Trends in Evaluation of Energy meters at consumer premises - A Case Study

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Abstract. On-site testing of energy meters is a meteorological concern. IS: 15707 and CEA guidelines state that, accuracy of the meters needs to be verified periodically on-site in actual operating conditions. Testing of meters at site or at consumer premises is quite challenging task due to various technical and non-technical difficulties. Unawareness of consumer about intelligent built in electronic meter is main hurdle in testing meters at consumer premises. This paper highlights the trends in evaluation of energy meters at consumer premises and field experiences encountered during testing of meters at site.

Key words: Energy Meter, Reference Meter, Sensor, % error, Earthing, Common Neutral.

I. INTRODUCTION

Power Sector in India has made rapid stride during the last decade in the field of generation, transmission, distribution and utilization of electric Energy. 100% metering was aimed in APDRP phase1 and all electromechanical meters are to be replaced with electronic meters. Energy meter is the only instrument which measures and registers actual energy consumed by the consumer. Economical viability of utilities and in power sector is dependent on Energy Meters. Thus, it is utmost important to have very reliable and correct metering of energy consumed and energy meter is a cash box to the utilities.

As per Electricity regulation, it is mandatory to test all meters in service periodically. IS 15707:2006 Testing, Evaluation, Installation and Maintenance of ac Electricity Meters code of practice gives the periodicity of online meter testing. Also, testing of Energy Meter is required at consumer premises on receipt of consumers compliant [1]. Periodic testing of meters in-service also minimises the revenue loss of utilities [2]. Metrological testing and functional verifications shall be carried out on meters in service as per requirement of Indian standard IS 15707. Apart from testing meter on line, it can also be tested in laboratory but it is quite time consuming and not economical to disconnect large numbers of meters from the site and test in the laboratory. There are several issues encountered during testing of meters in service. Basically, failure of electronic energy meters and electromechanical energy meters in the field are of different nature. Electromechanical Energy Meters become slow over a period of time or fault is developed in the register counter of these meters. On the other hand, major fault in electronic meters is component failure.

Central Power Research Institute has established on-site testing of energy meters as per IS: 15707.

- Functions of Electronic Energy Meters

An electricity meter or a watthour meter measures the electrical energy passing through the meter. The functionality and performance of an electronic energy meters is superior to that of the normal electromechanical energy meter [3]. Electronic energy meters use microprocessor/microcontroller based technology to record various parameters and are capable of providing all the data needed by the consumers and utilities in a reliable manner. Large power consumers require better data to make energy management decisions and utilities need more data to improve their services. Programmable features of Electronic energy meters has enabled to record very complex but important technological, commercial and administrative details like active energy, reactive energy, maximum demand, billing periods, multi tariff billing, recording of tampering events with date and time and many other features [4].

II. ON-SITE TESTING AT CONSUMER PREMISES

Reliability of energy meters in service is ascertained by testing meter online at the premises of the consumer. The challenging task is to convince the consumer for online testing and then to satisfy them about the results. Testing of energy meters at consumer premises becomes necessary when there is an anomaly between the recorded and the consumed quantities of energy and the consumer complains about it. However, conducting these tests without interrupting the power supply to the customer and without disturbing the customer meter installation assumes more importance from various techno commercial aspects. It also helps indirectly to reduce the commercial losses and energy frauds. By checking the billing as well as meter it is possible to know the class of consumer like residential, commercial or industrial and identification of single phase or three phase meter.

In on-site testing with consumer load method, the reference standard meter is connected to the meter under test, i.e., voltage in parallel and current in series using a clamp ON CT. This is a quick and economic method, but it rely on the running consumer load. The objective of such testing is to check the connection and any existing tamper condition, and to get a fair idea of the accuracy of the installation.

III. METHODS OF TESTING AT SITE/CONSUMER PREMISES

There are three methods of testing at site/consumer premises:

1. Pulse-Output Method

2. Energy Comparison Method

3. By installing On-Line Check Meter

- PULSE OUTPUT METHOD

On-line testing is conducted on energy meters without disturbing the power supply to the consumer. In this case the meter is tested without braking or disconnecting the existing wiring. A clamp ON CTs are connected in the load circuit and voltage is tapped from the outgoing terminals of the meter. A sophisticated scanner properly located in front of the meteorology pulse LED to detect the light pulses and counts pulses from a scanner for a specified test time. After counting the set number of pulses, the counter typically stops the reference meter display and calculate the accuracy of the meter under test. Number of pulses produced by the LED per unit measured quantity varies from manufacturer to manufacturer. These pulses are re-converted into the digital pulses through scanner and fed to the digital pulse comparator which is an integral part of the error computation logic of the standard meter. The reference meter displays the percentage of meter under test.

- Step by step procedure to be followed for Pulse output method :

a) Brief the testing method to the consumer and take the consumer in to confidence.

b) Position the reference standard meter and make necessary input connections.

c) Connect current and voltage sensors of the standard meter in series and parallel with the consumer energy meter as stated above.

d) Position the optical scanner of the standard meter precisely to the pulse output LED of the consumer Meter.

e) The test setup is shown in Fig. 1.

f) If the prevailing load is too small, an additional load of at least 2kW shall be connected to minimize the testing time.

g) Set the meter constant (Number of pulses per kWh) in standard/reference meter according to the name plate details of the consumer meter.

h) Each meter is tested for a minimum consumption of 1 kWh and minimum time of 30 minutes to get the better results.

i) Start recording the power consumption, after completion of testing from the reference meter. Reference Standard Meter will directly display the % error of the meter under test.

j) Authorised utility representative is required for resealing the meter whenever meter seals are removed.

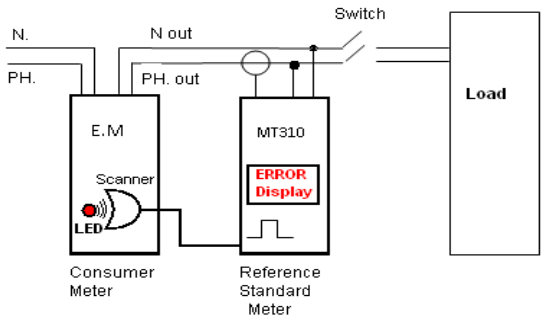

Fig. 1. Test setup showing connection diagram for verifying the accuracy of the meter.

- ENERGY COMPARISON METHOD

In this method a known amount of energy is supplied to meter under test. The percentage of meter under test is computed as

$$\% \text{ Error} = \frac{(\text{Actual Energy} - \text{Reference Energy})}{\text{Reference Energy}} \times 100$$

Step by step procedure to be followed for Energy comparison method :

a) Reference standard meter clamp ON CT's are connected in series with the load circuit and voltage is tapped from the outgoing terminals of the meter.

b) Known energy is drawn through meter under test by prevailing load of the consumer. If the prevailing load is too small during testing, additional load of at least 2kW is to be connected to minimize the testing time.

c) Initially switching off the complete load of the consumer and note down the initial kWh reading of the meter under test.

d) Switch on the prevailing load of the consumer till the known dosage period is completed as per the reference standard meter. After that immediately switching off the consumer load using main switch and note down the final kWh reading of the meter.

e) Calculate the % error of the meter using following formula.

$$\% \text{ Error} = \frac{(\text{Actual Energy} - \text{Reference Energy})}{\text{Reference Energy}} \times 100$$

- Advantages of Energy comparison method :

a) During the testing, it ensures the display of the meter is working properly or not.

b) Possible to ensure the tampering information of the meter.

c) Possible to verify the kWh of the meter is incremented or not.

d) This method is accurate compare to the pulse output method.

e) It is possible to verify the accuracy as well as display of the meter.

f) If the meter has more number of high resolutions, it will give accurate % error of the meter.

- BY INSTALLING ON LINE CHECK METER

a) In this method at least same or better accuracy class meter shall be installed in consumer premises in parallel along with the existing meter for at least six billing cycles.

b) Compare both the meter readings at each billing time and find out how much variation in the energy recording.

c) If the variation is more than the 1% there may be chance in the malfunctioning of meter reading or any abnormality in the meter.

d) This type of testing is costly compared to the other tests method because utility has to provide two meters for each consumer.

- METER TEST EQUIPMENT (MTE) :

The accuracy class of meter test equipment shall be as follows as per IS 15707.

Accuracy class of Meter Under Test	Accuracy Class of Meter Test Equipment
2.0S	0.3
1.0/1.0S	0.2
0.5S	0.1

The overall uncertainty of the test equipment as given in IS 15707: 2006 is reproduced below. All the test equipments shall be traceable to the national standards.

Sl. No.	Accuracy Class	Test points	Power factor	Max. Permissible error in %	Overall uncertainty of MTE in %
i	2.0	10%I_b to I_{Max}	1.0 and 0.5Lag	±3.0	±0.6
ii	1.0	10%I_b to I_{Max}	1.0 and 0.5Lag	±2.5	±0.4
iii	1.0S	5%I_b to I_{Max}	1.0 and 0.5Lag	±2.0	±0.3
iv	0.5	5%I_b to I_{Max}	1.0 and 0.5Lag	±1.0	±0.2

IV. ISSUES ENCOUNTERED DURING ON-SITE TESTING

- Advantages :-

a) No interruption of the power supply to the consumer during testing.

b) No need for dismantling or disconnection of the energy meter for testing.

c) Easy to detect the malfunctioning of the meter without disturbing the connections.

d) Easy to detect the tampering and theft information.

e) To detect load circuit problems easily.

f) Increase confidence level to the consumer about static meters.

- Difficulties faced:-

a) Requires additional safety precautions during the online testing. Voltage tapings must be taken at meter output terminal side, instead of that accessed by meter input terminal side that becomes a direct theft case.

b) Difficulty in accessing meter due to congested location at consumer site. For example Apartments, it is difficulty to identify the consumer wiring and main switch.

c) Testing requirement at different power factors requires carrying resistive and reactive loads.

d) Difficulty in accessing meter like meter installed more than six feet height.

e) Requires additional testing team to cater to the large number of meters installed in field.

f) Testing team visiting the consumer premises, it is observed that the consumer premises is locked and some times meter also replaced.

- Meter needs to be verified for the following-

a) Meter tampering can be identified easily by visiting the consumer premises..

b) Display of the meter and parameters are working properly or not that can be identified.

c) Meter LED is not blinking even though consumer utilizing the consumption.

d) Both LED and LCD of the meter is not working even though consumer utilizing their consumption.

e) Identification of Under voltage and Over voltage in meters.

f) Verification of seals and meter body and wiring.

V. ANALYSIS OF TEST DATA

Table below shows the statistics with positive and negative % error measured over 3 years. It is observed that, most of the meters reported % error are on positive side.

		No. of meters tested	
% ERROR (Negative)	Year-1	Year-2	Year-3
≤-0.5	38	45	60
≥-0.5&≤-1.0	16	8	5
≥-1.0&≤-1.5	2	3	8
≥-1.5&≤-2.0	2	2	3
≥-2.0&≤-2.5	1	1	1
≥-2.5	3	1	1
Total	62	60	78
% ERROR (Positive)	Year-1	Year-2	Year-3
≤0.5	210	303	340
≥0.5&≤1.0	246	269	300
≥1.0&≤1.5	118	80	95
≥1.5&≤2.0	45	41	38
≥2.0&≤2.5	12	13	16
≥2.5	27	47	30
Total	658	753	819

- ISSUES observed

The following issues were observed during on-site testing of electronic meters.

- Common problems

Most of the consumer face earthing problems. It is observed that, many consumer premises do not have earthing and poor earthing. Normally, consumers are not fully aware about the earthing. Further, the appliances connected may not have earthing provision. If the load does not return back to neutral of the meter, earthing indication on the meter will glow in case of single phase meter.

If the neutral of the single phase meters of different consumer connections are not isolated or if a common neutral is used as return from load of different consumers the meters do not record correctly energy consumption.

- Earthing problem

Indication of earth on meter indicates that the current in phase circuit and neutral circuit of the meter is not equal. In such case, check the current in the phase circuit as well as current in neutral circuit. If there is difference in the phase currents and the neutral current, it means that there is some leakage of current due to faulty wiring in the house of neutral connection. Energy/power calculation of energy meters does not get affected with earthing problem as energy measurement in electronic meters are based on logic of higher current. However, this will affect energy measurement of electromechanical meter.

- Common neutral problem

The most common problem observed during on-site testing in case of apartments/flats is the common neutral problem. This was also simulated in laboratory and effect of common neutral was analysed.

Fig. 2 shows the test setup used for simulating the common neutral problem. House 1 connected load of 8.297A (1.955Kw) and House 2 connected load of 4.412A (1.037Kw). House 1 neutral is connected to the House 2.

i) In the above case, the current drawn by two houses are different. House 1 current is more that House 2 current. Now due to difference of current and as the neutral is connected to each other, the current flowing in neutral will be shared between House 2 meter and House 1 meter will also record return current.

House 1 meter will record based on phase current of that meter. House 2 meter will record based on neutral current which is more than its actual load. This is because electronic meter records energy based on higher current either in phase or neutral.

ii) If load of House1 alone is connected and House 2 is not connected or load of House 2 is off. In this case, when the neutral of both meters are connected, both the meters will record same energy. One based on phase current and other based on neutral current.

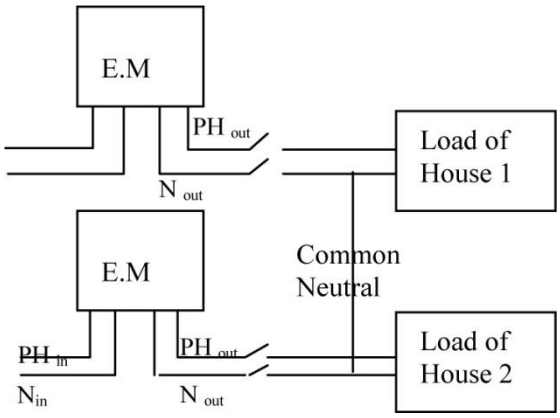

Fig. 2 Test setup for common neutral problem.6.0 Conclusion

The on-site testing assures that the measurement errors can be kept within the desired limits. On-line testing of static energy meters at consumer premises gives lot of benefits to utilities as well as to consumers. Indirectly it will reduce the commercial losses and energy thefts. Periodic testing of in service meters will ensure the correctness of energy recording and it also satisfies the regulatory requirement. Energy comparison method of meter testing is convenient and accurate in case of high resolution display meters. It gives the confidence to the consumer and the utility of energy recording. Experimental results relating its performance evaluation show that energy comparison method is suitable for the on-site testing of energy meters.

The suitable testing equipment with higher accuracy and clamp-on current sensors needs shall be used for online testing of meters in service. The supplied quality of meters at consumer end and meter quality verification is possible during this test.

REFERENCES

[1] IS:15707:2006"Testing,Evaluation,Installation and Maintence of ac Electricity Meters-Code of practice.

[2] J. Bandim, J. E. R. Alves, A.V. Pinto "Identification of Energy Theft and Tampered meters using a central observer meter: A Mathematical approach"2003 IEEE

[3] A.Ortiz, M. Lehtonem, M.Manana "Energy Meter behaviour under non-sinusoidal conditions"

[4] M. C. Ndinechi, O. A. Ogungbenro, K. C. Okafor "Digital Metering System: A Better Alternative for Electromechanical energy Meter in Nigeria" International Journal of Academic Research, Vol.3.No.5. September 2011,I part.