

Frauds in the Measurement of Natural Gas

Kazuto Kawakita, Rui Gomez Teixeira de Almeida
IPT-Instituto de Pesquisas Tecnológicas
Av. Prof. Almeida Prado 532
05508-901 São Paulo / SP BRAZIL
Phone: 55 (11) 3767.4756 - E-mail: kawakita@ipt.br, ruigta@ipt.br

Abstract: With the growing consumption of natural gas that has occurred in recent years, Brazil has also seen a great increase in the number of cases involving frauds in the measurement of this product, specifically concentrated at points where the gas companies distributes the product to the CNG stations. Such cases goes from a simple theft of gas from the pipeline using a by-pass to the meter, until a series of ingenious types of direct interventions on the gas metering system. Some of the fraudulently actions are being made even without the violation of the metrological physical sealing. Similar to the gas meters, the electronic gas volume converters are being defrauded. Besides the legal, economic and tributary issues, this problem impacts on the gas market because it may jeopardise the relationship between gas consumers and gas suppliers creating a confidence crisis, affecting all gas market and even delaying investments from gas companies. This article presents some of the frauds identified and shows some of the measures taken by the gas companies to remedy these problems, similarly to a cat-and-mouse game.

Keywords: frauds on natural gas metering, legal metrology, gas meter, natural gas

1. Introduction

According to the directives of Legal Metrology and OIML recommendations ^[1, 2, 3], after the initial verification and after any periodic verification a gas meter should be sealed in order to protect it against interferences likely to affect its measurement accuracy. In fact, this recommendation is very important since frauds on gas meters and on metering systems degrade the reliability of the measurement process, generate suspicious in the market and jeopardise the relationship between gas consumers and gas suppliers creating a confidence crisis affecting all gas industry and even delaying investments from gas companies.

For years IPT has been requested to inspect, exam and test gas meters and measurement systems in the calibration laboratories of its Flow Metrology Centre in order to identify the causes of differences between measurement results obtained by the gas deliverers and the gas receivers. The conclusions of such technical analysis usually point out to problems related to the metering system, measurement procedures, parameters configuration or equipment fails. In all these cases, it has been fairly unusual to evidence a dishonest behaviour of any of the parts involved.

Nevertheless, during the last years, the number of occurrences to be analyzed has increased many times, particularly regarding the gas distributed by the gas companies to the CNG (compressed natural gas) stations responsible for refuelling natural gas vehicles, a market share that has increased a lot in Brazil in the last years. In most of the cases analyzed, conclusions indicated that frauds had been made on the measurement system of the gas distributor.

These cases goes from a simple theft of gas from the gas company pipeline using a by-pass to the meter, until a series of types of direct interventions on the gas meters to make them totalise less

gas than it is being transferred or even creative gadgets to stop registering the gas for a period. Some of the fraudulent actions are being made even without the violation of the metrological sealing. In the same way of the gas meters, the gas volume converters are being defrauded.

In this paper it is shown several real cases of frauds detected in gas metering systems based on rotary gas meters and is discussed some of the solutions applied to try to minimise these actions and also to prevent the spreading of these practices to the rest of the market. Such information is really important to the gas companies, gas consumers and legal metrology entities and especially to the gas meter manufacturers.

2. Typical natural gas measurement system

Different types of gas meters and metering systems are used in the Brazilian natural gas industry. However, in the case of the measurement of the natural gas supplied to the CNG stations, due to some specific characteristics of the operating process, the gas distributor uses a system based on a rotary positive displacement meter assembled in a skid with a filter and a set of valves associated to a volume converter connected to temperature and pressure sensors. Figure 1 shows a picture of a typical gas measurement system with a rotary meter and identifies its main components.



Fig. 1 A gas measurement system

The rotary meter is based on a rotary positive displacement metering principle in which a fixed volume of gas is imprisoned upstream and released downstream at each complete revolution of the rotors and this is defined as the cyclic volume of the meter.

This movement enters a gear train that reduces its velocity, and is transmitted to the outside part of the meter case through a magnetic coupling to minimize the risks of gas leakage. In the outside of the meter case a totalizer is connected to the transmission shaft that registers the total amount of gas that passed through the meter.

In Brazil, a specific INMETRO Regulation ^[4] establishes the minimum conditions to which a rotary meter must comply with when used in gas measurements.

3. Cases of frauds in the meter

3.1 Gears changing

During a routine inspection in a measurement system installed in a skid for natural gas supply to a CNG station, it was decided to replace the gas meter for a recently calibrated one. The replaced meter was sent by the gas company to IPT laboratory for recalibration.

Analyzing the results obtained in the calibration, it was noticed that the indication error was of approximately -10 % in all calibrated flow range. The result was considered very unusual considering this type of meter. According to the practical experience it is known that if a gas meter presents an operating problem, it usually presents variable errors in different flow rates and particularly this error tends to be more negative in the lower operating range.

Due to this strange behaviour, after excluding some hypothesis, such as possible problems in the gaps or in the volumetric chambers of the meter, it was decided to open the meter and verify the transmission system.

Examining the gear train and comparing it with one from a new meter of the same manufacturer and model, it was detected that the meter pinion had only 17 teeth. In the original meter, the same gear has 19 teeth. Figure 2 shows the gear train and the pinion location.

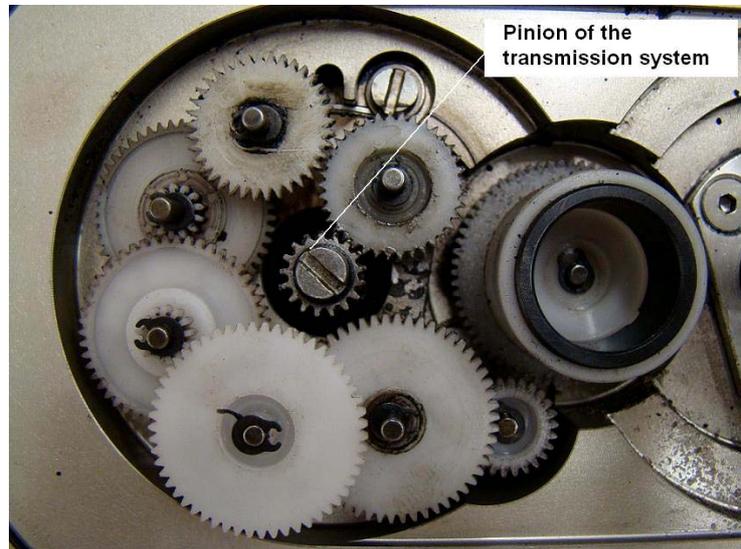


Fig. 2 Gear train and the pinion of the transmission system

Just to certify that this was the only factor of the detected problem, the 17 teeth pinion was replaced by an original 19 teeth pinion and the meter was calibrated again. The results were very good with a typical error curve close to zero. Figure 3 shows the calibration results of the gas meter using both pinions for comparison.

Several other similar cases were found with the same kind of fraud using different gears and, some times, a combination of different gears. In these cases, the mean errors detected varied from -5 % to -45 %.

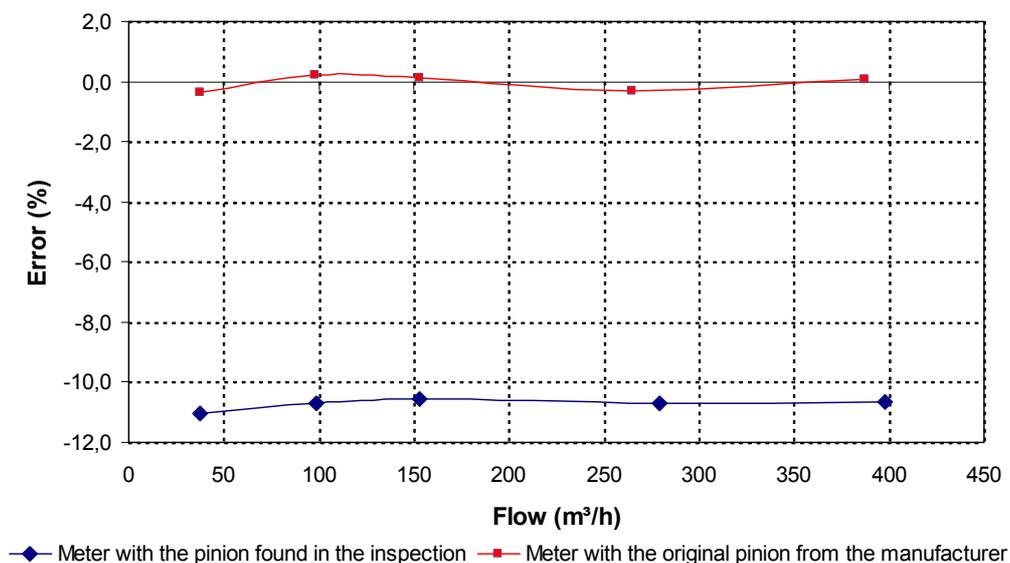


Fig. 3 Calibration results for one and the other pinion

3.2 Stopping the totalizer

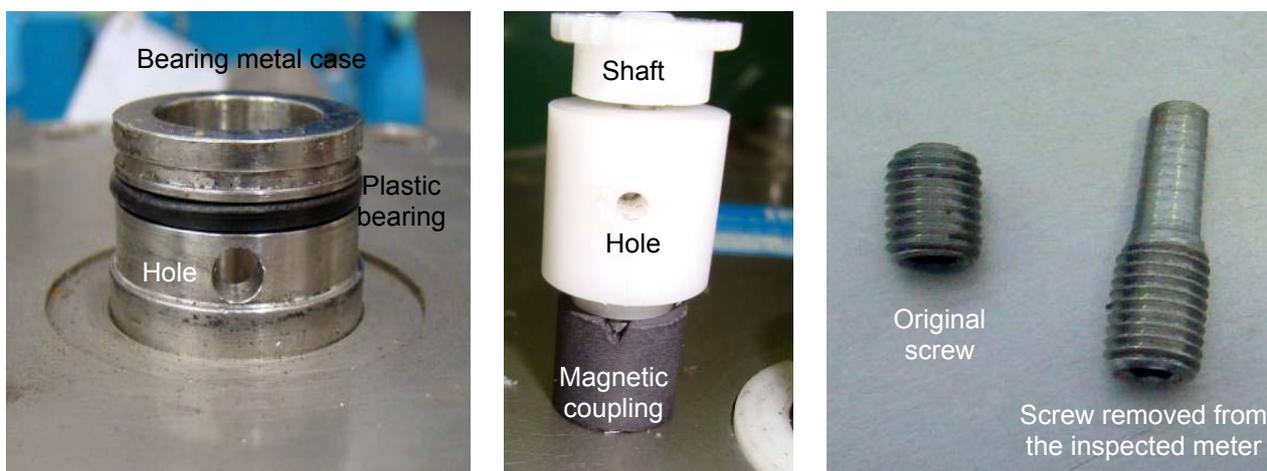
In another case, IPT was asked by a gas company to examine a gas station in which the monthly gas bill had dropped sharply in the last year with no apparent reason. A technical inspection was carried out in the metering system and, at first, no particular problem was detected. So, the gas meter and the volume converter were removed and sent to the laboratory for a more thorough inspection.

The flow calibration results for the gas meter and the calibrations, tests and configuration checking performed on the volume converter did not show any anomaly. Then, it was decided to open the meter in order to exam the internal parts of it.

In the inspection it was detected a small machined hole that was made in the outside of the bearing metal case and in the plastic bearing were the shaft (that drives the movement for the totalizer) and the magnetic coupling are installed. These internal holes were aligned with each other and with a thread hole that is part of the meter original project. This hole, in the original meter, is where a small screw is attached to make pressure on the metal case to prevent the totalizer body to rotate, once it is set in a fixed position. Removing this screw and forcing a toll into the holes it is possible to reach the transmission shaft. Then, by applying a small force in the toll, it is possible to avoid the shaft from turning because, as the coupling is magnetic, it does not transmit much torque and the shaft stops moving without breaking any part of the meter. Removing the tool and passing gas, the meter returns to work normally.

In other fraud cases identified based on the same principle it was found a screw that had identical characteristics of the original screw in the end part that appears to the outside of the meter. However, it had a needle in the other extremity and when the screw is completely squeezed, it makes contact with the shaft and the totalizer stops moving. On the other hand, if you release the screw a little bit, the totalizer returns to operate normally.

Figure 4 presents a set of pictures of the modified parts separately and also of the pieces assembled.



a) Bearing metal case and hole

b) Plastic bearing with the hole, shaft and magnetic coupling

c) Original screw



d) Place in the bottom of the totalizer where the screw is fixed

e) The pieces to be assembled

f) The all set assembled

Fig. 4 A set of pictures of the modified parts separately and the of the pieces mounted

Variations of the same type of fraud, based on the mechanical locking of the meter shaft, were found afterwards in other models of meters from different manufacturers.

3.3 Damaging the internal parts of the meter

In another case analyzed, it was observed what appeared to be an abnormal wear of the meter rotors especially for a metering skid with a filter installed upstream of the gas meter. Analyzing the damaged rotors, steel filings were detected inside the meter housing and that did not look like coming from the tubes.

In this case the gas meter operates with a considerable internal gas leakage between the rotors and the housing and the measurement error is quite negative. However, after some time operating under such conditions, the rotors are damaged so sorely that they just stop turning, forcing the gas company to replace the meter. In such cases, however, it has not been possible yet to clearly identify an intentional fraudulent action on the meter.

4. Cases of fraud in the measurement system

4.1 By pass

By passing the gas meter is a very obvious way of performing a fraud over the gas company. However, in fact, that is not so easy to conduct the fraud since it usually involves digging holes on the ground and welding tubes and connections, usually in a pressurized pipe. This procedure takes some time to be carried out and the action is not so easy to hide while it is being done. During the last years, several occurrences and suspicions cases of this type have been reported. In one confirmed case, the CNG station owner had installed a deviation in the gas line, in a place where the pipe is still underground, by passing the measurement system and supplying directly the compressor with a stolen gas. In an underground part of the by pass a pilot operated valve had been assembled for convenience and it was operated directly from the manager's office.

4.2 Returning the meter totalizer

This is a recently discovered type of fraud. The gas customer knows exactly the date when a reading of the gas meter totalizer will be carried out by the gas company. Some days before that,

the gas meter is removed from the metering skid and, probably, air is injected in the meter in the opposite direction making the totalizer to unregister the gas that had passed through the meter. This is done up to a certain value, just a little higher than the last meter reading made by the gas company. The electronic volume converter is shut off from all internal and external energy sources, to reset the history and the event log, and then powered on again. Then, an external pulse generator is connected to the volume converter inlet, feeding it until the uncorrected volume matches the same volume set in the meter. Then, the system is reassembled in the metering skid. During the next reading, gas company can identify that there occurred some problem in the volume converter but, usually, raise no suspicion concerning the uncorrected gas volume.

5. Discussion

Frauds involving changing the gears of the meter can be difficult to be detected only by an analysis of the consumption data, mainly if the difference is set in a lower value, for instance minus 10 %. That also can be hard to be detected in inspections or calibrations since the fraud can be undone when the defrauder receives a notification from the gas company advising him that there will be an inspection or a maintenance service in the metering station, since such a procedure is required according to the Brazilian regulations.

The fraud described in item 3.2 can also be difficult to detect based just on a consumption data analysis. It can be detected only by means of a careful inspection of the internal parts of the meter. So, the meter can go through a laboratory calibration and even a basic maintenance involving cleaning and adjusting and the fraud may still remain undetected. Another problem is that this fraud can be carried out even without breaking the meter seals and does not need to stop the gas supply and the risks are smaller than the previous one. However, once made, the fraud can not be undone.

Damaging the internal parts of the meter is dangerous and the results are uncertain because there is a possibility that it does not work properly and the gas supply may be interrupted. Moreover, it can only work for a small period of time, until the gas company discovers it and replace the meter, and if the fraud is made several times it will certainly become suspicious.

When the meter is by passed the fraud becomes very difficult to be detected and it can be used for a long period of time. However, this fraud can not be easily undone without leaving any evidence. It can be detected by means of an internal inspection of the pipe using proper cameras.

Decrementing the meter totalizer also requires the access to the system and breaking the physical sealing of the volume converter. But, it is not necessary to break the meter seals. Though a type of fraud that can be done some times, it can also rise suspicious if it is repeated.

To prevent the occurrence of such frauds, a series of actions have been taken by the gas companies:

- More care is being taken in the sealing process of the meter and the metering system. In some cases it was found that there was a lack of seals in certain points (that should be sealed) or a badly sealing process had made easier the access to the meter. After these analyses the process of sealing was improved and even some other sealing points were added.

- A special lockable metallic case to protect the meter and the volume converter and another hard plastic casing attached to the meter was developed to make it harder to access these equipment and to make it easier to observe any external drilling that could be made in them.
- During the inspections of some suspicious installations a special camera is being used to observe the internal parts of the pipes.
- Some inspections have been made with the public prosecutors and therefore in that cases, with no previous warning to the CNG station operator.
- More frequent and careful inspections are being carried out on the metering systems.
- Some of the old metering systems have a by pass that was installed to permit maintenance services in the meter without stopping the gas supply. Despite of the fact that no evidence was found that this was used for any fraud, in the new installations this by pass does not exist any more and in the old ones it is gradually being removed.

After taking these actions, the number of fraud cases has fallen drastically. But, even so, more measures are being taken to minimize the problems and to be mindful to new forms of fraud to prevent that this behaviour can spread and contaminate the gas market.

6. Conclusion

According to OIML, legal metrology comprises all activities for which legal requirements are prescribed on measurement, units of measurement, measuring instruments and methods of measurement, these activities being performed by or on behalf of governmental authorities, in order to ensure an appropriate level of credibility of measurement results in the national regulatory environment. It applies not only to trading parties, but also to the protection of individuals and society as a whole.

Based on this statement, this paper presented a variety of ingenious actions promoted by a small part of the CNG market on meters and metering systems to intentionally get some financial advantage in the gas trade. Similarly to a cat-and-mouse game, the remediation of this type of problem requires a technical and skillful investigation of the fraud so that countermeasures can be taken to ensure equity and fairness in the natural gas commerce.

References

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