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Field proving of a liquid displacement meter using Bi-directional Pipe Provers in Custody Transfer applications; case study of Libyan Zueitina Oil Port

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ABSTRACT

In this paper, a field study is conducted on proving a positive displacement meter with bi-directional pipe provers to determine the repeatability of the meter's generated pulses and the deviation of the Meter Factor percentage during the Meter Proving process at Zueitina Oil Port in Libya. Equipment, procedures, requirements, national and international standards, and precautions that will ensure accurate metering of fluids were considered. Detailed calculations were achieved, as can be seen in the given results average of total number of pluses (round trip), Repeatability, corrected prover volume(CPV), corrected meter volume (CMV), the new meter factor and deviation of meter factor are 119,873.000 Pluses,0.01502 %,122.44614 Barrel (BBL), 122.405389 Barrel(BBL), 1.000333, and 0.1058%, respectively. The findings of this research are consistent with national and international standards.

Keywords: Custody Transfer applications, Bi-Directional Pipe Provers, Meter-proving process.

1. Introduction

In hydrocarbon logistics, custody transfer requires exact volume measurements, which must be subject to legal meteorological requirements and state meteorological control [1]. Measurements of refined petroleum products (gasoline, diesel, and kerosene) have traditionally been performed using turbines [2], [3], and volumetric meters [4], [5]. The latter, specifically, are the meters of the highest metrological quality [6], [7]. It is a common misconception that measurement is an exact science. In reality, all measurements are simply estimates of the actual value measured, and the actual value can never be known. An estimate that implies that there is some degree of doubt about the accuracy of that measurement. Measurement uncertainty provides an indication of the quality or reliability of a measurement result [8].

Documenting the uncertainty in flows measured by fiscal flow gauge stations is essential in assessing the condition of these gauge stations. The authorities have requirements with respect to maximum uncertainty in order to guarantee national interests. Partners selling oil have an interest in uncertainty to secure their incomes. Ultimately, oil buyers have an interest in ensuring that they will not receive less oil than they pay for. To get all parties to agree to an uncertainty analysis, it is important to obtain standardized ways to perform such an analysis. In 1995, the International Organization for Standardization (ISO) published the "Guide to the expression of uncertainty in measurement" [9].

Moreover, proving methods that utilize incremental uncertainty analysis to determine when proving is finished will give operators the chance to achieve even greater efficiency. To confirm this method, it is necessary to keep collecting runs until the repeatability is equivalent to a meter factor random uncertainty of better than 0.027%. API MPMS Ch. 4.8 prescribes several different methods that can be applied to assess the repeatability of proving data. The objective of their design is to ensure that the average meter factor result is not above 0.027%. In case repeatability fails, it is typical to discard the data and begin a new proving attempt .To determine the uncertainty of the meter factor, it is important to determine the repeatability of the meter factor average or pulses generated during proving. This study calculated the most important parameters, including the repeatability of pulses generated by the meters and the deviation of the Meter Factor percentage during the Meter Proving process at Zueitina Oil Port in Libya.

A map illustrated in Figure 1 shows the location of Zueitina Oil Port in Libya. Zueitina Oil Port is located in Libya near the town of Ajdabiya on the coast of the Mediterranean Sea. Also, it is situated in the East of Benghazi. It is owned by the Libyan National Corporation (NOC). The company's production is from its field in the south of Ajdabiya city. Zueitina Oil port is responsible for all types of oil that arrive at the port from reaching the export stage. It receives three types of crude oil, in addition to condensed naphtha, and the types of crude oil that are received are Zueitina crude, Abu At-Tafel crude, and pure Zueitina crude. These types of crude oil and condensed naphtha are also stored and shipped through it. All operations are monitored and controlled, including receiving, storing, and shipping crude oil and condensed naphtha.

Figure 1. Map of Zueitina Oil Port (LIBYA)

2. Methodolgy

There are methods of proving a meter: proving a meter with a pipe prover, proving a meter with an open tank prover, and proving a meter with a master meter.

For this research, proving of a positive displacement meter (meter number 205) with a pipe prover in" Zueitina Oil Port– Libya "will be carried out as a case study for the export of Zueitina crude according to the procedures and requirements mentioned in National and International standards.

Positive Displacement flow meter with bi-directional prover

Positive Displacement flow meter (number 205) selected in this study is shown in Figure 2.

Figure2. Positive Displacement flow meter

Bi-directional prover selected in this study is shown in Figure 3.

Figure 3. Bi-directional prover

Preparation of proving report

A Positive Displacement Meter-proving using Bi Directional Prover is illustrated in Figure 4

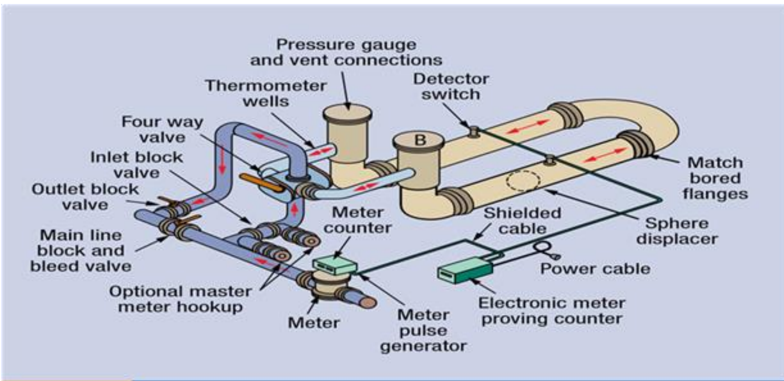

Figure 4. Bi Directional Prover

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A sample proving report illustrated in Table 1 will be applicable to reflect the correlations and information. During the preparation of this paper, Meter-proving requirements and procedures, troubleshooting, and Converting volumes to standards maintained in the American Petroleum Institute (API) and Libyan Measurement standards [10-18] should be taken into consideration at Zueitina Oil port.

Calculations of sections of the proving report will be presented according to the American Petroleum Institute (API) [10] as follows:

$$Repeatability\ \% = [(Highest\ Run - Lowest\ Run)/Lowest\ Run] \times 100 \text{..........(1)}$$

- To determine the corrected prover volume, multiplying the observed prover volume with all certain correction factors to convert the volume to standard temperature and Pressure as shown in Eq(2).

$$Corrected\ \ prover\ volume(CPV)\ = BPV \times Ctsp \times Cpsp \times Ctlp \times Cplp \text{........(2)}$$

- To determine the corrected meter volume(CMV), $Average$d pulse count is divided by n$umber\ of\ Pulses$ per barrel (k-factor),then multiplying with all certain correction factors to convert the volume to standard temperature and Pressure as shown in Eq(3).

$$(CMV\ ) = (Average\ Number\ of\ Pulses \div KF\ ) * Ctlm * \quad Cplm \text{.....(3)}$$

- Once both volumes have been corrected to standard temperature and pressure , the meter factor is determined by dividing the corrected prover volume (CPV) by the corrected meter volume (CMV) as shown in Eq(4)

$$(MF) = (CPV) \div (\mathrm{CMV}) \text{ ......(4)}$$

- Deviation of Meter Factor : Deviation of Meter Factor is calculated according to Eq(5)

$$Deviation\ (\%) = [(New\ M\ Factor - Previous\ M\ Factor)\ /Previous\ M\ Factor]*100 \ldots \quad (5)$$

3. Results

For guidance in interpreting the data on this report, calculations of sections of the report were explained in Table 1 as follows:

Table 1. Meter Prover Report

Date of Proving:	01/07/2023	Company	Zueitina Oil Port	Location	Zueitina city-libya		
Meter					Prover		
No	Serial No	Model	Size "İnches"	K factor PULSES/BBL	BASE VOLUME AT 60°F AND "0" PSI (BPV)	OD SIZE "inches"	WT WALL "İnches"
205	45778888	PD	16 "	956.87841	125.140020	26 "	0.375 "

Liquid Data			Previous Report	
Type	API at 60.0°F	Flow Rate	Flow Rate(bph)	Previous meter Factor
Zueitina Crude	39.8	8000 bbl/hr	8000 bbl/hr	0.999052

Run	Prover		Meter		METER COUNTER
No	Temp (F)	Press(ps)	Temp(F)	Press psig	total number of pluses for the round trip
1	106	54	105	53	119,877
2	106	54	105	53	119,860
3	106	54	105	53	119,878
4	106	54	105	53	119,877
5	106	54	105	53	119,877
AVG					119,873.000
Repeatability %		0.01502 %	acceptable		

A	B	C	D	E	F=A*B*C*D*E
BPV (BBL)	CTSp	CPSp	CTLp	CPLp	*CPV* (BBL)
125.140020	1.000800	1.0001	0.9773	1.0003	122.44614

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G	H	I=G/H	J	K	L=I*J*K
AVERGE PULES	K FACTOR	IV (BBL)	CTLm	CPLm	CMV(BBL)
119,873.000	956.87841	125.2750597644	0.9768	0.9768	122.405389

M=F/L	N=H/M
Meter Factor	NEW K FACTOR
1.000333	956.5598

$Deviation$ (%) = [($New\ M\ Factor - Previous\ M\ Factor$) /$Previous\ M\ Factor$]

0.1058 %, "acceptable"

3. Discussion

As can be seen in the given results average of the total number of pluses (round trip), repeatability, corrected prover volume (CPV), corrected meter volume (CMV), the new meter factor and deviation of meter factor are 119,873.000 Pluses, 0.01502 %, 122.44614 Barrel (BBL), 122.405389 Barrel(BBL), 1.000333, and 0.1058%, respectively. This discussion will focus on understanding the most important parameters as follows:

- Repeatability % is equal to 0.01502 %, which is acceptable according to the American Petroleum Institute (API) and Libyan Measurement standards [12-15], which recommend that, proving runs must be made until the calculated meter factor or meter generated pulses from five consecutive runs match within a tolerance of 0.0005 (0.05 percent) between the highest and the lowest value.
- The deviation of Meter Factor % in this paper is equal to 0.1058% -, which is an acceptable one according to Libyan Measurement standards [12,13], which recommend that the new meter factors should be within +/- 0.003 (0.3%) of the previous meter factors. The deviation of Meter Factor % obtained from this study is also acceptable according to the American Petroleum Institute (API) [16], which states that common practice for custody transfer applications is to accept new meter factors under like operating conditions within (0.001) 0.10 % to (0.005) 0.50% of the previous meter factor.

4. Conclusions

A comprehensive and detailed operation, computations, requirements, and procedures of meter proving using conventional bi-directional pipe prover of Zueitina oil port– Libya has been presented. The findings of this research are consistent with national and international standards. However, the results obtained show that regular proving, checkups of meters; and following the procedures and requirements of meter proving according to the national and international standards, would improve metering and lead to success in implementing the Meter-proving process and ensure that measurements are accurate, allowing operations to proceed in a safe and timely manner

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