Challenges to Calibrate "on-site" a 212 Bbls Prover by Water-Draw Method

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1 INTRODUCTION

Accurate volumetric measurement directly affects a company's financial value, making rigorous calibration procedures essential. One such procedure is the "Meter Proving" activity, which ensures maximum accuracy and traceability in flow measurement. Traceability in prover calibration involves establishing a transparent and documented chain of traceability from the calibration process to the original kilogram as depicted in Figure-1.

Original Kilogram → **Metrology Lab** → **Test Measures** → **Field Prover** → **Meters**

(Figure-1)

This paper shares a unique experience of on-site calibration for a 36" bi-directional field prover (with a volume of 212 barrels) connected to a metering skid (V-21). The metering skid comprises five 16" turbine meters and a 4" Coriolis meter for line packing. Since 2006, the metering skid has been used for custody transfer, and Kuwait Oil Company (KOC) regularly ensures the performance of the prover using a master meter calibration method to ensure accuracy and reliability. While KOC had a preference for water-draw calibration method, this had not been feasible since the factory calibration in 2001.

In 2017, KOC decided to employ the water-draw method to calibrate the field prover. This paper will discuss the operational issues encountered during the calibration process and the troubleshooting steps taken to overcome these challenges.

2 THE PROCESS OF PROVER CALIBRATION

Prover calibration is an indispensable process within the oil and gas industry, serving multiple critical functions. Firstly, it guarantees precise flow measurement, which is essential for effectively monitoring and managing the quantity of substances being transported through pipelines or other flow systems. By adhering to industry standards and regulations, prover calibration enables companies to meet legal requirements and maintain consistency in their measurement practices.

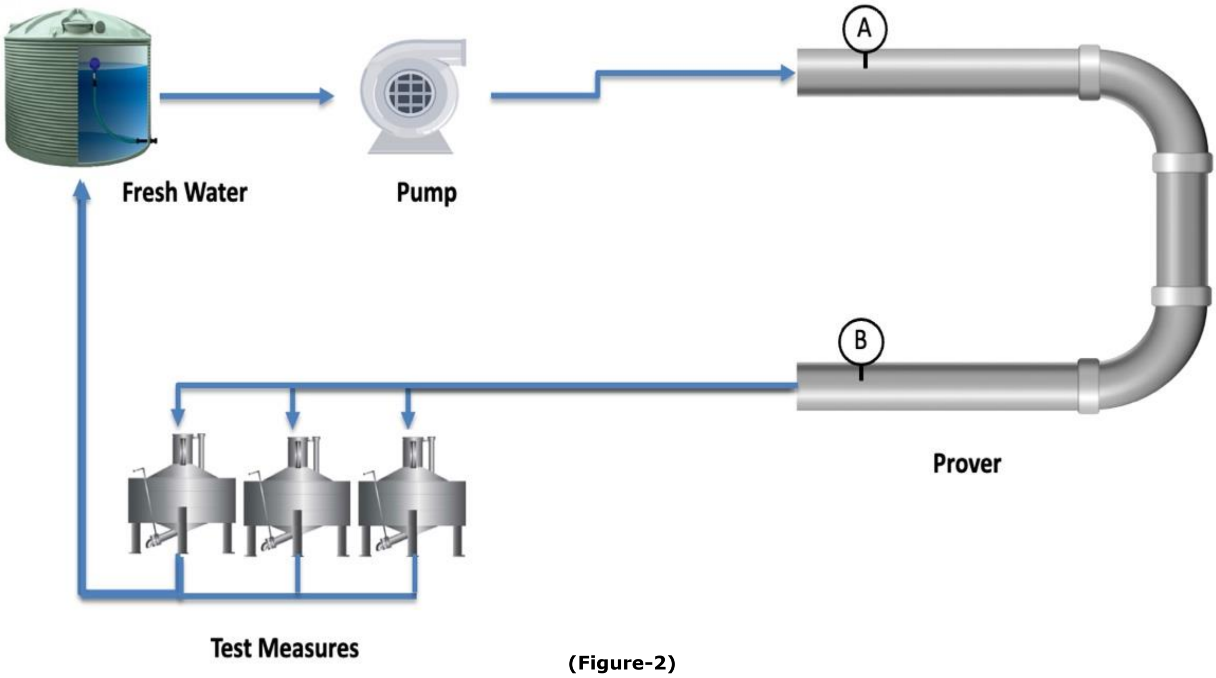
Moreover, prover calibration helps mitigate financial risks by minimizing the potential for inaccuracies in flow measurements that could lead to substantial financial losses or prestige with customers (in case of overbilling). Accurate flow measurement is particularly vital for billing purposes, ensuring that customers are charged correctly for the precise amount of flow they receive (Gross Standard Volume) and any inaccuracy quantity in prover base volume leads to direct loss as show in the below mathematical equations;

Meter Factor = (**Prover Volume**/Meter Volume)

Gross Standard Volume(60F) = Indicated volume(60F) x **(Meter Factor)**

2.1 How is a Calibration Performed

In the initial stages, it is vital to have a traceable test measure and a properly calibrated secondary instruments, along with skilled personnel, to successfully complete the task. Furthermore, the presence of a dependable source of fresh water and a functional pump, as depicted in Figure-2, is of utmost importance.



(Figure-2)

To ensure accurate calibration, it is necessary to conduct a minimum of three consecutive calibration runs that must meet 0.020% for repeatability and the corrected volumes obtained from each round trip run should be within this range to ensures consistent and accurate measurement results.

In order to achieve successful water-draw calibration, it is important to consider and keep in mind the following steps and guidelines:

- The prover is isolated, and the 4-way valve is thoroughly checked for any potential leaks. This step ensures that the prover is properly sealed and can provide accurate measurements.
- The prover is cleaned and prepared for fresh water. It is essential to remove any residue or contaminants that could impact the calibration process and the accuracy of subsequent measurements.
- Validate the functionality of the detector switches and ensure that they are operating correctly. These switches play a crucial role in detecting the displacement of water and triggering the measurement process.
- Validate the sphere size and ensure the proper inflation percentage. The sphere is used to displace water during the calibration process, and its size and inflation level need to be accurately determined for precise measurements. In order to prevent any leakage in the system, it is recommended to inflate the sphere by 2% to 5%. However, it is important to avoid over-inflation, as it can cause the sphere to get stuck and halt its movements.
- The system needs to be properly vented to eliminate any trapped air, which can affect the measurement accuracy.
- Utilizing a different flow rates, alternating between fast and slow, or slow and fast, to eliminate the possibility of passing or slippage.
- Validate the secondary instruments.

3 CALIBRATION OF V-21 METERING SKID

During the summer of 2017, Kuwait Oil Company began the water-draw activity with the aim of calibrating two volumes: A-C and B-D. This calibration was carried out using the water draw method, which had not been executed since the factory calibration in 2001.

(Picutre-1)

Kuwait Oil Company highlighted several key points during the preparation for this activity. The V-21 metering skid attached prover has a larger volume (212 US bbls = 8,900 gallons), which required additional/special steps in the calibration procedure such as the below;

- Each run for the roundtrip volume lasted a minimum of 16 hours.

- In order to obtain a valid volume measurement based on three runs, we had to work continuously for three consecutive days. (minimum of 16 hours a day)

- The ambient temperature posed a challenge since it was in summer, as it could reach up to 55°C at noon.

- The prover underwent its first cleaning in 16 years, which took six weeks to complete using fresh water, chemicals and solvents.

- To minimize human error, a single person was assigned to read the test measure scale per volume. This was necessary because there were only three cans available, each holding 100 gallons. Considering the volume required, approximately 90 can readings were taken for each volume measurement.

3.1 Calibrate A-C Volume

During on-site observation, several issues were encountered during the water-draw activity.

- Challenge:
- The Sphere was unable to move due to flow rate limitations.

- Action:
- Install a bigger pump that requires different hoses and a generator to overcome the flow rate limitations.

- Challenge:
- The first 4 consecutive runs were not repeatable, raising suspicions regarding the Sphere.

(Picutre-2)

- Action:
- Recheck the sphere for any potential issues that may be causing the lack of repeatability and it was in good condition.

- Challenge:
- Repeatability was still not achieved after five runs.

- Action:
- Despite the detectors being brand-new and recently installed before the water-draw activity, a decision was made to reinstall the old detector switches.

These actions were implemented to overcome the challenges encountered during the water-draw activity. This adjustment proved successful as repeatability was achieved thereafter. Overall, the entire activity spanned 12 runs and took place over a period of 24 days since its commencement.

3.2 Calibrate B-D Volume

After a week from completing the first volume (A-C), the second volume calibration was carried out and during on-site activities, several issues were encountered during this second water-draw volume calibration.

- Challenge:
- Repeatability was not achieved after three runs, and there was a noticeable change in the watercolor. It was believed that this issue was caused by the water stagnating in the prover for 7 days, following its previous use for volume calibration, which lasted 24 days.

- Action:
- To address this, the sphere was taken out, and the system was refilled with new fresh water to ensure accurate measurements.

- Challenge:
- Could not re-enter the sphere in the prover as overhead crane became unavailable due to an electrical motor failure.

- Action:
- The job had to be postponed until the issue with the motor was fixed, which took three weeks to restore the crane's operational status. Prior to commencing the calibration process, the water was replaced, and the sphere's inflation was checked before being greased and reinserted into the prover.

- Challenge:
- Repeatability was not achieved due to a 4-way valve leaking at a rate of 1 liter in 5 hours.

- Action:
- The 4-way valve was inspected, and the slips were found to be in good condition. However, rust was observed on the valve, which resulted in a minor leak. The valve was cleaned as initial step to resolve the issue.

(Picutre-3)

- Challenge:
- Despite removing the rust and cleaning the valve, it still exhibited passing issues.

- Action:
- To overcome this challenge, the 4-way valve was bypassed by spading it, and the drain point was utilized to maintain the flow.

- Challenge:
- Different results were obtained after 4 runs.

- Observation:
- The presence of air in the system was determined to be the root cause of the inconsistency, as depicted in picture-4. In this image, the technician can be seen swapping the hose to alter the flow directions, inadvertently introducing air into the system.

(Picutre-4)

- Action:
- To ensure precise and consistent measurements, the air was eliminated from the system. This was achieved in picture-5 by utilizing a bathtub and performing hose changes underwater, effectively preventing any air from entering the system.

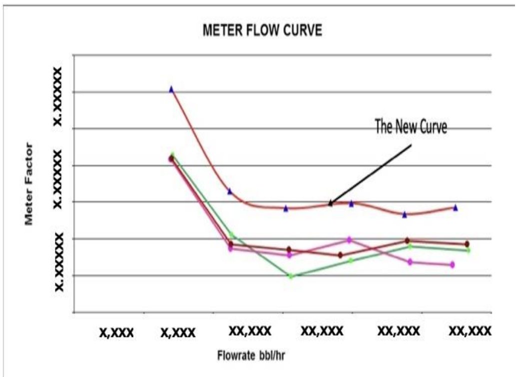
To overcome the challenges faced during the water-draw activity, proactive steps were taken. As a result, repeatability was achieved in subsequent attempts. In total, the activity spanned 17 days and consisted of 9 runs, starting after the overhead crane was repaired.

(Picutre-5)

4 RESULTS

The table below compares the most recent two master-meter calibrations prior to the site water-draw calibration and also the factory water-draw calibration volumes. These are compared in relation to the on-site water-draw calibration conducted in 2017. The findings reveal that the figures closely align with the factory calibration, while also indicating an increase in the base volume of the prover.

To validate this increase, curve generation was performed for the meters, which demonstrated a shift towards the positive side for the meter factor baseline (Graph-1) since base volume is close to factory calibration in 2001.



(Graph-1)

Table 1 – Water-Draw Volume Comparison

Activity	Year	Difference
Master-Meter	2015	0.0279%
Master-Meter	2014	0.0110%
Water-Draw	2001	0.0036%

5 CONCLUSION

Water draw on site can be a challenging task due to various factors that can impact its accuracy. It is important to be prepared for potential problems, as a single issue can have multiple underlying causes. To overcome these challenges, it is necessary to think creatively and come up with innovative solutions.

Using water draw as a calibration method is highly recommended over the master-meter method as shows in the table-1 where we have more uncertainty while using the master-meter method in comparison with water-draw. This approach minimizes uncertainty and improves the accuracy of the system, particularly in custody transfer applications where even small discrepancies can have a significant financial impact.

In the case of KOC, for example, even a slight increase in accuracy, such as in the fourth decimal place, can be highly valued when dispatching X,XXX,XXX bbls/day. By optimizing system accuracy through water-draw calibration, it can increase revenue, prevent from any potential losses, enhance reliability and ensure fairness in business transactions.