

Water meters for smart cities

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ABSTRACT

Water metering technology used in municipal water distribution system has developed tremendously during the last decade. Different types of water meters have evolved in the market which serves the water utilities and consumers in many ways. The trend has reached from traditional mechanical meters to “smart” meters as water has become more and more precious. Many water utilities across the world are recognizing the global need for adopting new technologies to monitor and conserve water. Timely and accurate metering is essential for better accountability and thus improved revenue collection. Traditional monthly visit for meter reading, for billing, may not help in improving monitoring and water consumption control system. A prerequisite for such system is the monitoring of water consumption in sufficiently short intervals in real time. Automated Meter Reading (AMR) is one of the new technologies introduced for accurate measurement and eases the task of meter reading. Different forms of communication links are used as communication medium in AMR systems. Based on the budget and service territory one can choose the technology they need for AMR or AMI system. The time and expense of periodic trips to the meter location for meter reading is saved by the use of AMR. This paper provides information on Automated Meter Reading technologies, its merits and demerits, cost implication and feasibility for Indian water supply system. An analysis will reveal that it may not be worth investing in AMR for domestic meters purely for monthly billing purpose. AMR will be beneficial in bulk meters where close monitoring is required for better accountability of supply and consumption.

KEYWORDS - Automated Meter Reading, AMR, Water meter, Metering, bulk meters

INTRODUCTION

The unprecedented economic growth of India in the recent past has resulted in drastic increase in water demand. With growing demand and resource scarcity, challenges in water industry is also growing day by day. Now the time has come to improve the operational efficiency, data accuracy, integrity of distribution system and of course, conservation. Apart from data accuracy, timeliness also has become very important for close monitoring of water distribution. Water utilities uses methods that were developed several decades ago to take meter reading for billing purposes. Most of the utilities are employing manual meter reading which is time consuming and also more prone to human error. Many water meters are installed in locations where it is required to schedule the meter reading with the consent and convenience of the user. Manual meter reading being more person dependant, it is becoming expensive and also time consuming. One of the primary drivers for the automation of meter reading is not only to reduce labour costs, but also to obtain frequent and reliable data that is difficult to obtain.

Automated meter reading is the method of automatically collecting consumption, diagnostic, and status data from water meter and transferring that data to a central database for billing, troubleshooting, and analysis. The timely information coupled with analysis can help both utility providers and customers a better control on water consumption. AMR systems uses various technologies like low power radio signals, Network, GPRS based loggers and hardwired meters for different types of consumer locations.

In India, majority of the water supply system has been managed by water utilities under the government. State Water Supply and

Sewerage Boards were formed to improve the efficiency and to attract investment in this sector. Most of the water utilities in India have made several attempts to ensure quality of water meters in addition to cost reduction during the last two decades. This has resulted in the availability of several quality water meters at reasonable cost. Focus is shifted from cost of the meter to total cost of metering, which includes cost of meter, installation, maintenance, meter reading, data processing and billing. Any water utility should try to reduce the total cost for a particular period, which is the sum of all these costs. It is important to note that the cost of the meter and the installation cost are one time initial costs and the other costs are recurring in nature. Procurement of large quantity of meters requires comprehensive knowledge of available water meters. This includes technology, standards, types, tests, selection etc. and the buyers should adopt a proper quality assurance procedure. There is no standard or guideline available in India for quality assurance of water meters. Due to this reason several utilities have developed and tried different strategies. Some strategies have resulted in good results while some others failed miserably.

There are different types of water meters. In addition to mechanical water meters, meters based on electromagnetic, ultrasonic and fluidic oscillation principles are also available. In India, water meters up to 50mm are called Domestic type and meters above 50mm are called Bulk type. Based on the measuring mechanism, meters are generally classified as volumetric and velocity type. Volumetric type is not produced or used for water supply applications in India. However no adverse remarks are reported so far against volumetric type meters. Velocity type, which are also called as inferential type meters are further classified as single-jet and multi-jet in domestic type, and woltmann type in bulk type. Single jet and multi-jet meters consist of a turbine rotor rotating about the axis perpendicular to the flow whereas woltmann type meters consist of helical blade rotating about the axis of flow. In single-jet water meters water jet impinges at a single place on the periphery of the rotor and in multi-jet meters, water impinges at several points simultaneously. Due to this difference multi-jet meters are preferred at custody-transfer

locations in many developed countries. However, many water utilities have selected single jet meters and achieved satisfactory performance in India.

Irrespective of the above classifications, water meters are classified based on the flow rates of operation. Indian standards mention Class A and B only. Class O specified earlier in Indian standard has been removed in August 1999. Class C and Class D meters are also mentioned in international standard. However, they are not generally used in India. Successive letters indicate the capability of measuring lower flow rates. Class of water meter required by water utilities should be specified in the tender document. A study for assessing the amount of water passing to consumers at very low flow rate and its impact on revenue considering the water tariff and metering cost is essential for deciding a particular class.

QUALITY ASSURANCE OF WATER METERS

Several quality assurance methods are adopted by water utilities for selecting good quality water meters. However, the procedure followed by different utilities is found to be quite different and many procedures have resulted in some setbacks. In fact, there is no guideline in India, for right engineering practices for ensuring the quality of meters. Realizing the importance of accurate metering, several utilities have initiated programmes to improve this situation in a short span. This has resulted in huge investment towards bulk purchase of water meters of different sizes. It may be noted that accumulation of poor quality meters is resulted mainly due to lack of quality assurance practice in the past.

Many utilities have taken constructive steps to achieve efficient and cost effective metering. Usually, procurement of meters is carried out through tendering process and the tender document should convey the strategy adopted for meter selection and the specification of the meter. The meter specification shall be formulated purely based on the requirements of water utilities and shall be in such a way that maximum number of bidders can participate in the tender. Specifying insignificant requirements which are not appropriate for the application

will eliminate good quality meters and thus reduce competition.

The metrological and technical requirement of water meters and test methods are given in international and Indian standards. The international standard ISO 4064 and the Indian standard IS 779 are widely used by water utilities for preparing the meter specifications and the qualification criteria. ISO 4064 -1: 1993, ISO 4064-2:2001, ISO 4064-3:1999 are widely used by utilities even after revision of these standards in the year 2005 and 2014. IS 779: 1994 which is in line with ISO 4064-1: 1993, is also referred in many tenders in India for domestic meters. In ISO standards revised in 2005 and 2014, the critical flow rates are Q_1 , Q_2 , Q_3 and Q_4 compared to Q_{min} , Q_t , Q_n and Q_{max} in the older version and in Indian standards. According to IS 779 Q_{min} , Q_t , Q_n and Q_{max} for 15 mm Class B meters are 30 lph, 120 lph, 1500 lph and 3000 lph respectively. These flow rates are approximately equal Q_1 , Q_2 , Q_3 and Q_4 of 15 mm meter with Q_3/Q_1 ratio of 80. The error limits of water meters at various flow rates and a typical error curve is given in figure 1.

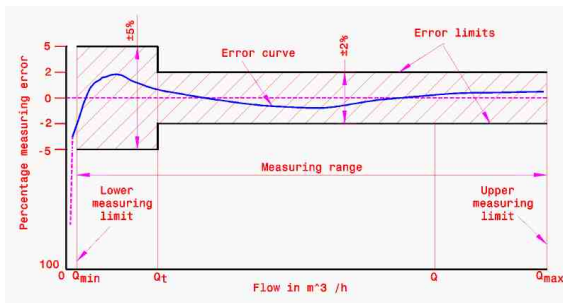


Figure 1. Characteristic curve of water meter.

• Testing of meters

Proper testing is the only way to evaluate the quality of meters. Endurance testing is generally considered as the minimum qualifying criteria for selection of the supplier. Endurance testing involves testing the meter at specific conditions over a significant period of time, to discover how the meter behaves under sustained use. This helps to assess the operational life span of the meter. It may be noted that the endurance tests are conducted on the samples provided by the manufacturer at their discretion. Even though these limited tests on the “Golden samples” do not reflect the quality of a particular brand, this

procedure is highly suitable for eliminating sub-standard brands.

• Lot acceptance test

Routine tests are usually conducted on sample meters selected at random from the lot supplied to ensure that the meters supplied are also of same quality similar to the meters submitted for endurance test during selection of supplier. During the supply of each lot of meters, samples are obtained by random sampling basis. The sampling plan for testing of meters for acceptance of lot can be based on the standard IS 4905: “Methods for random sampling”. This procedure is used commonly for lot acceptance test of any products. A summary of the sampling plan based on this procedure is mentioned in IS 779:1994.

Now a day's there is a tendency to choose less quantity of meters for testing, ie; 1 % of lot size or very few meters from the total number of meters purchased. This is a highly incorrect practice because there is no scientific basis for the acceptance criteria set for this kind of testing and a proper decision cannot be taken from the test results of the samples.

As far as the testing charges are concerned, for bulk purchases, the total testing charges comes only less than 1% of the meter cost when compared with the lot size. This is a meager amount when considering the importance of quality of meters being procured.

AUTOMATED WATER METERING SYSTEMS

Emerging technologies in metering can be adopted in suitable areas for improving the efficiency of water supply system and for conservation of water resource. Automated meter reading (AMR) and Advanced Metering Infrastructure (AMI) are the latest technologies which can be tried in bulk water meters for leakage detection, close monitoring of water usage, improved customer service by providing detailed billing and altogether conservation of water. Periodic reading of meters are essential for consumption based water rates. Except in remote or automated meter reading these readings are usually done by meter readers.

Typically, AMR systems are drive-by systems in which meters are read using laptops or handhelds capable of receiving a radio signal. AMI systems, on the other hand, tend to be fixed base systems where meters can be read centrally from the utility office.

- **Automated Meter Reading (AMR)**

AMR is a method in which metering data are automatically collected and transmitted to a central database for analysis and billing purposes. By using AMR, detailed water usage data can be obtained continuously at regular intervals and can be sent to the water utility's central management and billing system. Automated Meter Reading is one of the new technologies introduced to ease the task of meter reading. Different forms of communication links are used as communication medium in AMR systems. Based on the budget and service territory one can choose the technology they need for AMR system. Linking of a real time wireless communication network to digital water meters with a centralized management system is also available in AMR systems. Monitoring of hundreds of meters frequently or continuously and also leak detection and spot the location of leak is possible with this real time network system.

Various methods, ranging from a simple drive-by meter using a hand held unit to automatic communications with the water utility is available in AMR. The AMR Systems include information transmitted via GSM, RF (radio frequency) and/or GPRS and also M-BUS to stand alone computer system and/or hand held terminal.

- **Walk/drive By System**

The Walk/Drive By System uses radio frequency transmitters that are attached to each metering device that requires monitoring. The transmitter operates like a mini data-logger. The radio frequency transmitters continuously send information until the client walks or drives by the devices and collects the data. Mobile or "drive-by" meter reading is where a reading device is installed in a vehicle. The meter reader drives the vehicle while the reading device automatically collects the meter readings. Often for mobile meter reading the reading equipment includes navigational and mapping features provided by GPS and

mapping software. With mobile meter reading, the reader does not normally have to read the meters in any particular route order, but just drives the service area until all meters are read. As there is no need to site and install fixed network infrastructure devices such as repeaters or data concentrators, once deployed the system requires no maintenance. The benefits of walk by system are cost effective, no special skills required to install, allows for full submersion of meters.

- **Fixed Network AMR**

From an operational point of view, Fixed Network AMR can provide a true insight into a networks performance highlighting leakage, tampering, flow rate variations and backflow detection. In this a transmitter is installed in the water meter and this transmitter intelligently monitor, profile and log consumption and flow data of the consumer. Data is transmitted to the utility in periodic intervals, via various methods like Wi5, RF (Radio Frequency) and GPRS, for processing. GSM & GPRS transmitters are used to monitor the readings of a water meters with pulse output facility. The transmitter is connected to the pulse output of the water meter and readings can be obtained on pre programmed intervals. The water meter readings can be monitor via GSM to the mobile or GPRS to the computer.

Automatic meter reading provides increased performance in the data collection, eliminates reading errors and missing meter readings. Avoiding manual data entry or manual data transfer, a potential source of error, is eliminated. Constant access to real-time data and have meter readings available on request helps handling customer complaints. Costs for meter reading will be reduced and thereby total costs of operation. Reduced cost over the life time of the AMR system. With automatic meter reading utility bills can be made based on actual consumption and estimated bills are no longer necessary. With accurate utility invoices there is no need for estimates or adjusted billing. Demand reads can be done as part of the customer service and action can be taken quickly in abnormal situations and monitor demand and consumption closely.

- **Advanced Metering Infrastructure (AMI)**

Two-way communication between the meter and utility and between the meter and consumer is the main advantage of AMI over AMR technology. This means that in addition to providing readings, the meter can also receive instructions sent from the utility or consumer. Advanced metering infrastructure includes new communications networks and database systems that will modernize the supply system and provide important benefits to utilities and consumers. Two-way communications with meters allows companies to respond more quickly to potential problems and to communicate real-time prices. These price signals provide consumers with financial incentives to reduce their water usage.

The benefits of AMI are reduced meter reading costs and associated management and administrative support, increased meter reading accuracy, improved utility asset management, easier theft/tampering detection, and easier outage management. Customer benefits of AMI includes early detection of meter failures, billing accuracy improvements, faster service restoration, flexible billing cycles and creating customer usage profiles for targeting Efficiency / Demand Response programs.

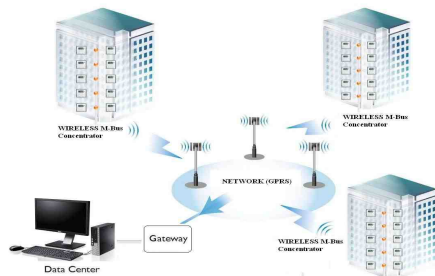


Figure 2. AMR/AMI system network

SELECTION OF TECHNOLOGY

Various options are available for the utilities to improve their performance. While going for advanced technology, the cost involved in its implementation increases. In Indian scenario cost implication is an important factor that has to be evaluated. Of course, the advantages of AMR and AMI, discussed above is beneficial for the utilities in way of reduced metering cost, leak detection,

improved billing, improved customer service etc., but the returns from the implementation and the cost of maintenance also need to be reviewed before selection of a new system. There are various categories of consumers like Domestic, Commercial (Business entities, Hotels, Industries etc.), Government bodies, Partly Commercial and Bulk Consumers. Even though the frequency of billing governs the cash flow of the water billing system, the quantity of water consumed is the important factor contributes to the revenue. The frequency of billing depends mainly on the type of system used. For non-metered system the billing could be quarterly and for the metered system the billing could be bi-monthly. But in both cases all non-domestic, Industrial, Bulk Consumers must be billed monthly.

Now the situation has come in which the cost of producing potable water has increased drastically so that it has become difficult to supply sufficient quantity of water even for domestic use. In most of the domestic water supply system in India, the water supply is intermittent. There are a few pilot projects of continuous supply, known as 24x7, in different parts of the countries. For establishing this, the water supply lines must be repaired to reduce leakages and good meters have to be installed to control water loss. Repairing and increasing the capacity of water distribution system infrastructure to switch to continuous supply is very expensive and likely out of reach for many utilities in the short term. In India continuous supply is the long-term vision for most utilities, intermittent supply is the reality of water access for millions of people around the world that has been in existence for decades and will continue to be for many more. Some researchers suggest that increasing scarcity of water from climate change and increasing demand may in fact make intermittent supply more common (Vairavamoorthy et al, 2008).

Theft and tampering of water meter is a major issue faced by many water utilities. Instances of even recently installed automated digital meters being stolen from housing societies have been reported in one of the metropolitan city of India. There are several cases where societies themselves had deliberately removed the water meter to hide actual water consumption. In such a situation AMR meters can help in detecting tampering of meters. But at the same time

the cost implication for installation and maintenance of AMR / AMR ready meters is an over burden for the utilities as well as to the users. The financial and other benefits expected out of implementing AMR/AMI in such environment needs to be reviewed by comparing with the cost involved in such systems.

When considering the life of water meters it is not worth installing AMR ready meters for future system upgradation, unless it is implemented in a couple of years. By installing AMR ready meters for future upgradation, the utility will be forced to buy other components like communication network, data acquisition system including software etc from the same manufacturer/supplier of the meter, which will make the system cost uncompetitive.

While going for a new technology like AMR, its feasibility for the utility and the revenue collecting from the users also need to be considered. In India the numbers of domestic water connections are very much higher than the bulk meter connections. However the revenue coming from the domestic users is very less compared to the huge investment required for AMR / AMI. As mentioned above, in most of the domestic connections the water supply is intermittent and the volume of water consumed also is less. Thus continuous monitoring of water usage in such a connection by using AMR / AMI is not worthy. There are water utilities in India which had gone back to cheap meters from AMR meters due to the difficulty in maintaining such meters in certain areas.

The chances of loss due to leakage are high where there is huge consumption. One of the places where maximum leakage occurs is in the distribution system. Pinpointing the location of leak, tampering detection, frequent meter reading or real time monitoring of water consumption is essential in preventing loss. The various advantages of AMR/AMI discussed above can be helpful in improving the efficiency of bulk water meters. AMR can be used in the bulk meters of supply mains of domestic water supply. A close monitoring of water supply in the supply mains can help the utility in better accountability of supply and consumption.

CONCLUSION

Water meters with automated meter reading system are used in many countries for speedy and error-free reading of meters. In India, automated meter reading is getting popular and more and more water utilities are adopting it, at least to a limited extent. These meters provide tremendous amount of valuable information about the consumer supply in addition to the reading for billing purpose. Utilities are expected to understand the advantages against the cost of implementation before adopting AMR technology. While going for large scale projects it is always better to go for any proven technologies rather than any new technology which is yet to be established. A pilot project can be undertaken for studying the cost implication and pros and cons of the new system. An analysis will reveal that it may not be worth investing in AMR for domestic meters purely for monthly billing purpose. AMR can be tried in bulk meters where close monitoring is required for better accountability of supply and consumption.

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