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# OVERALL PERFORMANCE OF DOMESTIC GAS METER OPERATIONS

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## ABSTRACT

In the current era of technology and its applications, the usage of gas in industries and daily activities is on the rise. Under the PGU scheme, the demand for Methane or sales gas raised ten folds from about 100 million standard cubic feet per day (MMscfd) in 1984 to approximately 1,000 MMscfd in 1995. The gas distribution mix of 65 percent or 1,300 MMscfd was reserved for electricity generation, 8 percent for export market (Singapore) and the remaining 27 percent was for industrial, commercial and resident consumers as well as for use feedstock by petrochemical industries. The Malaysia Government's four-fuel diversification policy aimed at reducing the country's dependence on oil as an energy source and the emphasis towards the usage of a more efficient and cleaner burning fuel also give a momentum to increase the usage of natural gas [1]. In line with this, Malaysia has attained and thus practicing the knowledge of gas transmission and distribution. The metering process is something that can be foreseen because of its dauntless importance in the gas industry. As much as the importance of metering, the accuracy of each and every meter is very important. Based on the specification and standards, a series of mechanical contrivances such as valves, regulators, detectors and meters are placed accordingly as to attain the best result in the calibration. At present, the increasing number of gas domestic customer either employing Natural Gas (NG) or Liquefied Petroleum Gas (LPG) as their burning fuel has driven attention towards accuracy of gas transfer. Losses to custodian may have significant impact in terms of monetary returns[2]. This type of losses may be directly related to the effect of measurement accuracy and pressure losses. Therefore there is a need to study the overall performance in low flowrate gas system in the domestic sector. By the development of a scale model flow system using domestic gas meters, the pressure losses performance and other factors such as flow rate, compositional effect of test fluid can be monitored carefully and could lead to the formulation and understanding of the pressure capacity and its consequence effect to the metering accuracy. This is also in line with SIRIM initiative to establish standards in the domestic gas meter applications.

***Key Words:*** Gas Custody Transfer, Pressure Drop and Domestic Gas Meter.

## 1.0 INTRODUCTION

The accurate metering of gas has become extremely important to companies involved in its transmission and distribution over the last decade. The main reasons for this are the increasing cost of energy, the mutual desire for fair dealing between the buyer and the seller and the increasing involvement of the official/ governmental departments. Furthermore, metering is now directly involved in determining the financial resources of gas companies. It is the 'cash register' of the incoming moneys, and must by its definition be accurate and dependable [4]. Therefore, technical factors such as pressure drop that

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effect the flow patterns of fluids through this meters is of great importance and should be investigated and analyzed.

This project has been carried out through the development of gas custody transfer modelling using domestic gas meter and reference meter to establish the operational accuracy of meters. This in hand will establish the operating conditions of the meter operations [4]. Subsequently, the rig is used to obtain several test data by means of studying the overall performance and losses in the model developed. The impact of the study will lead towards the understanding of the whole operations of the gas transfer in the domestic sector between supplier and gas users. The effect of factors such as pressure drop, flow rate analysis, compositional effect of test fluid, the usage of old and new meter, and uncertainty of meter is mainly studied [5]. It had also established significant pattern and trending towards style of demand in the domestic sector based on pressure system studied.

## 2.0 PERFORMANCE TEST

After the verification of the wet type gas meter, it is said that the system is ready for commission. At this instance, the calibration bench is considered ready for operation. Calibration of domestic diaphragm gas meters of various types with different flow rate and different type of test fluids can therefore be commenced. Prior in running calibration, leakage test need to be carried out in order to determine leakages in the tubing and connection system. The overall gas calibration process has been carried out with several other tests including pressure drop, flow rate, composition and varieties of domestic diaphragm meters.

## 3.0 EFFECT OF PRESSURE DROP ON CALIBRATION BENCH

The pressure drop test is carried out to investigate the effect of pressure drop at different flow on used and new diaphragm gas meters. Pressure drop is highly dependable on the friction coefficient, tubing or passage length, tubing diameter and mean velocity of the fluid. In this particular work, parameters such as length, diameter and fluid medium for each experimental procedure were fixed. The only parameter that varies is the velocity of the fluid. In other words, pressure drop increases with the velocity of the fluid medium.

As the velocity of the test fluid increases, the friction loss in the tubing also increases. This condition causes increase in pressure losses with the increase of velocity of the test fluid. Whenever test fluid passes through meters, some energy of the test fluid had is used to generate the movement of mechanical part of the meter in order to obtain the reading measurement of the test fluid [7]. The internal resistance of the meter subsequently creates pressure drop in the meter which is considered as unavoidable. In the common practices, pressure drop data of gas meters will be provided by the meter manufacturers. Generally, the total pressure drop obtained from this experiment is below 2.0 ″ w.c. (0.005 bar) and its in with the manufacturers requirements and the European Standards which was mentioned previously.

Figure 1 to Figure 6 shows the pressure drop against gas meters for different flow rates using different gases.

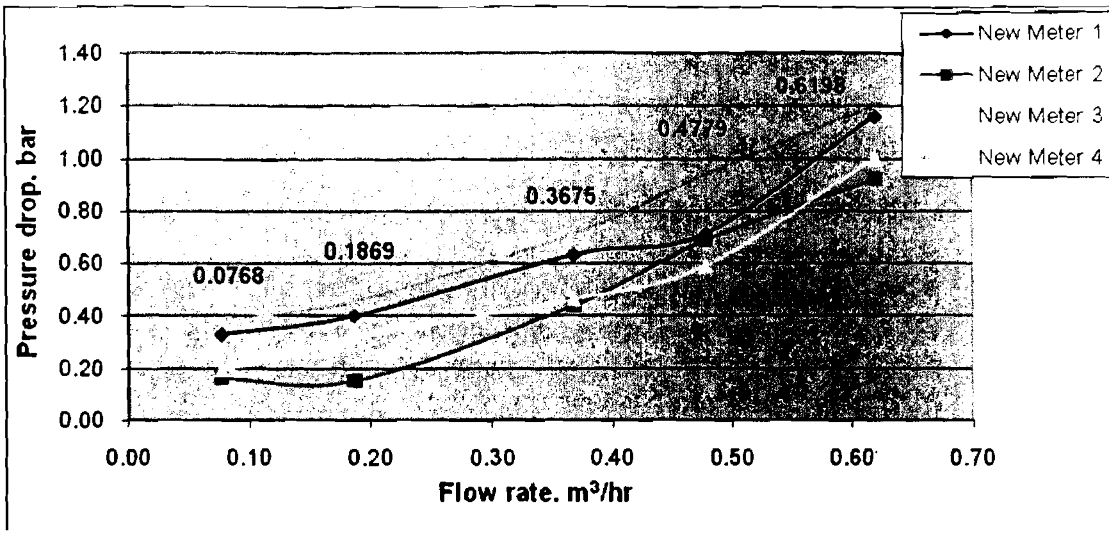


**Figure 1** Pressure drop against new gas meters for different flow rates using LPG

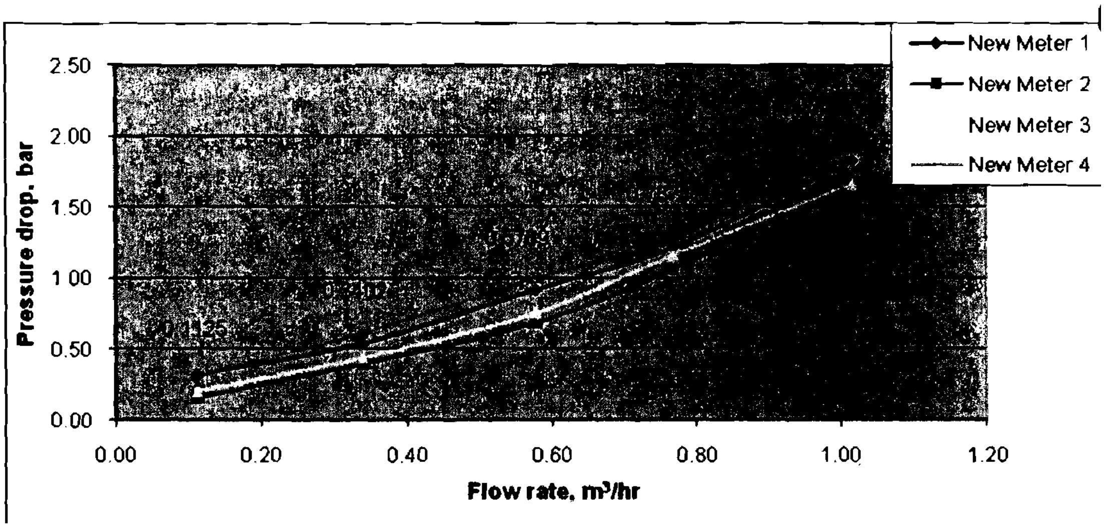


**Figure 2** Pressure drop against new gas meters for different flow rates using nitroge

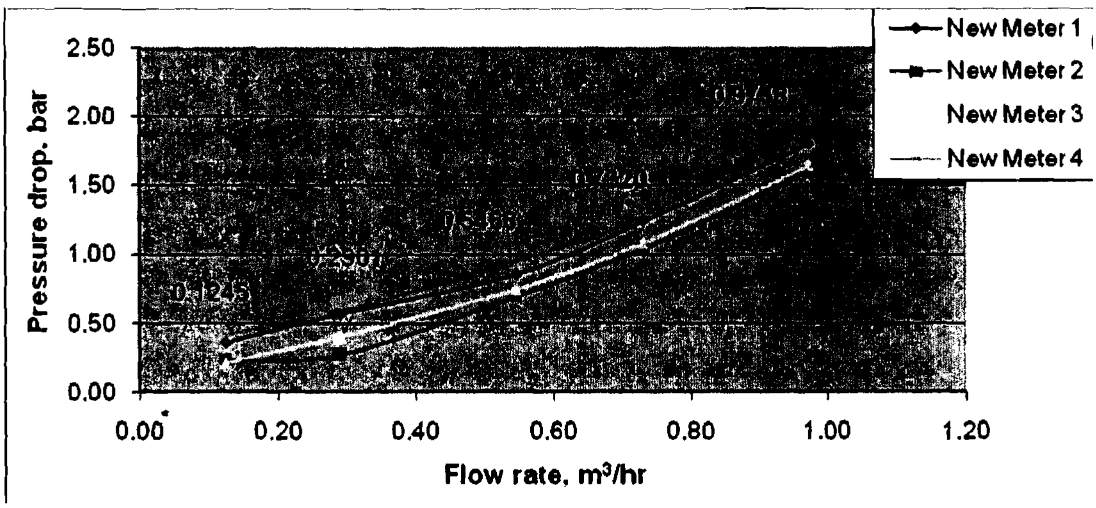


**Figure 3** Pressure drop against new gas meters for different flow rates using compress air

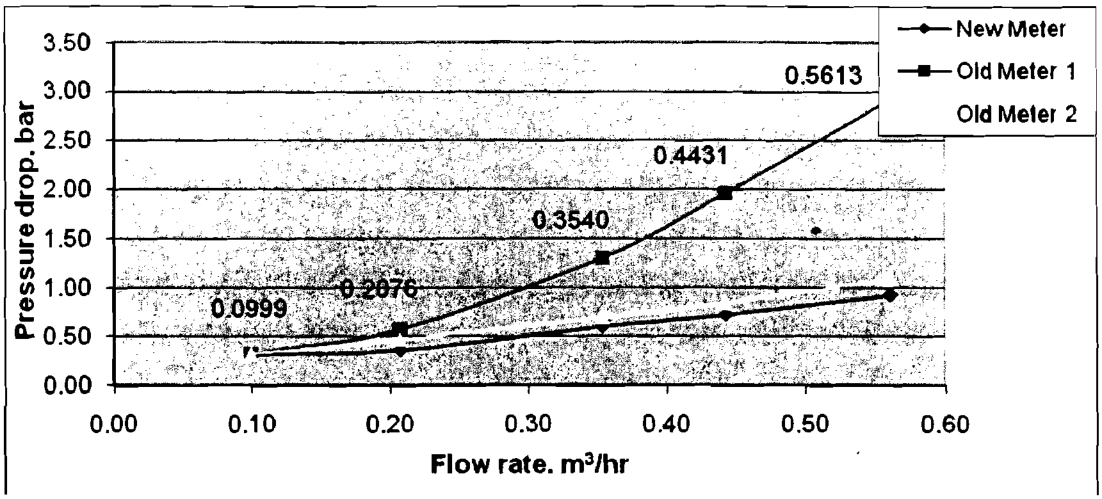


**Figure 4** Pressure drop against new and used gas meters for different flow rates using LPG

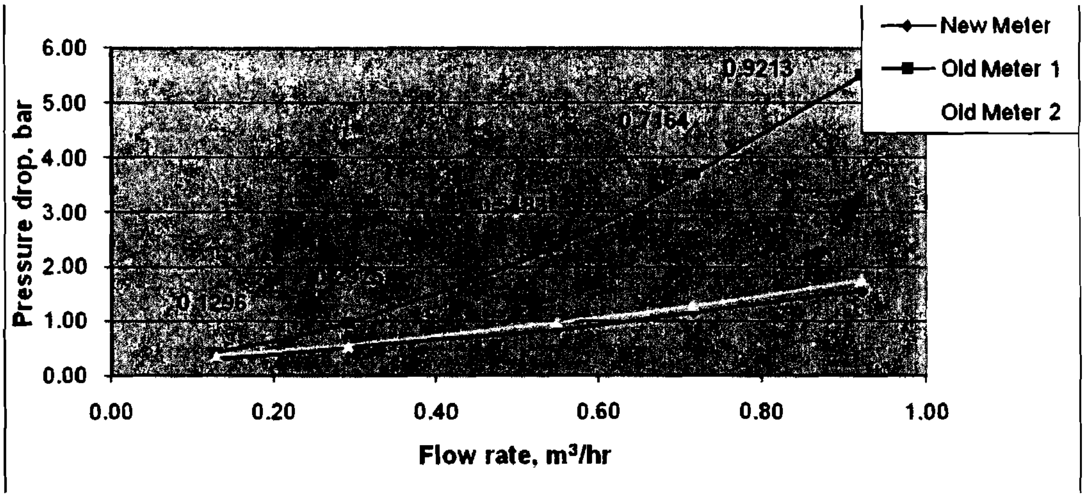


**Figure 5** Pressure drop against new and used gas meters for different flow rates using nitrogen

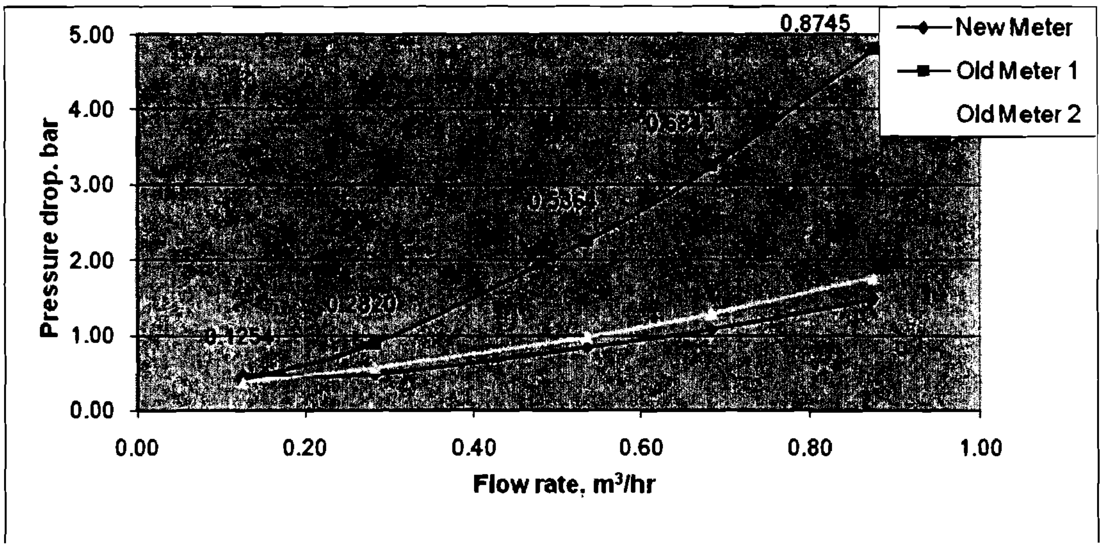


**Figure 6** Pressure drop against new and used gas meters for different flow rates using compressed air

From these figures (Figure 1 to Figure 6), differences of pressure drop obtained a substantially contributed by the tubing losses and individual characteristic the meters. F other diaphragm gas meters, namely New Meter 1, New Meter 2, New Meter 3 and Ne Meter 4 manufactured by the same factory thus indicate small differences of pressu drop. Each of theses meters has slight differences in pressure drop range due manufacturing differences and minor tolerance in the mechanical parts. Howev difference of pressure drop limit does not exceed 1.0 " w.c. (0.0025 bar) except for met indicated as Old Meter 1. This meter probably experienced internal failures. The sar problem does not arise for other meters because the pressure drop data obtained falls the tolerable range. Figure 4 to Figure 6 show pressure drop versus different flow rate f new and used meters. The results show that used meter had almost similar range pressure drop with the new gas meter. Therefore the operation duration of the meter do not give significant effect to the pressure drop of the meters.

## 4.0 FLOW RATE ANALYSIS

The calibration process has been divided into two stages. At first stage, the diaphra gas meter is tested with different flow rate to investigate the effect of flow rate on t meter performance. The part is important to identify relationship between the flow ra of the test fluid on the meter performance [8]. For second stages, the test medium of t meter is then changed in order to study the effect of composition of the test fluid to t meter.

Figure 7 to Figure 12 show the error result of diaphragm gas meter against fl rate using different type of test fluids. It is clearly shown that at a lower flow rate bel 0.5 $m^3$/hr, the error of meter indicates increment with flow rate. As the flow r increases, the error also increases gradually until eventually reaching a maximum val before it begins to fluctuate and acquire stability at the maximum point. After the fl rate reaches 0.5 $m^3$/hr, the error of each diaphragm gas meter were almost consistent. T fluctuation is drastically reduced. The trend also agrees well with the error provided the manufacturer at flow rate range up to 1.2 $m^3$/hr. For all type of test fluid, the n diaphragm gas meter has indicates the error difference of less than 1.0 % between t experiment and the manufacturer data. For the used meter, the error is slightly larger th the new one to about ± 1.0% to ± 2.0%.

From this set of figures, it is quite clear that the new meters showed be performance than the used one in term percentage of errors. Wide range of errors clea shown in the used meter plots and this is absolutely due to a mechanical failu Basically, the ideal form should be constant between flow rate and the error obtain from the flow meter but this ideal relationship form is very hard to be reached. Normal we followed the ordinary relationship which is proportionality between flow rate a errors. From this point of view, the new meter under test showed an acceptable error w flow rate. This relationship is acceptable from practical point of view.

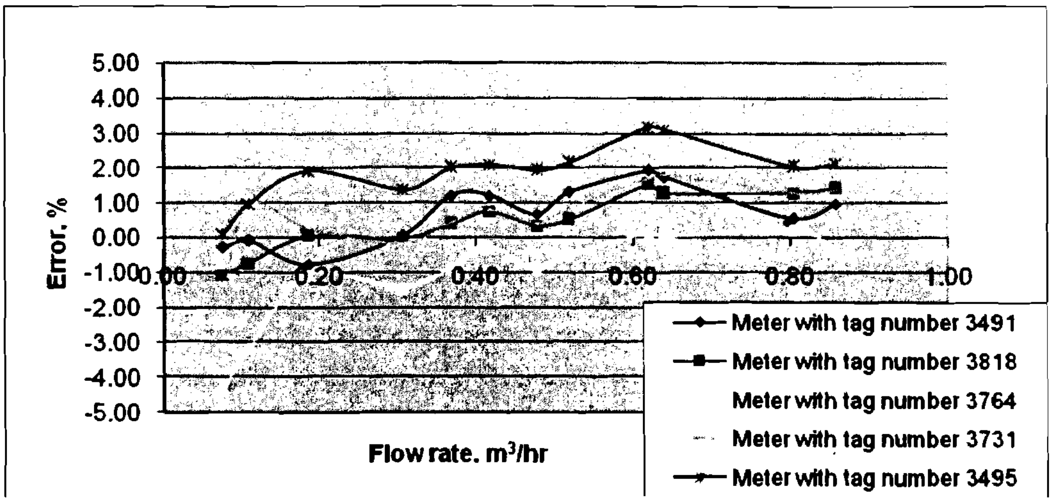


**Figure 7** Error against flow rate for 5 set of new gas meters using LPG

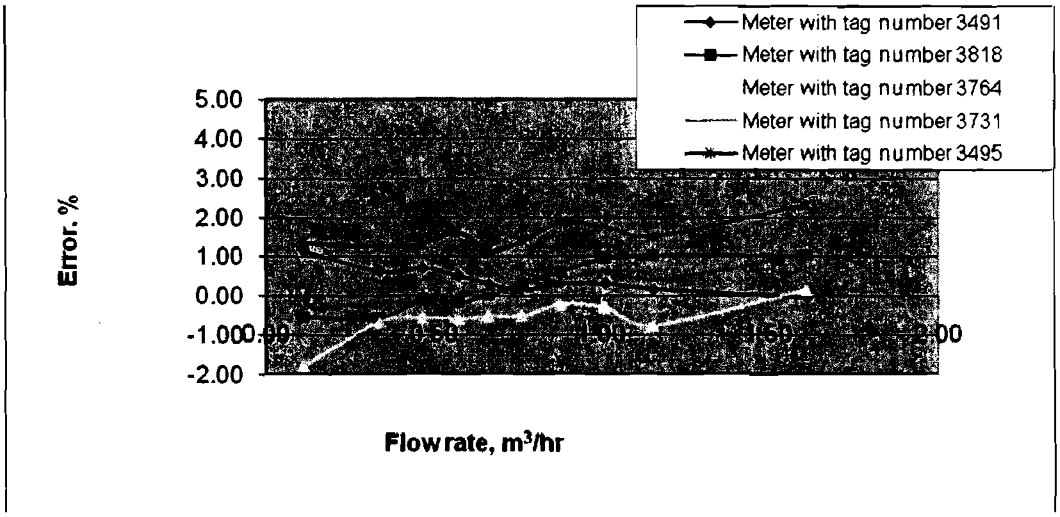


**Figure 8** Error against flow rate for 5 set of new gas meters using nitrogen

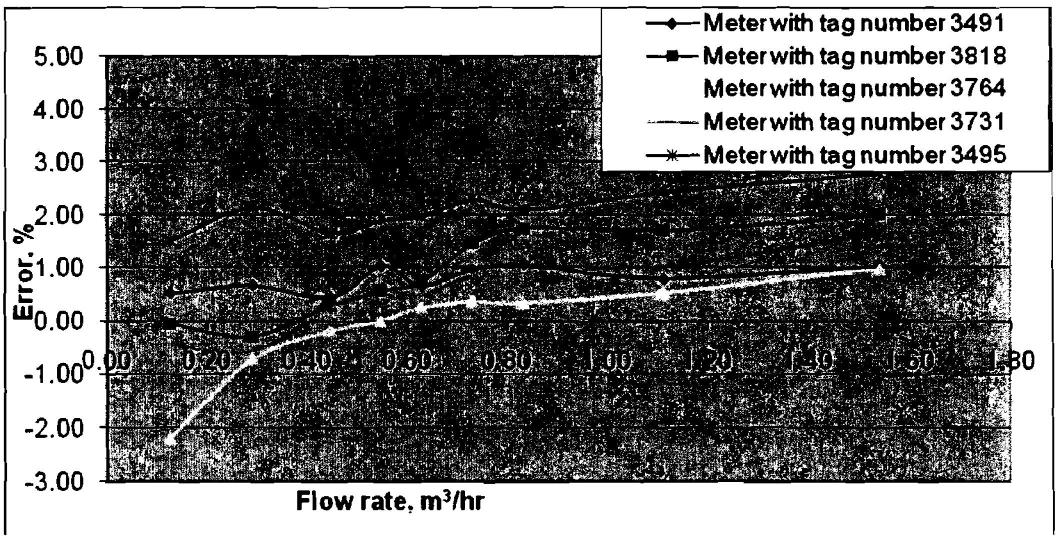


**Figure 9** Error against flow rate for 5 set of gas meters using compressed air

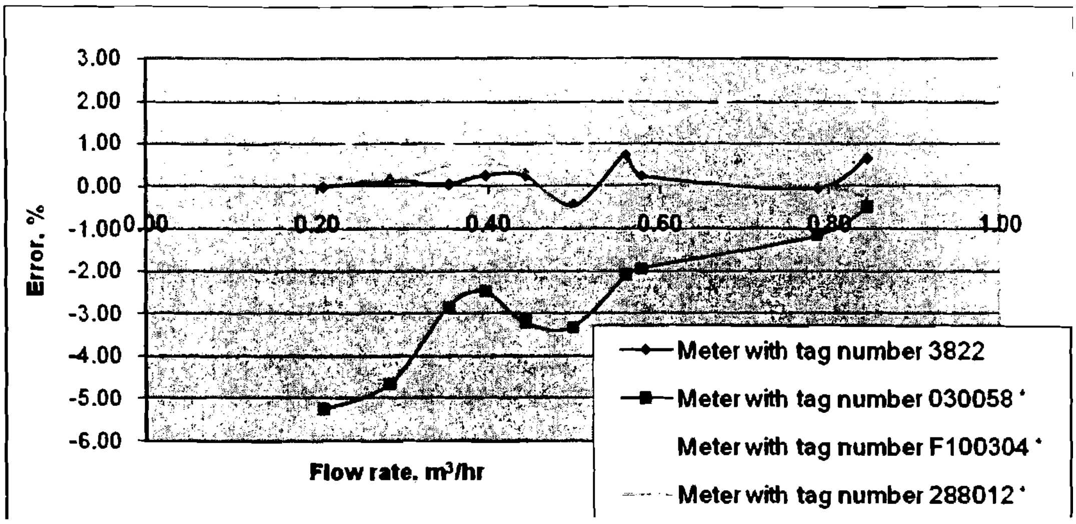


**Figure 10** Error against flow rate for 4 set of new and used gas meters using LPG

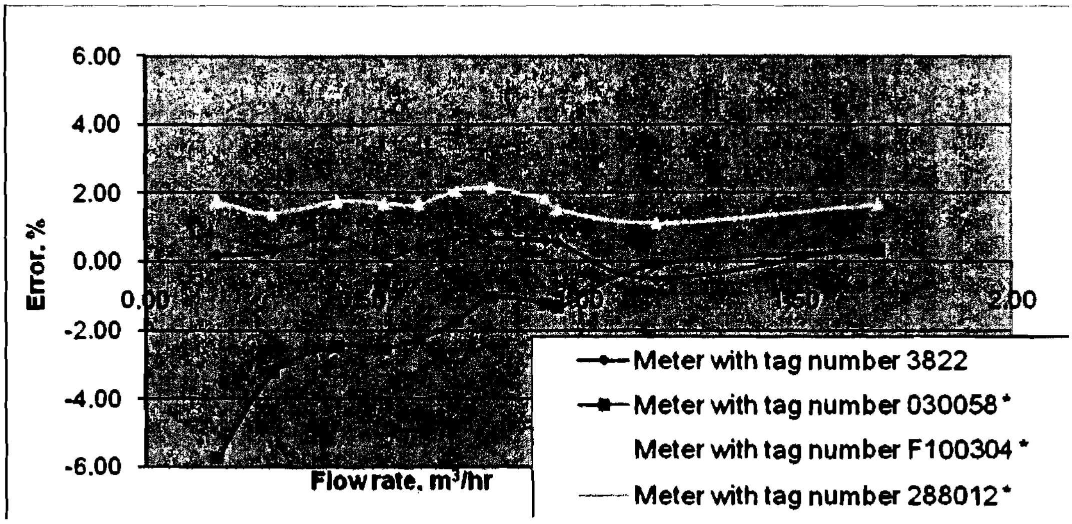


**Figure 11** Error against flow rate for 4 set of new and used gas meter using nitrogen

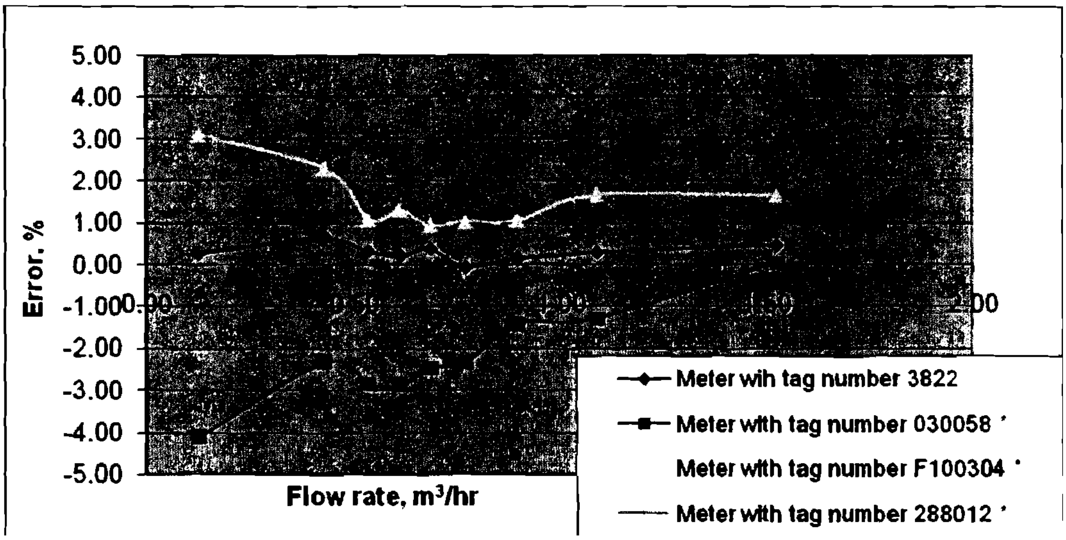


**Figure 12** Plot of error against flow rate for 4 set of new and used gas meter using compressed air

## 5.0 COMPOSITIONAL EFFECT OF TEST FLUID

The effect of composition of the test fluid is one of the parameters which is included in this research work. Three types of test fluids were tested comprising of compressed air, nitrogen and LPG. Each of the test fluid is used to calibrate diaphragm gas meters. Error plot for different gas meters using compressed air, nitrogen and LPG are given in Figure 13 to Figure 21. It can be seen that the errors occurs for different types of gases are relatively small. The errors nearly stable and fluctuate in certain limit within ± 2.0%. As flow rate increases, the error value increased gradually.

The composition should be considered as an important parameter on the meter performance during the calibration process. The presence of oxygen in the nitrogen introducing the oxygen to the nitrogen environment by means of air has affected the meter performance result in term of accuracy. Therefore, we extended our understanding to LPG characteristics where the result also shows a slight difference compared to nitrogen and compressed air. This phenomenon can be noticed as follows: as the fluid molecular structure increase in its complexity, the kinetic challenges on the flow rate plays significant role. By increasing viscosity of gas, the molecular weight of its component components will also increase. However, differences encountered are considerably small to affect meter performances and accuracies in the industrial application but it should be critically considered in the design and construction of calibration systems such as covered in this particular work.

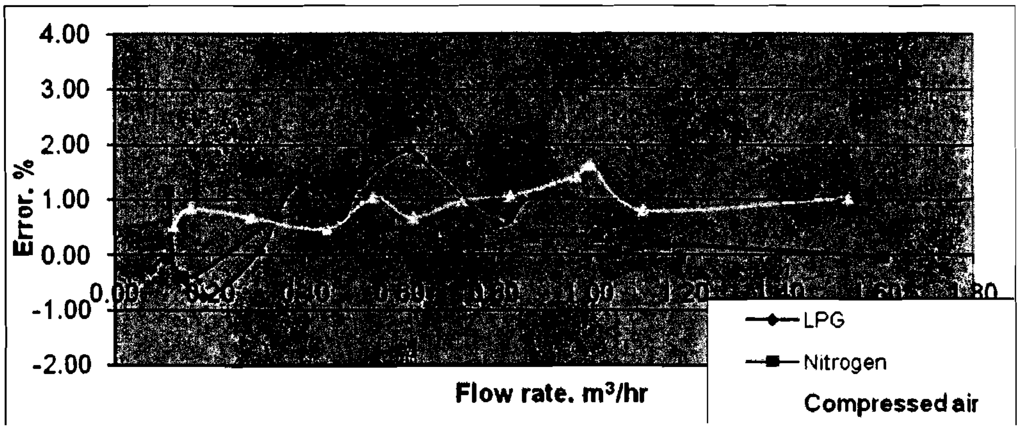


**Figure 13** Error against flow rate using LPG, nitrogen and compressed air for meter tag number 3491

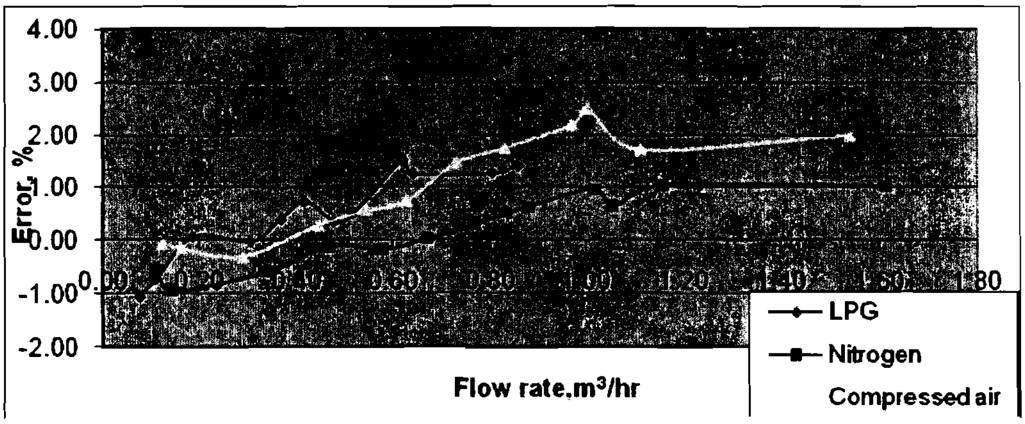


**Figure 14** Error against flow rate using LPG, nitrogen and compressed air for meter tag number 3818

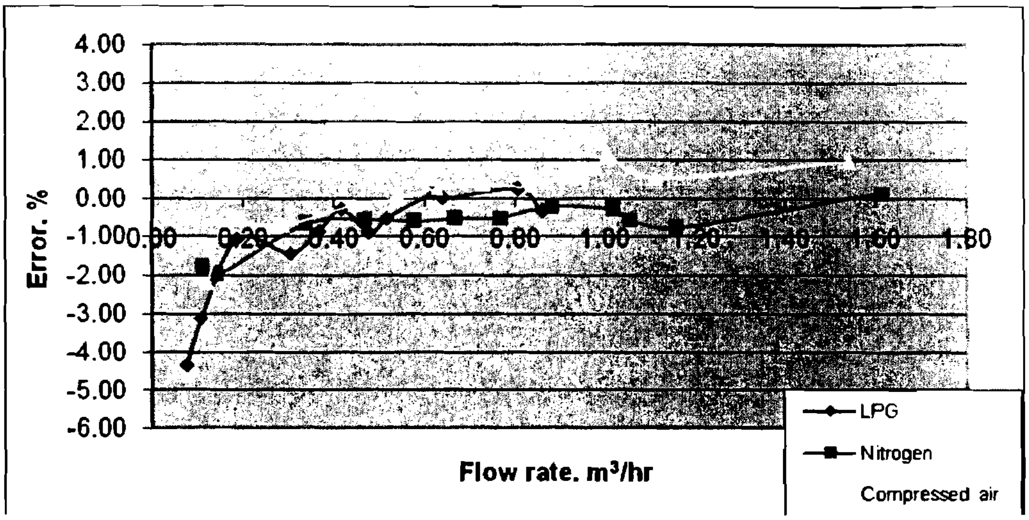


**Figure 15** Error against flow rate using LPG, nitrogen and compressed air for meter tag number 3764

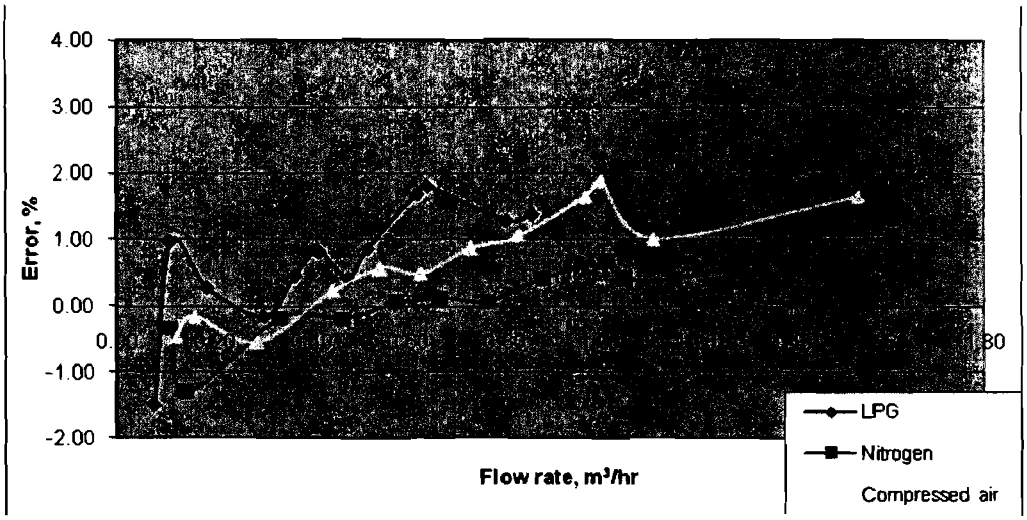


**Figure 16** Error against flow rate using LPG, nitrogen and compressed air for meter tag number 3731

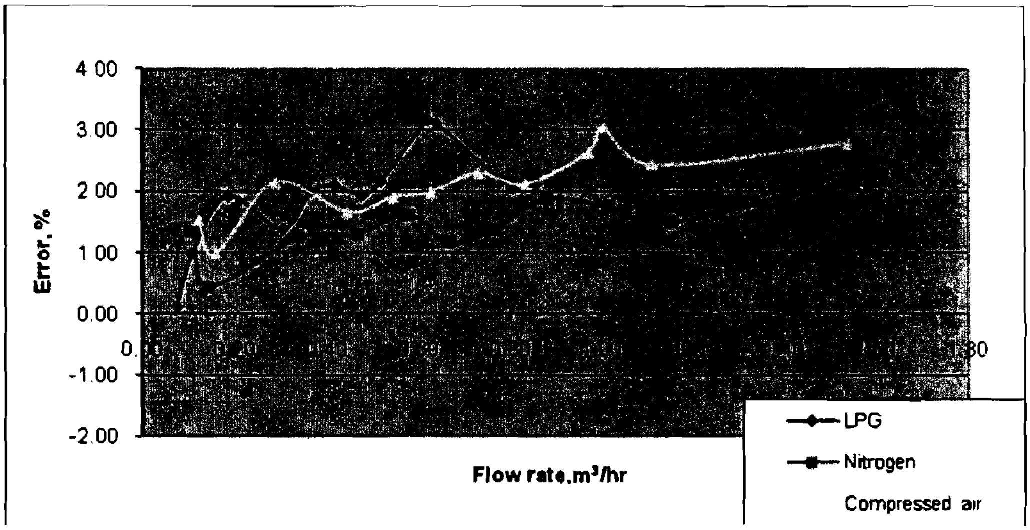


**Figure 17** Error against flow rate using LPG, nitrogen and compressed air for meter with tag number 3495

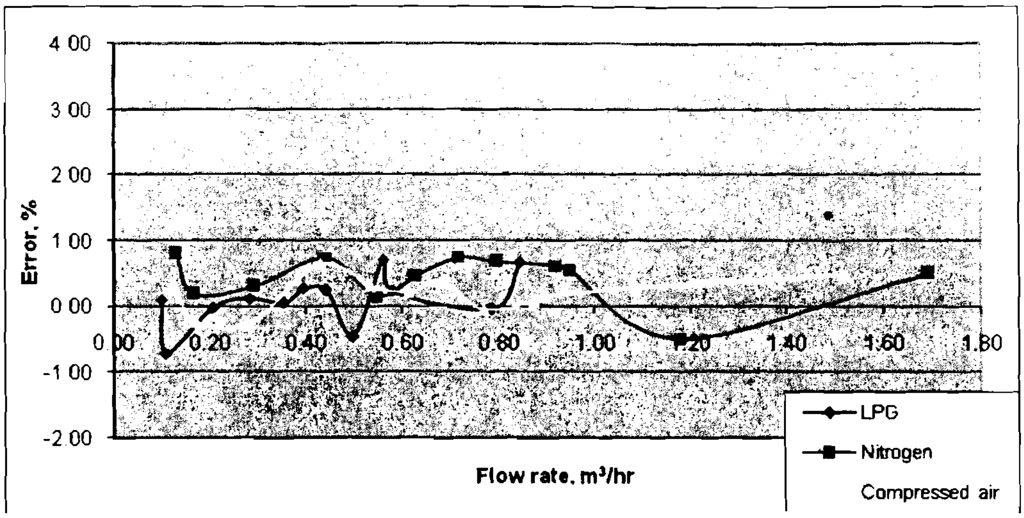


**Figure 18** Error against flow rate using LPG, nitrogen and compressed air for meter with tag number 3822

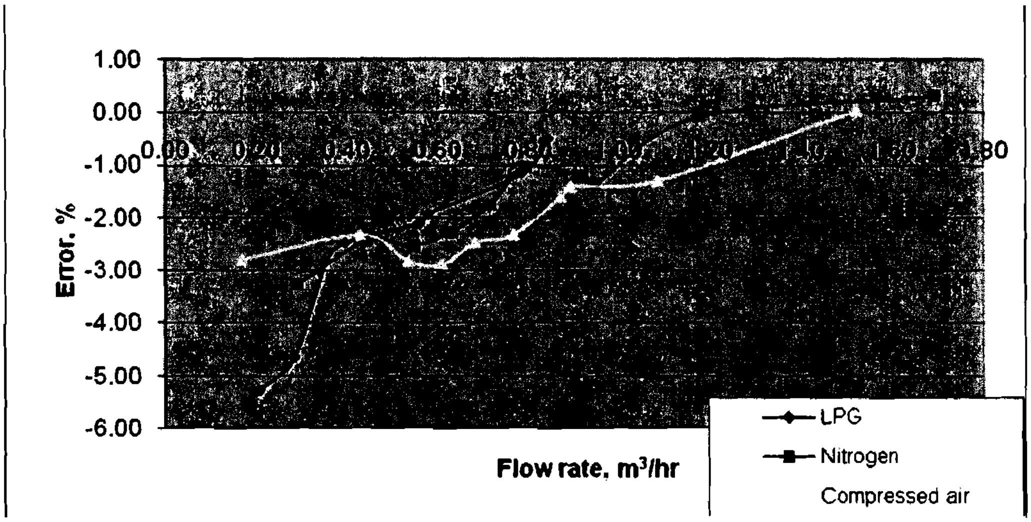


**Figure 19** Error against flow rate using LPG, nitrogen and compressed air for meter with tag number 030058*

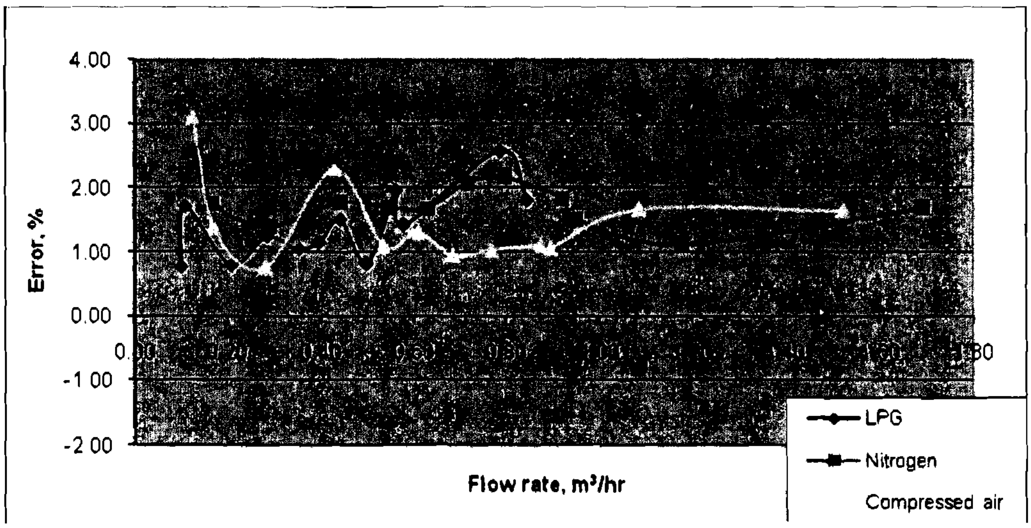


**Figure 20** Error against flow rate using LPG, nitrogen and compressed air for meter with tag number F100403*

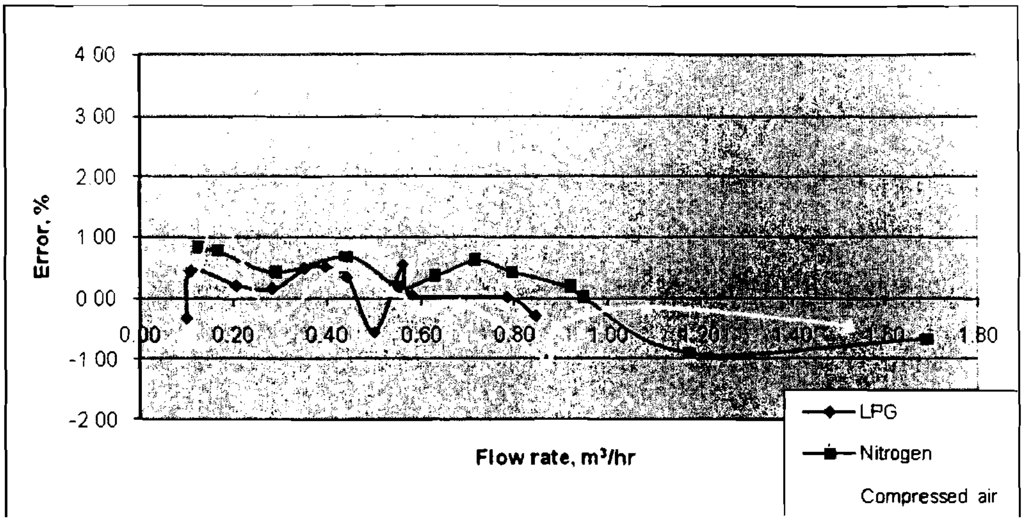


**Figure 21** Error against flow rate using LPG, nitrogen and compressed air for meter with tag number 288012*

## 6.0 UNCERTAINTY OF METER

Uncertainty is one of the factors to evaluate the performance of meters. The of each meter has been calculated and shown in Figure 22 to Figure 24 for new meters and Figure 25 to Figure 27 for used meters. Generally, the new meters uncertainty calculation performs similar value compared to used meters except for meter with tag number 030058*. Meter bearing tag number 030058 shows a pattern of large variations of uncertainty probably due to the internal problem of the meter. Basically, the diaphragm gas meter showed stable uncertainty value for both used and new meters.

From Figure 22 to Figure 27, it is clearly shown that the new meter showed a better limit than used meter and this fact is further supported by good agreement with our reference and previous discussion on this work. The situation is totally different from one meter which is meter bearing tag 288012* in Figure 27 where it had shown a better uncertainty than the new one. This probably cause by combination for some internal failures which contribute those results of the outcome. However, the uncertainty for all new meters falls in acceptable ranges and generally seen better than the used one.

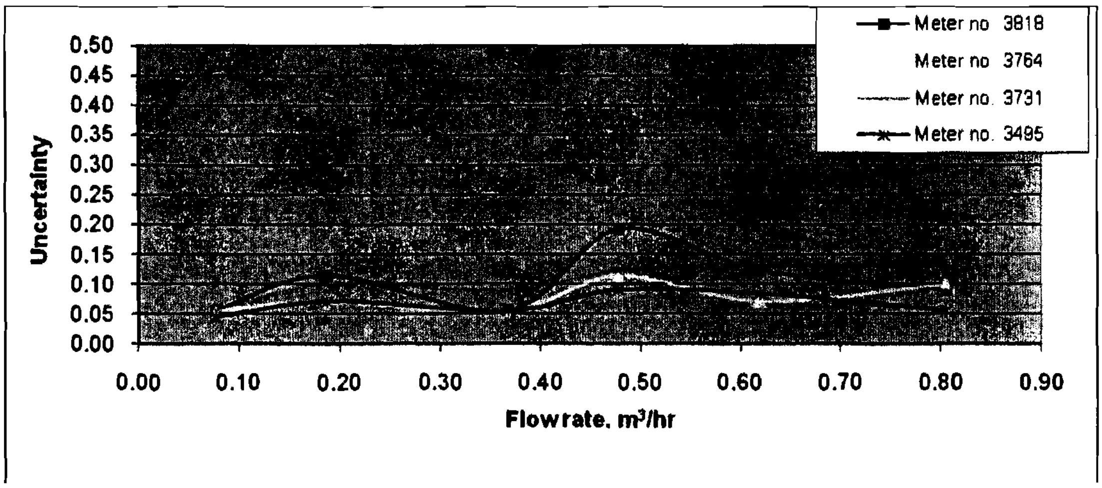


**Figure 22** Uncertainty against 5 set of new gas meters for different flow rate using LPG

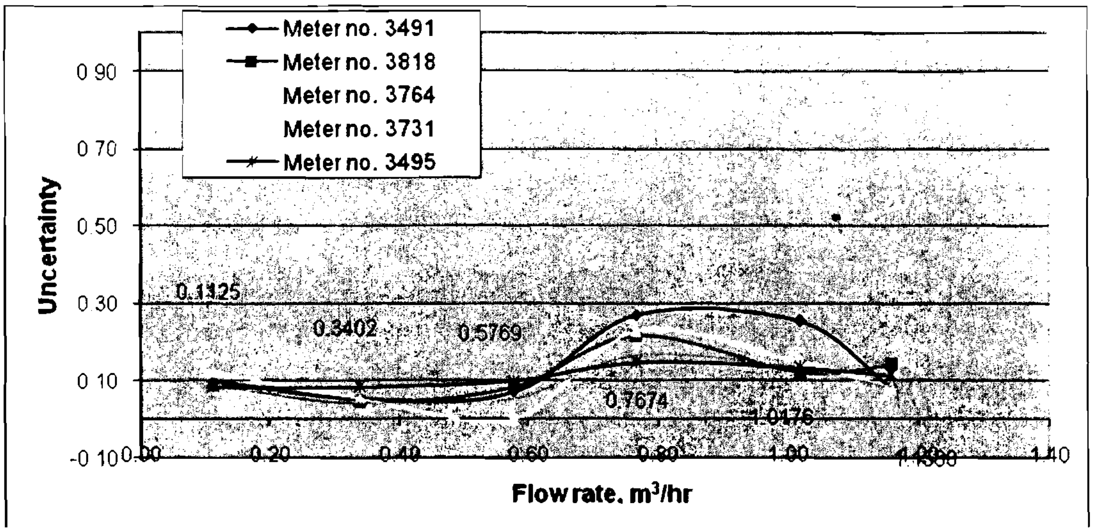


Figure 23 Uncertainty against 5 set of new gas meters for different flow rate using nitrogen

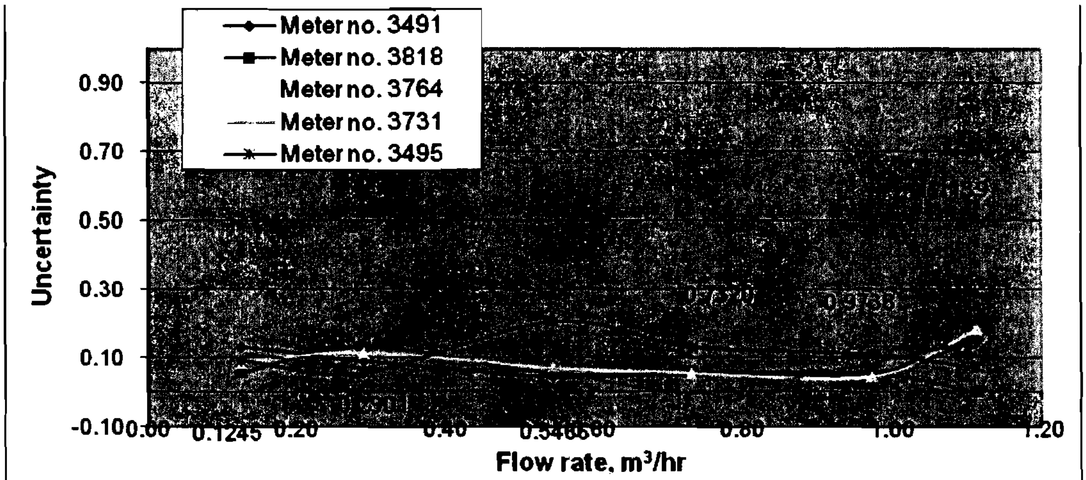


Figure 24 Uncertainty against 5 set of new and used gas meter for different flow rate using compressed air

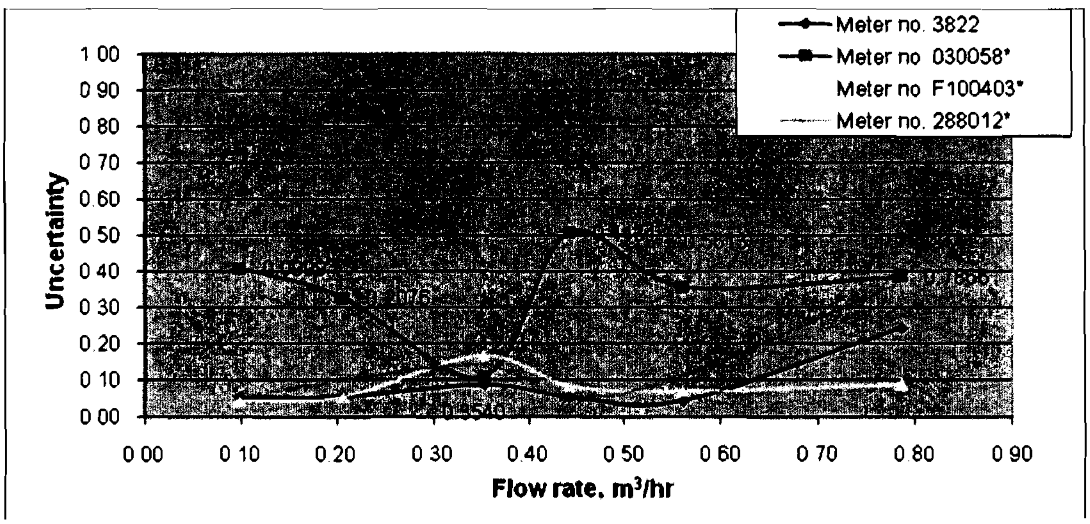


Figure 25 Uncertainty against 4 set of new and used gas meter for different flow rate using LPG

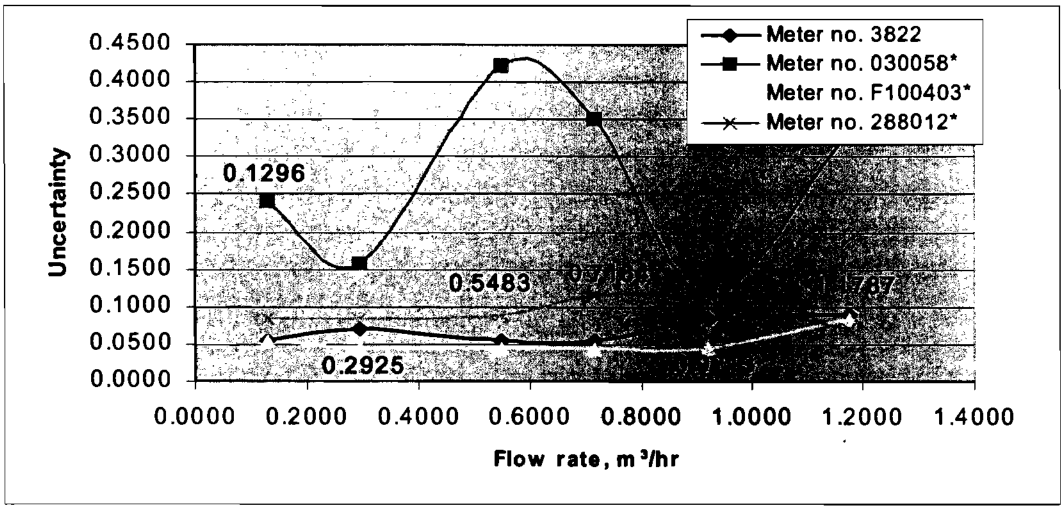


**Figure 26** Uncertainty against 4 set of new and used gas meter for different flow rate using nitrogen

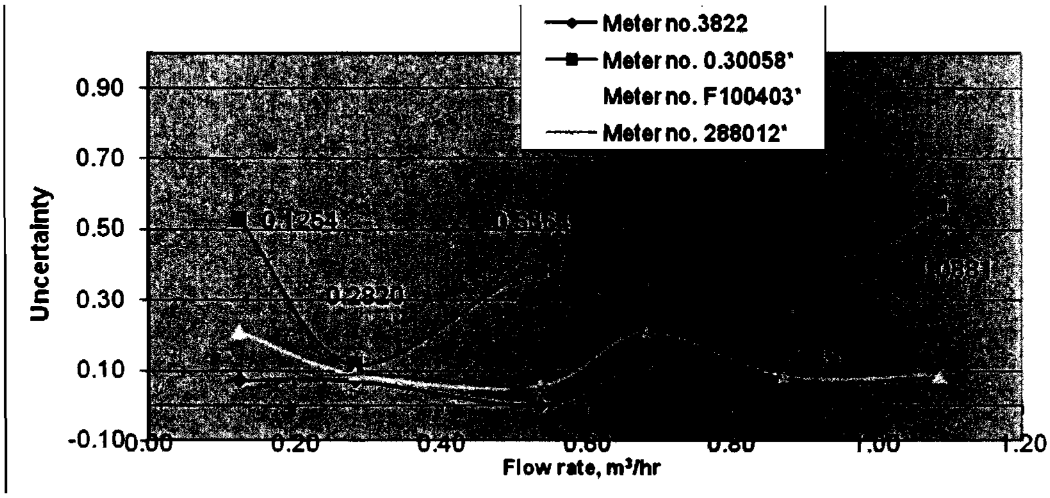


**Figure 27** Uncertainty against new and used gas meter for different flow rate using compressed air

## 7.0 CONCLUSION

The developed calibration bench has been tested on several numbers of meters, both ı and used. The used diaphragm gas meters were obtained from field. The purpos( introducing variations of meter in this experiment is to investigate the effect of t duration of meters to accuracy of the meter measurement. The used diaphragm gas m has been supplied at courtesy from Petronas Gas Berhad (PGU). The used meter had t in operation at field for more than 2 years. The following Figure 19 to Figure 21 sh( the performance between new meter and used meter. From Figure 19 to Figure showing that the used meters have larger error compared to the new meter the e difference is from about ± 1% to ±2% from the new diaphragm gas meter. The e differences occur from at low and high flow rate. Generally, time duration g considerable an effect to the diaphragm gas meter. After 2 years, the diaphragm gas m became inaccurate. This phenomenon shows that after certain period of opera accuracy the meter accuracy will definitely reduced due to the environmental and drif factor.

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