

Are we over reporting LGS content in non-aqueous fluids?

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Abstract

Retort data is perceived as a relatively inaccurate number that is nonetheless useful for assessing a “trend”. It is a test run daily to control mud properties. The solids content at which a mud system is maintained has a large effect on drilling performance and cost. In most cases, field practice is to report volumetric results solids based on sample density measured prior to the start of the retort procedure. An alternative retort procedure, commonly but less frequently used, is a gravimetric method.

The gravimetric method quantifies the mass of the sample before heating, the mass of the residual solids post-heating, and the mass of the condensed liquid. It can be used to identify concentrations of specific constituents by weight. It also serves as a quality control check when retort results are reported volumetrically. Analysis of an extensive database of 50 ml retort data run gravimetrically on samples of NAF muds and of NAF cuttings found that the mass discrepancy before and after distillation is not a random error but a systematic error. There is never an increase in mass, only missing mass, in nearly 100% of the samples. The combined mass of the condensate and of the residual solids is always less than the mass of the original sample.

This systematic error is consistent. The missing mass is predominately from the liquid phase of the sample not the solid phase. Failure to capture and condense this missing liquid in the graduated cylinder causes measurement errors and results in reporting solids contents higher than actual.

Introduction

Oilfield retorts are used to determine solids contents in muds and also for analyzing constituent concentrations in waste streams. Retort cells are manufactured in a variety of sizes. All retort data in this paper is based on 50 ml retorts run gravimetrically. Calibrated scales with accuracy of 0.1 gram or better were utilized. The data is from actual drilling operations and the samples were collected for the purpose of assessing solids control performance.

The gravimetric procedure requires that the mass of the sample loaded into the retort mud cup is measured before distillation, and then mass of both the condensate and residual solids are measured after distillation. The retort temperature was 930 F. All tests were started only after the retort oven temperature had dropped below 200 F. Samples were heated in the retort oven for a minimum of 60 minutes. An illustration of the gravimetric retort procedure can be found in Figure 5.

The target at which LGS are maintained in a mud system affects costs for drilling fluid products, base fluids used to dilute, solids control equipment employed, and for waste disposal. The discussion below describes a methodology to correct an observed systematic error in solids content reporting.

Missing Mass Discrepancy

In the course of running hundreds of retorts on mostly weighted oil based muds, it became evident that in virtually 100% of gravimetric retorts there is missing mass. The initial sample mass exceeds that of the combined mass of the residual solids dehydrated in the cell and the liquid that collects in a receiver. It is common to use this mass balance as a QC procedure, the missing mass value will be used to reject retort data as invalid when the absolute value exceeds a threshold. The author’s used 1.0 gram as the threshold for data in this paper. This missing mass begs a question. What is the effect on reported solids as a result of this missing mass?

Sources of Missing Mass

When retort tests are run on drilling fluids or cuttings, there are several possible causes of missing mass. Some are inherent in the fluid test, some are procedural. Common causes of missing mass are bulleted below.

- Pre-heating the retort cell will often cause a steam explosion within the cell as the water heats rapidly through boiling point. The pressure spike causes leakage at the mud cup’s threaded connection to the upper retort cell and sometimes forces and/or splashes condensate out of the graduated cylinder that receives condensate.
- If the mud or cuttings sample contains organic materials that will “ash” in the retort cell, then the missing mass will be large. This is common with muds treated with cedar fiber, walnut shells, or other LCM.
- The threaded connections of the mud cup to upper cell body do not seal well and some leakage of vapor routinely occurs. This causes the condensation commonly observed in the retort housing the lid is opened post-heating. This lack of an “air tight” thread to thread seal can be seen easily by having a willing tobacco user blow backwards through a clean retort cell after taking a drag on a cigarette. Figure 1 gives photographic evidence of condensate accumulation.



Figure 1: Condensation build up inside Housing

Effect of Missing Mass

The effect of the missing mass on *reported* versus *actual* solids content can be modeled if the following assumptions are made:

1. The missing mass is due to a portion of liquid phase of the sample failing either to report to or condense in the graduated cylinder.
2. None of the missing mass is due to organic material “ashing” inside the retort cell which would cause an out-gassing of CO₂ or other gasses that do not condense at room temperature.
3. One last assumption made for the sake of simplifying the correction model is that all missing mass is water. The authors do not claim to prove this assumption, but a qualitative assessment of condensate routinely found inside retort housings post-cooking appears to be mostly water.

Correction Modeling

Raw retort data for a sample of cuttings, “**Sample A**”, is shown in Figure 2. The cuttings are “screen overflow” rejected by a rig owned shale shaker. The data in table was obtained by running a 50 ml retort using the gravimetrically method. Note that the data meets the authors’ criteria for acceptable mass loss of equal to or less than 1.0 gram. For this sample, the weight discrepancy was 0.8 grams.

A mathematical correction for the missing mass in Sample A can be very easily made by simply adding the mass and volume of the missing mass (e.g. “missing water”) to the empirical data. The uncorrected empirical data from which mass is missing is in the left data column. The mathematically corrected data is in the rightmost column. As can be seen, the 0.8 grams of missing mass was added to the row that reads “Weight of 50 ml Graduated Cylinder w/ Condensate”. Since 0.8 grams equates to 0.8 ml of water volume, 0.8 ml was added to two rows with words that start with “Cylinder Reading”. As

shown, less than 1 gram of uncondensed water vapor causes a LGS reporting error on the high side.

- Uncorrected LGS content is 51%^v
- Corrected LGS content is 43%^v

Sample Type	Shaker Cuttings (Diesel OBM)	
	Sample A	Sample A Corrected
Wgt. of Empty Retort Cell w/Steel Wool (g)	858.61	858.61
Weight of Retort Cell loaded (g)	912.63	912.63
Weight of Retort Cell after topping off (g)	929.9	929.9
Weight of Retort Cell after Cooking (g)	899.74	899.74
Sample Density	15.3	15.3
Wgt. of Empty 50 Graduated Cylinder (g)	45.61	45.61
Weight of 50 ml Graduated Cylinder w/ Condensate (g)	74.97	75.77
Weight Discrepancy (g)	-0.8	0
Cylinder Reading at Top of Oil (ml)	34.5	35.3
Cylinder Reading at Top of Water (ml)	3.5	4.3
% Oil Concentration by Volume in Sample	35.5%	35.5%
% HGS Concentration by Volume	1.9%	6.6%
% LGS Concentration by Volume	50.8%	43.3%

Figure 2: **Sample A** - Uncorrected Data vs. Corrected

Figure 3 shows uncorrected/corrected data for “**Sample B**” which is a drilling fluid sample. In this case, the fluid is diesel based 10.1 ppg OBM sample collected from a suction pit. The mathematical correction has been applied in exactly the same way yielding:

- Uncorrected LGS content is 10.2%^v
- Corrected LGS content is 4.1%^v

The addition of the missing water in the right data column is shown in yellow highlighted font. There are three rows where a correction occurs. This exercise mathematically zeros out the weight discrepancy. The observed systematic error is assumed to be exclusively water that should have reported with the condensate if test procedures and apparatus were flawless.

Sample Type	Active Mud (Diesel OBM)	
	Sample B	Sample B Corrected
Wgt. of Empty Cell w/Steel Wool (g)	859.00	859.00
Weight of Retort Cell loaded (g)	901.50	901.50
Weight of Retort Cell after topping off (g)	914.16	914.16
Weight of Retort Cell after Cooking (g)	875.37	875.37
Sample Density	10.1	10.1
Wgt. of Empty 50 Graduated Cylinder (g)	47.59	47.59
Weight of 50 ml Graduated Cylinder w/ Condensate (g)	85.60	[85.6+0.78=]
Weight Discrepancy (g)	-0.78	0
Cylinder Reading at Top of Oil (ml)	44.70	[44.7+0.78=]
Cylinder Reading at Top of Water (ml)	6.25	[44.7+0.78=]
% Oil Concentration by Volume	66.9%	66.9%
% HGS Concentration by Volume	4.9%	8.8%
% LGS Concentration by Volume	10.2%	4.1%

Figure 3: **Sample B** - Uncorrected Data vs. Corrected

When the above mathematical correction was applied to a large database of 50 ml retort data, the results given in Figure 4 were found. The data was broken down by sample types that the authors frequently analyze for solids content to determine LGS, HGS, oil content, etc... A simple model was created to correct the data for missing mass, and then analyze the effect this correction has on the reported LGS content. This correction means, in all cases, that the LGS is corrected downward. Some average corrections are shown in Figure 4 below. This chart is meant to be illustrative only because the correction would always be applied to empirical results for individual samples. Nonetheless, the chart below gives a rough idea of the size of the correction to be applied if the missing mass were to be “zeroed out”. For drilling operations using weighted OBM, the correction will lower the reported LGS in the range of 4% to 8% across a broad range of sample types.

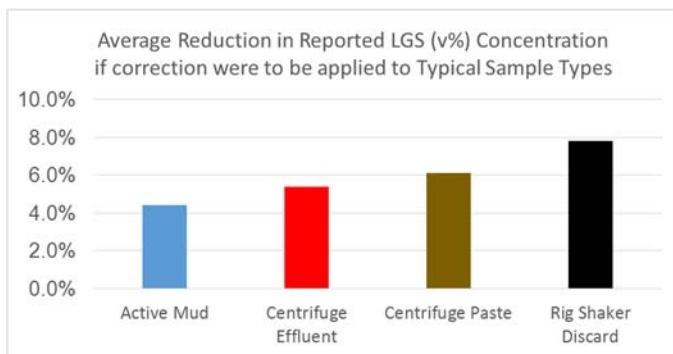


Figure 4: Average Correction for Multiple Sample Types

Conclusions

Several conclusions can be drawn:

- Mass is always lost when a 50 ml retort is run
- Qualitative evidence points to water as the most likely constituent failing either report to or condense in the graduated cylinder liquid receiver.
- LGS concentrations in drill mud and cuttings are likely being over reported due to this missing mass when empirical data from 50 ml retorts is accurately reported
- Further lab work must be undertaken to confirm the nature of the mass missing and establish a statistical basis for mathematically correcting empirical data so that LGS concentrations can be more accurately reported.

Nomenclature

$v\%$	percent by volume
ppg	pounds per gallon
NAF	Non-Aqueous Fluid
LGS	Low Gravity Solids (assume 2.6 Specific Gravity)
OBM	Oil Base Mud

References

1. Taylor, John R.: *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*, University Science Books, 1997

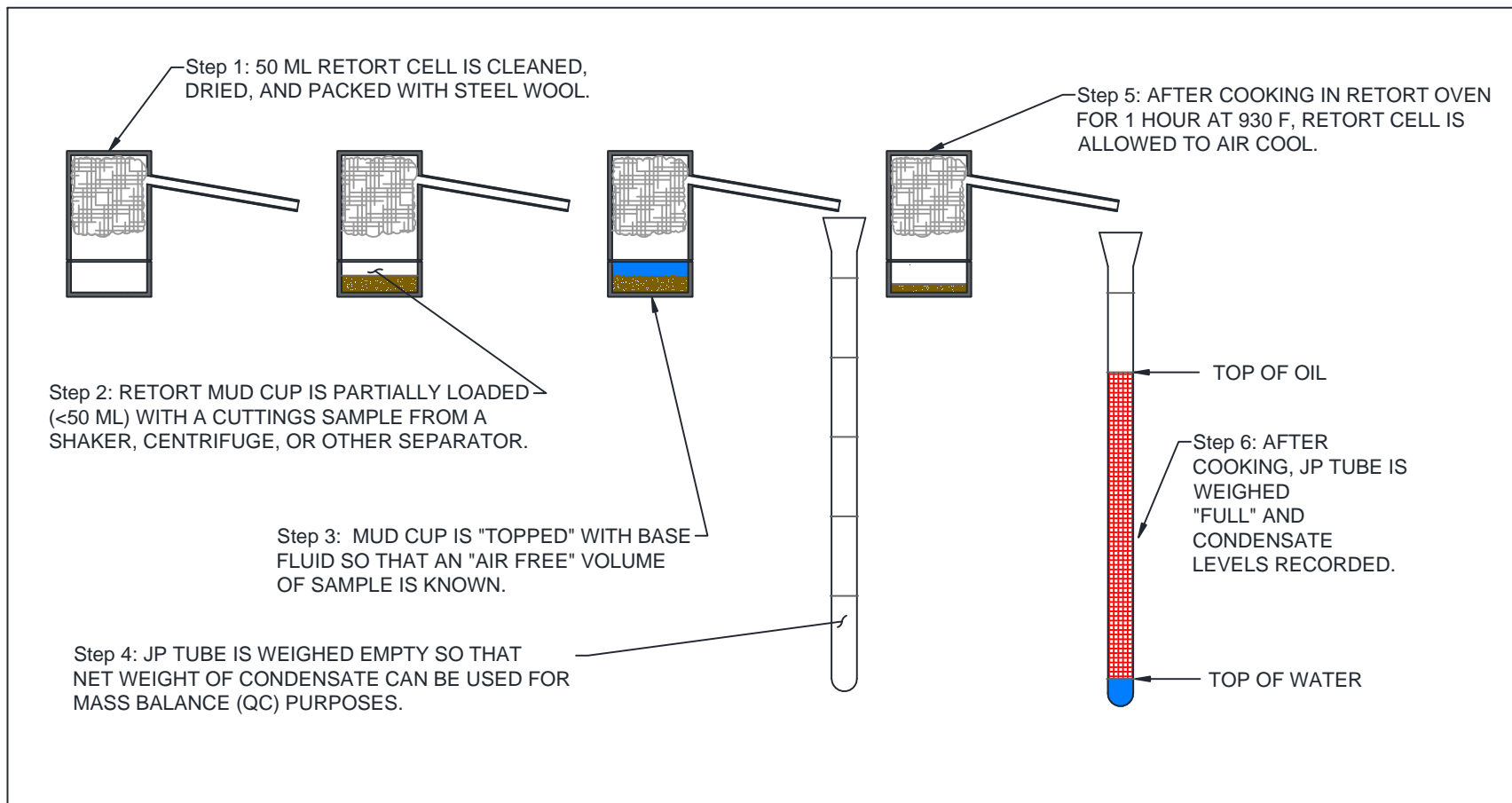


Figure 5: Illustration of Retort Procedure