce vibrations and hydrometer movement.
3. Keep people from leaning on table where checking hydrometers as the two units need to be stable (not moving) to compare their readings. *In addition, the solution will stain porous surfaces (hands, wood, clothing, etc.) if spilled.*
4. Store solution in sealed containers when checking is completed.
5. **Never let the hydrometer checking solution freeze.**

Setting the Density Point for Hydrometer Accuracy Checking Solution:

Density Set Points: Typically, ideal checking density for syrup hydrometers is within the range of 60˚ to 65˚ Brix *(32.5˚ to 37.5˚ Baume)*. For sap hydrometers, the 2˚ to 4˚ Brix range is best. Once set, the solution will stay close to the initial set point and is easily adjusted if required..

Making Syrup Density Solution:

The Potassium Iodide, 99+% for analysis typically comes in a granular form. It is important to do the mixing procedure slowly. Using distilled water, dissolve approximately ¼ but less than ⅓ of the 500grams of potassium iodide into the water (helps if distilled water is warm during mixing). Stir iodide into water to dissolve completely.

Pour solution into 500ml measuring cylinder. Carefully check with certified master long stem hydrometers. **Caution:** If solution density is too light, hydrometer will sink to the bottom. If solution density is too light, add small amounts of potassium iodide to water mixing thoroughly to get to a desired density. If solution density is too heavy, hydrometer will not want to float and could pop up out of cylinder. If solution density is too heavy, add small amounts of distilled water mixing thoroughly to reach desired density. Make sure of thorough mixing when adding water or potassium iodide to adjust the solution.

Making Sap Density Solution:

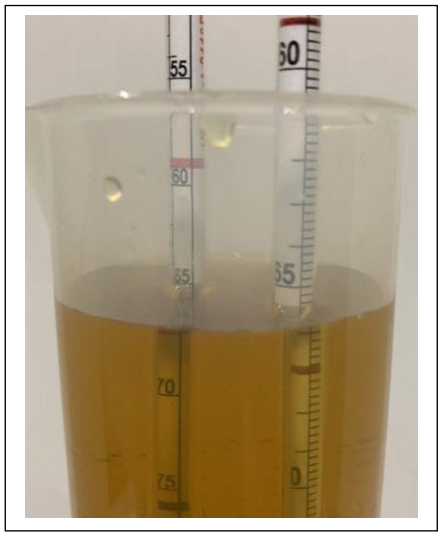
Start with a couple quarts of distilled water add only a couple of grams of potassium iodide and mix thoroughly. It takes very little iodide to make a density of 2˚ to 4˚ Brix. Pour into 500ml cylinder and check with certified master sap hydrometers. Follow procedure described for obtaining desired syrup density solution for the sap density solution. **Caution** use very little water and or potassium iodide to adjust to desired sap density as it will change rapidly at this lower density.

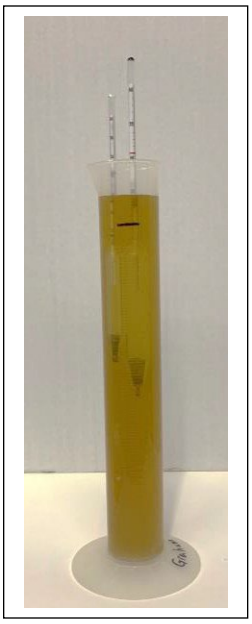
Type or Style of Hydrometers to Use:

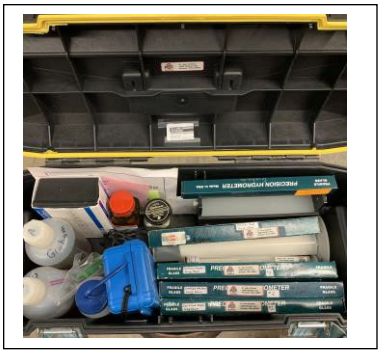
This is a producer preference. However, producers should always have a minimum of two hydrometers. One will always break when needed most. Having two hydrometers can allow the continual checking of one against the other for accuracy. Floating both at the same time often to assure they are reading the same is good practice. If one starts reading off, it is detected right away, not after drums or containers develop problems (fermented or sugar crystals).

Brix to Baume Conversion

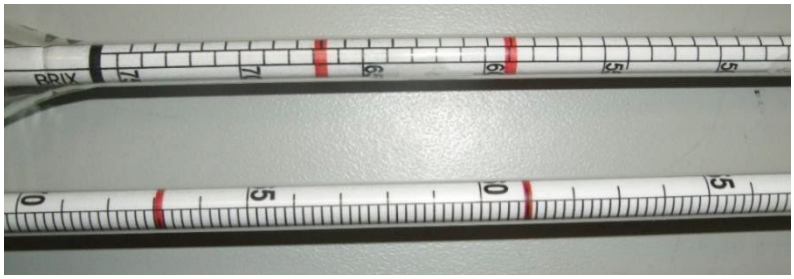
°Brix °Baumé	°Brix °Baumé
64.7.....34.9	67.4.....36.3
64.8.....34.9	67.5.....36.3
64.9.....35.0	67.6.....36.4
65.0.....35.0	67.7.....36.4
65.1.....35.1	67.8.....36.5
65.2.....35.2	67.9.....36.5
65.3.....35.2	68.0.....36.6
65.4.....35.2	68.1.....36.6
65.5.....35.3	68.2.....36.7
65.6.....35.3	68.3.....36.7
65.7.....35.4	68.4.....36.8
65.8.....35.5	68.5.....36.8
65.9.....35.5	68.6.....36.9
66.0.....35.6	68.7.....36.9
66.1.....35.6	68.8.....37.0
66.2.....35.7	68.9.....37.0
66.3.....35.7	69.0.....37.1
66.4.....35.8	69.1.....37.1
66.5.....35.8	69.2.....37.2
66.6.....35.9	69.3.....37.2
66.7.....35.9	69.4.....37.3
66.8.....36.0	69.5.....37.3
66.9.....36.0	69.6.....37.4
67.0.....36.1	69.7.....37.4
67.1.....36.1	69.8.....37.5
67.2.....36.2	69.9.....37.5
67.3.....36.2	70.0.....37.6







Degree Scale Difference Between Long Stem and Short Stem Hydrometers.



Short Stem
1 ˚Brix/Baume

Long Stem
10ths ˚Brix/Baume

A special thank you to Mr. Tom McCrumm, Dr. Abby van den Berg, Dr. Tim Perkins and Mr. Marc Paquette for reviewing the material within this assembled document.