International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 02, ISSN No. 2455-2143, Pages 08-21
Published Online June 2024 in IJEAST (http://www.ijeast.com)

UPGRADE OF CUSTODY TRANSFER METERING SYSTEM AT PETROLINES COMPANY (PETCO), MARINE TERMINAL

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Abstract: **Upgrading a custody transfer metering system is a critical task in industries like oil and gas, where accurate measurement of fluids is essential for financial transactions and regulatory compliance.**
The control system of our custody transfer metering system is integral to ensuring accurate measurement, efficient operations, and regulatory compliance. However, the existing control system is outdated and lacks the functionality required to meet evolving industry standards and operational needs. Upgrading the control system is crucial to enhance system performance, reliability, and compliance.
While performing a flow measurement in a process control, the accuracy of measurement is typically not as important as the repeatability of the measurement. When controlling a process, engineers can tolerate some inaccuracy in flow measurement as long as the inaccuracy is consistent and repeatable. In some measurement applications, however, accuracy is an extremely important quality, and this is particularly true for custody transfer. The money paid is a function of the quantity of fluid transferred from one party to another. Small error in the metering can add up to big losses in terms of money.
Periodic proving of the flow meter is necessary to confirm or re-establish the performance accuracy of the accounting meter before, during, and after a custody transfer. A flow prover can be installed in a custody transfer system to provide the most accurate measurement possible.
The purpose of this paper is to determine the frequent failures of Crude Oil Custody Transfer Metering System for Petrolines for Crude Operating Company (PETCO), Marine Terminal at Portsudan. Those frequent failures have been taking place few years later after commissioning that took place in 2006.
To identify the cause of failures, a study carried out for design, erection, commissioning, operation and maintenance.
Upon completion of study and execution of the project for the metering system together with its facilities, the system operation has been closely monitored and all measures recorded and compared with the approved standards.

Key words: **Custody transfer metering, accurate, control system, crude, repeatability**

I. INTRODUCTION

A Fiscal metering system essentially is a supervisory system for liquid and gas flow measurement. The system may communicate with flow computers. Fiscal measurement is also referred to as custody transfer measurement. By definition, custody transfer refers to the fiscal measurement, which is used to determine the quantity and financial value of a petroleum product transaction (delivery).
Flow Measurement Concepts
Fiscal measurement is a general word: measurement for money.
Fiscal measurement includes:

Allocation
Is the numerical distribution of products between parties according to their equity share.

Custody Transfer
Custody transfer is contract driven: that means that there is a contractual obligation between buyer and seller which may require adherence to accuracy, repeatability, linearity or

uncertainty standards as defined by measurement standards such as API, GOST (Russian equivalent to API), etc.
The terms custody transfer and fiscal metering are often interchanged. Custody transfer takes place any time fluids are passed from possession of one party to another.

Accuracy vs. Uncertainty and Validation

All meters and metering systems are subject to uncertainty and it is a common mistake to mix accuracy and uncertainty as they are subtly different.
Accuracy is matching the meter output to a known standard or reference and will include terms like bias, readability and precision, this can be considered the best estimate according to the scale of the measurement.
Uncertainty is more related to repeatability and is an estimate of the limits where the true value is expected to lie for a given confidence level.
Validation, before we can report any data, we should be able to make sure our obtained data is valid! It takes some equipment, observation, time and money but it totally worth it, because all these data is useless if they are not valid.

II. LITERATURE OVERVIEW

2.1 Flow Measurement Overview

Determination of liquid quantities for custody transfer purposes can be achieved by either static or dynamic measurements. Using static measurements, the quantity transferred is determined by gauging the quantity of product in a storage vessel before and after the transfer. Dynamic measurement, utilizing a flow metering system that determines the quantity of product passing a fixed point in the pipeline.
Measurement of a static quantity at substantially stable conditions might reasonably be expected to be simpler and therefore, a more accurate method than measurement of a flowing quantity of liquid conditions of temperature, pressure and possibly composition which may vary during the period of time over which the measurement is made.
Experience has however established that, a well-designed, operated and maintained metering system, demonstrates significantly better short-term accuracy than can be achieved by tank gauging. Long term accuracy is comparable.
The improved short-term accuracy, coupled with the facility for demand verification of this accuracy, has resulted in steadily increasing utilization of metering system for determination of custody transfer quantities.

2.2 Measurement Basics:

During a typical crude oil bulk (Tank gauging) movement activity several opportunities arise for measurement. Experience tells us that no two sets of measurement, taken on a given quantity of any bulk crude oil, will ever yield precisely the same result.
Exact volume measurements must be made either in the pipeline or at storage facilities to ensure that the volume transferred is accurate.

2.3 Crude oil bulk or Tank gauging system

It is the measurement of liquids in large storage tanks with the purpose of quantifying the volume and mass of the product in the tanks. The oil and gas industry generally uses static volumetric assessments of the tank content. This involves level, temperature and pressure measurements.
Tank gauging accurately measure volume by using level, temperature and pressure data. Different gauging techniques are used depending on the types of tanks and the unique properties of the liquid being stored. In general tank gauging methods can be divided into two categories –manual and automatic.

2.3.1 Tank gauging techniques

I. Manual gauging
II. Float and tape gauges
III. Servo gauges
IV. Radar gauges
V. Hydrostatic tank gauging
VI. Hybrid inventory measurement

- **Manual gauging**

Using dip tape or dipstick, the accuracy of dip tape measurement +_ (0.1+0.1 L) mm, Where L = the level.
We can deduce from this is that absolute accuracy is virtually impossible to achieve, and this is clearly due to the presence of measurement errors.
Here, we identify the types and sources of errors which are most frequently encountered.

2.4Metering Basic Concepts: -

Petroleum products originate at the well head. They are then transported, processed, and stored a number of times, until they reach the ownership of the product may change. However, in some transportation and storage situations, the ownership of the product remains the same: only the responsibility for the product changes. Whoever owns or is responsible for the product is said to have custody of the product.

2.5All about Prover: -

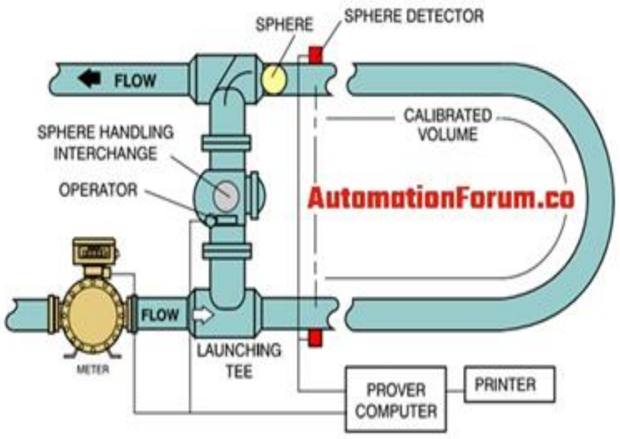

Figure 1.1: Prover Skid

A prover is a device that is used to check the flow meter and we can use this to check the liquid or the gas flowmeter and a prover can be used to calibrate the flow meter. We can test a flowmeter by using a prover, the meter proving is done to determine the accuracy of the flow meter. The proving principle is the same for all the flow meters. By doing the meter proving we can ensure that the flow measurement will be accurate. By doing the meter proving we can determine certain factors like K factor, accuracy, linearity over the flow range, and also we can determine the repeatability of the flow meter. We can determine the deviation of the flow meter by doing the proving, the deviation magnitude is the factor meter. The factor meter can be used to determine the amount of flow that occurs and it will be measured by the measuring equipment. So by doing the meter proving we can determine how the meter performs and how it deviates and according to this, we can adjust the measured quantities for the inaccuracies. The inaccuracies can happen in a flow meter because of the installation and also due to the operations.

2.5.1 Why proving should be done to flow meter: -

The proving must be done to a flow meter because the operating conditions would vary from the conditions under which the meter is calibrated. The performance of a flow meter would vary in the field because of the installation effect from the piping, mechanical wear of the meter, and it could also happen because of the changes in the physical property of the measured fluid. So a flow meter must be proved to adjust to these changes. Most flow meters are proved on a periodic basis, certain meters are proved for each batch transaction. The meter proving can be considered as the calibration of the flow meter, because of the change in the operating conditions the flow meter should be recalibrated. The flow meter proving would provide a good relationship between the meter output and also the fluid flow rate. It would also correct the fluid operating conditions which are varied and they also correct the variation due to the mechanical degradation. The error in the flow meter can also be determined by proving and because of this proving is inevitable in the case of flow meters. By proving a flow meter we check not only the meter but also the entire meter system. A flow meter would cause an error in case if the meter is dirty, in case we install a new meter it could have debris due to the construction and all this can be determined by meter proving.

III. PROBLEMS DESCRIPTION: -

As the custody transfer metering system is used to determine quantity of purchased, sold or transferred product passing through it, then rehabilitation of the whole metering system either by repairing, replacing of the defective parts or upgrading the obsolete ones, will lead be accurate, reliable, provide precise oil flow calculations, and both the metering accuracy and the economic risk related to measurement errors will be low.

The metering system installed in 1999 by NUOVO PIGNONE Company, Italy.

Upgraded by FMC (Metering System Manufacturer) in 2006.

There were so many problems have taken place during the operation of the metering system few years later such as: -

Due to embargo, FMC suspended its technical support and supply of spare parts. Since then, the system has been running without any maintenance.

Attempts carried out to procure HMI from FMC through a third party, but failed because the existing system at MT is obsolete.

The system is unreliable due to lack of maintenance.

The HMI (Human Machine Interface) system hanging. Report generation is very low; MOVs (Motorized Operating Valves) and FCV (Flow control Vales) can't operate automatically.

The HMI (Human Machine Interface) hanging during loading with the result to fail to print out batching report.

Meter proving fails at high flow rate (1700 m3/h).

PDM (Positive Displacement Meter) for stream No.6 is totally damaged. And the whole system is running manually.

IV. PROPOSED SOLUTIONS:

To select new Flow Computer (FC) and connect with the PDM.

To select new software (HMI) system, and to ensure its compatibility with the control system.

To study the old system components, both hardware and software, and determine the source of failures.

To assess the PDM (Positive Displacement Meter) to find whether to maintain, repair or replace.

V. UPGRADING THE CONTROL SYSTEM

Upgrading is the process of replacing a product with a newer version of the same product. In computing and consumer electronics, an upgrade is generally a replacement of hardware, software or firmware with a newer or better

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version, in order to bring the system up to date or to improve its characteristics.
Upgrading the custody transfer metering system aims to enhance accuracy, efficiency, and reliability in measuring and transferring oil or gas ownership. This introduction will explore the key improvements and benefits associated with the system upgrade.
Control systems play a vital role in keeping operations running smoothly in factories. Older controls systems can of course be fit for purpose for many years, they add value as they still manage production; automate the processes, and reporting any issues. Upgrading is also seen as a non-value-added activity, however, be wary – catastrophic failures will soon eclipse the upgrade cost if not taken seriously. Consideration of upgrading to a more modern system should be a priority in today's technology-driven world.
There are many reasons to upgrade a distributed control system (DCS) for a process control system, but there are many considerations and challenges to consider when doing so.
The process control system is the brain running behind any automated process facility being core system behind the overall process; distributed control systems (DCSs) control the process directly together with integration of packaged process units having independent programmable logic controllers (PLCs).
DCSs were built on proprietary protocols historically, but as the technology is reshaping very quickly and customers are becoming more demanding, the requirement of integrating everything (control systems) under one system (DCS) has become the key to success (together with cost effectiveness) causing the DCS original equipment manufacturers (OEMs) to move towards more open systems.
Upon completion installation of all control system, validation has been carried out for all metering components pressure transmitters, temperature transmitters etc. by third party.

VI. ASSESSMENT OF PDM IN COMPARISON TO TM

Key parameters to compare between (TM) and (PDM) parameters:

- Volumetric accuracy.
- Rangeability
- Product viscosity.
- Cost.
- Capacity
- Weight & size.
- Backpressure.
- Upstream Filter / strainer.
- Upstream / Downstream straight pipe run.
- Electronic microprocessor controls.

Parameters	Turbine meters (TM)	Positive displacement meters (PDM)
Volumetric Accuracy	0.2% of measured value	0.2% of measured value
Rangeability	10:1	30:1 and more
Product	Generally used for product viscosity of 10cst or lower	Preferred over TMS for product viscosities more than 10 cst. PDMs with special clearance are the choice for metering very viscous products such as asphalt.
Cost	Lower capital cost for the same	Higher capital cost for the same capacity
Capacity	Generally, up to 9000m/h	Generally, up to 2000 m/h
Weight and size	Lighter & smaller	Heavier & bigger
Back Pressure	Minimum backpressure required	Backpressure requirement not so critical

Upstream Filter/Strainer	yes	yes
Upstream/Downstream Pipe run	Generally, 5 to 10 pipe diameters required	Requirements for straight pipe run not so critical. Generally lower than TM
Electronic Microprocessor	Currently available as part of integral meter package for control and monitoring	Currently available as part of integral meter package for control and monitoring

Table 5.1 Comparison between PDM & TM Parameters

6.1 Comparing the two Flow Meter Types: -

TYPE	TM	PDM
Advantages	Excellent short-term repeatability for size above 2”. Typically, +/-0.02%	Excellent short-term repeatability. Typically, +/-0.02%
	Good linearity of output. Typically, +/-0.15% depending on liquid viscosity, density and size.	Good linearity of output. Typically, +/-0.15%
	Wide range of sizes readily available from 0.75” – 24”	
	Suitable for use at temperature up to 400 F	Suitable for use at elevated temperatures above 400 F
	Maximum pressure rating is limited only by the flange rating	
	Compact construction allowing ease of handling for installation and maintenance.	
	Reliable. Only one moving component.	
		Suitable for high viscosity fluids
		Little sensitive to uneven flow distribution across the area of the pipe, it does not matter the flow is pulsing.
	Low maintenance, long life.	
Disadvantages		
	Not suitable for use on high viscosity products	
	Sensitive to flow condition, particularly swirl, which will occur if two 90 bends in different planes are located in close proximity upstream of the meter.	
	Frequent calibration or ‘proving’ at actual operating conditions is necessary to maintain accuracy	Periodic calibration is required for meter using in extreme conditions
	Sudden change in flow may damage the moving parts due to inertia.	In large pipe diameter PD flow meters are heavier and expensive.
		Expensive and bulky to install and maintain relative turbine meter
	Over speeding can cause extensive damage in certain types	
		Reduced throughput for given line size relative to turbine meter

Table 5.2 Advantages & Disadvantages of PDM & TM

The TM having the following disadvantages against PDM:

1- Not suitable for use on high viscosity products.
2- Sensitive to flow condition, particularly swirl, which will occur if two 90 bends in different planes are located in close proximity upstream of the meter.
3- Sudden change in flow may damage the moving parts due to inertia.
4- Over speeding can cause extensive damage in certain types.

VII. ANALYSIS & DISCUSSION: -

Custody Transfer Measurement in the oil and gas business has been described many ways. It has been called accuracy in measurement, which both the buyers and sellers can agree upon," or "The best that can be achieved to meet the contract conditions.

The calculation of petroleum quantities requires an exacting attention to detail and precision not only in the calculation process, but also in the underlying supporting processes, such as the primary measurement value determination, calibration of instrumentation such as temperature and pressure transmitters, tank calibration, gauge tape verification or calibration, density meters and/or thermo hydrometers, and meter provers.

In the Petroleum industry as hydrocarbons are purchased, sold or transferred there are two key elements that must be determined. These elements are the quantity and quality of the hydrocarbon in question.

The determination of the quantity of hydrocarbon can be further subdivided into: Static quantity determination and Dynamic quantity determination

Static quantity is determined when the hydrocarbon is measured under non-flowing conditions, such as when contained in a tank, rail car, truck or vessel. Conversely Dynamic quantity determination occurs when the hydrocarbon is measured under flowing conditions.

Exact volume measurements must be made either in the pipeline or at storage facilities to ensure that the volume transferred is accurate.

The petroleum industry has developed standardized calculation methods, which are expressed in the API Manual of Petroleum Measurement Standards.

Custody Transfer Metering System is the process used to measure the volume of product as it moves past a particular point in the pipeline. Accurate custody metering to ensure correct trading and avoid losing money for owner and tanker. This metered volume represents a transfer of ownership from a producer to a customer; hence, there is no revenue generation without custody transfer measurement.

The Metering application provides the ability to determine net metered volumes for each point of measurement on the system.

7.1 Methods to determine the exported crude quantity: -

7.1.1 Metering System (Dynamic quantity determination)

This is the agreed method between buyer and seller in presence of third party, provided that metering validation should be carried out every six months, and issued certificate will be attached with all loading documents. All streams proving documents during loading should be attached as well.

The role of the third party, also called independent inspector, is to ensure certain procedures are being performed correctly and to make a number of observations to confirm the integrity of the metering system.

API requires an accuracy of the prover volume of 0.02%.

7.1.2 Crude oil bulk or Tank gauging system (Static quantity determination)

Is the measurement of liquids in large storage tanks with the purpose of quantifying the volume and mass of the product in the tanks. The oil and gas industry generally uses static volumetric assessments of the tank content. This involves level, temperature and pressure measurements.

Tank gauging accurately measure volume by using level, temperature and pressure data. Different gauging techniques are used depending on the types of tanks and the unique properties of the liquid being stored. In general tank gauging methods can be divided into two categories –manual and automatic.

Normally, manual dipping is carried out for on shore tanks immediately before every loading. Before, that the tanks drained from water then left for 2 days to allow sediments settle down.

Using dip tape or dipstick, the accuracy of dip tape measurement +/- (0.1+0.1 L) mm, Where L = the level.

We can deduce from this is that absolute accuracy is virtually impossible to achieve, and this is clearly due to the presence of measurement errors.

7.2 Types of error:

A. Spurious error.
B. Systematic error.
C. Random error.

7.3 Sources of Error:

A. Measurements object error.
B. Measurement instrument error.
C. Instrument calibrator or operator error.
D. Measurement environment error.

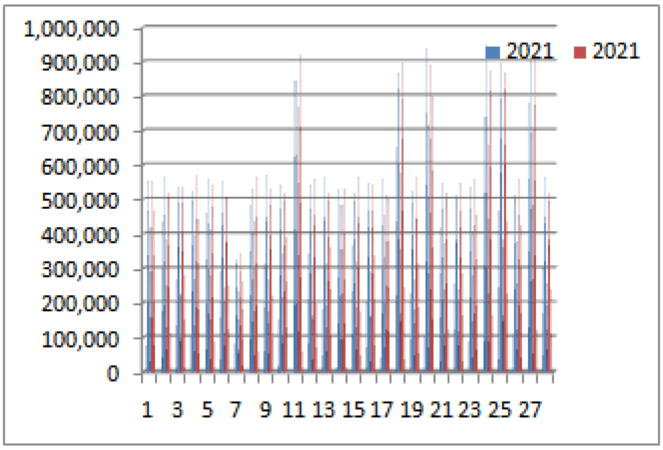
As agreed between buyer and sellers that the metering system will be the official shore figure for calculation of sold crude or product as general, while the shore manual dipping will serve as back up for metering system and just for comparison. As general, the bill of lading will be issued upon shore figure. The ship figure will be kept just for monitoring.

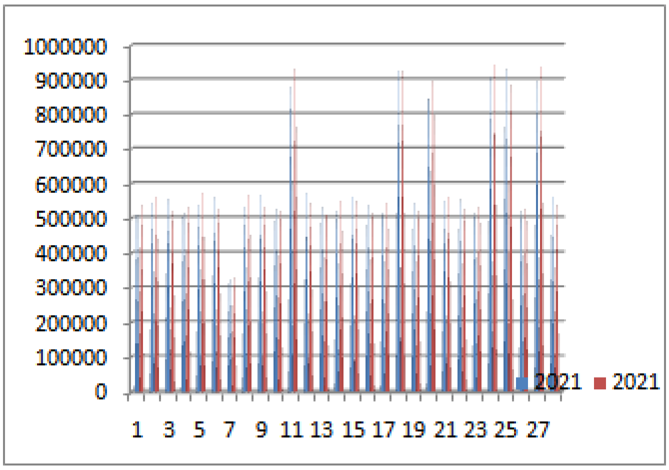
The ship/shore figure difference is +/- 0.3%. This procedure is agreed among all parties.

Here, below are the tables and figures for the loading for the years 2021, 2022 and 2023 that showing the comparison between shore figures and metering figures.

2021		
SHORE GROSS	**METRING GROSS**	**DIFF**
574,535	**574,316**	**-219**
574,647	**574,320**	**-327**
577,455	**577,503**	**48**
575,507	**575,349**	**-158**
574,681	**574,553**	**-128**
573,688	**573,498**	**-190**
360,641	**360,529**	**-112**
571,489	**571,576**	**87**
571,371	**571,427**	**56**
571,905	**572,019**	**114**
952,607	**952,480**	**-127**
572,084	**571,978**	**-106**
571,868	**571,963**	**95**
571,761	**571,577**	**-184**
571,273	**571,306**	**33**
570,999	**570,798**	**-201**
572,738	**572,510**	**-228**
951,749	**950,665**	**-1,084**
570,772	**570,570**	**-202**
952,008	**952,156**	**148**
572,315	**572,045**	**-270**
572,281	**571,865**	**-416**
570,853	**570,501**	**-352**
951,819	**951,873**	**54**
951,689	**951,439**	**-250**
570,954	**570,606**	**-348**
951,559	**951,744**	**185**
570,835	**570,737**	**-98**

Table 6.1 Comparison between Shore Gross Vs Metering Gross for year 2021





2021		
SHORE NETT	**METRING NETT**	**DIFF**
570048	**569830**	**-218**
570308	**570476**	**168**
570196	**570439**	**243**
570586	**570429**	**-157**
570624	**570357**	**-267**
570510	**570292**	**-218**
356198	**355970**	**-228**
570323	**570309**	**-14**
570480	**570535**	**55**
570727	**570569**	**-158**
950654	**950527**	**-127**
570482	**570282**	**-200**
570558	**570693**	**135**

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570595	**570212**	**-383**
570388	**570280**	**-108**
570405	**570262**	**-143**
570848	**570521**	**-327**
950502	**950219**	**-283**
570110	**569909**	**-201**
950751	**950501**	**-250**
571525	**571256**	**-269**
571537	**571121**	**-416**
570265	**570081**	**-184**
950544	**950511**	**-33**
950452	**950111**	**-341**
570366	**570432**	**66**

Table 6.2 Comparison between Shore Nett Vs Metering Nett for year 2021

2022		
SHORE GROSS	**METRING GROSS**	**DIFF**
571214	**571110**	**-104**
571288	**571354**	**66**
573548	**573331**	**-217**
572401	**572372**	**-29**
573915	**573837**	**-78**
953643	**953232**	**-411**
571900	**571798**	**-102**
571361	**571174**	**-187**
571640	**571204**	**-436**
571122	**570811**	**-311**
572809	**572608**	**-201**
1025834	**1026072**	**238**
630570	**630390**	**-180**
629599	**629229**	**-370**
630287	**630420**	**133**
953332	**953122**	**-210**
572102	**572171**	**69**
571776	**571586**	**-190**
571314	**571136**	**-178**
571962	**572032**	**70**
572464	**572114**	**-350**
571846	**571357**	**-489**

Table 6.3 Comparison between Shore Gross Vs Metering Gross for year 2022

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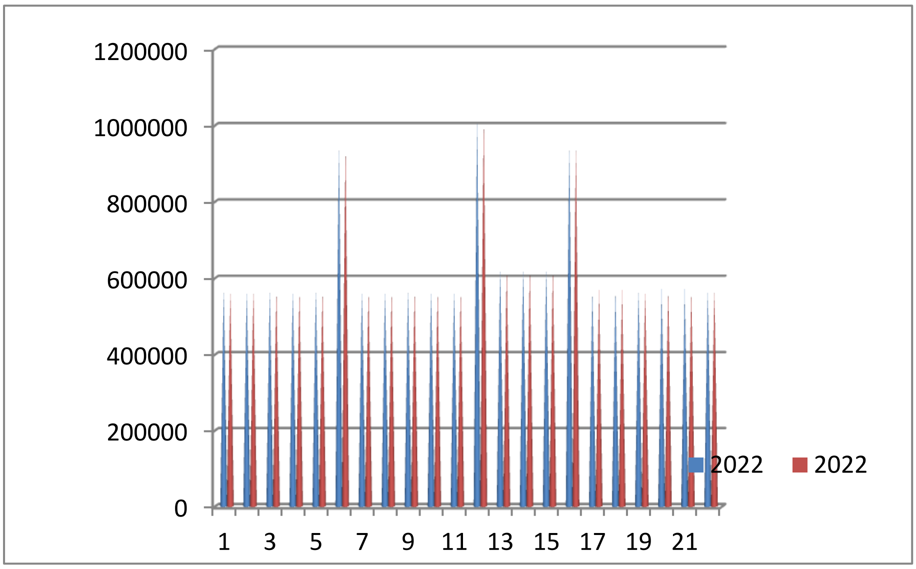
2022		
SHORE NETT	**METRING NETT**	**DIFF**
570714	**570560**	**-154**
570214	**570380**	**166**
570617	**570303**	**-314**
570203	**570106**	**-97**
570873	**570786**	**-87**
950258	**950017**	**-241**
570447	**570107**	**-340**
570167	**569990**	**-177**
570611	**570276**	**-335**
570362	**569979**	**-383**
570334	**570150**	**-184**
1023639	**1023976**	**337**
629063	**628984**	**-79**
628768	**628298**	**-470**
628270	**628542**	**272**
950405	**950148**	**-257**
570477	**570482**	**5**
570850	**570061**	**-789**
570577	**570399**	**-178**
571053	**571122**	**69**
570981	**570632**	**-349**
570668	**570180**	**-488**

Table 6.4 Comparison between Shore Nett Vs Metering Nett for year 2022



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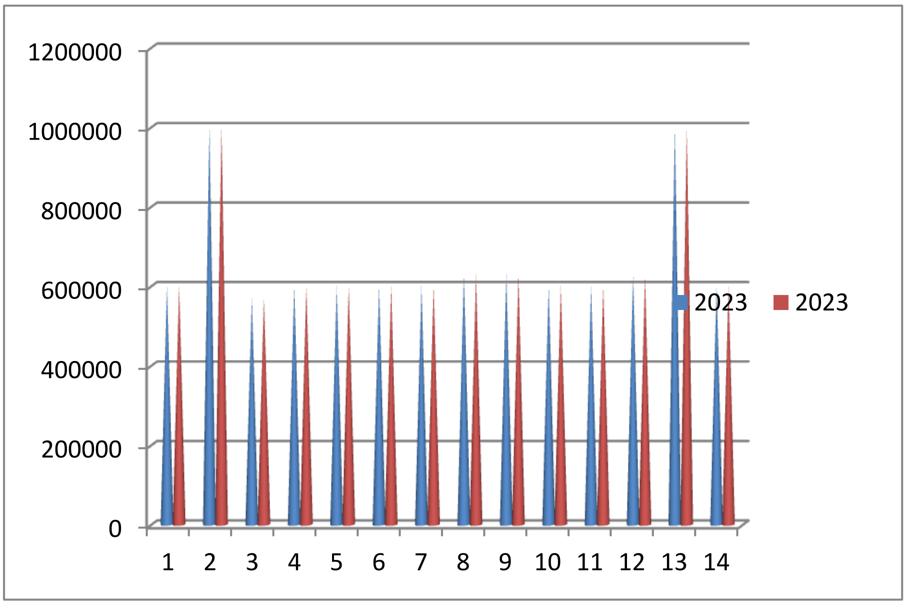
2023		
SHORE NETT	METRING NETT	DIFF
600750	**600478**	**-272**
1001385	**1001687**	**302**
571023	**570693**	**-330**
600622	**600309**	**-313**
600869	**600442**	**-427**
601364	**600944**	**-420**
600687	**600396**	**-291**
629221	**628992**	
629352	**629555**	**203**
601192	**601271**	**79**
600498	**600148**	**-350**
628299	**628137**	**-162**
1000584	**1000102**	**-482**
600903	**600596**	**-307**

Table 6.5 Comparison between Shore Nett and Metering Nett 2023



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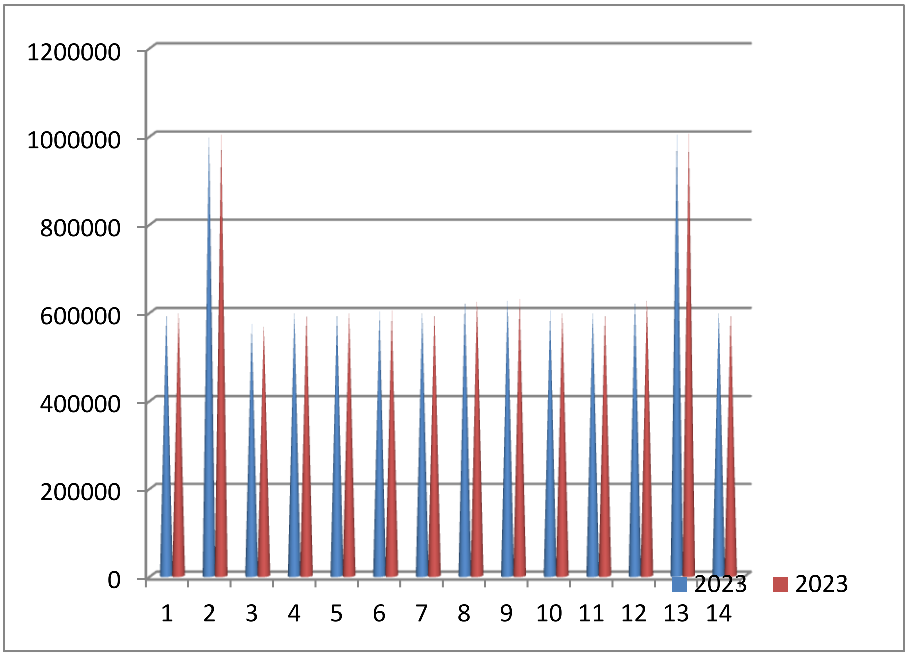

Upon completion of installation of all control system, validation has been carried out for all metering components: pressure transmitters, temperature transmitters, transducers, etc. by third party with the result to comply with accuracy of 0.02% as stipulated in the API that requires an accuracy of the prover volume.

7.4 Critical Success Factor (CSF) -Custody Transfer Metering System;

Key CSFs for custody transfer metering systems include:

- Comprehensive training.
- Rigorous maintenance.
- Reliable supply chain for spare parts.
- Ongoing technological upgrades.

Each of these factors contributes significantly to the system's overall performance.

VIII. CONCLUSION AND RECOMMENDATIONS:-

8.1 Conclusion

The problems that taken place during the operation of the metering system were:

- The system is unreliable due to lack of maintenance.
- The HMI system hanging during loading with the result to fail to print out batching report. Report generation is very low; MOVs and FCVs can't operate automatically.
- Meter proving fails at high flow rate (1700 m3/h).
- PDM for stream No.6 is totally damaged, and the whole system is running manually.

Upon completion of installation of all control system, and replacing the PDM for stream No.6, validation has been carried out for all metering components by third party, with the result to comply with accuracy of 0.02% as stipulated in the API that requires an accuracy of the prover volume.

The 4-way valve for prover, recommended to be replaced.

8.2 Recommendations

1. Upgrade the Control System:

- Adopt Modern Control Technologies: Implement advanced control systems with enhanced functionalities to meet current industry standards and operational requirements.

- Ensure Compatibility and Integration: Ensure the new control system is compatible with existing infrastructure and can be seamlessly integrated.

2. Enhance Measurement Accuracy and Reliability:

- Utilize Advanced Flow Meters: Replace outdated flow meters with high-precision, modern meters that offer better accuracy and reliability.

- Periodic Calibration and Proving: Establish a regular schedule for flow meter calibration and proving to maintain measurement accuracy.

3. Implement Robust Monitoring and Maintenance Procedures:

- Regular Monitoring: Implement continuous monitoring systems to track the performance of the metering system and detect anomalies early.

- Preventive Maintenance: Develop and adhere to a preventive maintenance schedule to reduce the frequency of failures and extend the lifespan of the equipment.

4. Focus on Data Integrity and Compliance:
- Data Logging and Analysis: Incorporate advanced data logging and analysis tools to ensure data integrity and facilitate regulatory compliance.
- Adhere to Standards: Ensure all upgrades and operations comply with relevant industry standards and regulations.

5. Train Personnel and Improve Operational Procedures:
- Staff Training: Provide comprehensive training for staff on the new system to ensure proper operation and maintenance.
- Update Operational Protocols: Revise and update operational protocols to align with the new system capabilities and industry best practices.

6. Conduct a Thorough Failure Analysis:
- Investigate Causes: Perform a detailed analysis of the frequent failures reported since commissioning in 2006 to identify root causes.
- Implement Corrective Actions: Based on the failure analysis, implement corrective actions to prevent recurrence of similar issues.

7. Invest in Redundancy and Backup Systems:
- Redundant Systems: Install redundant systems to ensure continuous operation and minimize downtime in case of component failure.
- Backup Power Supplies: Ensure backup power supplies are available to maintain system functionality during power outages.

8. Collaborate with Stakeholders:
- Engage with Stakeholders: Involve all relevant stakeholders, including engineers, operators, and regulatory bodies, in the upgrade process to gather input and ensure all requirements are met.
- Regular Reviews: Conduct regular review meetings to track progress and address any emerging issues promptly.

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