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PERFORMANCE CURVE IN DOMESTIC GAS METER CALIBRATION SYSTEM

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Abstract. This project is focused on the performance curve of gas metering calibration system for low pressure low flow rate domestic gas meter. Visual Basic 6.0 has been employed to carry out comparison of the calibration performance curve. Data gathered from previous work will be used to enable performance comparison. Wet type gas meter will be used as the reference meter in order to calibrate domestic gas meter due to its high accuracy and suitable operating condition at low pressure and low flow rate. Diaphragm gas meter has been selected as predominant domestic gas meter that normally represents common domestic gas meter application as a gas-measuring device.

From the experiment, several operating condition will be carried out to obtain high accuracy measurement to calibrate the diaphragm meter with flow capacity up to 1.20 m^3/hr at an operating pressure of 35 milibar (14 inches water column), with setting temperature of 19 °C to 23 °C. The operation of calibration process incorporates the use of three types of test fluid namely; compressed air, nitrogen and liquefied petroleum gas. Results obtained show that pressure drop increases when flow rate increases and error of new meters increases with the increasing of flow rate until a maximum point reached at less than 2.0%. Therefore all the results obtained are valid and traceable.

Keywords: Calibration; domestic gas meter and liquefied petroleum gas; performance curve; pressure drop

Abstrak. Kajian ini bertujuan untuk mengkaji prestasi keluk satu sistem penentukuran meter gas bagi tekanan operasi dan kadar alir yang rendah untuk sistem meter gas domestik. Sistem penentukuran menggunakan asas 'Visual Basic 6.0' digunakan untuk membandingkan graf perbandingan prestasi penentukuran yang diperolehi. Data masukan yang diperolehi daripada kajian awal akan digunakan. 'Meter Gas Basah' digunakan sebagai meter rujukan kerana keupayaannya menentukur meter gas domestik dengan kejituan yang tinggi dan sesuai digunakan pada tekanan dan kadaralir yang rendah. Bagi meter gas domestik, pengguna biasanya menggunakan meter gas jenis diafram sebagai alat mengukur gas.

Daripada eksperimen yang dijalankan, beberapa keadaan pengoperasian dicirikan untuk memperolehi kejituan yang tinggi, iaitu menentukur meter gas diafram dengan kapasiti sehingga 1.2 m^3/jam pada tekanan operasi 35 milibar (14 inci turus air) dengan suhu antara 19 °C hingga 23 °C dengan menggunakan 3 jenis bahan bendalir, iaitu udara termampat, nitrogen dan gas petroleum cecair. Daripada uji kaji didapati bahawa kejatuhan tekanan bertambah apabila kadar alir bertambah. Dengan pertambahan kadar alir maka ralat meter gas mengalami pertambahan

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sehingga mencapai satu titik maksimum kurang daripada 2.0%. oleh sebab itu, semua keputusan yang diperolehi adalah sah dan dapat dikesan.

Kata kunci: Tentukuran; meter gas domestic; petroleum gas cecair; lengkuk prestasi; kejatuhan tekanan

1.0 INTRODUCTION

Meter used in the measurement of gas flow can be divided into two main classes. Those are quality or positive displacement types and rate-of-flow or inferential types. Positive displacement types measure the alternatively filling and emptying compartment or cavities of fixed volume. To obtain the average flow rate this quantity must be divided by the time taken. Those meters are such as diaphragm meter, rotary displacement meter and wet type gas meter. Inferential types measure the actual flow rate through the meter by inference from the interruption of the flowing gas stream and the primary elements, on the basis of established fluid thermodynamics and empirical data. If the total quantity that flows in a given time is required, the quantities flowing in each small interval of time must be integrated [1]. The inferential meters include turbine meters, differential pressure meters, variable area types, ultrasonic types, anemometer meter and vortex shedding types.

John Reid had stated that calibration is a process that relates the standard to practical measurement. For most gas measuring devices these however depends on the flow rate, the condition of the gas such as line pressure and temperature and gas composition. Gas meter calibration usually involved in a difficult process, most calibration devices are suitable only for laboratory usage. ANSI/ASQC M1-1987 calibration is defined as "*The comparison of an ensemble of unverified uncertainty to a calibration ensemble of quantified uncertainty to detect or correct any deviation from required performance specification*". MIL-STD-45662A described calibration as "*The comparison of measurement and test equipment or measurement standard of unknown accuracy to a measurement standard of known accuracy in order to detect, correlate, report or eliminate by adjustment any variation in the accuracy of the instrument being compared*". Calibration is a process to relate the standard to the practical measurement. Therefore, calibration of a gas meter is to determine the performance of that device by comparing its indication with a known measurement value of same measuring quantity [2].

In gas calibration system, there are two main standard methods used. There are primary standard methods or methods in which the performance of the device used to meter the reference flow can reliably be predicted from theoretical analysis. Primary methods refer to a method, which the reference flow is determined by measurements of the basic dimensions of mass, length, temperature and time. The secondary standards method refers to a method that the reference flow is determined using a flow meter, which has been calibrated, by a primary method. The secondary standards methods, the most commonly used gas flow meters are wet type gas meter, positive displacement meters and turbine meters. Several standard methods may be employed to calibrate gas-measuring devices [4].

Generally, those methods can be grouped into two reference standards. The accuracy estimates given for each method refers to the best accuracy at present attained in a well-equipped standards laboratory. The flow rate measurement uncertainties given for methods where flow is passed from vessels or flows through or into a vessel, for a measured period of time refers to the uncertainties associated with the measured mean reference flow rate during the measured time period [5]. Since the timing errors are small, the mean reference flow rate uncertainties are generally of similar magnitude to the uncertainties with which quantity measured can be determined using these methods.

2.0 METHODOLOGY

The domestic gas meter calibration of the laboratory scale using wet type gas meter is purposely dedicated for the calibration of domestic gas meters and has a capability to carry out series of test meters in one single operation. Compressed air, nitrogen and liquefied petroleum gas could be used as source medium. These gases are in a constant pressure and stabilised by passing through pressure regulator. After selecting the test item, inspection and pressure drop test procedure is commenced, followed by the opening and closing sequence of the control valves using logic controller. After certain accumulated amount of standard flow rate, test results could then be obtained using temperature and pressure conversion.

The wet gas meter is probably the only type of positive displacement meter where the problem of sealing the moving parts without friction is fully solved without recourse to an awkward compromise. This remarkable feat is achieved by using a bath of water to provide the seal, as shown in Figure 2.2. The result is the most accurate gas volume meter known, with accuracies as good as ±0.25 % over a flow rate range of 10:1 being claimed. But there is a high price to be paid for this accuracy. The speed of rotation of the drum must be kept very low to avoid any significant disturbance of the water level. This means that the wet gas meter also holds the record for being the bulkiest flow meter in existence. For example, a meter with an internal volume of around 0.5 m^3 cannot safely be used at flow rates above 0.005 m^3s^{-1}. The instrument needs a highly trained operator, because great care must be taken if its full potential as an accurate meter is to be realized. One pitfall to be avoided is supplying this type of meter with dry air; since the air leaving a water-filled meter is liable to be saturated with water vapour, the operator must ensure that the incoming air is also saturated. Alternatively the meter may be filled with suitable oil instead of water, in which case humidity problems should not arise, unless the oil is allowed to become wet. The liquid level inside the meter must always stand level (Hayward, 1979).

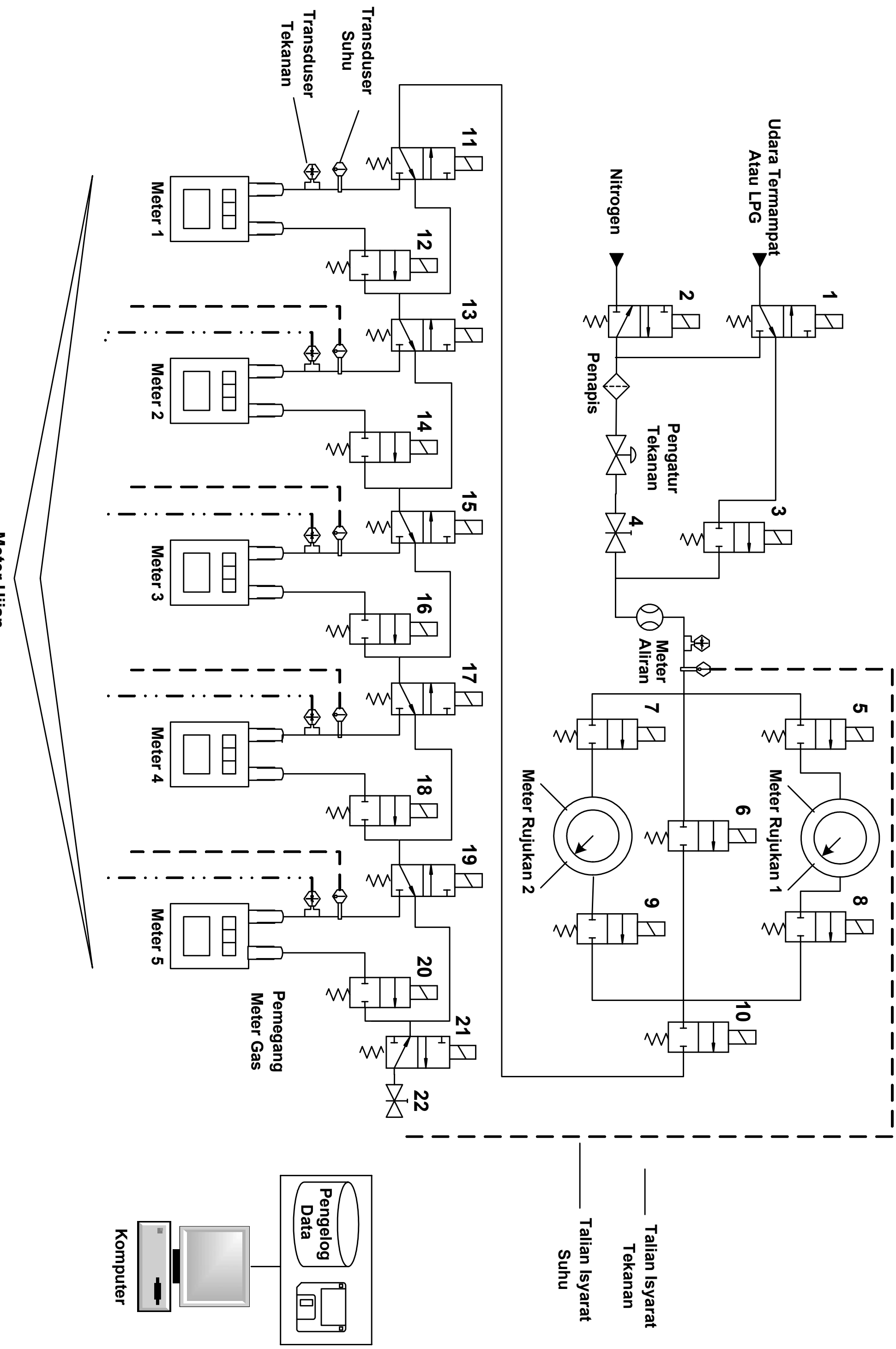

Figure 2.1 The conceptual design of the testing system of gas meter

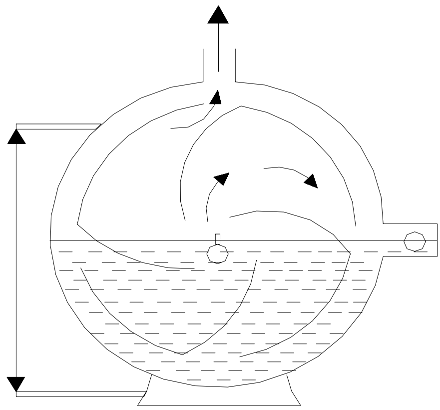

Figure 2.2 Principle of wet type gas meter (Hayward, 1979)

3.0 DEVELOPING SYSTEM

Several steps were involved in developing a system to cater for automated performance calculation process. This program is developed based on 'on-line active form'. Users can use this main form as an option as to proceed with this program and exit from program. This ca be done by clicking on he execute function and exit on the file at left top handed. The main form can be seen as in Figure 3.1. by clicking the run

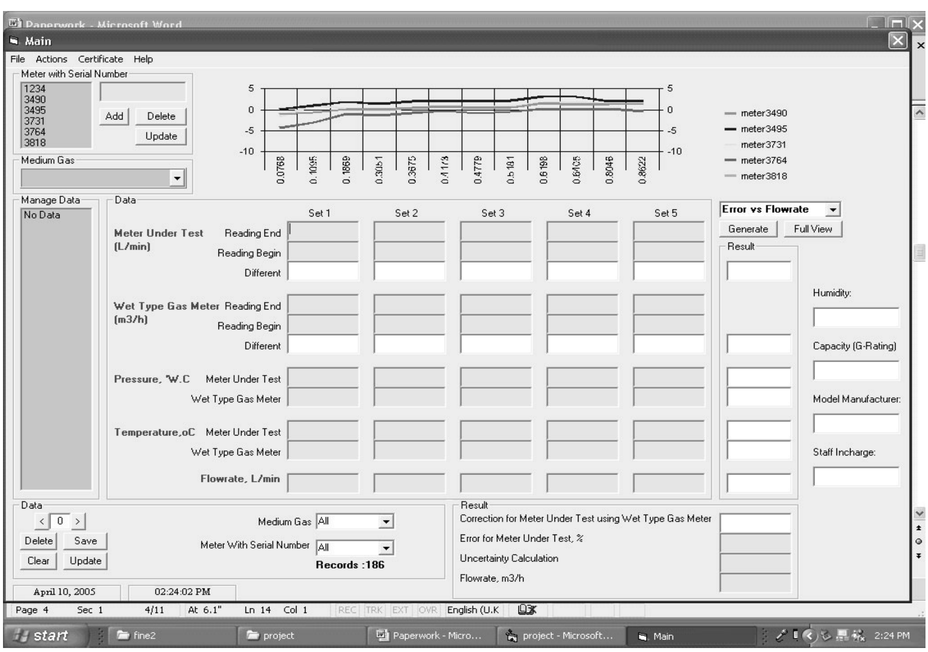

Figure 3.1 Main menu display screen

function, a message box will be straight away appear to inform the user to key in the data in the textboxes or load previous data.

User has to insert all the required data in the textboxes. Besides, the user can obtain all values directly from any file if they have one by clicking the 'Open' in action at the top interface. After clicking the button, another form that is shown in Figure 3.2 is displayed. Results in the right side of the main menu form is needed as it has to be used for calculations error, uncertainty and pressure drop for each tag meter, for example pressure in inch water column for meter under test and wet type gas meter. These values can be seen in the same form. If the user intends to save all the input data, he/she can just click directly to the save button and Figure 3.3 will be shown straight away.

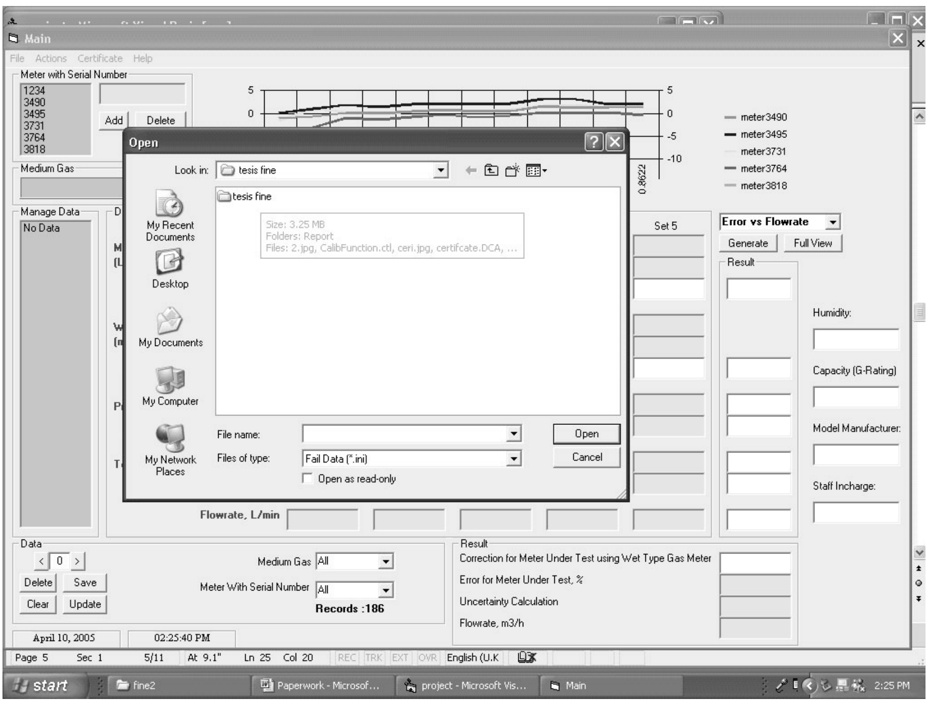

Figure 3.2 "Open" interface to load previous data screen

They purpose of having a 'delete' button is to erase all data in textboxes as shown in Figure 3.4. This will be easier for the user as not to erase the data one by one. On top of that, this model is specially built, as it can change the values of the results straight away only if the user changes any of the input data. This model was designed as to make the user enters the data only in numerical format.

When the command button for 'Error Vs Flow rate', 'Pressure Drop Vs Flow rate' and 'Uncertainty Vs Flow rate' is pressed, message box stating the user has to insert

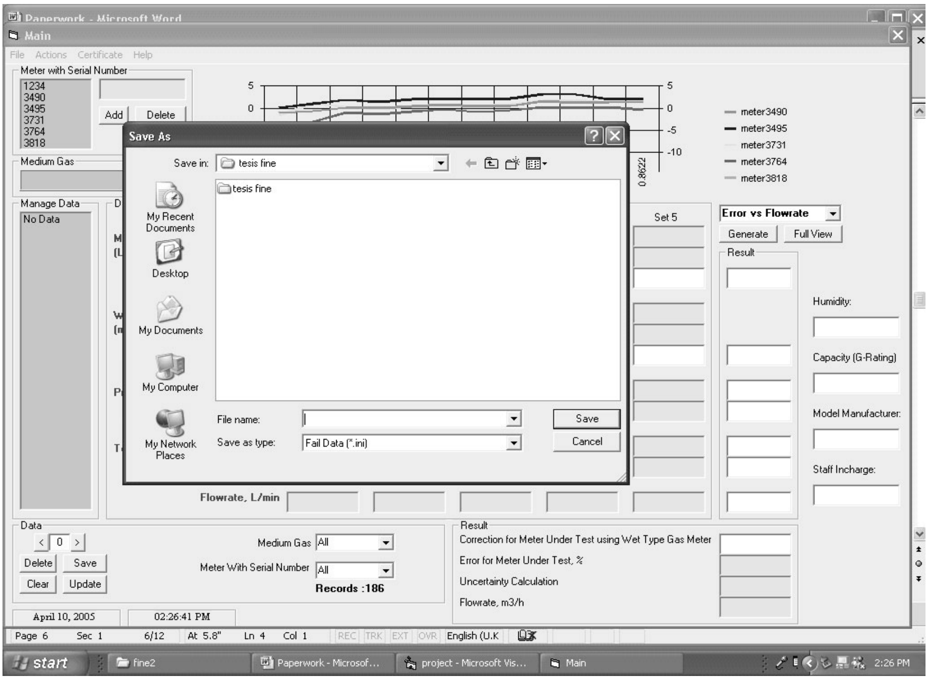

Figure 3.3 "Save As" interface to save data screen

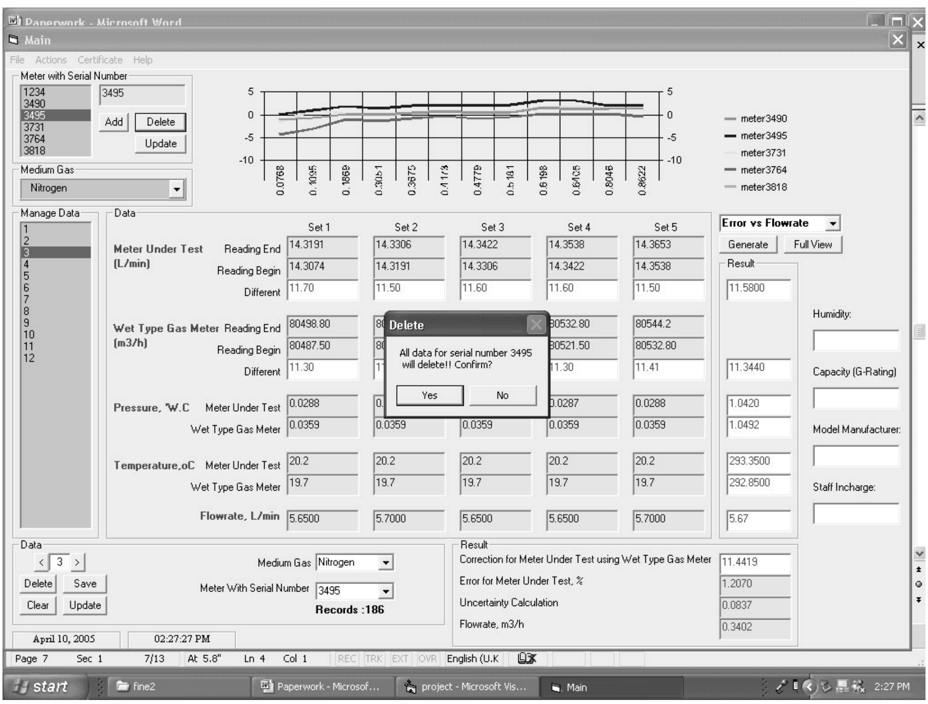

Figure 3.4 Message box selection request screen

all data will only be displayed if the user does not fill up the all data in main menu. If the user intent to make some adjustment to the data, the user only click 'Update' button which will then display data from the databases. All data will be saved in databases in a long characteristic. When the data has been completely saved, user will be able to carry out comparison between simulated graph with a manual vale. When all the input filled in all the textboxes, user can click on 'Certificate' to documenting and print the data. The data will be reported in three phases at in terms of a Calibration Forms, Gas Meter Calibration Group or graph for each meter as shown in Figure 3.5.

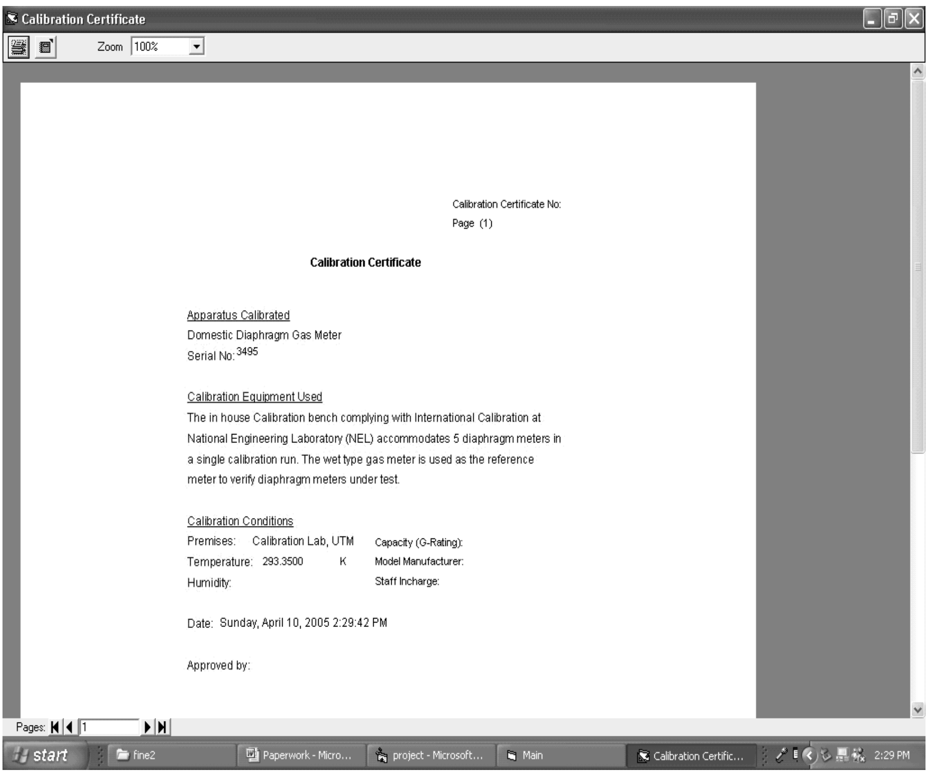

Figure 3.5 A sample of calibration certificate

4.0 RESULTS AND DISCUSSIONS

The main objective of this work is carry out performance test by means of automated documenting program in domestic gas meter calibration system such as effect of pressure drop for calibration bench, flow rate analysis, compositional effect of the test fluid and uncertainty of meters.

4.1 Effect of Pressure Drop on Calibration Bench

The pressure drop test has been carried-out to investigate the effect of pressure drop at different flow rates to wet type gas meter and diaphragm gas meter. The experimental results of pressure drop tests with different flow rate within the ranging 0.1 to 1.1 m^3/hr and given in the following figures (Figure 4.1-Figure 4.6).

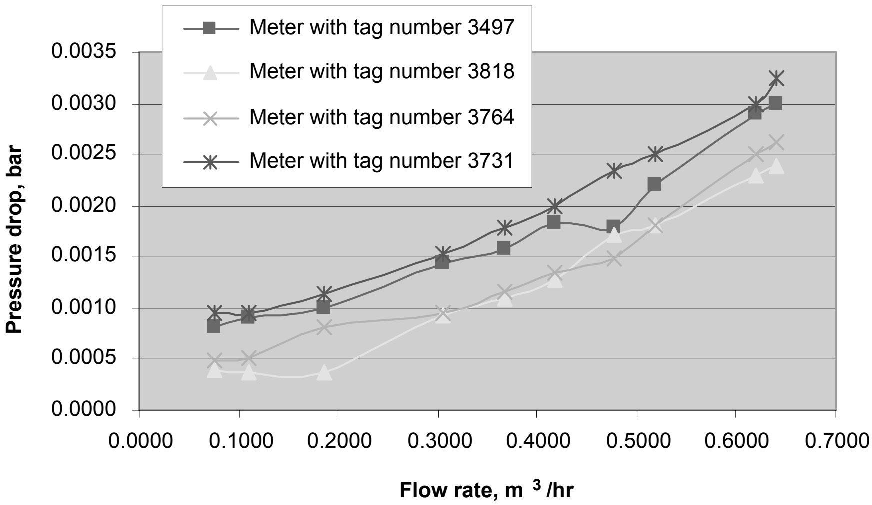

Figure 4.1 Plot of pressure drop against flow rate for different new gas meters using LPG

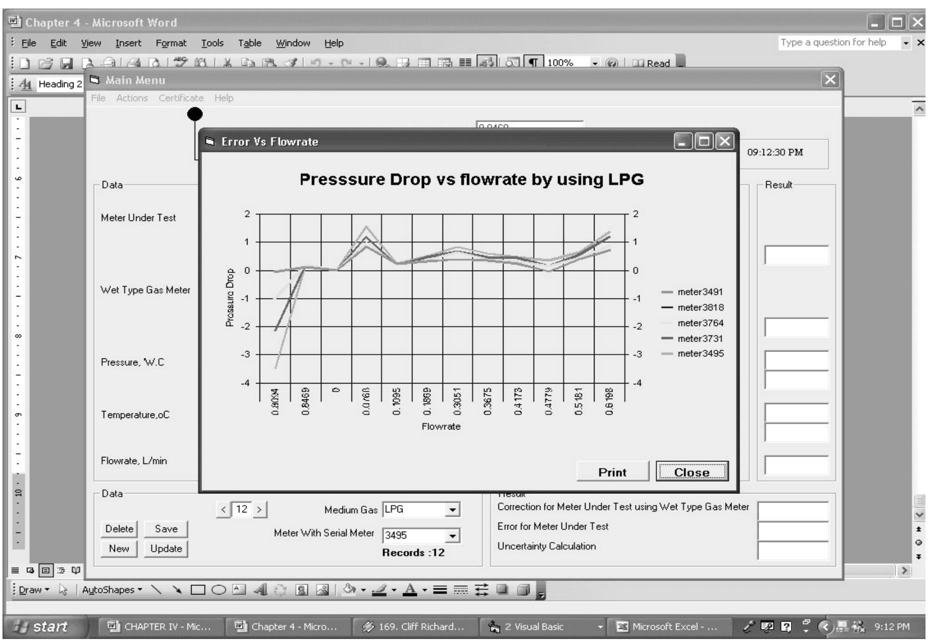

Figure 4.2 Plot of pressure drop against flow rate for different gas meters using LPG

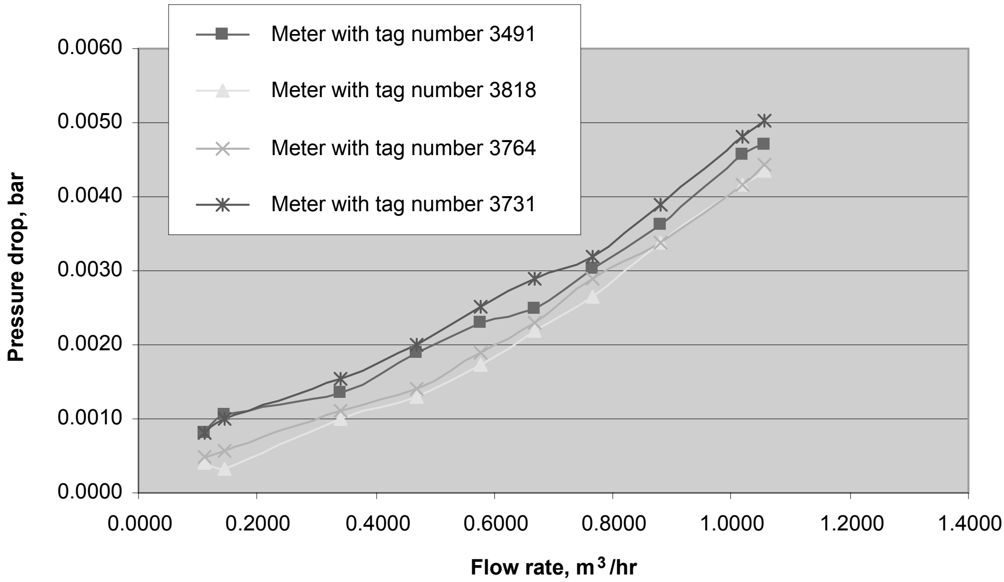

Figure 4.3 Plot of pressure drop against flow rate for different new gas meters using nitrogen

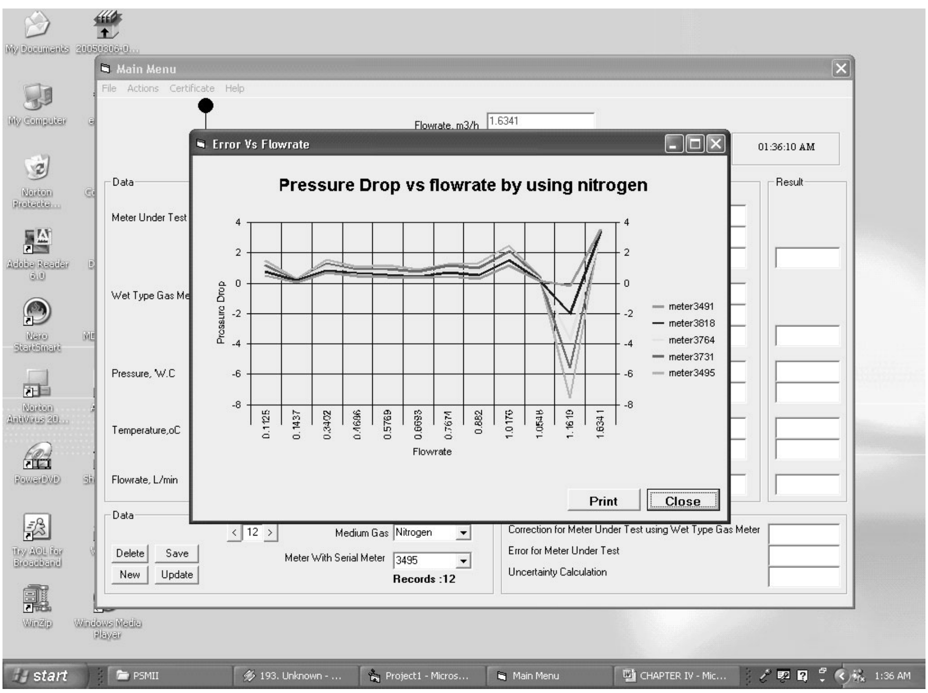

Figure 4.4 Plot of pressure drop against flow rate for different gas meters using nitrogen with Visual Basic as a programming

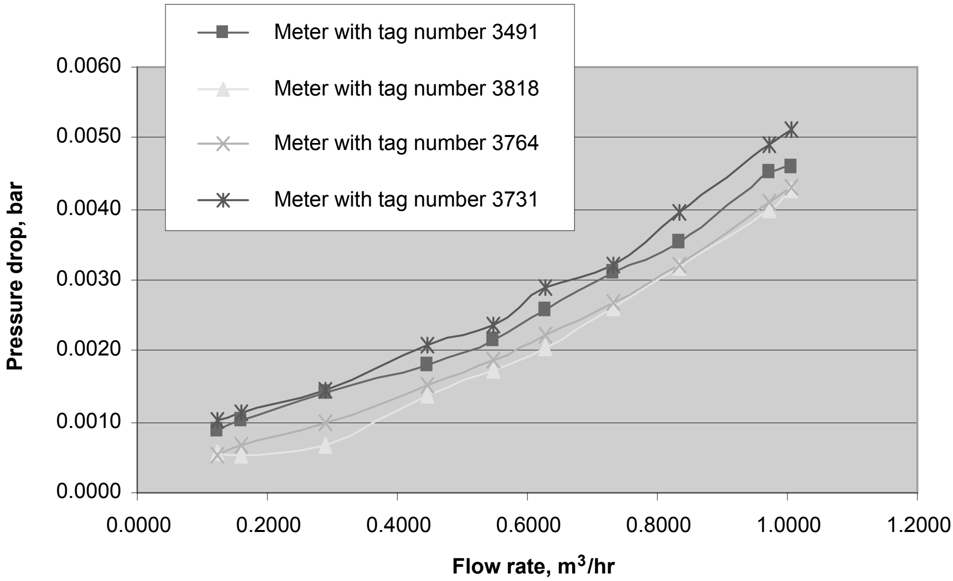

Figure 4.5 Plot of pressure drop against flow rate for different new gas meters using compressed air

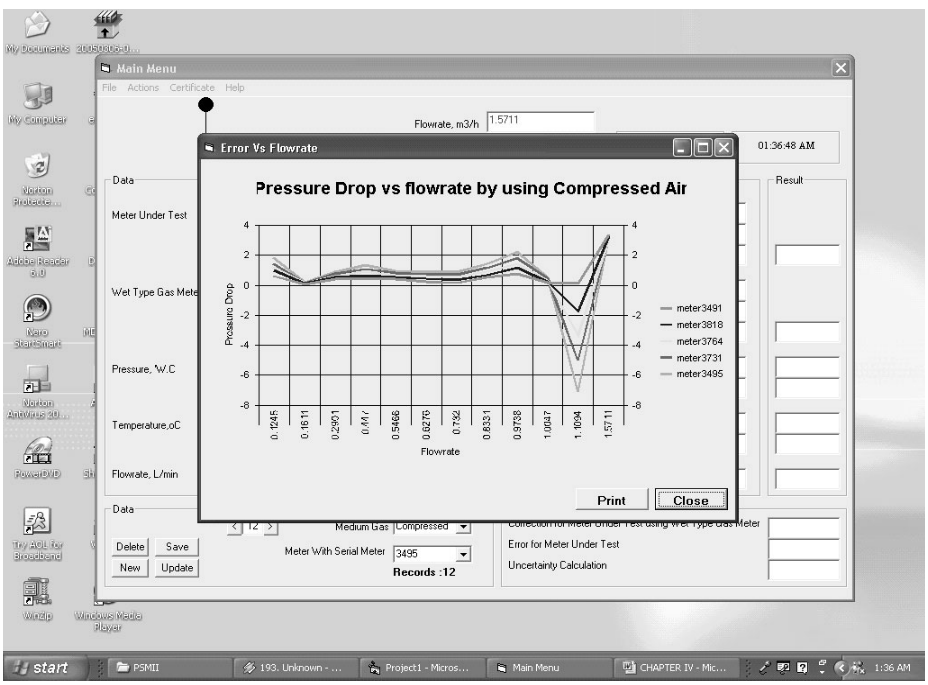

Figure 4.6 Plot of pressure drop against flow rate for different gas meters using compressed air

Actually, pressure drop increased when flow rate is increased across each gas meter. It is shown in a graph above that pressure drop increase gradually from 0.4"w.c to 2.00"w.c when flow rate increase for each gas meter. From previous work [6 – 7] only test of a different velocity hs been compared to other parameter such as friction coefficient, tubing or a passage length and tubing parameter. Basically, pressure drop increases with the velocity of the fluid medium, $\Delta P \alpha U^2$. When the velocity of the test fluid increases, the friction loss in the tubing also increases. This phenomenon thus causes increase in pressure losses with the increase of velocity of the test fluid [8]. From the graph above, graph between manual result obtained comparison using Microsoft Excel and newly developed program show slightly differences. Visual Basic uses algorithm in order to ensure complete data entered to provide successful plot of graph.

4.2 Flow Rate Analysis

Comparison between Microsoft Excel and Visual Basic in test the errors of diaphragm gas meter against flow rate are given to the following figure. The effect performance of flow rate of the meter performance to identify relationship between the flow rates of the test fluid on the meter performance is also given.

Figures 4.7 to 4.12 show that at a lower flow rate using Microsoft Excel below 0.5 m^3/hr, the error of meter is increasing with flow rate then when the flowrate reaches 0.5 m^3/hr, the error of each diaphragm gas meter almost consistent. It indicates that when the error increases gradually until reaching a maximum value, flow rate is also increases. The fluctuation is drastically reduced. While, Visual Basic is slightly different because all the data are given without any selection.

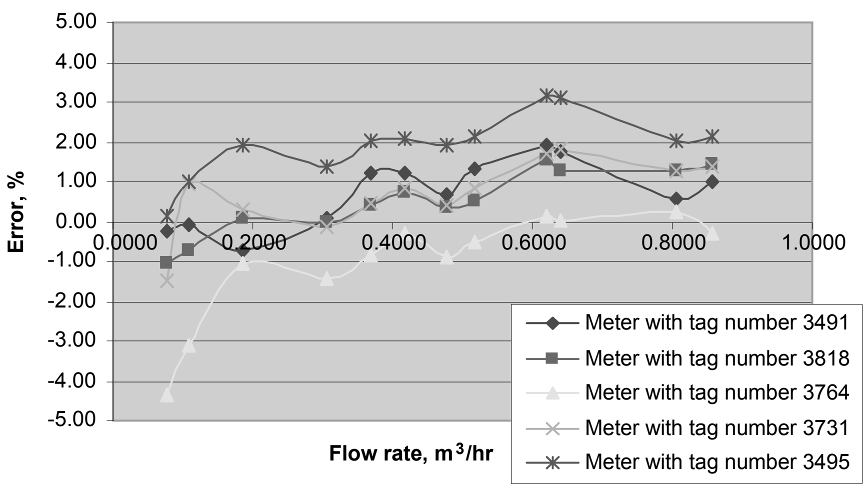

Figure 4.7 Plot of error against flow rate for 5 set of new gas meters using LPG

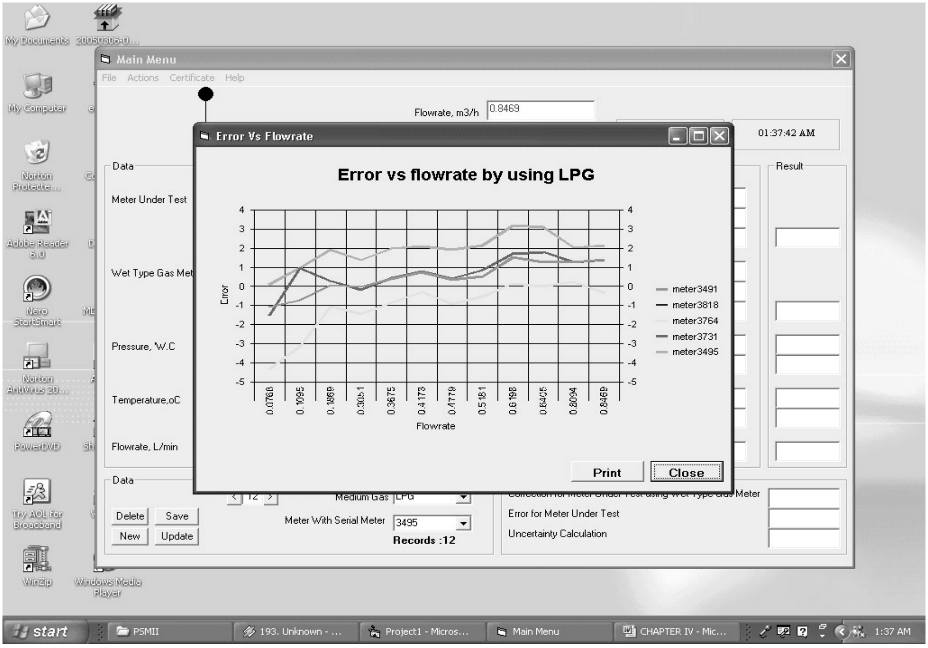

Figure 4.8 Plot of error against flow rate for 5 set of gas meters using LPG

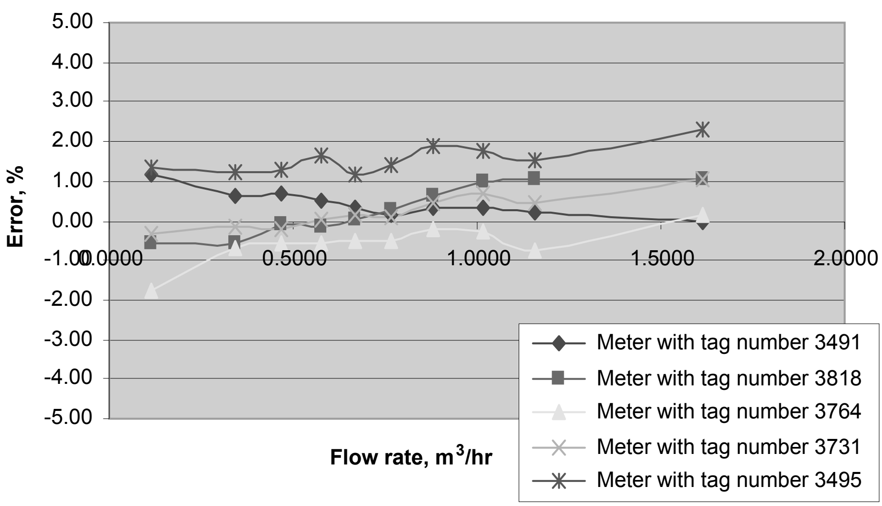

Figure 4.9 Plot of error against flow rate for 5 set of new gas meters using Nitrogen

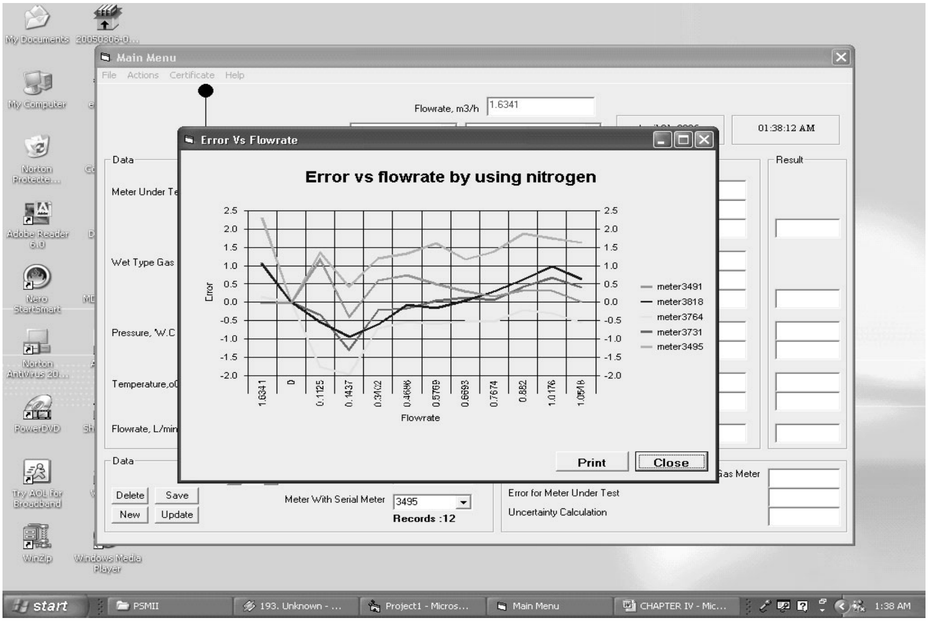

Figure 4.10 Plot of error against flow rate for 5 set of gas meters using Nitrogen

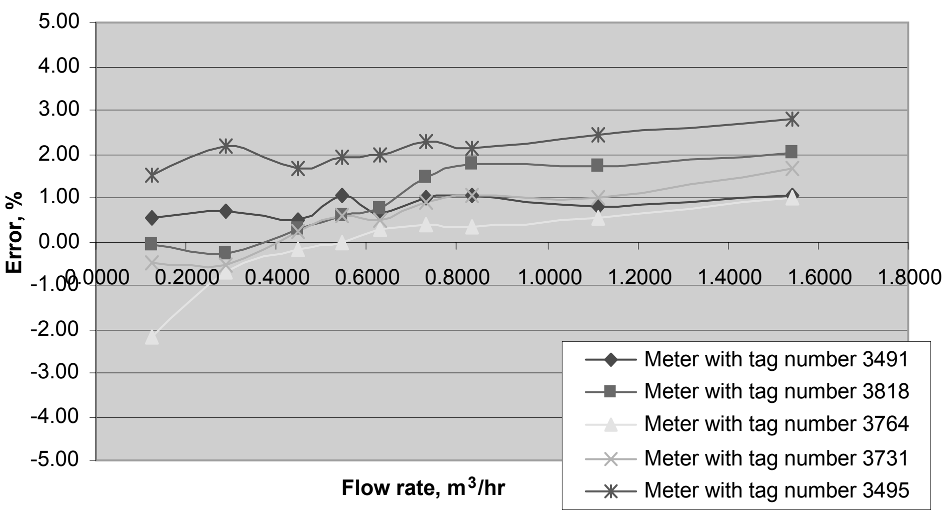

Figure 4.11 Plot of error against flow rate for 5 set of gas meters using compressed air

4.3 Uncertainty of Meter

Uncertainty is properly used to refer to the quality of the measurement and correctly refer to an instrument reading having an uncertainty of ±1 %, provided define under what circumstances is valid. From Figures 4.13 to 4.15 clearly shown that the new

Figure 4.12 Plot of error against flow rate for 5 set of gas meters using compressed air with Visual Basic

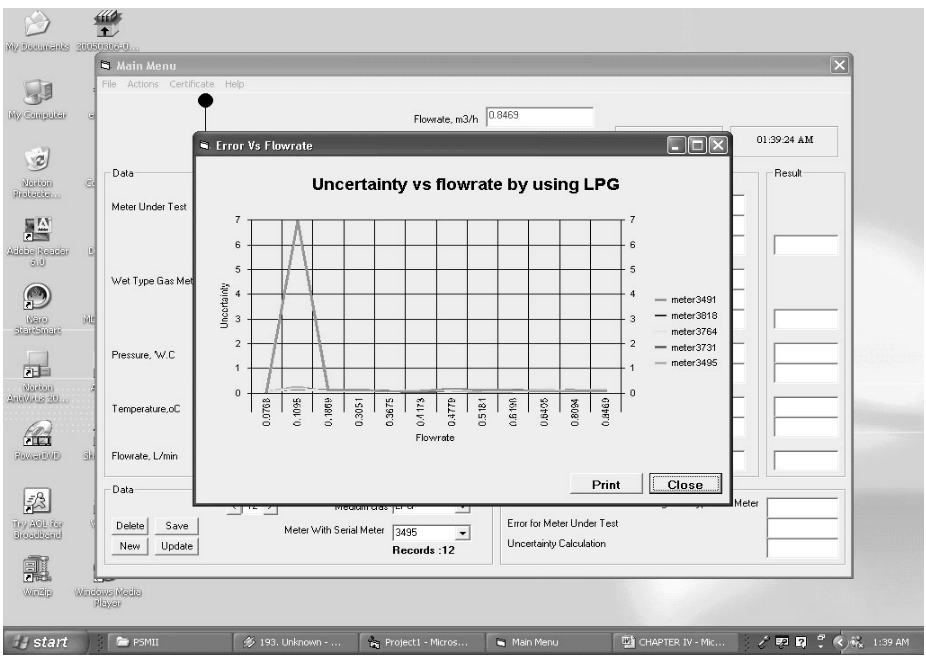

Figure 4.13 Plot of uncertainty against 5 set of new gas meters for different flowrate using LPG

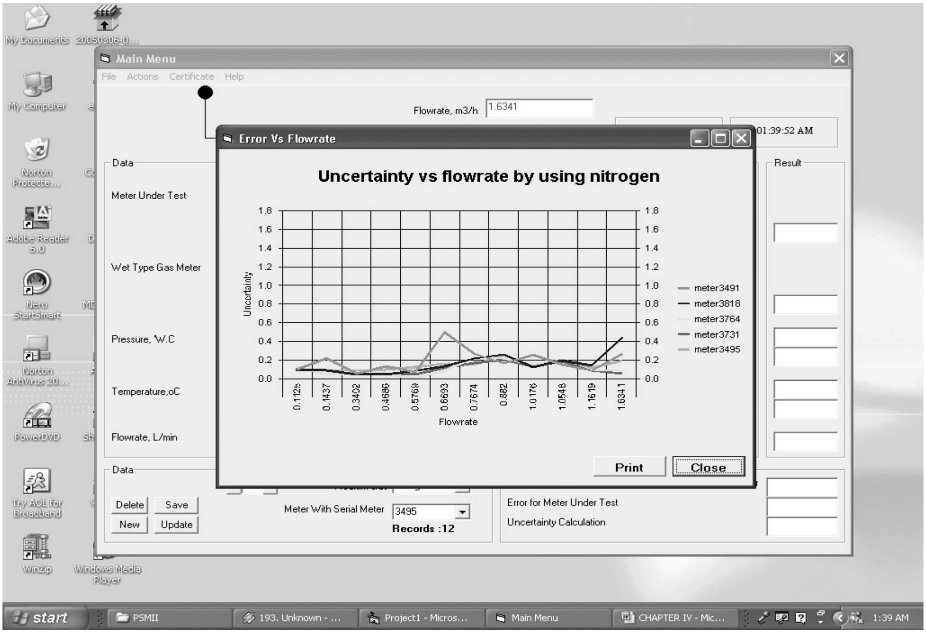

Figure 4.14 Plot of uncertainty against 5 set of new gas meters for different flowrate using Nitrogen

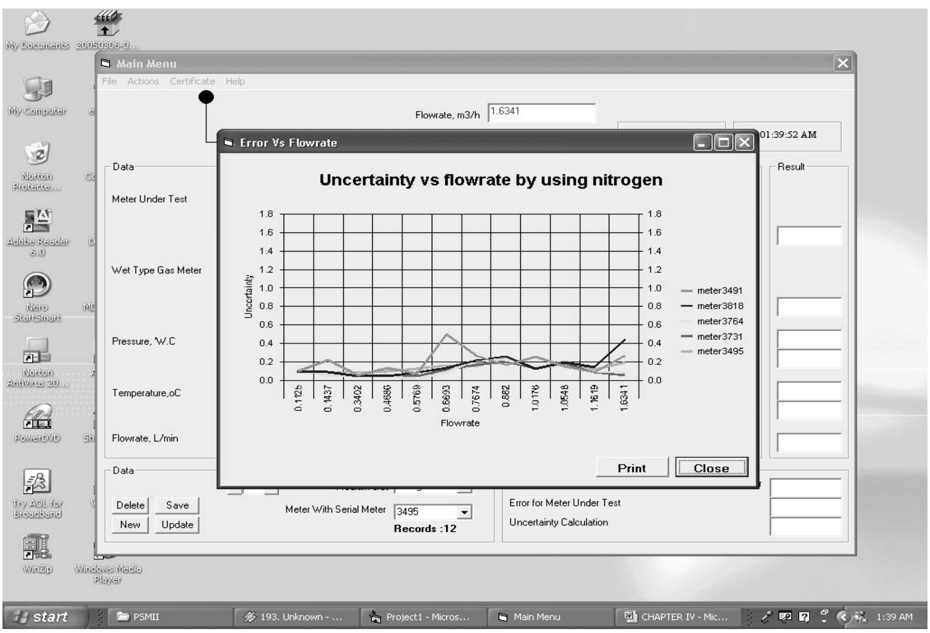

Figure 4.15 Plot of uncertainty against 5 set of new and used gas meter for different flow rate using compressed air

meter supported good arrangement with our reference and previous discussion on this work and Visual Basic also slightly different for certain meter because of mismatch algorithm.

5.0 CONCLUSION

The program developed is applicable to automate part of calibration calculation and documentation of the development of calibration system for domestic gas meter. In overall, the project has reached its objective to build a program that runs the system using Visual Basic 6.0. Performance tests include pressure drop for calibration bench, flow rate analysis, and certainty of meters. The bench has shown its operability and capable to handling different type of gas meter and can be used to calibrate 5 sets of diaphragm gas meter simultaneously. However, the bench had its flow rate limitation only up to 1.2 m^3/hr. From the discussion, pressure drop increases with the increasing of velocity of the test fluid.

As flow rate increase, error increases gradually until reach a maximum value. By increasing viscosity of gas, the molecular weight of its component will also increase due to different characteristic between LPG, nitrogen and compressed air. The simulation here applied from an English proverb, that prevention is better than cure' and it is hoped that the model that was built will provide benefit to all users. This system can also be used as a reference for laboratory study scale and can be used to preventive action when the domestic gas meter is not properly function. Finally, the experimental proves from the research has significant usage to promote domestic metering calibration technology and local capability.

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