INTERLABORATORY COMPARISON OF INSTRUMENT CURRENT TRANSFORMER STANDARDS IN THE RANGE UP TO 800 A AT 50 HZ

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Abstract - The article describes results of an interlaboratory comparison of instrument current transformers performed in the Czech Republic. An operating instrument current transformer with ratios 400 A/5 A and 800 A/5 A has been used by this comparison. A common instrument transformer has a big dependence of errors on burden and its phase displacement. This dependence is also illustrated. The various results are compared and determined their differences for single laboratories.

Keywords - Comparison measurement, instrument current transformer, ratio error, phase displacement

1. INTRODUCTION

The main metrological laboratories of the Czech Republic have taken part in this comparison. The pilot laboratory was the Czech Metrology Institute (CMI), Laboratory of Fundamental Metrology (LFM) in Prague. The participants were the regional branch (RB) CMI in Prague and the authorized laboratory IVEP in Brno, which provides testing of instrument transformers in the Czech Republic.

This comparison has linked with the preceding international comparison performed as the Dunamet project D7 [1], when the range of primary current was up to 25 A and the real burdens were 1 VA and 5 VA. The range of measured current has been extended up to 400 A/5 A and 800 A/ 5A and the burden was 15 VA; cos β = 0,8 and 3,75 VA; cos β = 1 in this case. The operating transformer KPB Intra CTS 25; class 0.5 has been used as the transfer transformer.

The recommended scheme of the measurement of ratio error ε_I and phase displacement δ_I is in Fig.1. The deviations ε_I and δ_I between transfer transformer and laboratory standard have been measured by means of a system for transformer error evaluation [2]. The errors of transfer transformer have been measured by (1, 2, 5, 10, 20, 50, 100 and 120) % of rated value of primary current I_R. By reason of the error dependence of the transfer transformer on the value of burden it has been recommended to keep the values of burden with the uncertainty ± 1 %

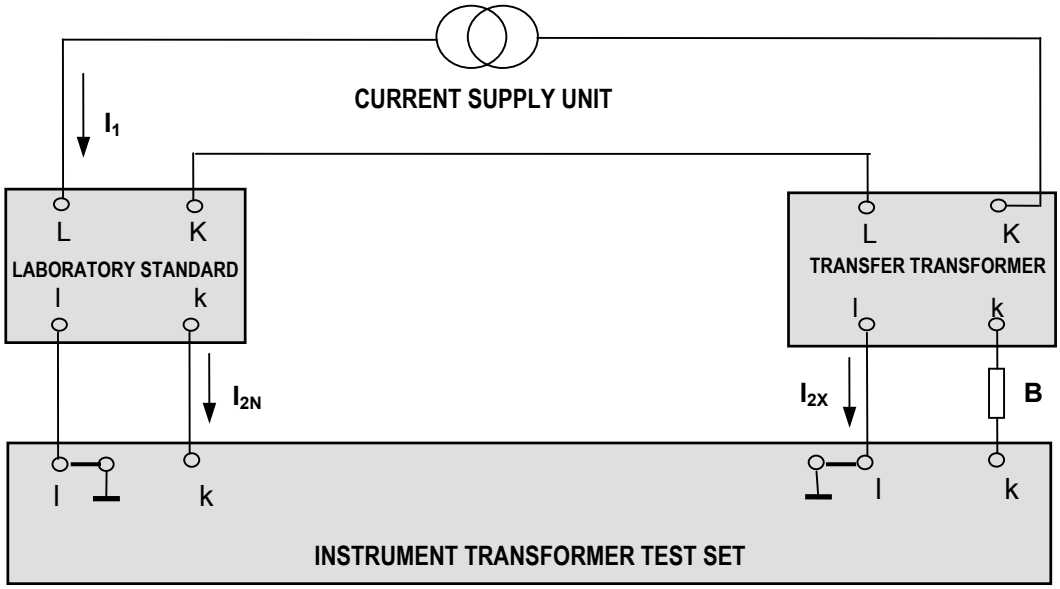

Fig.1 - The recommended connection for the measurement of ratio error ε_I and phase displacement δ_I .

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All participating laboratories have used the equipment from the Swiss firm Tettex Instruments. The current comparator Tettex 4764 has served as a laboratory standard; the systems Tettex 2767 or 2761 have been used for the measurement of ratio error and phase displacement. The both laboratories of CMI has used the programmable electronic current burden Tettex 3691, the passive current burden Tettex 3671 has been used in the laboratory of IVEP Brno. The supplementary measurement by toroidal current comparator Custer's type [3] has been carried out in LFM CMI in Prague.

The standard current transformers operate usually with rated real burden (1 ÷ 5) VA. The common operating transformer CTS 25 used in this case has rated burden 15 VA; cos β = 0,8. It can be presumed that its errors will depend on a proper adjusting of burden. For that reason the measurement of error dependence on an adjustment of burden has been performed in the pilot laboratory.

k_I [A/A]	I_1	CMI LFM		RB Prague		IVEP Brno		reference value		standard deviation		comparator	
B [VA]	[% I_R]	$\varepsilon_{I\,LFM}$ [%]	$\delta_{I\,LFM}$ [']	$\varepsilon_{I\,RB}$ [%]	$\delta_{I\,RB}$ [']	$\varepsilon_{I\,IVEP}$ [%]	$\delta_{I\,IVEP}$ [']	$\varepsilon_{I\,R}$ [%]	$\delta_{I\,R}$ [']	σ_ε[%]	σ_δ[']	$\varepsilon_{I\,KPK}$ [%]	$\delta_{I\,KPK}$ [']
	120	-0,0367	1,42	-0,037	1,40	-0,0392	1,396	-0,0376	1,40	0,0014	0,0117	-0,0389	2,03
	100	-0,0367	1,61	-0,037	1,61	-0,0395	1,589	-0,0377	1,60	0,0015	0,0118	-0,0380	1,528
	50	-0,0354	2,38	-0,035	2,44	-0,0387	2,377	-0,0364	2,40	0,0020	0,0349	-0,0362	2,385
400/5	**20**	-0,0324	3,38	-0,033	3,45	-0,0346	3,075	-0,0333	3,30	0,0012	0,1984	-0,0337	3,367
3,75	**10**	-0,0290	4,10	-0,030	4,11	-0,0329	3,693	-0,0306	3,97	0,0020	0,2389	-0,0310	4,033
	5	-0,0249	4,75	-0,027	4,67	-0,0313	4,230	-0,0278	4,55	0,0033	0,2800	-0,0272	4,637
	2	-0,0173	5,52	-0,025	5,18	-0,0313	4,805	-0,0245	5,17	0,0070	0,3564	-0,0212	5,225
	1	-0,0063	6,25	-0,024	5,50	-0,0351	5,175	-0,0218	5,64	0,0145	0,5486	-0,0163	5,53
	120	-0,1035	0,48	-0,104	0,49	-0,1047	0,516	-0,1041	0,49	0,0006	0,0190	---	---
	100	-0,1037	0,40	-0,104	0,41	-0,1054	0,409	-0,1044	0,40	0,0009	0,0081	-0,1154	0,491
	50	-0,1252	1,45	-0,126	1,49	-0,1286	1,418	-0,1266	1,45	0,0018	0,0362	-0,1376	1,517
400/5	**20**	-0,1558	3,64	-0,159	3,79	-0,1469	3,328	-0,1539	3,58	0,0063	0,2354	-0,1741	3,819
15	**10**	-0,1760	5,28	-0,181	5,43	-0,1663	4,775	-0,1744	5,16	0,0075	0,3427	-0,1988	5,505
	5	-0,1919	6,89	-0,199	6,95	-0,1834	6,178	-0,1914	6,67	0,0078	0,4291	-0,2205	7,205
	2	-0,2040	8,83	-0,218	8,64	-0,2114	7,955	-0,2111	8,48	0,0070	0,4612	-0,2359	9,180
	1	-0,2080	10,30	-0,228	9,68	-0,2320	9,243	-0,2227	9,74	0,0129	0,5327	-0,2387	10,525
	120	-0,0373	1,43	-0,037	1,43	-0,0412	1,488	-0,0385	1,45	0,0023	0,0344	---	---
	100	-0,0375	1,67	-0,037	1,64	-0,0417	1,630	-0,0387	1,65	0,0026	0,0183	-0,0389	1,55
	50	-0,0364	2,46	-0,036	2,45	-0,0418	2,427	-0,0381	2,45	0,0033	0,0180	-0,0375	2,28
800/5	**20**	-0,0336	3,53	-0,033	3,46	-0,0386	3,168	-0,0350	3,38	0,0031	0,1904	-0,0353	3,22
3,75	**10**	-0,0307	4,19	-0,031	4,14	-0,0368	3,818	-0,0328	4,05	0,0034	0,2022	-0,0333	3,87
	5	-0,0276	4,82	-0,028	4,70	-0,0360	4,363	-0,0305	4,63	0,0047	0,2362	-0,0302	4,47
	2	-0,0221	5,54	-0,025	5,23	-0,0372	4,953	-0,0281	5,24	0,0080	0,2914	-0,0251	5,064
	1	-0,0151	6,04	-0,024	5,45	-0,0425	5,348	-0,0272	5,61	0,0139	0,3752	-0,0207	5,4
	120	-0,1044	0,53	-0,103	0,55	-0,1063	0,510	-0,1046	0,53	0,0017	0,0201	---	---
	100	-0,1049	0,48	-0,104	0,45	-0,1062	0,372	-0,1050	0,43	0,0011	0,0556	-0,1182	0,44
	50	-0,1284	1,57	-0,126	1,48	-0,1289	1,401	-0,1278	1,48	0,0016	0,0856	-0,1414	1,5
800/5	**20**	-0,1602	3,87	-0,159	3,77	-0,1477	3,278	-0,1556	3,64	0,0069	0,3158	-0,1742	3,64
15	**10**	-0,1812	5,57	-0,181	5,42	-0,1672	4,748	-0,1764	5,24	0,0080	0,4362	-0,2037	5,48
	5	-0,1985	7,13	-0,200	6,95	-0,1852	6,300	-0,1946	6,79	0,0081	0,4361	-0,2222	7,16
	2	-0,2126	9,05	-0,219	8,65	-0,2173	7,913	-0,2163	8,54	0,0033	0,5776	-0,2410	9,24
	1	-0,2176	10,29	-0,229	9,57	-0,2406	9,113	-0,2291	9,66	0,0115	0,5949	-0,2415	10,6

Table 1 – Results of comparison measurement.

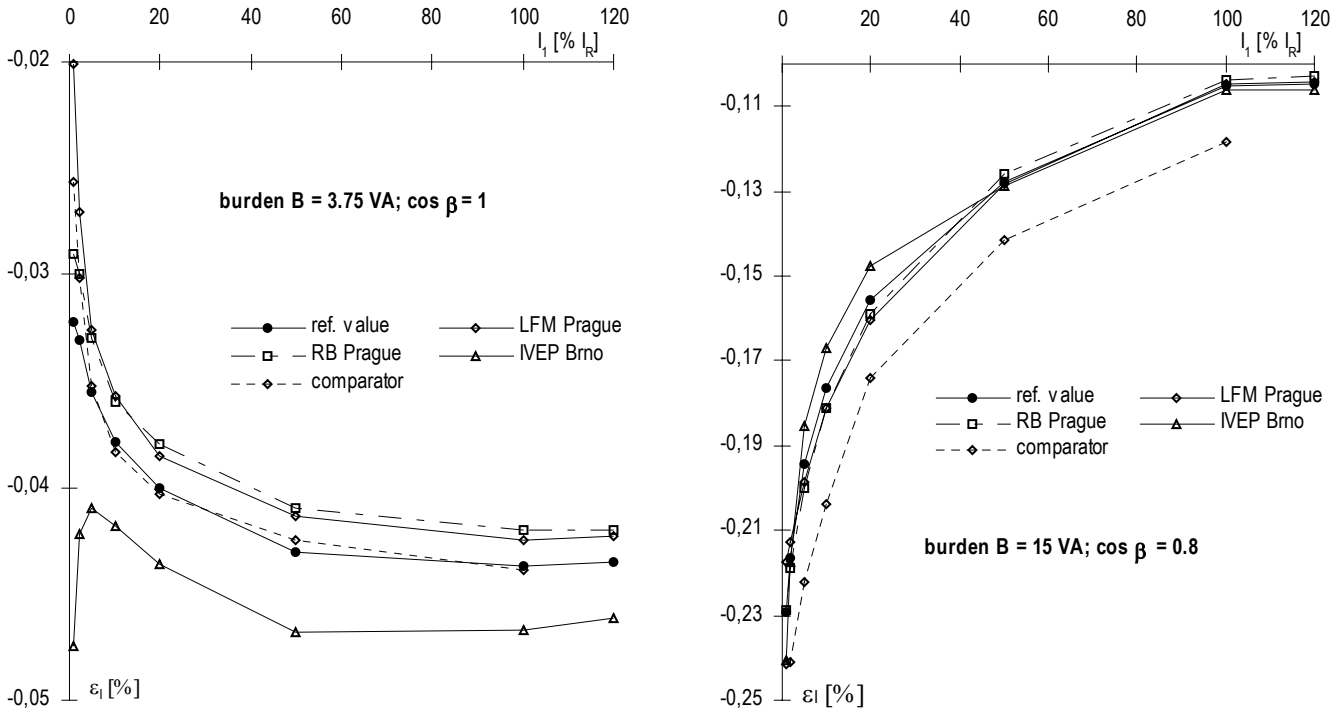

Fig. 2 - Dependence of ratio error ε_I on primary current I_1 of instrument current transformer CTS 25, ratio 800 A/5 A.

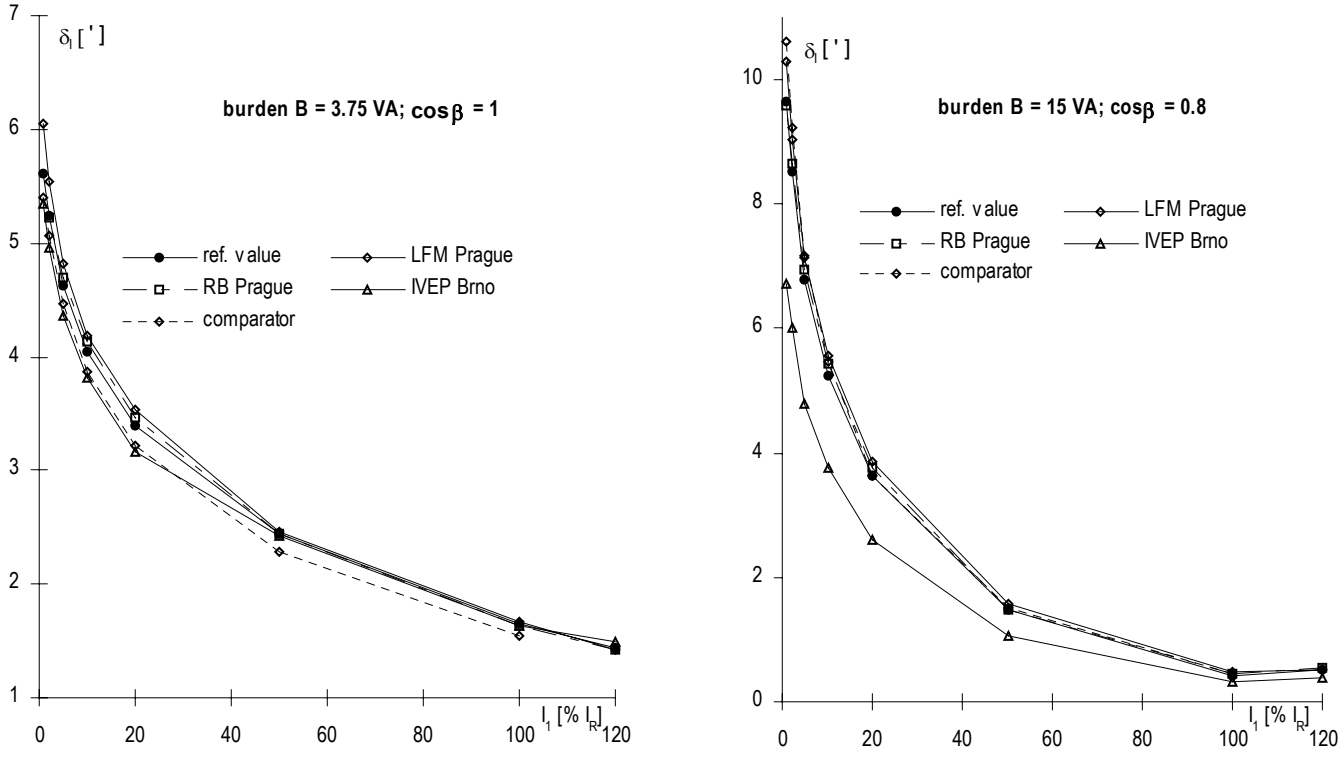

Fig. 3 - Dependence of phase displacement δ_I on primary current I_1 of instrument current transformer CTS 25, ratio 800 A/5 A.

2. RESULTS OF MEASUREMENT

The results of measurement of participating laboratories are given in Table 1. The graphical representation for the transformation ratio 800 A/5 A is in Fig. 2 and 3. The combined uncertainties given by participating laboratories are not essentially different and so the reference value has not been calculated from weighted mean [4], [5] but as arithmetic mean according to the formulae

$$\varepsilon_{IR} = 1/3\ (\varepsilon_{LFM} + \varepsilon_{RB} + \varepsilon_{IVEP})$$

$$\delta_{IR} = 1/3\ (\delta_{LFM} + \delta_{RB} + \delta_{IVEP}) \qquad (1)$$

where the subscripts LFM, RB and IVEP indicate the results of measurement in participating laboratories.

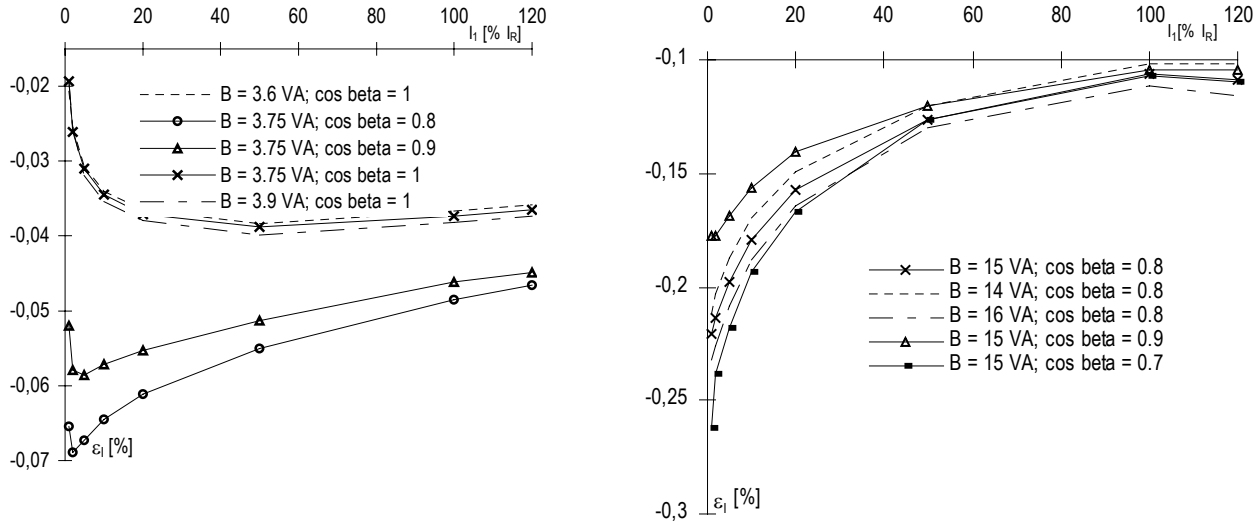

Fig. 4 - Dependence of ratio error ε_I on primary current I_1 of instrument current transformer CTS 25, ratio 800 A/5 A for various burden.

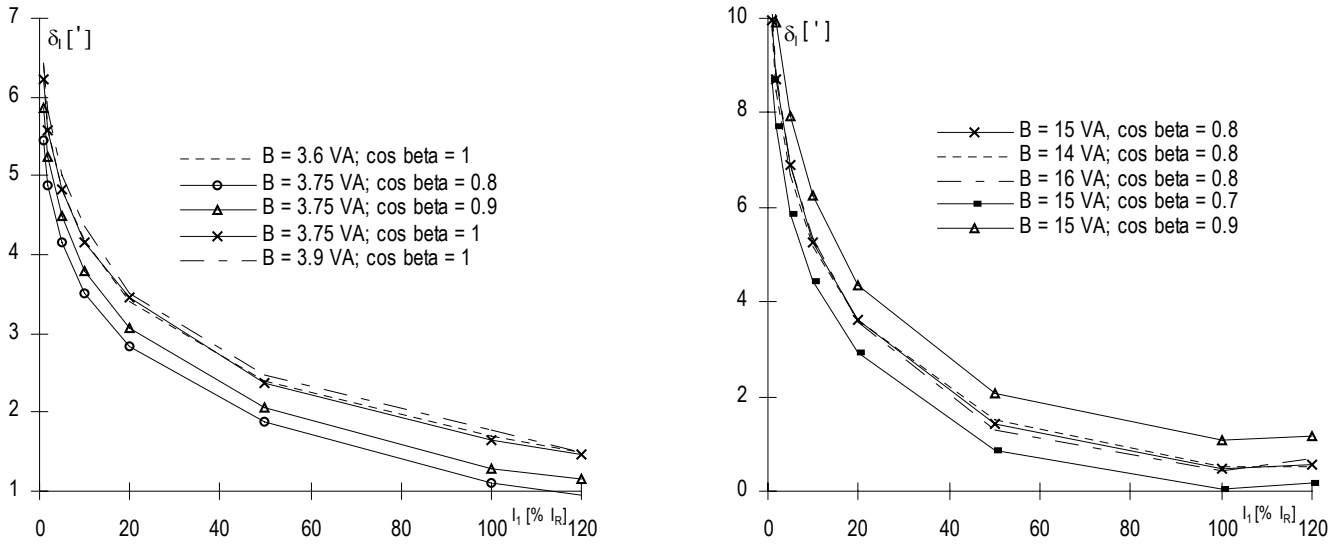

Fig. 5 - Dependence of phase displacement δ_I on primary current I_1 of instrument current transformer CTS 25, ratio 800 A/5 A for various burden.

The results of participating laboratories have been compared by means of experimental standard deviation of ratio error σ_ε and phase displacement σ_δ, which are given by formulae

$$\sigma_\varepsilon = \sqrt{\frac{(\varepsilon_{LFM}-\varepsilon_{IR})^2+(\varepsilon_{RB}-\varepsilon_{IR})^2+(\varepsilon_{IVEP}-\varepsilon_{IR})^2}{2}};$$

$$\sigma_\delta = \sqrt{\frac{(\delta_{LFM}-\delta_{IR})^2+(\delta_{RB}-\varepsilon_{IR})^2+(\delta_{IVEP}-\varepsilon_{IR})^2}{2}}. \quad (2)$$

The errors of common transformer are dependent on burden. In order to evaluate this dependence it has been carried out a special measurement for the ratio 800 A/5 A, which results are introduced in Fig. 4 and 5.

3. CONCLUSION

From the results of measurement presented in Table 1 and Fig. 2 and 3 it is obvious that the standard deviation σ_ε does not exceed 30 ppm for ratio error and σ_δ 0.08' for phase displacement for both transformation ratios and both values of burden. For smaller values of currents I_1 the standard deviation increases and for 1 % I_R it gains the value up to 145 ppm for ratio error and 0.6' for phase displacement. The ground for it is the rise of errors of a transformer test set with decrease of measured current. The proper adjusting of burden and particularly its phase displacement cos β substantially affects the transformer errors as is obvious from Fig.4 and 5. The proper adjusting of burden is very important especially for measured current I_1 smaller than 20 % I_R. The supplementary measurement by means of toroidal current comparator Custer's type showed very good agreement of results for the real burden 3.75 VA and both transformation ratios. The comparator is not apparently convenient for bigger burdens of tested transformers as is obvious from the results. The given results are sufficient for testing of common instrument transformers and the obtained standard deviations are only twice bigger than by the comparison of standard transformers.

ACKNOWLEDGMENTS

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