Using Density 12MF.xls

Introduction:

This spreadsheet is designed not simply to calculate the various density Vs. Temperature solutions but also as a practical aid for use during sampling and testing fuels and other hydrocarbons during transfers when time is at a premium and where a record of the results is needed.

The description here uses marine bunkering as an example that could be relevant to many other operations.

The spreadsheet has some details entered into the “User Fluid Reference” column that define the actions taken. The whole spreadsheet can be saved using the fuel or transaction reference as a name. All the measurements are saved and the calculations can be reproduced at any time.

The calculations are based on the Manual of Petroleum Measurement Standards which declares that it is now the calculations that are the standard and not the tables.

A caution: In the marine industry where the sampling and testing uses hydrometers and originally used the tables, it has become practise to round densities to the nearest 0.5kg/m^3. Therefore a number of proprietary PC solutions present results that may differ from the results here. The calculations in this spreadsheet have been independently tested and no errors have been found. Therefore, if differences are found this is the most likely solution. To replicate the results of other programs simply round the measurements to the nearest 0.5kg/m^3 before calculation.

Marine Bunkering:

Marine fuels should be supplied accompanied by a BDN (Bunker Delivery Note) which will detail the certain fuel properties, or a CQ (Certificate of Quality), a laboratory analysis report. In either case the exact density of the fuel is reported as required by MARPOL Annex VI.

This is the density at 15°C. The operator knows that his first test will reveal the actual density of the fuel and may indicate if the fuel quality has been compromised between being analysed and delivered.

He will sample the fuel and measure the density of the sample with either a digital viscometer or a hydrometer.

If he is using a digital density meter then this device will usually report not just the density at the measurement temperature, but also the density at 15°C. If so then the first line on the spreadsheet is not needed. However, if he is using a hydrometer, he probably will measure the density at some suitable temperature such as 50°C. To find the density at 15°C he must apply a hydrometer correction, then use tables to look up the value. He might use a proprietary calculation but this will also require he manually record the results on an appropriate form. This all consumes time.

The first line of the spreadsheet is intended to allow the operator to determine, from the density at 15°C, what the hydrometer reading should be if the fuel is as described. He will be able to determine the moment he takes a hydrometer reading if the fuel is as it should be without any further steps. He will know what the density at 15°C should be ahead of time and well before bunkering starts.

After that he will take frequent samples, record the fuel temperature and check the base density. He will also be taking tank dips and will want to know the Volume Correction Factors to be applied. This involves two steps, finding the density at 15°C and then finding the density at the fuel temperature and calculating the VCF from the fuel temperature to the reference temperature.

The following steps are based on this sequence of actions.

Steps to follow:

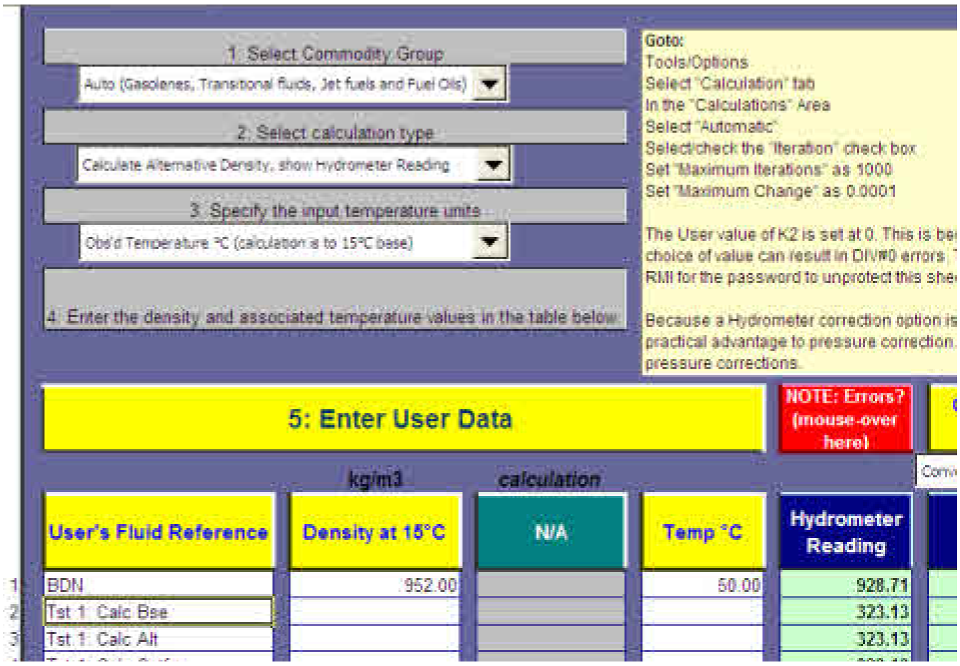
Preparation:

The initial set up of the spreadsheet is to ensure that EXCEL options are correctly configured. Some versions of EXCEL may disrupt calculations if there are conflicts between the options settings for different workbooks open at the same time. If this is the case then close any other unnecessary spreadsheets and configure the options as indicated on the spreadsheet.

Next use the drop downs to set up the commodity group. This can be “fuel oils” or it can be “Auto”. The temperature (drop down 3) should be set to “Observed temperature is in DegC”.

Step 1: BDN (or CQ)

The operator wants to know what hydrometer reading he should see, if the fuel is of the quality declared in the BDN. He therefore sets the calculation option to “Calculate Alternative Density, use hydrometer correction.”

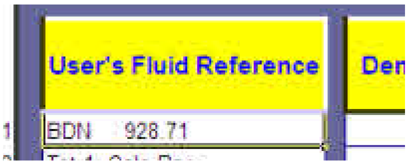


Notice that the data entry column headings will change to suit this calculation.

The operator enters the density at 15°C from the BDN and the temperature at which the hydrometer will be used.

In this example the density from the BDN is 952.0kg/m^3 and the temperature he will measure the density with the hydrometer is 50°C.

The reading he should get with the hydrometer is 928.71kg/m^3 and this value should now be copied into the “User fluid reference” column as subsequent calculations will change this calculation.



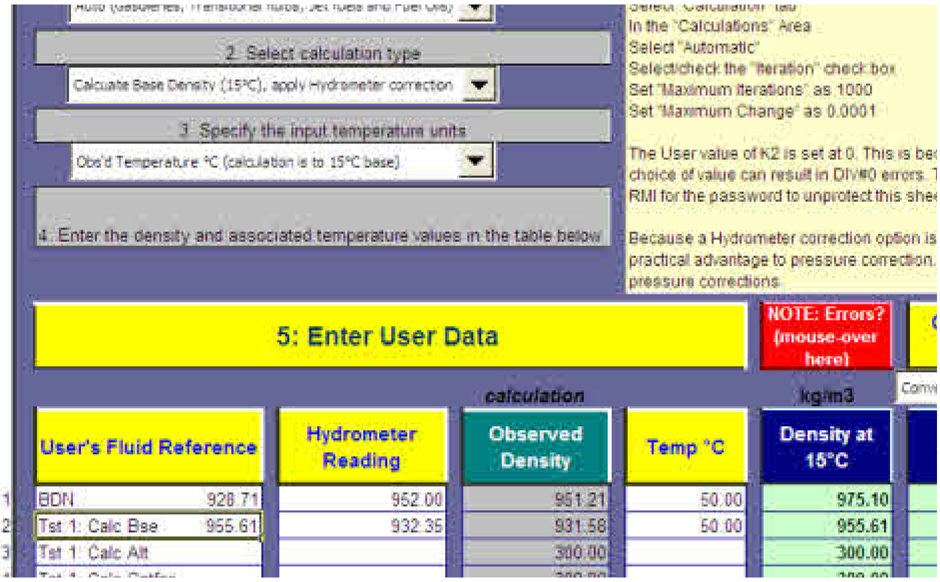
This should be done with all subsequent calculation results if required to be instantly visible. It will be seen that in the next step, the calculation result will be lost and the column headings will change. The observed data is always retained in the white cells and the results of any calculation can be recreated by setting up the appropriate calculation in drop down 2.

Step 2: Calculating base density for the first sample

The actual density may differ from the BDN value but the fuel may be considered safe and bunkering will continue. Some fuels may show some natural variation in density, most usually the result of some stratification in the suppliers tanks and as one supply tank gives way to another. Therefore it is important to track the density variations and make appropriate decisions during bunkering.

This next step is to set up the calculation as: “Calculate Base Density, apply Hydrometer Correction.”

It will be noticed that the column headings will change and that the calculation result in line one has changed because the data in the white cells is now defined as an observed density rather than a base density. It will be seen that changing the calculation function back to “Calculate Alternative Density, apply hydrometer correction” will restore the column headings and the appropriate calculation result.



The screen shot at right shows this next calculation set up and the result recorded in the “User Fluid Reference” column.

The advantage of this spreadsheet is that each calculation takes place on a new line which allows the operator to record all his measurements on one spreadsheet and recreate his calculation at any time. This can be a useful record for use in any disputes that might arise. The original measurements arre all preserved and the calculations can be independently tested at any time.

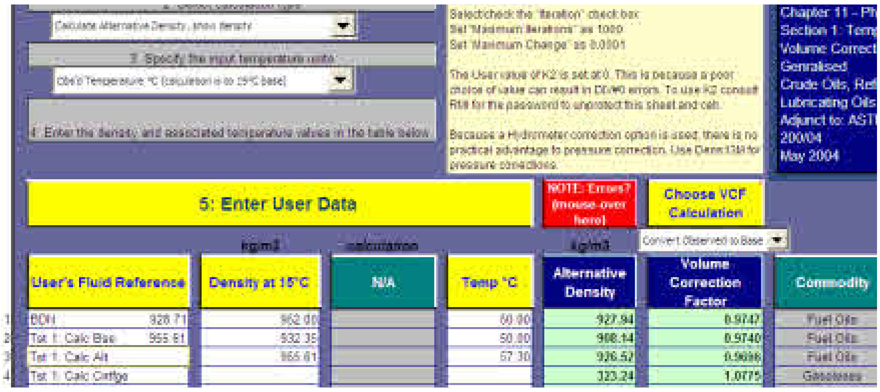
Notice that the “User Fluid Reference” is used to show the calculation type.

“BDN” indicates that user data is the base density from the BDN and the temperature is the hydrometer measurement temperature irrespective of the column headings or calculation set up and that the value recorded next to it in the User Fluid Reference Cell “is the result of that calculation.

In the second row, “Tst 1: Calc Bse” indicate that the user data is a hydrometer reading, the temperature is the temperature at which the hydrometer reading was taken and the result added to the “User Fluid Reference” is the base density calculated.

In the third row the operator will now calculate the density at the fuel delivery temperature and the volume correction factor.

Step 3: Calculate density at Fuel Temperature



The operator will enter the base density just calculated and the fuel delivery temperature. It helps not to change the calculation type till this has been done as the value is still visible in the calculation result column for row two.

Now set the calculation to “Calculate Alternative Density, show density.” The operator needs to know the actual density at the fuel temperature and there is thus no need for a hydrometer correction.

The Volume Correction Factor calculation has been the source of some confusion so in this spreadsheet the operator can select the calculation he wants. In this case it is the factor required to convert the volume at the fuel temperature to the volume at the base temperature.

Always check that the factor calculated is as expected.

Again, record the calculation results in the “User Fluid Reference” column.

These last two calculations are performed every time a sample is taken and tested. The spreadsheet allows for 9 or 10 test sample calculations dependent on whether the BDN calculation is included or not.

If more tests are performed, simply open a new workbook and each time, save the workbook under an appropriate reference for the fuel.

Online sensors for both density and viscosity measurements can provide a real time accurate measurement of the following Parameters:

- Density at flowing temperature
- Density at 15°C
- Dynamic Viscosity at flowing temperature (cP)
- Kinematic Viscosity at flowing temperature (cSt)
- Kinematic Viscosity at 50°C
- Ignition Index (CCAI and CII) - some versions only
- Density at 98°C (Centrifuge operating temperature) - some versions only.

These sensors allow data logging which will also reveal a range of fuel management issues including excess air. To see examples of actual data logged during bunkering of fuels, visit [“Bad Bunkers”](#) on the RMI web site.