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A Method of Evaluating Operation of Electric Energy Meter

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Abstract: The existing electric energy meter rotation maintenance strategy regularly checks the electric energy meter and evaluates the state. It only considers the influence of time factors, neglects the influence of other factors, leads to the inaccuracy of the evaluation, and causes the waste of resources. In order to evaluate the running state of the electric energy meter in time, a method of the operation evaluation of the electric energy meter is proposed. The method is based on extracting the existing data acquisition system, marketing business system and metrology production scheduling platform that affect the state of energy meters, and classified into error stability, operational reliability, potential risks and other factors according to the influencing factors, based on the above basic test score, inspecting score, monitoring score, score of family defect detection. Then, according to the evaluation model according to the scoring, we evaluate electric energy meter operating state, and finally put forward the corresponding maintenance strategy of rotation.

1.Introduction

As one of the important assets in power measurement assets, smart electric energy meter is also in the process of being intelligent, systematic, modularized and diversified as the basic equipment for data collection of smart grid. There is a huge demand for energy meters in our country Faced with dual domestic and foreign customers, and involving economic accounting, product supervision and control more stringent, which on the reliability of the operation of the meter has a higher demand ^[1]. Now the implementation of the rotation meter overhaul is in accordance with regulations which setting energy meter for sampling rotation on a regular basis to ensure the reliability of long-running meter, which is bound to spend a lot of manpower and resources, and therefore for the smart meter running state assessment and overhaul rotation policy, becoming a problem to be solved ^[2-5].

The main content of this paper is to analyze the factors that affect the operation of electric energy meter. Combining with the data from multiple systems, the factors influencing the operation of electric energy meter are scored comprehensively. The operating states are determined according to different scores and the corresponding rotation maintenance strategies are formulated.

2.Meter state quantity selection

2.1 Selection Principles



At present, the state analysis of the electric energy meter relies on the single data obtained by the periodic sampling strategy, which can not monitor the full status of the electric energy meter.

There are many factors that affect the running status of the electric energy meter, including the manufacturing process, the on-site environmental factors, the original basic error factors, the operation time factors, the on-site abnormal factors, etc.^[6-9].

Based on the data of information system, such as electric information collection system, marketing business system, metrological production scheduling platform (MDS system), etc, the classification rules are classified according to the error stability, operation reliability, potential defects and other elements, as shown in Figure 1 below.

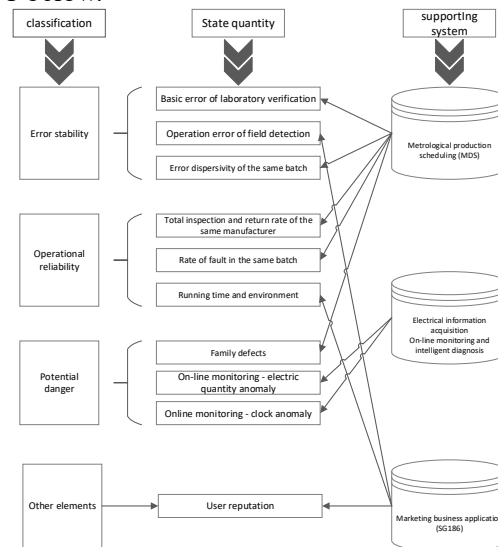


Fig.1 State volume classification diagram

The principle of error stability: The basic error (S_1), that is, the basic error of the power point meter in the laboratory at the selected load point, which can reflect the inherent measurement performance of the energy meter. The running error (S_2) The error of load test, the state quantity reflects the performance of the energy meter running measurement performance; Error dispersion (S_3), that is, the standard deviation of the basic error of the same batch of qualified watt-hour meter load point statistics, Meter quality control is good or bad.

The principle of operational reliability: Full inspection acceptance batch return rate (S_4), that is, the same manufacturer for three-phase meter due to unqualified return batch ratio statistics, the state quantity meter manufacturer reputation, management and quality Level; Run batch (S_5), the same batch of energy meter running failure rate statistics, the state quantity reflects the quality of the operation of the batch meter good or bad. Operating time and environment (S_6), that is, the operating hours of the watt-hour meter and the environment in which it operates, the minimum resolution of the operating year is 0.5 years. This status quantity reflects the impact of operating time and environment on the operating performance of the watt-hour meter.

Potential risk principle: family defects (S_7), that is, the defects of the electric energy meter caused by the common factors such as design, materials, technology and software are all called family defects, and this status quantity reflects the size of the hidden trouble of running the watt-hour meter; Online monitoring of abnormal power (S_8), that is, using the system-line monitoring and intelligent diagnosis module found the real power meter abnormal power type and quantity, the state quantity reflects the real-time operation of the meter; online monitoring clock anomaly (S_9) Using the real-time power meter clock anomaly type and quantity discovered by the on-line monitoring and intelligent diagnosis module of the system, the state quantity reflects the real-time operation of the power meter.

Other elements of the principle: The user reputation (S_{10}), that meter users have occurred such as theft of electricity affect the credibility of the behavior^[10-11].

2.2 Status list

According to the principle of selecting the state quantity, the following describes in detail the state quantity formed by extracting each system data.

Basic error S_1 , select the error value of 3 load points: (1) the error values of $U_n, I_n, \cos\varphi=1.0$ is S_{1-1} , (2) 0.2S and 0.5S levels take the error values of $U_n, 0.02 I_n, \cos\varphi = 0.5L$ as S_{1-2} , or one level and two level take the error values of $U_n, 0.05 I_n, \cos\varphi = 0.5L$ as S_{1-2} , (3) the error values of $U_n, I_{max}, \cos\varphi = 1.0$ is S_{1-3} , (4) the error values of $U_n, I_n, \cos\varphi = 0.8C$ is S_{1-4} which is optional. The main source is the MDS system basic error conclusion table (if this data can not be added missing, the default 0.5 times the error limit).

Operation error S_2 is the field actual load test error. The source is SG186 marketing business application system operation and maintenance (power meter field test data, power meter field test shows).

The error dispersion S_3 is the standard deviation of the basic error of the same batch of qualified electric energy meters at the rated load point and power factor 1. The data come from the basic error table of the MDS system, and the formula is as follows:

$$S_3 = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2} \quad (1)$$

Total check and acceptance batch return rate S_4 is the same manufacturer's three phase electric energy meter for nearly 3 years unqualified return batch rate. The data is derived from the MDS exchange task table. The formula is as follows:

$$S_4 = \frac{\text{Number of unqualified return batch}}{\text{Total number of meters supplied}} \times 100\% \quad (2)$$

Batch running S_5 is the running failure rate of the same arrival batch electric energy meter, from the MDS operation fault statistics table, the calculation formula is as follows:

$$S_5 = \frac{S_{5-1}}{\text{Total number of batch of meters}} \times 100\% \quad (3)$$

The S_{5-1} is the number of electric energy meters out of operation due to the quality problem of the meter.

The running time and the environment S_6 are divided into 2 categories, (1) S_{6-1} indicates the number of energy meter running years, the minimum resolution is 0.5 years, only to abandon the non-carry. For example: 0-5.9 months for 0 years, 6-11.9 months to 0.5 years; (2) S_{6-2} represents the operating environment of the meter, which is divided into indoor air conditioning, indoor air conditioning, outdoor. Different environments have different weights. The running time takes the runtime field of running-time data provided by the SG186 marketing business application system and the installation environment needs the fields newly added by the SG186 marketing business application system C_METER table.

The family defect S_7 is the size ^[12] of the confirmed family defect influence ^[12]. The on-line monitoring of electric quantity anomaly S_8 is the real quantity of abnormal electric quantity found by on-line monitoring within 1 evaluation cycles, and the data are derived from the on-line monitoring module using the mining system. The online monitoring clock anomaly S_9 is the real number of clock anomalies detected by on-line monitoring within 1 evaluation cycles, and the data are derived from the on-line monitoring module using the mining system. The user's reputation S_{10} is the behavior of the user who has been stealing electricity and other unauthorized movements and destroys the metering device in the last 1 years. The data comes from the marketing business application system.

3. Operation evaluation model

Based on the state quantity of electric energy meter selected in the second section of this paper, an evaluation model with a score of 100 based on the basic test score B, inspecting score T, monitoring score M, and score of family defect detection F is established.

3.1 Basic test score B

The basic test score B reference object is the same manufacturer supply electric energy meter, the

same batch meter, the rated electric energy meter and the user. The return rate of the whole inspection and acceptance batch of S_4 for the total inspection and acceptance batch related to the electric energy meter of the manufacturing plant is as follows:

$$B_1 = A_{B1} \times (1 - S_4 * 80) \quad (4)$$

The same batch of energy meters includes batch error dispersion status quantity S_3 and batch operation failure S_5 , and the calculation formula is as follows:

$$B_2 = A_{B2} \times \left(1 - \frac{S_3}{0.2 \times \text{Error limit}}\right) \quad (5)$$

$$B_3 = A_{B3} \times (1 - S_5) \quad (6)$$

The graded energy meter includes the basic error S_1 and the running time and the environment S_6 . The calculation formula is as follows:

$$\begin{aligned} B_4 = & A_{B4-1} \times \frac{(\text{Error limit} - |S_{1-1}|)}{\text{Error limit}} \\ & + A_{B4-2} \times \frac{(\text{Error limit} - |S_{1-2}|)}{\text{Error limit}} \\ & + A_{B4-3} \times \frac{(\text{Error limit} - |S_{1-3}|)}{\text{Error limit}} \\ & + A_{B4-4} \times \frac{(\text{Error limit} - |S_{1-4}|)}{\text{Error limit}} \quad (7) \\ B_5 = & 20 - 2.5 \times S_{6-1} \times S_{6-2} \quad (8) \end{aligned}$$

The user includes the state quantity user reputation S_{10} , whose score is based on the behavior of destroying the electric energy meter such as electricity stealing in the last year, or $B_6=0$, otherwise $B_6=A_{B6}$.

$A_{B1}, A_{B2}, A_{B3}, A_{B4-1}, A_{B4-2}, A_{B4-3}, A_{B4-4}, A_{B6}$ are configurable and require the following guarantees $A_{B1} + A_{B2} + A_{B3} + A_{B4-1} + A_{B4-2} + A_{B4-3} + A_{B4-4} + A_{B6} = 80$, default $A_{B1}=10, A_{B2}=10, A_{B3}=20, A_{B4-1}=10, A_{B4-2}=10, A_{B4-3}=10, A_{B4-4}=0, A_{B6}=10$; S_{6-2} is run by the environment that the default weight weight, refer to table 1:

Tab.1 Running environment rating reference table

Operating environment	S_{6-2}
Indoor air conditioning	100
Indoor without air conditioning	120
Outdoor	200

Referring Table 1, the basic score is $B = \sum_{i=1}^6 B_i$.

3.2 Inspecting score T

Inspecting score is the field test meter running error score. The score is between 100% and 0%, with 100% corresponding to the running error well below the error limit. Inspecting score reference object is the rated electric energy meter, the corresponding state is the operation error S_2 , the calculation formula is as follows:

$$T_i = \frac{\min(\frac{|\text{Error limit}| - |S_2|}{|\text{Error limit}|}, A_T)}{A_T} \times 100\% \quad (9)$$

If $T_i < 0$, then $T_i = 0$. The default is 50%.

e test score T is finally obtained as $T = \frac{\sum_{i=1}^n T_i}{n}$, where n is the latest n detection scores. $N = 3$ for Class I electric energy meters, $n = 2$ for type II electric energy meters, and $n = 1$ for type III electric energy meters. When the number of detections is less than n times, the item is not scored, $T = 1$.

3.3 Monitoring score M

The monitoring score is the score that the on-line monitoring module discovers the abnormal operation of the electric energy meter. The score was between 100% and 0%, and 100% was corresponding to no

operation failure. The monitoring score was referred to table 2 under reference:

Tab.2 Reference table for monitoring and scoring

Object	State quantity	Scoring method
Rated electric energy meter	Online monitoring of power abnormal number S_8	$M_1 = A_{M1}^{\sqrt{S_8}} \times 100\%$
	Online monitoring of the number of abnormal clocks S_9	$M_2 = A_{M2}^{\sqrt{S_9}} \times 100\%$

A_{M1} , A_{M2} can be configured, A_{M1} default is 90%, A_{M2} default 80%, monitoring score is finally obtained by $M = M_1 \times M_2$.

3.4 Sore of family defect detection

Familial effects refers to the same manufacturer due to the same production materials, production technology, design concepts and ideas caused by a wide range of regularity affect the life of the meter. When family defects are present, those family defects that have not yet undergone family defects are classified according to the size of the defects according to the following table 3 before the hidden danger is eliminated:

Tab.3 Reference table for family defect score

Defect	S_7
no significant impact on metering performance, small risk of sudden deterioration	86%~100%
a certain influence on the metering performance, be monitored	51%~85%
a certain influence on the metering performance, not be monitored	16%~50%
influence on the metering performance	0~15%

Family defect scores are finally obtained as $F = 1 - \frac{1-S_7}{n/N}$, where N is the total number of family electric energy meters and n is the number of electric energy meters for which family defects occur ($n > n \geq 1$). According to the "State Grid Corporation Energy Meter Quality Supervision and Management Measures" on the meter family defects to determine and assess the company's marketing department issued a unified defect rating. If the hidden dangers related to family defects have been eliminated, no longer consider its impact.

3.5 Operating status evaluation

According to the basic score, inspecting score, monitoring score, family defect score calculated score, the final state score $G = BTMF$, where B said the basic score, T said test score, M said monitoring score, F said family defect score. According to the status of the resulting score to assess the state of the meter, the decision based on the following table 4 shows:

Tab.4 State reference table of electric energy meter

Operating status	Absolute score	Last month cycle score - this
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		month score	cycle
stable	[80,100)	$(-\infty, 5]$	
attention	[30,80)	$(5, 30]$	
early warning	[0,30)	$(30, +\infty)$	

Table 4 shows that the power meter operating status from good to bad order: stable > concern > early warning. When the absolute score and the state score (the previous month periodic score, the monthly cycle score) difference between the state judged inconsistent, take the poor state

4. Inspection strategy

According to the status of the electric energy meter evaluated on a monthly basis, a polling strategy for the maintenance of the watt-hour meter is proposed as shown in Table 5 below (the period in the table is one year):

Tab.5 Inspection strategy reference table

Operating status	Inspection strategy
stable	Prolonged 1 times, the normal cycle inspection
attention	1/2 periodic inspection and timely inspection
early warning	Inspect immediately

Inspection strategy in stable state: what kind of inspection strategy should be determined according to the service life. In the normal condition, the field inspection is arranged according to the extension of the inspection cycle of 1 times within 6 years, and the field inspection is arranged over 6 years according to the normal inspection cycle.

The inspection strategy under the state of attention: the way to determine the way of inspection according to the service life. In the normal condition, the field inspection is arranged according to the 1/2 inspection cycle within 6 years, and the state inspection and remote inspection are arranged over 6 years, and the timely inspection is arranged.

Inspection strategy of early warning state: real-time inspection and remote inspection, and immediate site inspection.

5. Conclusion

According to the customary method that can not get the operation status of the electric energy meter in time. The improved method combines the data of the existing mature system with the multi-dimension test variables that affect the state of the electric energy meter. The evaluation model of the operation of the electric energy meter is established and the score Assess the state of the energy meter, put forward the corresponding maintenance strategy of the power meter on the basis of the evaluation state, and provide auxiliary decision for the maintenance strategy of the power meter.

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