Reasons of Domestic Gas Meter Failures

N.Nehzat\textsuperscript{1}, E.Soltani\textsuperscript{2}, A.R.Fadaei\textsuperscript{3} and R.Biriya\textsuperscript{4}

Department of Mechanical Engineering
Isfahan University of Technology, Isfahan, Iran
E-mail: nnehzat@cc.iut.ac.ir

Abstract
Diaphragm gas meter is one of the important and most valuable pieces of equipment used in gas supplies. One of the problems facing today’s customers, is the numerous failure and replacement with a new meter before finishing its lifetime. In this study, 274 faulty diaphragm gas meters are selected randomly as sample. After tracing the reasons of causing these faults, faults are classified in 4 main groups with special code that defines the type of fault. Based on the results for reducing the failures some recommendations are made.

Keyword: Distribution gas, Diaphragm gas meter, Gas flow equipment, flow meter

Introduction
Displacement or by inference. Meters, which use the positive displacement principle, are of the diaphragm and rotary types, while gas volume is inferred through either orifice meters or turbine meters.

With today’s tighter economic conditions in the production industry, gas sales may be the factor keeping some producers profitable, and the gas meter is his cash register. Accurate measurement not only provides economic paybacks, but it is also an invaluable aide in trouble shooting measurement disputes and production problem. Several types of metering devices are available and diaphragm meter will be discussed in this study. [2]

One of the problems facing today’s users and companies is the numerous failure diaphragm gas meters that causes rejection from the gas distribution line.

In this study, 274 diaphragm gas meters are selected and inspections based on these samples are made. After testing the meters which causes loses the results show most failures are due to index counter, leakage, assembly, part material. All samples classified in 4 main groups that each defines a special fault. In order to prevent this problem, some recommendations are made that would help the companies involved in the manufacturing of these devices.

2 Meter selection
The most important factor for good measurement is the selection of the proper gas meter. Meters cover flow rates from a few cubic feet per hour to over ten million cubic feet per hour. Most meters are designed for a limited pressure range. When selecting the proper meter a few guide lines must be followed.

Meters are priced by maximum capacity and pressure rating. The higher the capacity or the pressure, the higher the price. The least expensive is not always the most economical. The meter selected must do a good job for a long period of time. Good measurement is the backbone of the industry and there is no such thing as a maintenance free meter.

Deciding which type of meter is the best choice for a particular application depends upon the following:
1) The pressure of the gas being measured
2) The maximum flow rate to be measured
3) The minimum flow rate to be measured

2.1 Maximum flow rate
Capacity ratings for the various types of meter overlap as shown in the Figure1.

However, considering line pressures of 0.25 psig, the flowing meter choices are typical: 

\textsuperscript{1}-Assistant Professor, Department of Mechanical Engineering, IUT, Iran
\textsuperscript{2}-Mechanical Engineering Group, Islamic Azad University of Najafabad Branch
\textsuperscript{3}-Assistant Professor, Department of Mechanical Engineering, IUT, Iran
\textsuperscript{4}-Iranian National Gas Company, Isfahan
A) Diaphragm meter (max. flow rates of 10000 SCFH or less)
B) Rotary meter (max. flow rates of 1500-15000 SCFH)
C) Turbine meter (max. flow rates of 1000 SCFH and above)

2.2 Gas pressure
Diaphragm meters have pressure ratings up to 100 psig. Rotary meters can operate at pressures up to 285 and above select a turbine meter. [3]

3 Diaphragm gas meter
The diaphragm meter is the oldest positive displacement device used by the industry. Diaphragm meters are positive displacement devices that have fixed volume measurement compartments formed by a tow-sided convoluted diaphragm. The twin chambers are each fitted with a flexible and gas-tight diaphragm which moves by the differential inlet and outlet pressure. A small pressure drop across the meter causes it to cycle so these compartments alternately fill with gas at the inlet, and then empty at the outlet. By counting of cycles, the meter provides a measure of gas volume. [4] The main advantage of this type of meter would be its excellent range ability. It can provide accurate measurement down to 1/200th of its rated maximum capacity. If the producing well has a wide varying production rate, the diaphragm meter may be a logical selection. The diaphragm meter has remained basically unchanged in operation. Only the materials of construction have been updated to keep pace with technology. [1] All diaphragm gas meters have a case and a measuring nodule is inserted into the casing to form a complete unit. In the more advance form of these gas meters, there is a magnetic coupling that transmits the meter movement to the index counter which reduces gas leakages. [3]

4 Typical Equipment to measure, control and manage
Figure 2 illustrates the basic elements of a gas meter installation with the associated equipment normally included.[3]
1) Filters remove particulate such as pipe scale, which could impair the operation or accuracy of regulators, meters or gas burning equipment.
2) An upstream pressure regulator reduces line pressure and provides a stable pressure to the meter.
3) The meter itself could be used to monitor the gas usage of an entire plant or a single piece of equipment.
4) An electronic flow computer, or correcting device, can be used to correct for variations in pressure and/or temperature.

5) A downstream regulator further reduces gas pressure as required by a specific of equipment.

5 Main study
5.1 Procedures
Today, there are many companies that produce the diaphragm meter such as AMERICAN METER, ELSTER, ACTARIS, EQUIMETER, SCHLUMBERGER. There are two main Iranian companies (G.N.I.G and G.S.C) that produce diaphragm gas meter in different types located in Tehran and Najafabad.

5.2 Sample selection
Selected meter have flow rate below 16 feet per hour which are mostly used for domestic purposes and for this study 274 gas meter made by the Iranian companies are selected randomly according to the following table.

5.3 Inspection of samples
All meters are inspected according to the following steps:[4]
1) External leakage
2) Operation condition
3) Internal nodule inspection

5.4 Faults classification
Most faults depended on one of the following causes:
1) Index counter fault
2) Faults in magnetic coupling
3) Faults due to assembly and material
4) External leakage
After testing the samples according to the BS EN1359(1999) for diaphragm gas meter, each of samples were put in special group that has an error code and this title define fault and cause of failure. Error codes classifies the samples as following:
1) Error code 1: This code defines when the gas flows through the gas meter, but the numerator does not indicated due to numerator failure.
2) Error code 2: This code defines when the gas flows through the gas meter but the numerator does not indicated due to coupling failure.
3) Error code 3: This fault causes noise for the meter. Index counter moves with some difficulties which depend on the material used, manufacturing and assembly method.
4) Error code 4: External gas leakage due to sealing parts.
Result of inspections are shown in figure 3.
6 Discussion of the results
1) This study show that index failure (code 1) is one of the main causes, shown by figure 4. Inspections indicated that these failures are due to material and structural integrity.
2) Graph shows that a high percentages of the failures are related to code number 2. This failure is mainly due to the foreign materials present in the gas supply such as crud oil, pipe scale and etc.
3) Figure 3 shows that design, use of material, assembly and manufacturing methods have significant role in the soundness of the gas meters.
4) Gas leakage is causing error code 4. These are due to manufacturing methods used for inlet and outlet of the gas meter, sealing the case halves and installation of the gas meter.

7 Recommendation
7.1 Meter protector devices
1) Use a positive shot off drip on the inlet side of the meter, stopping crude oil or brine contamination.
2) Use an inlet strainer to prevent pipe scale or frac sand damage such as wear out the bushings and valves of diaphragm meters.
3) All meters should have a pressure relief valve.

7.2 Part material
1) Use of high impact engineering materials such as UV stabilized clear Polycarbonate for index box reduce tampering and vandalism.
2) Use of Nylon guides can minimize friction.
3) Use of Teflon-faced Bakelite valves will minimize friction.
4) Specially treated synthetic materials is a benefit for diaphragm and would give higher life to diaphragm gas meters.
5) Use of oil impregnated powdered metal bushing and bearings at all potential wear points and the use of powdered metal timing gears for maintaining the relationship between the valves, are instrumental in keeping friction to a minimum and assuring a smooth glide for the Bakelite valves.
6) The top case and central bodies can died with aluminum-alloy and treated the surface with epoxy resin, Polyester powder and plastic coating helps the meters to last longer with less noise.

7.3 Meter instruments
1) Electronic correcting instrument can be equipped to provide intrinsically safe pulse output for remote reading.
2) An electronic flow computer or correcting device can be used to correct for variation in pressure and/or temperature.

8 Acknowledgments
The authors are expressing their gratitude to the Iranian Gas company for (Isfahan branch) conducting this research and any other individuals and companies that are involved in this project.

9 References
Table 1: Number of selected meter as samples.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iranian Manufacturers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G.N.I.C</td>
<td>----</td>
<td>----</td>
<td>50</td>
<td>30</td>
<td>----</td>
</tr>
<tr>
<td>G.S.C</td>
<td>50</td>
<td>50</td>
<td>----</td>
<td>50</td>
<td>44</td>
</tr>
</tbody>
</table>

MAXIMUM GAS FLOW TO BE MEASURED-STANDARD (scfh).

**Figure 1:** Capacity ratings for the various type of meter

**Figure 2:** Basic elements of gas meter installation
(a) Failure causes for type G6(G.N.I.G)  

(b) Failure causes for type G4B(G.S.C)  

(c) Failure causes for type G10(G.S.C)  

(d) Failure causes for type G4(G.N.I.G)  

(e) Failure causes for type G4A(G.S.C)  

(f) Failure causes for type G6(G.S.C)  

Figure 3: results of the samples.
Figure 4: Comparison chart