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Influence of ambient temperature on current transformers used in power distribution networks

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Abstract. Most of current transformers (CT) used at power frequency in high voltage networks have little dependence of temperature on errors. Indeed, international standards do not propose any specific accuracy test varying the temperature. However, we have detected that some commercial units of CTs, used in power distribution systems, exhibit large temperature dependence in the range -5 °C to 40 °C. It is proposed to add, to standard CT accuracy tests, an additional one at different temperatures.

Keywords. Ratio error, phase-shift, accuracy class.

1. Introduction

The incidence of temperature on the accuracy of current transformers (CT) is not, in general, significant. However, some units show large changes in the values of their errors when the temperature varies [1]. The IEC standard [2], for all instrumentation transformers, establishes ambient temperature ranges for the environment where they are used. The smallest range goes from -5 °C to 40 °C, which covers most of the places where these transformers are installed. For extreme conditions, other higher ranges are defined. The IEEE standard [3] specifies minimum ambient temperatures of -30 °C for outdoor installation and -5 °C for indoor; and maximum of 40 °C.

Nevertheless, any of these standards has a specific test to prove that the CT fulfills the accuracy limits in the mentioned range of ambient temperature. Perhaps, this is due to the fact that most CTs have very little dependence of errors with temperature. Anyway, we have detected some units that increase ratio and phase-shift errors when the ambient temperature change, exceeding the limits of their accuracy classes.

This report shows temperature tests on a sample of commercial CTs used in distribution power networks. Some CTs do not present important variations, but others have a significant error variations.

2. Tests

Four units of indoor CTs, epoxy isolated, from different manufacturers were calibrated between -5 °C and 40 °C to determine the incidence of the temperature on their errors (see figure 1). Their characteristics are:

CT A: 200-400 A / 5 A, cl. 0.2S, 10 VA, 36 kV
CT B: 150 A/ 5 A, cl. 0.5, 10 VA, 12 kV
CT C: 200 A/ 5 A, cl. 0.5, 15 VA, 36 kV
CT D: 200-400 A/ 5 A, cl. 0.2S, 10 VA, 36 kVA

Fig. 1. Sample of CTs tested in error temperature dependence.

Table 1. Results of calibration of four CTs at different temperatures and 100% of load.

CT A 400:5 0.2S	**-5 °C**		11 °C		24 °C		40 °C	
I (%)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)
1	0,01	7	0,07	5	0,07	5	0,08	5
5	0,05	6	0,08	4	0,09	4	0,09	3
20	0,07	4	0,11	2	0,10	3	0,11	2
100	0,09	3	0,12	1	0,12	1	0,13	0
120	0,08	3	0,12	1	0,12	1	0,13	0

CT B 150:5 0.5	**-5 °C**		11 °C		24 °C		40 °C	
I (%)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)
5	-0,73	24	-0,71	23	-0,72	24	-0,72	24
20	-0,35	12	-0,32	12	-0,33	13	-0,31	12
100	-0,05	5	-0,04	4	-0,04	5	-0,03	5
120	-0,03	3	-0,02	4	-0,01	4	0,00	4

CT C 200:5 0.5	**-5 °C**		11 °C		25 °C		40 °C	
I (%)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)
5	-0,57	27	-0,51	25	-0,52	25	-0,51	25
20	-0,3	16	-0,26	15	-0,26	15	-0,26	15
100	-0,03	4	-0,03	5	-0,03	6	-0,03	6
120	-0,02	5	-0,01	5	-0,02	5	-0,01	5

CT D 200:5 0.2S	**-5 °C**		11 °C		26 °C		40 °C	
I (%)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)	ε (%)	δ (min)
1	-1,45	69	-1,32	57	-1,01	45	-0,77	31
5	-0,81	36	-0,68	26	-0,48	21	-0,30	11
20	-0,53	21	-0,42	15	-0,24	12	-0,11	6
100	-0,21	8	-0,16	5	-0,07	5	0,03	2
120	-0,18	8	-0,13	5	-0,05	4	0,04	2

Table 1 shows the results at nominal load, although similar variations were obtained at loads of 0% and 25%. The expanded uncertainties of these calibrations were 0.05% in ratio and 1 min in phase-shift. No significant variations were detected due to the effect of temperature in three of these transformers (A, B and C). On the contrary, the results of one of them (D) show large variations. At 20% of the rated current, the error differences between -5 °C and 40 °C were 0.42% and -15 min, which largely exceeds the limits of the IEC standard for its accuracy class (0.2%, 10 min). Fig. 2 and 3 show the trend of error variation against the current (in percentage of nominal current). Other units of the same model had similar behavior showing that it is not a single case, but a systematic one.

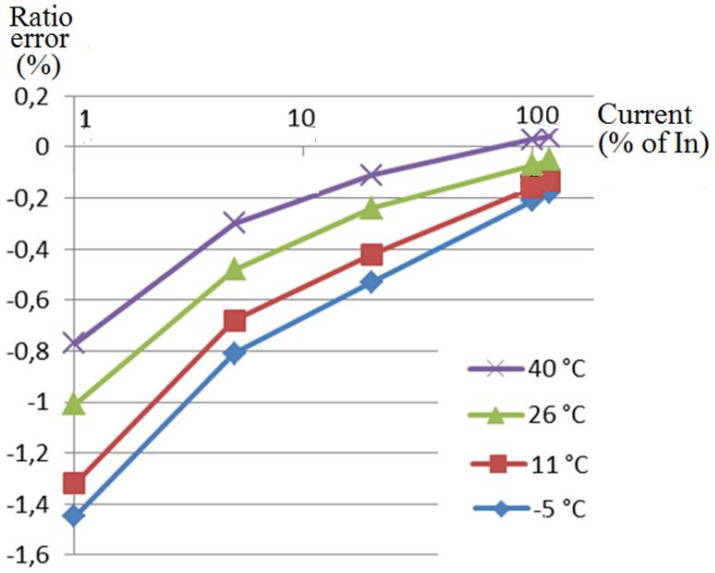

Fig. 2. Ratio error of CT D in function of current, at different ambient temperatures.

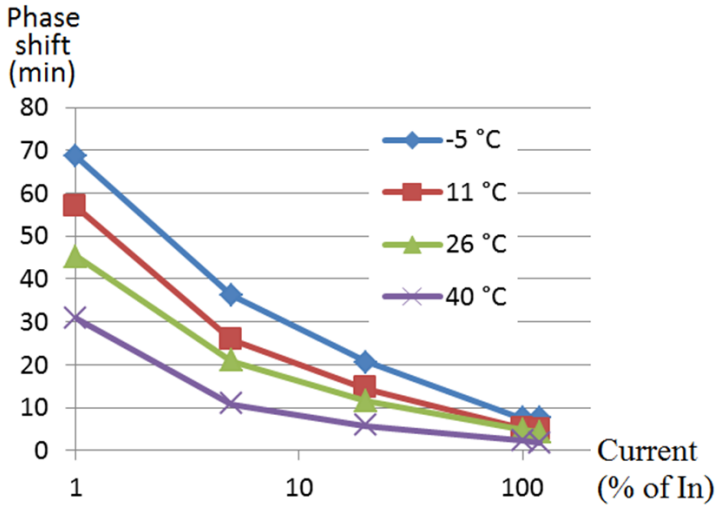

Fig. 3. Phase shift of CT D in function of current, at different ambient temperatures.

3. Conclusions

Several instrument metering CTs were tested by varying the temperature between -5 °C and 40 °C. Three of them do not show appreciably variation in their errors, but one of them increased its ratio and phase errors around two times the limits of IEC standard for its accuracy class. As usually, as all accuracy tests are done at laboratory temperature, around 20 °C, these variations cannot be detected. It is proposed that international standards add a specific accuracy test varying the ambient temperature over the entire range for use, declared by the manufacturer.

References

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[2] IEC 61869-1-2011, "Instrument transformers - Part 1: General requirements".
[3] IEEE Std C57.1-2016, "IEEE Standard Requirements for Instrument Transformers".