Formation water detection and the effect of MEG

Kenneth Gundersen, PhD, TechnipFMC
Richard Streeton, MSc, TechnipFMC
Prashant Bajpayee, MSc, TechnipFMC

1. INTRODUCTION

Detection of formation water breakthrough for high GVF wetgas wells is important for flow assurance purposes, including scale, hydrate, and corrosion management. The small amount of water present makes this distinction between fresh condensed water and saline formation water a very challenging task. In some applications, this is further complicated by the fact that hydrate inhibitoers, e.g. MEG, is injected upstream the point of measurement and might influence the detection.

Traditionally, formation water detection uses the fact that formation water is saline (i.e. electrically conductive). Low salinity and temperature will however reduce the sensitivity of such methods. TechnipFMC has therefore, for the MPM meter, developed and qualified two methods for formation water detection (FWD), handling both high and low water salinities. These are presented in chapter 2. Methods for evaluating the sensitivity of both methods have been developed and are presented, and these methods allow one to choose the most sensitive method for a given application.

First, the 3D Broadband (microwave measurements) can be used to directly detect saline water by analyzing the so-called S-factors. The microwave based S-factors are highly sensitive to water conductivity and can thereby indicate the first presence of saline water [1]. Secondly, the meter can, knowing the reservoir and meter conditions, use its embedded PVT software (MultiflashTM) to predict the condensed water rate. Condensed water rate is then subtracted from the measured produced water rate to obtain the formation water rate. Statistical methods are applied to verify if formation water rate is significantly greater than zero (i.e. indeed non-zero) [2].

In 2017 a test was carried out by TechnipFMC at ProlabNL to investigate the effect of MEG on formation water detection and flow rate measurements for individual phases. Realistic field conditions were simulated and a large test matrix was repeated with three different MEG to water ratios, and three different water salinities. Results and conclusions from this test are presented in chapter 3.

The first version of the salinity based method applied by the MPM meter, using the S-factors, was presented at NSFMW 2009 [1]. In recent years, improvements to this method have been developed, and several blind tests at 3rd party test facilities have been carried out. The paper presents the results from the most comprehensive of these blind tests in chapter 0.

2. Formation water detection methods

As described in the introduction the MPM meter has built in two methods for formation water detection. These are described in more detail in chapter 2.1 and 2.2.

2.1 Formation water detection using Wetgas Salinity

Formation water breakthrough can be detected by detecting when the produced water goes from being fresh condensed water, to being saline. The wetgas salinity method of the MPM meter is based on a patented differential phase microwave measurement within the pipe. The ressonance frequency, identified as a differential phase shift between two receiving antennas, determines the permittivity of the wetgas mixture fluid. The permittivity in turn effectively gives the water fraction of the wet gas. Further, the slope of the phase shift vs. frequency at the ressonant frequency is related to the conductivity of the water. An increase in water conductivity causes a decrease in the slope of the curve, as indicated in Figure 1.

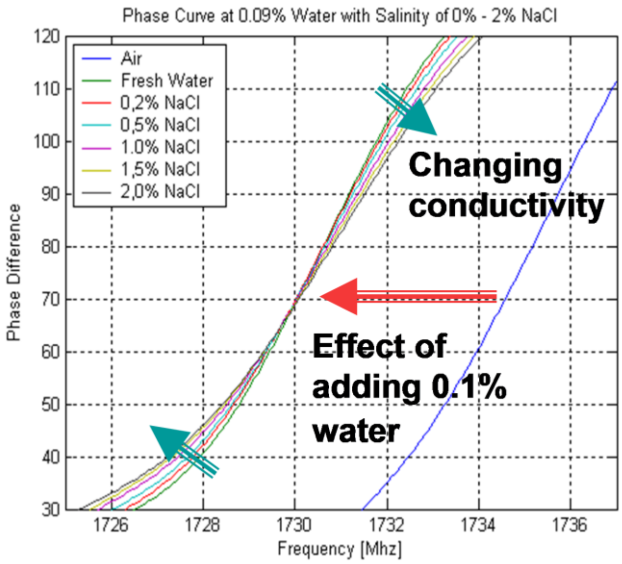

Figure 1 - 3D BB phase curve for wetgas salinity

The wetgas salinity functionality consist of two steps:

1. Detection of salinity by the Salt Water Index
2. If salt is present, then the produced water salinity is measured

In the current context the first of these steps, detection, is the focus.

From the differential phase shift curve, illustrated in Figure 1, a parameter called the S-factor is calculated. The S-factor can be calculated for each direction and is closely related to the slope of the phase curve. Before using it in the wetgas salinity calculation, the S-factors are normalized using a calibration constant representative for the value in gas. There are two ways for obtaining this value. First, it can be measured after installation and when the meter is filled with gas during for example a shutdown. This can be done both manually, or one can use the gas insitu functionality of the MPM meter to automatically detect such periods and store the measured S-factors (along with measured gas density and permittivity). The stored values can then be evaluated and implemented by an MPM service engineer or other operator. Typically, this is done during commissioning and startup of a meter. The second way to obtain the calibration constant for the S-factor is to use the value measured during the early production phase, where it often can be verified that only condensed water is present. By correcting for the measured water volume fraction (of condensed water) the calibration value can be back-calculated by using an empirically determined relationship.

This measurement of S-factors can in principle be performed in all the 27 measurement directions, or antenna combinations, used by the 3D BB tomographic system. An extensive amount of test data have however shown that three specific directions stands out as giving the most robust and reliable detection and measurement of salinity. These are the longitudinal directions, where the receiving antennas are positioned along the longitudinal axis of the pipe.

Salt Water Index (SWI)

The Salt Water Index (SWI) is calculated from the normalized S-factors and measured WVF. The SWI is a strong indicator for water salinity, but test data hace shown that the detection accuracy can be improved by including the WVF. This is illustrated in Figure 2 where a typical pattern for S-factors vs WVF is shown. There is clear separation between fresh and saline water points, but the S-factor value is affected by both salinty and WVF.

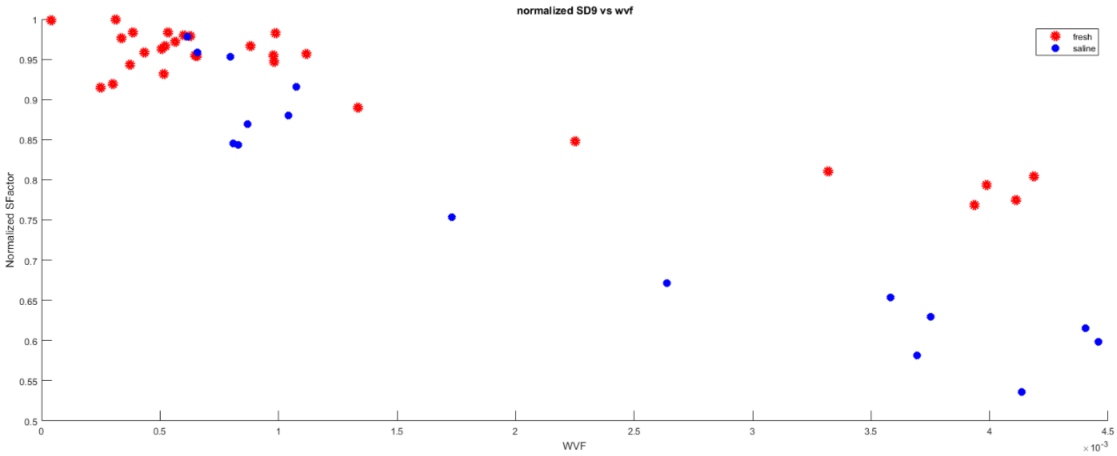

Figure 2 - Variation in S-factors with WVF

The calculated SWI is compared to a pre-configured classification threshold to indicate salinty, or in other words, presence or absence of formation water. The SWI can take on values from 0 to 1, and the standard threshold for salt water indication is 0.5. However, there is a trade-off between false alarms and missed detections and it can be optimized for a specific application. As shown below in , a lower threshold (e.g 0.5) will give more false alarms, while a higher (more strict) threshold (e.g 0.8) can result in more missed detections.

WVF Range (%)	False Positive Rate (%)	False Negative Rate(%)
0.00-0.025	12 [58 points]	77.7 [85 points]
0.025-0.050	0 [10 points]	56.4 [101 points]
0.050-0.075	0 [1 point]	31.4 [54 points]
0.075-0.100	0 [0 point]	28.8 [45 points]
0.100-0.150	0 [0 point]	13.0 [54 points]
0.150-0.200	0 [0 point]	9.5 [21 points]
0.200-0.400	0 [0 point]	0 [6 points]

Detection Threshold 80%

WVF Range (%)	False Positive Rate (%)	False Negative Rate(%)
0.00-0.025	36.2 [58 points]	72.9 [85 points]
0.025-0.050	10.0 [10 points]	42.5 [101 points]
0.050-0.075	0 [1 point]	24.1 [54 points]
0.075-0.100	0 [0 point]	22.2 [45 points]
0.100-0.150	0 [0 point]	11.1 [54 points]
0.150-0.200	0 [0 point]	9.52 [21 points]
0.200-0.400	0 [0 point]	0 [6 points]

Detection Threshold 50%

Table 1 - Impact of SWI threshold on detection for a previous test

The first version of the wetgas salinity method of the MPM meter was presented at NSFMW 2009 [1]. The current version is based on the same principle as the original method, and the enhancements can be summarized as the inclusion of WVF together with S-factor in SWI calculation, and a different selection of which 3D Broadband directions are used for S-factor measurement.

2.2 Formation water detection using Multiflash™

As mentioned above TechnipFMC has developed a new method for FWD using the embedded PVT software Multiflash, and details of the method has been presented in [2]. In this section, we will summarize the method and theory behind it as well as give some practical examples to compare this method against wetgas salinity method.

The produced water flow rate measured by the meter reperesents the sum of both formation water and condensed water in liquid form. Water vapour will be measured as part of the gas since the water vapor content in the gas is included in the permittivity model for the gas phase.

The fluid compositional model which is stored on the meter, and used by the embedded Multiflash SW, can be saturated in real-time at reservoir conditions, given that these are provided to the meter, for example through a Modbus input. The water-saturated PVT model may then be used to estimate water vapor content at reservoir condition and at actual condition, and the difference can then be used to estimate the condensed water at actual condition. Since the meter measures the total water rate, the formation water flow rate can be calculated as follows [2]:

$$Q_{vFormWater} = Q_{vWater} - Q_{vWc} \qquad (1)$$

where $Q_{vFormWater}$ is the estimated volume flow rate of formation water, Q_{vWater} is the volume flow rate of produced water (measured by the meter) and Q_{vWc} is the volume flow rate of condensed water (as predicted by Multiflash™) at actual conditions.

Using mass balance between reservoir and actual conditions,

$$Q_{mWc} = Q_{mResWv} - Q_{mWv} \qquad (2)$$

Where Q_{mWc} is the mass flow rate of condensed water at actual conditions, Q_{mResWv} is the mass flow rate of water vapour at reservoir conditions and Q_{mWv} is the mass flow rate of water vapour at actual conditions. To obtain Q_{mResWv} and Q_{mWv} Multiflash predictions of water vapor mass fraction is multiplied by the gas mass flow measured by the MPM meter.

The uncertainty of the predicted water vapor saturation is important because it, together with the meter's uncertainty for the measured produced water flow rate, determines the uncertainty of the predicted condensed water flow rate. The expected uncertainty of the CPA Equation of State model in the prediction of the water vapor saturation of the gas is +/-2.5 to 10 mol% [3-6], depending on conditions. By making the conservative assumption that uncertainties of the saturated water at meter and reservoir are uncorrelated, and that it is +/-10 mol% for all cases, the total uncertainty in the predicted flow rate of condensed water at actual conditions can be calculated as

$$Uncertainty\_Q_{mWc} = \sqrt{\sigma^2_{Q_{mResWv}} + \sigma^2_{Q_{mWv}}} \qquad (3)$$

The formation water flow rate is calculated as the difference between the produced water flow rate as measured by the meter and the predicted flow rate of condensed water. The minimum amount of formation water required for detection at 95% confidence is then evaluated using the standard deviation in the produced and condensed water flow rates as given below (one sided hypothesis test):

$$FWDLimit = 1.64 * \sqrt{\sigma^2_{Q_{vWc}} + \sigma^2_{Q_{vWater}}} \qquad (4)$$

Where $\sigma_{Q_{vWater}}$ and $\sigma_{Q_{vWc}}$ are standard deviation of produced water rate measured by the meter and the poredicted condensed water rate respectively.

Gas In-situ Reference

It should be noted that the *Multiflash*™ method of formation water detection assumes monophasic water-saturated gas at reservoir conditions. In the relevant GVF range (typically GVF>99%), it is the single phase gas permittivity which is most important configuration parameter to achieve an accurate measurement of the produced water flow rate. The MPM meter has built-in functionality for performing manual and automatic gas-insitu measurements of gas properties. The objective of this method is to use the meter to measure the gas properties at operating conditions and therefore to reduce some of the uncertainties inherent in the PVT model. The meter automatically performs the measurement whenever it detects pure gas using the DropletCount functionality. Adjustments to the gas density and permittivity can be applied automatically or manually through the MPM meter GUI. In this way, the uncertainty in the produced water flow rate is minimized which improves the sensitivity of the *Multiflash*™ method for formation water detection.

Detection Limit Example

A project-specific evaluation is required to determine the detection limit for each formation water detection method; how small amounts of formation water can be detected. For the wetgas salinity method, the detection limit is impacted primarily by the magnitude of the formation water salinity – the higher the salinity, the easier formation water is to detect. For the *Multiflash*™ method, it is the uncertainty in the measured produced water flow rate (or measured WVF), which has the greatest impact on the detection limit.

The example below demonstrates the way in which the detection limits varies between the two methods. In this case the MPM meter is installed upstream choke conditions of 300 barg, 100 ºC whilst reservoir conditions are 500 barg, 150 ºC. An assumed flow rate of 150 MMscfd has been considered.

	Parameter	Actual Conditions	Comments
Condensed	Q_{vWc} (m3/d)	4.4	Difference between water vapour at reservoir and actual conditions
	Standard deviation in Q_{mWv} (kg/d)	614.9	Uncertainty of water vapour prediction using CPA model is up to +/- 10 mol%
	Standard deviation in Q_{mResWv} (kg/d)	839.8	Uncertainty of water vapour prediction using CPA model is up to +/- 10 mol%
	Standard deviation in Q_{vWc} (m3/d)	1.04	Root sum square
Produced	Uncertainty in measured WVF (%abs.)	0.02	From MPM meter uncertainty specification
	MPM standard deviation in Q_{vWater} (m3/d)	2.8	
	Standard deviation in $Q_{vFormWater}$ (m3/d)	2.1	Root sum square
	Formation water detection limit (bpd)	22.1	Converting to bpd and including factor 1.64 (one sided hypothesis test for whether actual value of formation water is >0)

Table 2 - Detection limit using MultiflashTM method

The detection limit for formation water is very low – 22.1 bpd. This indicates a detection limit of about 0.15 bbl/MMscf at the nominal gas rate of 150 MMscfd. It should be noted that this analysis is performed at 95% confidence interval. This means that when the formation water measurement is at the given detection limit there is a 5% probability that the resulting alert is a false alarm. As for the wetgas salinity method a higher detection limit could in practice be considered to increase conservatism and reduce the number of false alarms, or vice versa.

The table below shows two calculations of the formation water detection limit using the wetgas salinity method for the same example. As shown, when the formation water salinity is low at 0.4 %, the detection limit is 96 bpd which is significantly higher than the *Multiflash*™ method. On the other hand, if the formation water salinity was 4%, then the wetgas salinity method would be more effective.

Parameter	Actual Conditions
Salinity (wt%)	0.40
detection limit salinity based method (bpd)	96.0
Salinity (wt%)	4.0
detection limit salinity based method (bpd)	10.0

Table 3 Detection limit using wetgas salinity method for two different formation water salinities

2.3 Formation Water Detection (FWD) Alarm

Having two different methods for FWD in the meter, provide unique flexibility to users and they can configure the formation water alarm based on field conditions. It is possible to configure the FWD alarm by selecting 1 of 4 different configuration in MPM GUI.

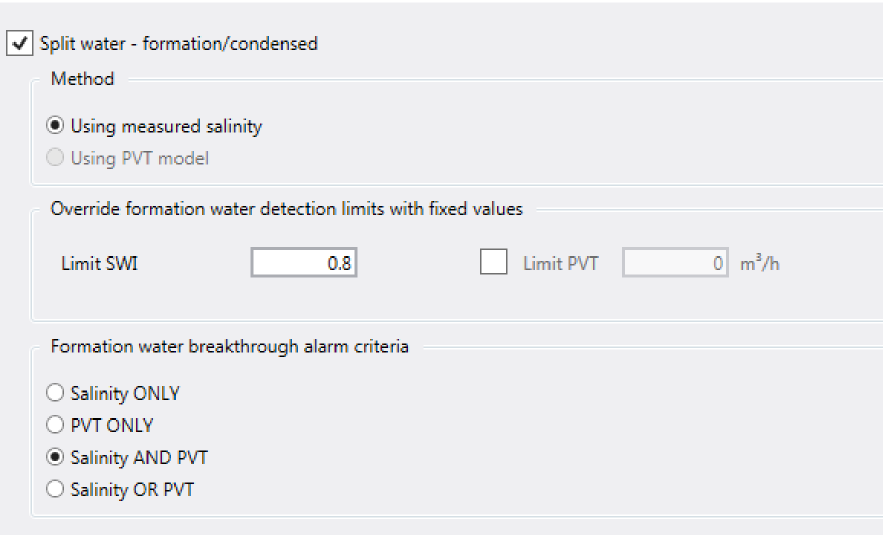

Figure 3 – Configuration of Formation Water detection

3. The Effect of MEG on Formation Water Detection and flow rate measurements

Gas hydrates are formed in the presence of water, low temperature, and high pressure. In most cases, injection of a thermodynamic hydrate inhibitor is used to prevent hydrate formation. Methanol and mono-ethylene glycol (MEG) are common inhibitors and sometimes these are injected upstream the wetgas meter. One important question is then how the presence of for example MEG affects the flow rate measurements and the formation water detection. To investigate this TechnipFMC conducted a flow loop test at ProlabNL in April 2017. Realistic field conditions were simulated and a large test matrix was repeated with three different salinities and three different MEG to water ratios at high GVF wetgas flow conditions (GVF > 99.5%). Results and conclusions from this test are presented in the following.

The permittivity of MEG is around half that of water, and the permittivity of both MEG and water are an order of magnitude larger than that of the hydrocarbons. Consequently, MEG, from a dielectric measurement point of view, will be measured as a mixture of oil and water. In addition, the density of MEG is about 1110kg/m3 at standard conditions. As MEG has a density that is generally higher than the oil-water mixture it was expected to increase the liquid mass flow rates measured by the meter, directly according to the injected MEG mass rate. No effect on gas rate was expected. The main question was considered to be how much of the MEG that would be measured as water and oil respectively. It was hypothesised that MEG could be accounted for by including it in the permittivity mixing model as a fourth phase, and where the MEG fraction is calculated from the MEG injection rate and total volume rate from the meter.

For the salinty based FWD the main question was whether MEG affects the relationship between measured S-factor and WVF for a given water salinity, as illustrated in Figure 2. Or in other words: whether the Salt Water Index calculation had to include a MEG term.

3.1 Results, salinity based Formation Water Detection

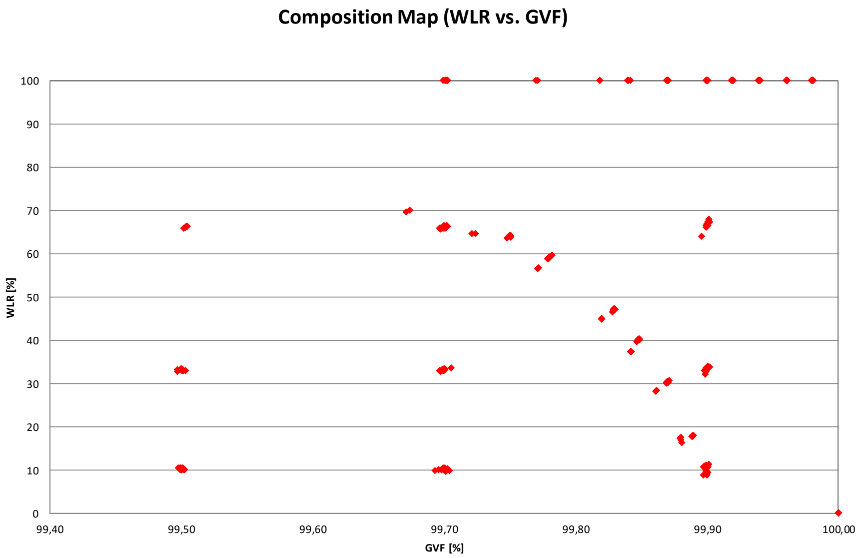

Figure 4 - Composition Map for MEG Test

The composition map for the testmatrix that was run is shown in Figure 4. This matrix was repeated with all combinations of water salinity 0, 2.1 and 10%weight NaCl, and MEG to water ratios of 0, 0.6 and 1.0 (volumetric). The test pressure was 60barg and temperature was 60°C. Fluids were methane gas and Oseberg Crude. Gas density at test conditions were 39 kg/m3 and oil density 791 kg/m3.

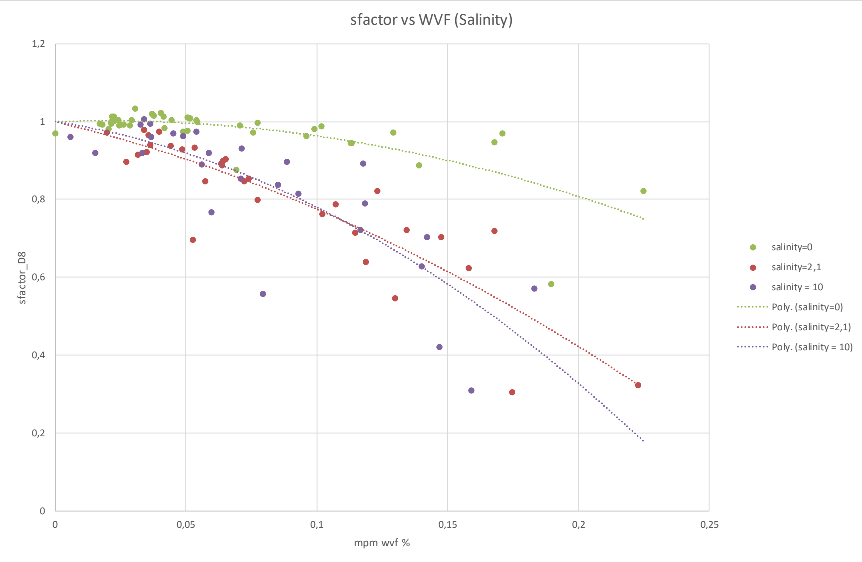

Figure 5 - S-factor vs measured WVF, No MEG

Figure 5 shows a normal relationship between S-factors, measured WVF and water salinity for test points with different salinities and without MEG. In general the average S-factor will decrease with increasing salinity for a given WVF. The overlap seen for the 2.1 and 10% salinity groups at low WVF is interpreted as being due to the limited number of test points.

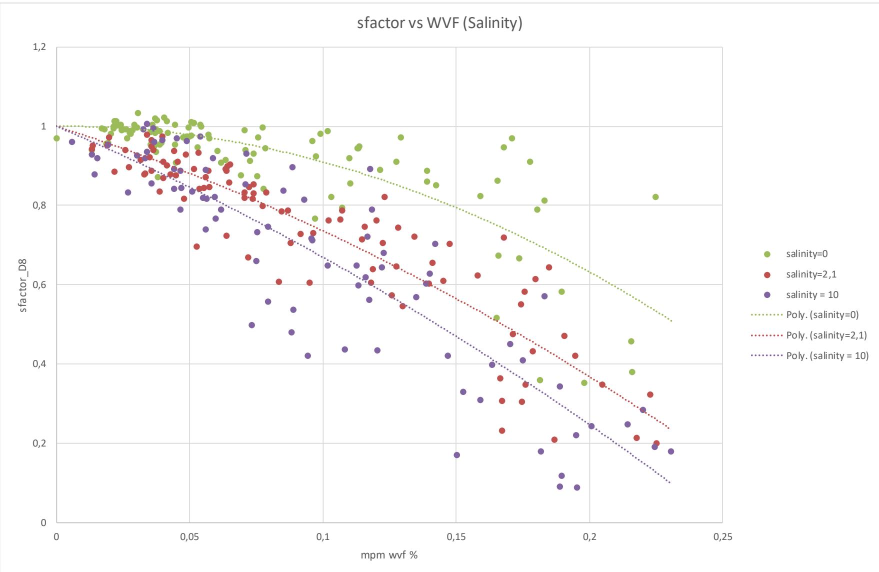

Figure 6 - S-factor vs measured WVF, all points

Figure 6 shows all test points with different MEG levels including no-MEG points, (points are color coded based on salinity values). As can be seen the S-factor and WVF follow the expected relationship even in presence of MEG i.e. S-factor decrease with higher salinity and higher water volume fraction. Therefore, the existing, unmodified, algorithm of calculating salt water index (SWI) based on measured WVF and S-factor was expected to produce accurate detection also with MEG.

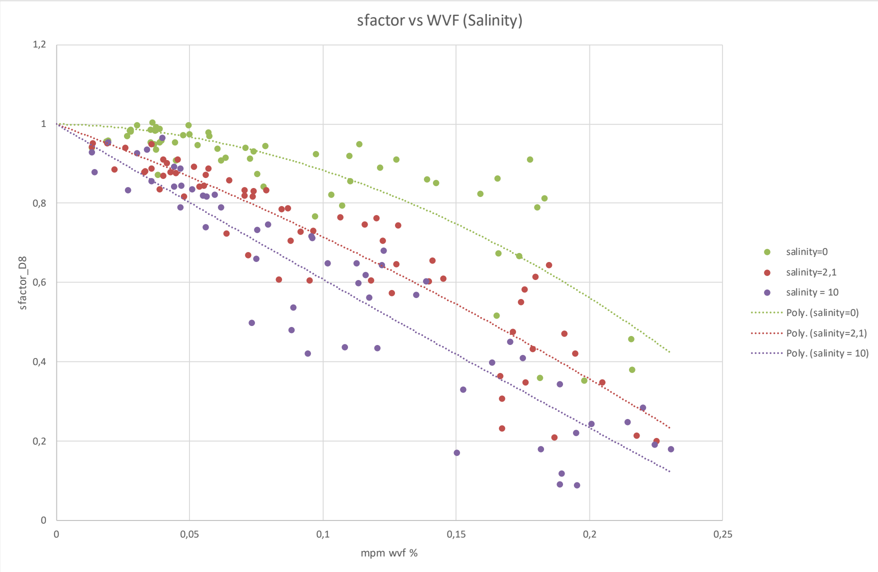

Figure 7 - S-factor vs MPM WVF, only MEG points

In Figure 7, showing only points with non-zero MEG ratio, it can again be verified that the presence of MEG does not have a significant effect on the relationship between S-factor and WVF. The data follows the same S-factor vs wvf pattern as for no-MEG points (Figure 5).

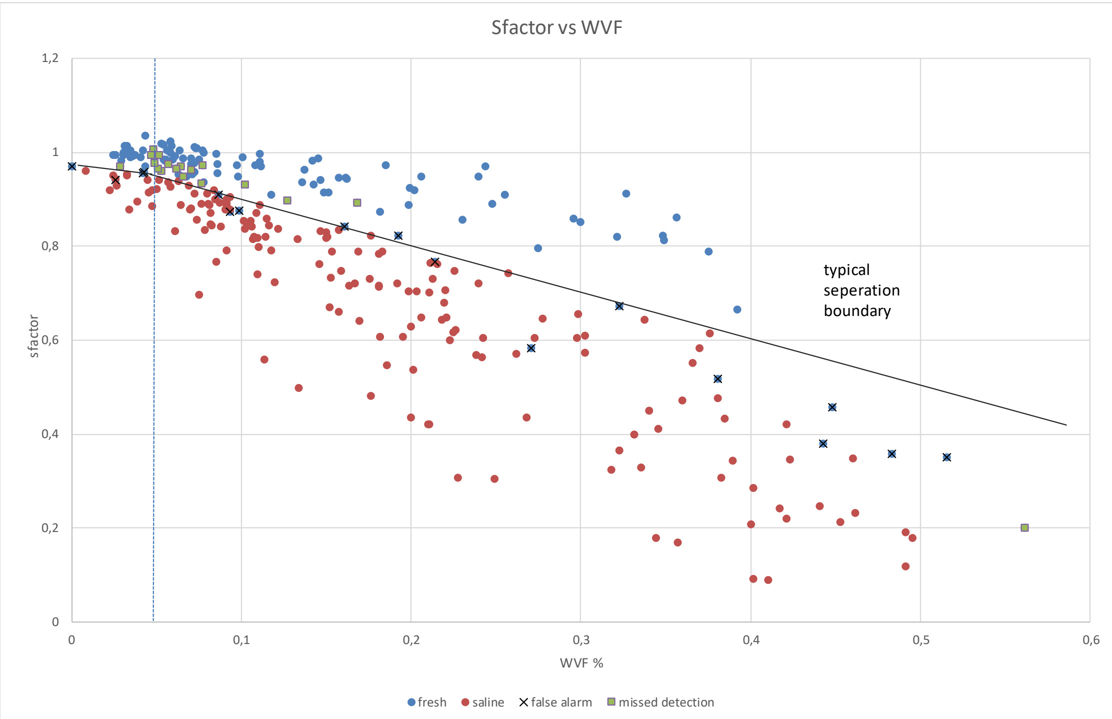

Figure 8 - S-factor vs measured WVF, classification boundary

Figure 8 shows S-factor plotted against WVF along with an illustration of a detection boundary where the different sides of the boundary line indicate saline(below) and no saline regions. The overlap between saline and non-saline points increase somewhat below 0.05% WVF (i.e. less certain detection in this area)

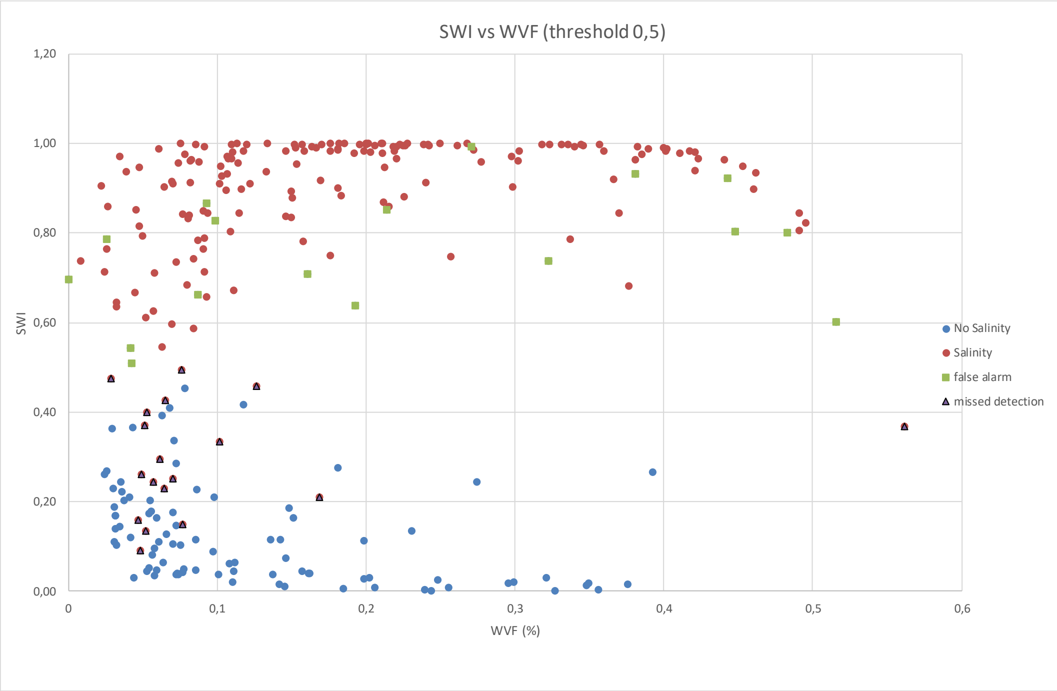

Figure 9 – Salt Water Index vs. measured WVF

The meter ultimately detects salinity based on the calculated SWI, which is a non-linear function of S-factor and measured WVF. If SWI is greater than a threshold the meter indicates Formation Water. Using the unmodified function for SWI (derived from previous test data with no MEG) and the default threshold of 0.5, 6.4% of saline points in this test will go undetected (missed detection) and 6% of fresh points will give False Alarm. Based on field requirements, the threshold can be configured to reduce missed detection or false alarm, as illustrated in

Table 1.

3.2 Results, flow rate measurements

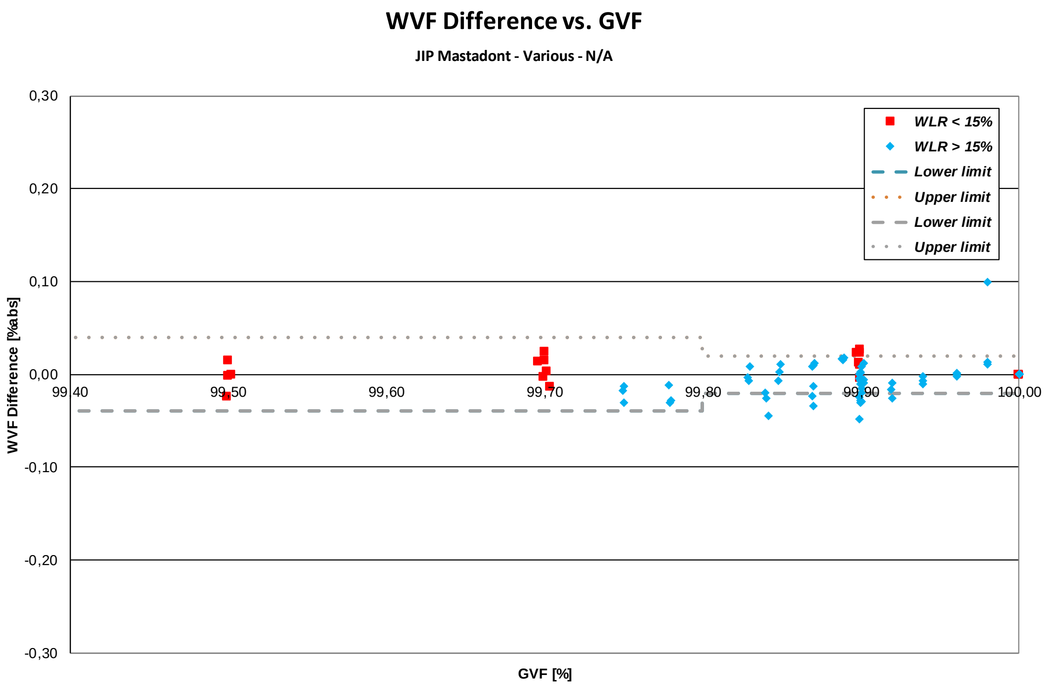

Figure 10 – WVF difference vs. GVF, no-MEG points

Figure 10 shows the absolute WVF difference between measured and reference WVF against GVF for test points without MEG. These points have a mean square error (MSE) of 0.03%.

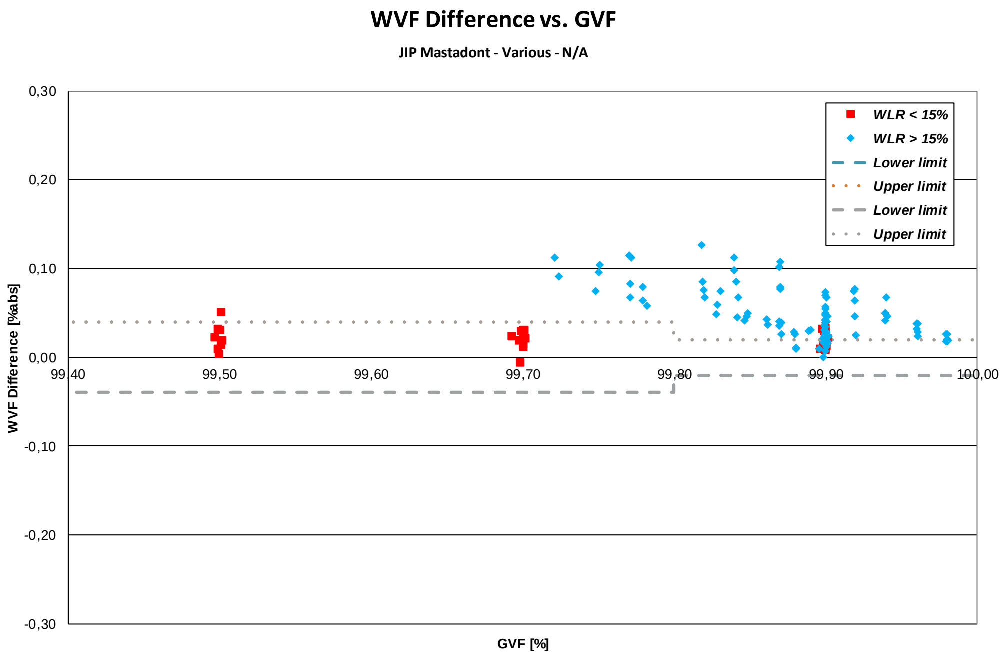

Figure 11 - WVF difference vs. GVF, MEG points

As can be seen in Figure 11 injecting MEG increases the measured water rate. This was as expected and means that the presence of MEG must be corrected for. By using the reference flow rate for MEG, and incorporating the MEG fraction in the permittivity mixing models (as the fourth phase), a corrected water rate measurement was obtained. Figure 12 shows the WVF difference for MEG points after correction for MEG has been applied. After correction the uncertainty of the water volume fraction measurement is increased by 40% (relatively) with a MEG to water ratio of 1:1 (compared to no MEG). In a field application the meter must be given the MEG injection rate, for example via modbus, to be able to do this correction.

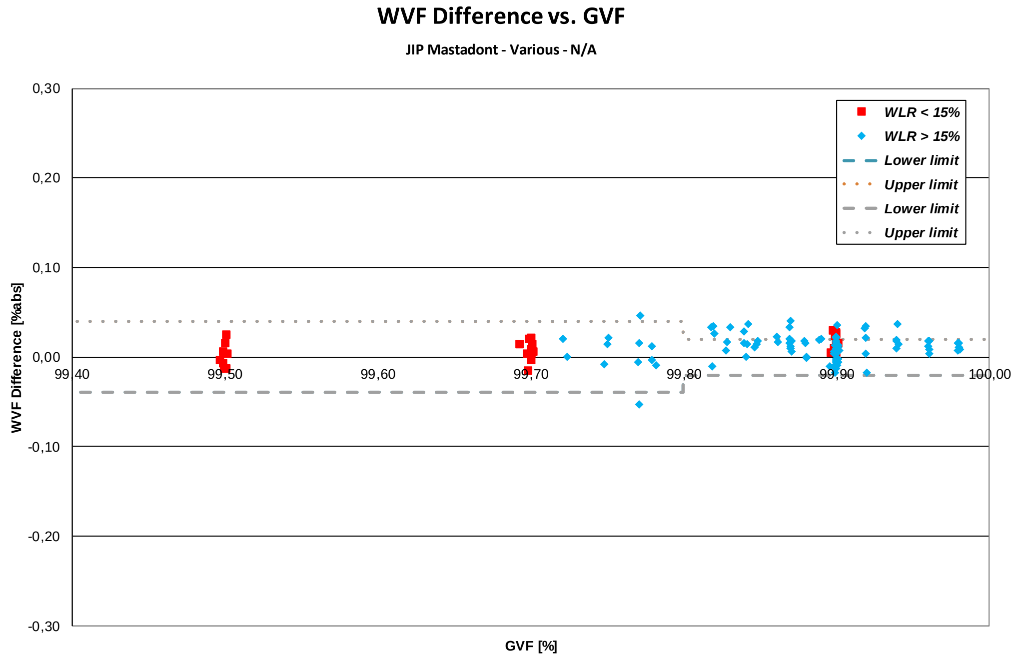

Figure 12- WVF difference vs. GVF, MEG points, corrected WVF

Further it was found that the remainder of the MEG mass flow shows up as oil in the measurement and can therefore easily be corrected for. No significant effect on measured gas rate was observed.

4.3 Effect of MEG for Multiflash based FWD

The embedded *Multiflash*™ method is also able to account for the presence of MEG. The user can input a MEG injection rate as part of the meter field configuration or provide this information real-time through the control system as Modbus input parameter. The measured produced water flow rates is then corrected as described in the previous chapter. The formation water rate then becomes:

$$Q_{vFormWater} = Q_{vWaterMEGCorrected} - Q_{vWc} \tag{6}$$

where $Q_{vFormWater}$ is the volume flow rate of formation water, Q_{vWc} is the volume flow rate of condensed water (as predicted by *Multiflash*™*)* and $Q_{vWaterMEGCorrected}$ is corrected water rate measured by meter.

Using the above relationship and considering the uncertainty in each measurement, Table 4 below shows the revised calculation of the expected detection limit for formation water using the *Multiflash*™ method in the presence of MEG for the same case given previously in Table 2. Notice that the uncertainty for the measured WVF has been increased 40%, according to the test results given in 3.2

	Parameter	Actual Conditions	Comments
Condensed	Q_{vWc} (m3/d)	4.4	Difference between water vapour at reservoir and actual conditions
	Standard deviation in Q_{mWv} (kg/d)	614.9	Uncertainty of water vapour prediction using CPA model is up to +/- 10 mol%
	Standard deviation in Q_{mResWv} (kg/d)	839.8	Uncertainty of water vapour prediction using CPA model is up to +/- 10 mol%
	Standard deviation in Q_{vWc} (m3/d)	1.04	Root sum square
Produced	Uncertainty in measured WVF (%abs.)	0.028	From MPM meter uncertainty specification
	MPM standard deviation in Q_{vWater} (m3/d)	2.6	
	Standard deviation in $Q_{vFormWater}$ (m3/d)	2.1	Root sum square
MEG	MEG flow rate (m3/d)	4.4	MEG is injected with 1:1 ratio relative to produced water
	Standard deviation in MEG flow rate (m3/d)	0.1	Uncertainty of MEG flow rate measurement assumed to be +/-3.0%
	Formation water detection limit (bpd)	29.1	Converting to bpd and including factor 1.64 (one sided hypothesis test for whether actual value of formation water is >0)

Table 4 - Detection limit using *Multiflash*™ method and accounting for MEG injection

As shown above MEG injection will increase the detection limit for formation water with the Multifalsh based method. The main reason for this is that uncertainty in the measured WVF is increased.

3.4 Conclusions MEG effect for FWD

With regards to the salinity based formation water detection the conclusion of the test is that the existing detection method can be used without modification. The current test did not have enough data to detect a significant reduction in detection accuracy, but a slight degradation should be expected since the uncertainty of the measured WVF increases somewhat. A larger test would have been necessary to quantify this effect further. In the current test 6.4% of saline points went undetected and 6% of fresh points will gave a false alarm. The relationship between water salinity, S-factors and measured WVF does not change in the presence of MEG and there are indications that the fact that meter measures more water in presence of MEG helps salinity detection at lower WVFs.

For the flow rate measurement it was verified that for WVF measurement MEG could be corrected for by including MEG in the permittivity mixing models as the fourth phase. The MEG injection rate needs to be input to the meter to be able to calculate the other phase fractions. Further it was found that the remainder of the MEG mass flow shows up as oil in the measurement and can therefore easily be corrected for also in this sense. No significant effect on measured gas rate was observed.

Overall therefore, both methods of formation water detection can be adjusted to handle MEG injection given adequate information on the inhibitor concentration (purity) and injection rates.

4. Blind test Formation Water Detection at Prolab

Recently TechnipFMC participated in a blind test in cooperation with one of our clients at ProlabNL. Permission to present the results have been given under the condition of anonymizing the data.

The wetgas salinity based formation water detection was tested to evaluate the minimum water rate needed for formation water detection for a high GVF wetgas field. In total over 100 test points were done for the MPM meter, aproximately 20% were fresh water points and the rest saline points, with salinity varying from 1 to 10%. GVF and WLR were in the range >99.0% and <10% % respectively.

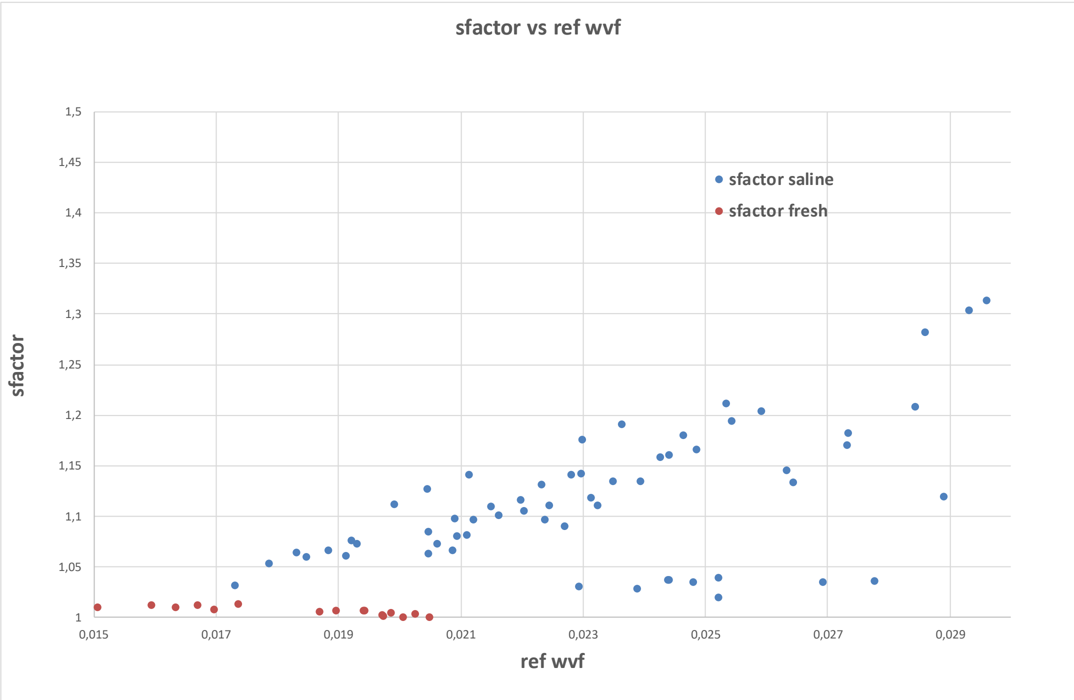

Figure 13 - S-factor vs WVF for test data

In Figure 13, S-factor is plotted against reference WVF for saline and fresh water points. As can be seen there is good separation between saline and fresh water points. The Salt Water Index (SWI) has been developed from an extensive amount of previous test data and is calculated from S-factor and measured WVF. It represents a single value (scalar) indicator for saline water, and can be used for classification by comparing it to a threshold. As with any classification, there will be some false positives (false alarms, fresh water points misclassified as saline) and some false negatives (missed detections of saline water).

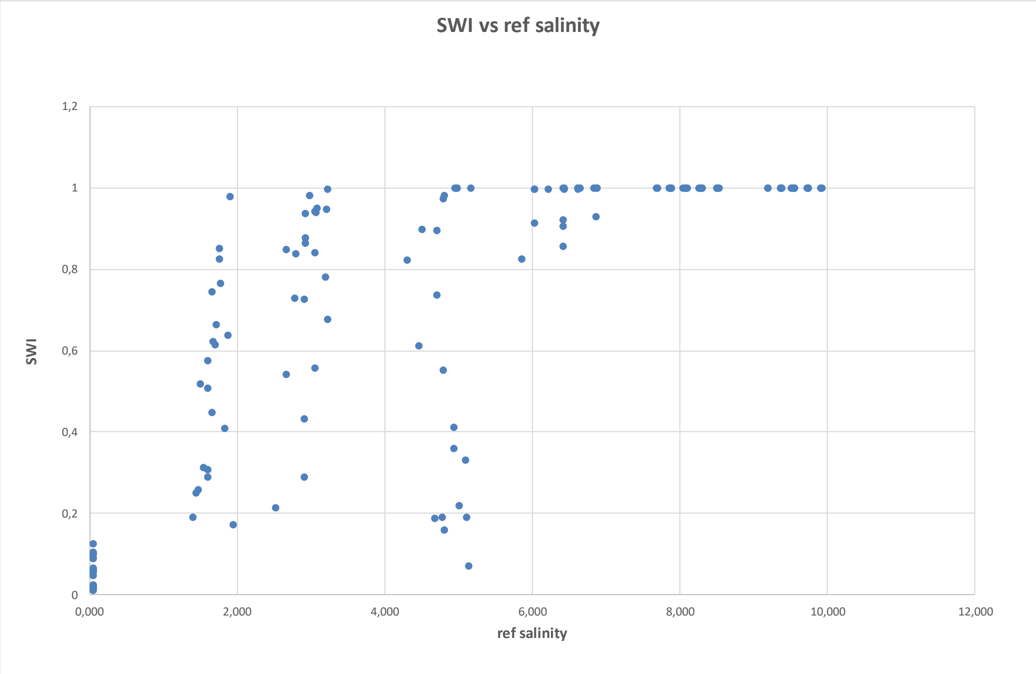

Figure 14 - SWI vs reference salinity

Figure 14 shows the calculated SWI against reference salinity. As can be seen there is very little overlap between saline and fresh water points. For fresh water points the SWI stays within an upper bound of 0.14, the average SWI increases with salinity, and for salinities higher than 6% the SWI is always greater than 0.83.

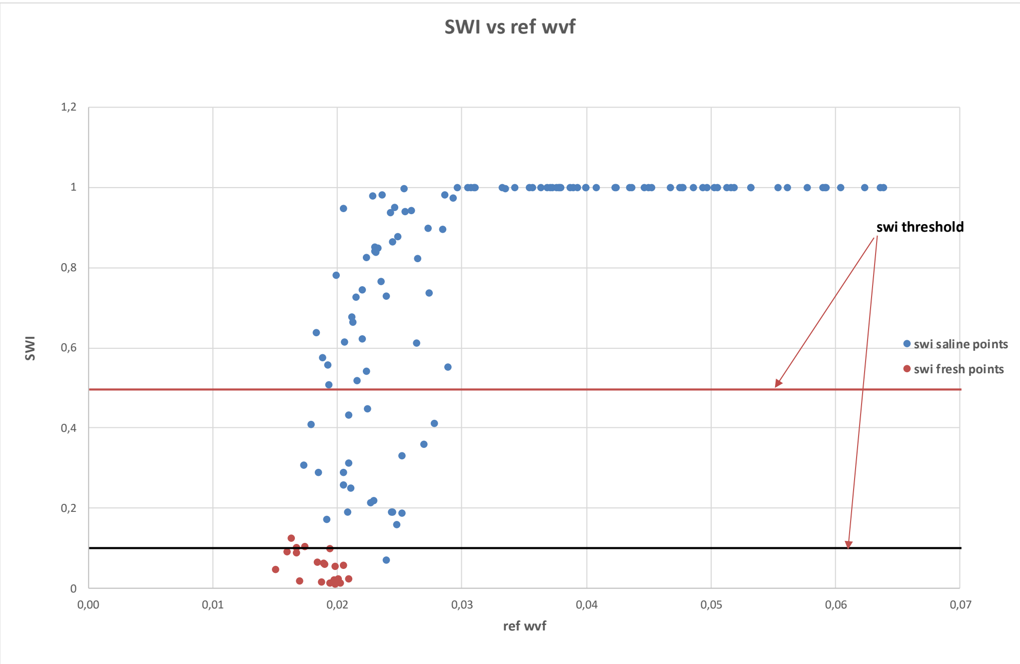

Figure 15 - SWI vs reference WVF

Figure 15 shows SWI against reference WVF and it clearly shows the effect of choosing different thresholds for SWI, and how the detection can be optimized for sensitivity (few missed detections) or specificity (few false alarms). If SWI threshold was set to 0.1, then 5% of fresh points, and <1% of saline points would have been misclassified. With the standard threshold of 0.5 all fresh water points was correctly classified (no false alarms), and 18% of saline points was misclassified as fresh water points (missed detections). The higher rate of missed detections in this test compared to the MEG test, see 3.1, is related to the lower WVF in the current test. As can be observed in Figure 8 the classification accuracy decreases when the WVF falls below ~0.06% and this is reflected in the current test. From an operations and flow assurance point of view the important point is however what flow rate of formation water can be detected by the meter, and this is illustrated below in Figure 16.

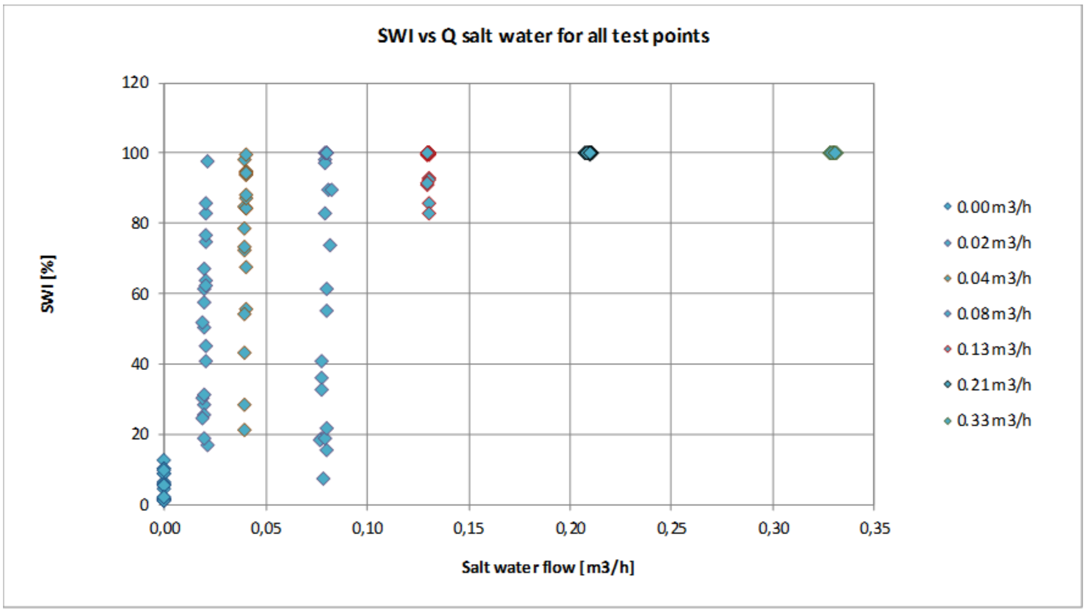

Figure 16 - SWI vs Water Rate

Figure 16 shows the calculated SWI against Salt Water rate. The results indicate that for the current conditions the meter can detect 1 m3/d (0.04 m3/h) of formation water flow. At this flow rate 86% were correctly classified as saline (SWI>50%). This detection limit depends on formation water salinity and total water flow rates of the specific application.

5. Conclusion

In the current paper two different approaches to formation water detection have been presented. Together they cover applications with high and low formation water salinity. Methods to calculate the sensitivity of the detection for both methods have been presented.

Further, results from a test to document the influence of MEG on formation water detection and flow rate measurements have been presented. It was showed that the existing detection method can be used without modification even in the presence of MEG. In this test 6.4% of saline points went undetected and 6% of fresh points gave a false alarm.

For the flow rate measurement it was verified that for WVF measurement MEG could be corrected for by including MEG in the permittivity mixing models as the fourth phase, and having MEG injection rate as an input to the meter. Further it was found that the remainder of the MEG mass flow shows up as oil in the measurement and that no significant effect on measured gas rate was observed.

Results from an operator run blind test of the salinity based formation water detection functionality has been presented. The results showed that the detection limit for formation water rate was 1 m3/d, for the flowing conditions of that specific field.

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