General Information for Hydrometers

All hydrometers work on the principle of displacement. If a hydrometer has a constant mass (which it does), and is being used a definite temperature, then the volume up to a certain graduation mark is also constant. So the reading of a hydrometer is a direct measure of the mass of a certain volume of liquid (that which it displaces). It is directly proportional to the density of the liquid at the temperature of observation.

”Huh!! In English this time please”, I hear you say. Well this is the abridged way of putting it. You should see the full text! The aim of the following information is to try to explain the way a hydrometer works and some of the problems that go with it. It should go some way to assist you understanding some of the questions we receive on hydrometers. For a more precise and detailed explanation, consult the relevant standard for the hydrometers you are using.

So, all hydrometers work the same. But if they all work the same, how is it that there are so many different types available? The simple answer is that people are lazy and that people make mistakes. You can work out the percent of alcohol in a solution by using a density hydrometer, but it is possibly easier to use an alcoholometer. You need to convert density to % alcohol by using a chart or mathematically, and this takes time and mistakes can be made. However, percentage readings are very sensitive to temperature, so can cause other problems. There are many other types such as Twaddle, Sikes and the like that are not very common any more. There are usually formulas to covert S.G. or density to Twaddle, etc. but why they were invented I’m not sure. I guess there was a need at the time.

Barkometers used in the tanning industry aim to make it easier for operators to take S.G. readings by removing the “1” in front. For example, a reading of 200 on a Barkometer is the same as 1.200 S.G. Obviously this only works for liquids heavier than water. This may or may not be less confusing, but they are a type we still sell.

Density Hydrometers

Density is the basic unit of hydrometery. Density hydrometers read mass by unit of volume at a given temperature. For example, a reading of 1200 on an Australian Standard density hydrometer indicates that the liquid has a mass of 1200 kg per cubic meters at 20ºC. Another way of thinking of it is that a block of water 1m x 1m x 1m would weigh 1200kg if the water was at 20ºC. British and International standards hydrometers read in g/ml, which in the example above would change to 1cm x 1cm x 1cm with a mass of 1.200 g/ml.

Specific Gravity Hydrometers

Specific Gravity, or SG hydrometers are probably the most common type of hydrometers used. The most asked question we receive is “What is the difference between SG and Density? I thought it was the same thing?” Well kind of!

A simple definition of SG is that the reading taken on an SG hydrometer is a ratio of that liquid compared to water. For example, a reading of 1.200 SG indicates that the liquid is 1.2 times more dense than water. SG is a common unit mainly because much of the early research on density was done with water. Being the most common liquid, it was used as the base line for other liquids. The difference is in the third decimal place, so again, it makes a bigger difference on the more accurate hydrometers. SG readings are also fairly susceptible to temperature, and can require large corrections.

Brix Hydrometers

Brix hydrometers read percent of sugar by weight in solution at a given temperature. That is, 20 parts of sugar in 80 parts of water would read 20% on a brix hydrometer. The standard temperature of most brix hydrometers is 20ºC, but they are available at other temperatures.

Baume Hydrometers

There are actually two types of Baume hydrometer. The most common is the one used in the wine industry, which measures liquids heavier than water. The other type measures liquids lighter than water. They should be marked “Lighter than Water” somewhere on the scale. Lighter than water Baume hydrometers are very rare and are a type that we have not actually made for a customer before.

Alcohol Hydrometers

Alcohol Hydrometers read % alcohol by volume. Being a percentage type hydrometer, they are susceptible to changes in temperature. As mentioned earlier, correction tables are available for alcohol solution in Australian Standard AS2371. A common question we get is “When I put my alcoholometer in my wine/beer it gives a funny reading. Your hydrometer must be crook!” The standard reply is “send it back, then”. Alcoholometers ONLY measure alcohol and water solutions. Any sugar or other dissolved solids etc will give inaccurate readings. To use with wine or beer, the alcohol must be distilled out of the solution and the mixed with water to make up the same volume as you started with. Then you can use an alcoholometer to take a percentage reading.

IsoPropyl Alcoholometers

IPA hydrometers are used extensively in the printing industry. They read percentage of IPA by volume. Our IPA hydrometers are calibrated at 10ºC

Salt Hydrometers

Our salinometers read percent of salt in solution. That is a reading of 100% means that the solution is fully saturated and no more salt will dissolve. This is different from a hydrometer that reads percent salt by weight. If you made a solution of 24 parts salt and 76 parts water, you would get a reading of 100% on a salinometer, and 26% on a %/weight hydrometer. Both indicate a saturated solution.

Soil Hydrometers

Soil hydrometers are a variation of a density hydrometer. The main difference is the shape of the bulb. They have a lozenge shape so that the particles of soil tend to slide off and not sit on the shoulder of the hydrometer. Ours are made to ASTM standards.

Twaddle

Twaddle hydrometers are a fairly common hydrometer. 1º Twaddle is the same as .005 SG. I guess this makes life a little easier for an operator in that messy decimals are done away with.

Draught Survey/Load Line

Draught Survey hydrometers are use in the shipping industry to calculate the value of cargo aboard bulk carriers. They are a density hydrometer calibrated to read the density of sea water.. Load Line is similar, this time reading Specific Gravity.

So far so good! Now it gets tricky!

Temperature Corrections

Hydrometers are usually calibrated to be read at one temperature. Density is often 20ºC, SG is often 15.6ºC. If the temperature of the liquid is much different from the hydrometers calibrated temperature, a correction may need to be made. There are two types of temperature corrections. The first is a correction for the hydrometer. A hydrometer will expand in size when hot and will contract when cold. This obviously changes the volume of the hydrometer. If it expands, it floats higher in the liquid and gives an incorrect reading. A minus correction needs to be applied to allow for the change. This correction is minimal on some hydrometers and quite large on others. It depends on the accuracy of the hydrometer, and what the hydrometer reads. The more accurate the hydrometer, the more important the correction. Density hydrometers may vary by 5 degrees with only a small correction required, whereas a Brix hydrometer will need to be corrected for small changes in temperature. This is true of most hydrometers that read percentage.
Correction tables found in the standards give corrections to be applied to correct the hydrometer for temperature. The corrected reading gives the density of the liquid at the temperature of observation, or for an SG hydrometer, the SG of the liquid at the observed temperature relative to water at the calibrated temperature. ie. 15.6ºC.

But the liquid that is being tested is also subject to the same changes in temperature. If you look at the label on any bottle of lab chemical, say sulphuric acid, you will see a density or specific gravity reading for the liquid at a given temperature. If the temperature of the liquid is not what it says on the bottle, then the reading will not be accurate. Just as the hydrometer expands and contracts, so too does the liquid. Imagine a glass cube 1m x 1m x 1m filled with water. The water is at 20ºC and has a mass of 1000kg. If the temperature of the water increases, the water will expand and some will overflow. So now you still have 1 cubic meter of water, but you have lost some of the mass. You might now have 950kg of liquid at 25ºC.

OK, so who cares! Why is that important? Consider that the water is petrol, and that you are paying for a cubic meter of it. The standard temperature for fuel is 15ºC, so if the temperature is higher than that, you are not really getting as much as you would if the temperature was lower. Charts that correct for this temperature change are available for a number of liquids. Petroleum, ethanol, IPA, sugar and salt solutions and water are the more common ones. For example, the Australian Standard for glass Alcoholometers, AS2371, runs to 132 pages. Only 8 of the pages refer to the manufacture and use of the hydrometer, the rest are temperature correction charts. Obviously, for accurate readings you also need a decent thermometer.

Scale Correction

All hydrometers usually have a tolerance. While it is in theory possible to make a hydrometer that would be perfect at every point, I would not like to be the one to do it. While the tube we use in our hydrometers is fairly consistent in diameter and ovality, it is not perfect. There for you would need to check every single point. Very time consuming. So all hydrometers have a tolerance. In general, the standards require an accuracy of plus or minus 1 scale division, although there are a few that require less. Some, such as the cheap battery hydrometers used for checking car batteries, will tell you if the battery is OK or not, but little else. The readings are not necessarily correct.

Meniscus Corrections

Most hydrometers are calibrated to be read at the underside of the meniscus. The meniscus is the interface of the hydrometer and the liquid. If the liquid is opaque, a reading is taken at the top of the liquid, and a correction must be applied. A good meniscus is required for accurate readings. It should be even without any crinkles. If the meniscus is uneven, the hydrometer or the liquid is probably not clean. Some hydrometers, for example some Plato hydrometers, are calibrated to be read at the top of the meniscus. They should be clearly marked as such on the scale.

Surface Tension Corrections

All liquids have a surface tension. If you have ever seen one of the little water walker insects zipping around a puddle, they stay afloat due to surface tension. Hydrometer readings can vary greatly due to surface tension. It is important that the hydrometer and the vessel holding the liquid be as clean as possible, and that the liquid be free of contaminants such as solids, and particularly dust etc on the surface. You can take 10 readings and find none the same if everything is not spotless. Very frustrating! Overflowing the liquid helps to minimize surface contaminants, and can make things much easier when taking readings. Surface tension is more of a concern in aqueous solutions or mixtures of salt, sugar, acids and the like, and weak alcohol solutions. Stronger alcohol solutions, oils and other solutions with low surface tensions are usually not affected as much. Density and SG hydrometers usually state what surface tension they are calibrated for. Hydrometers over 1000 are usually medium surface tension, lower than 1000 is usually low surface tension. All of these corrections are available from the relevant standard.