ONTARIO HYDRO
RESEARCH DIVISION REPORT

To Mr. F.J. Simpson
Director of Research

EFFECT OF REMANENCE ON THE METERING ACCURACY OF 230-kV CURRENT TRANSFORMERS

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The errors of current transformers can be adversely affected by remanence. Test results on one transformer indicate that remanence will deteriorate its metering accuracy from the 0.3 class to 0.6 class. Even larger errors are expected to persist for short periods of time. Because of the demagnetizing effect of normal load currents these larger errors persist only for a short period of time.

Measurements of remanence on high-voltage current transformers in service have revealed that a large percentage of these transformers operate with high levels of residual flux/1/. Remanence may be set up in a current transformer core by a dc continuity test on the secondary winding or by transient component of fault current. It has been known for some time that remanence does adversely affect the metering accuracy of current transformers/2/. Since high-voltage current transformers are used in tie-line metering applications, where 0.3 accuracy class is required and 0.6 accuracy class may not be acceptable, it was desirable to obtain information pertaining to the effect of remanence on the accuracy of these transformers.

This report summarizes Ontario Hydro 60 Hz tie-line metering installations and presents data and comments on the results of accuracy tests of one Westinghouse type OPC-230 current transformer, operating at various levels of remanence.

TIE-LINE METERING INSTALLATIONS

Ontario Hydro has metering installations on five tie lines in January 1976. The current transformers used in those installations are shown in Table V, appended. The Canadian Westinghouse transformers used in those installations are free-standing, multiple core units with a tapped secondary winding. The cores are made of grain-oriented silicon steel, and have both metering and relaying accuracies.

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The Canadian General Electric and ASEA units are also free-standing, but have only one core and use a series-parallel arrangement on the primary for setting the ratio. Similarly to the Canadian Westinghouse units, these transformers use grain-oriented silicon steel cores, but have only a metering accuracy.

CURRENT TRANSFORMER ACCURACY TESTS

To obtain data pertaining to the effect of remanence on the accuracy of current transformers, one Westinghouse type OPC-230 current transformer was accuracy-tested with and without residual flux. The accuracy tests were performed only on the 800-5 ampere ratio. This ratio was rated at CSA accuracy 0.3 B-1.8 for metering and 2.5 L600 for relaying applications.

The following procedure was used in obtaining the test data. The transformer was saturated with direct current and then its accuracy at a particular burden was determined at gradually increasing test currents. The transformer was saturated whenever the burden on the transformer was changed.

Tables I to IV give the results of the accuracy tests. Figure 1, appended, shows how the errors of the transformer change as the core is demagnetized by gradually increasing the load current.

For reference purposes, the excitation characteristics were measured for the transformer and are shown plotted in Figure 2.

DISCUSSION

As can be seen from Tables I to IV and Figure 1, remanence adversely affects the ratio correction factor (RCF) and the phase angle defect (PA) of grain-oriented silicon-steel core current transformers. The errors at a B-1.8 burden exceeded 1.2 per cent ratio, and 70 minutes in phase error at low current (0.5 A). This is about four times larger than allowed by specifications for a transformer with 0.3 per cent accuracy. At reduced burdens the errors of the saturated transformer are markedly lower than at rated burden (B-1.8), but still several times higher than in the demagnetized condition. Figure 1 also indicates that the abnormally large errors would be, rather quickly, reduced to smaller values by the demagnetizing action of the load current, power swings, or currents supplied to distant faults. One could deduce from Figure 1, that it is not very likely that the transformer operates with large errors for long periods of time. One might also estimate that the transformer, possessing CSA 0.3 B-1.8 accuracy class under demagnetized condition, probably operates within the CSA 0.6 B-1.8 accuracy class under field conditions, the degradation in accuracy being solely due to remanence.

To obtain information on remanence after some demagnetization, Figure 3 was plotted. It shows the remanence, in per cent of maximum flux density, as a function of demagnetizing voltage for a grain-oriented silicon steel core. Since demagnetization with 25 amperes in Figure 1 is approximately equal to demagnetization with 10 per cent in Figure 3, it may be concluded that the current-transformer errors increase rapidly when remanence approaches its maximum value. Reasonably good accuracy is maintained by the transformer at remanence values less than 70 per cent.

CONCLUSIONS

The errors of current transformers, using grain-oriented silicon steel cores, are adversely affected by remanence. The metering accuracy class of such transformers is probably reduced by two, once the transformer is saturated by transients on the power system or by other means. Immediately after saturation, such current transformers may operate for a short period of time with a composite error of about 2 per cent. These large errors are rather quickly reduced to smaller values by the normal demagnetizing action of load current.

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REFERENCES

1. Remanent Flux in Current Transformers. Research Division Report No 70-60-K.

2. Effect of Residual Magnetism on Accuracy of Current Transformers. Research Division Report No E-54-155.

TABLE I - Ratio Correction Factor, with CT in a demagnetized condition. Ratio 800-5.

RATIO CORRECTION FACTOR						
Secondary Current	0.5 A	1.0 A	2.0 A	3.0 A	4.0 A	5.0 A
<u>Burden</u>						
B-0.0	1.0005	1.0003	1.0002	1.0002	1.0001	1.0001
B-0.2	1.0007	1.0005	1.0004	1.0003	1.0003	1.0002
B-0.5	1.0010	1.0007	1.0005	1.0005	1.0004	1.0004
B-0.8	1.0014	1.0010	1.0007	1.0006	1.0006	1.0005
B-1.8	1.0021	1.0015	1.0011	1.0011	1.0010	1.0010

TABLE II - Ratio Correction Factor, with CT in a magnetized condition. (Core was magnetized before each change in burden.) Ratio 800-5.

RATIO CORRECTION FACTOR						
Secondary Current	0.5 A	1.0 A	2.0 A	3.0 A	4.0 A	5.0 A
<u>Burden</u>						
B-0.0	1.0009	1.0008	1.0009	1.0010	1.0010	1.0010
B-0.2	1.0025	1.0022	1.0022	1.0020	1.0019	1.0019
B-0.5	1.0046	1.0041	1.0035	1.0031	1.0029	1.0028
B-0.8	1.0068	1.0060	1.0054	1.0046	1.0041	1.0038
B-1.8	1.0125	1.0108	1.0086	1.0073	1.0065	1.0059

TABLE III - Phase Angle with CT core in a demagnetized condition. Ratio 800-5.

PHASE ANGLE (in minutes)						
Secondary Current	0.5 A	1.0 A	2.0 A	3.0 A	4.0 A	5.0 A
<u>Burden</u>						
B-0.0	5.0	3.0	2.0	1.6	1.3	1.1
B-0.2	5.2	3.3	2.0	1.8	1.4	1.2
B-0.5	6.0	4.0	2.4	1.9	1.7	1.6
B-0.8	7.3	4.3	3.0	2.4	2.0	1.9
B-1.8	8.0	5.0	3.5	3.0	2.6	2.4

TABLE IV - Phase Angle with CT core in a magnetized condition. (Core was magnetized each time the burden was changed.) Ratio 800-5.

PHASE ANGLE (in minutes)						
Secondary Current	0.5 A	1.0 A	2.0 A	3.0 A	4.0 A	5.0 A
<u>Burden</u>						
B-0.0	20.5	17.0	12.6	10.2	8.6	7.7
B-0.2	28.3	23.3	16.7	13.2	11.3	10.1
B-0.5	41.1	32.6	22.7	17.2	14.7	12.8
B-0.8	56.0	44.0	28.2	21.9	17.8	14.9
B-1.8	70.0	54.0	35.0	25.1	20.3	17.1

TABLE V

STATIONS AND CURRENT TRANSFORMERS USED IN THE ONTARIO HYDRO INTERTIES*

Station	Line	Make	Type	Serial No	Ratio Used
St. Lawrence TS	L33P	ASEA	IMBA20000D	4574921 4574922	800-5
Sir Adam Beck GS	BP76	CWH	OPC-230	693070 693071	800-5
Keith	J5D	CWH	OPC-230	739667 739670 739677	1600-5
Mississagi	P21G	CGE	KG230	660512 660513	800-5
Mississagi	P22G	CGE	KG230	660511 660510	800-5

* 1975 Data

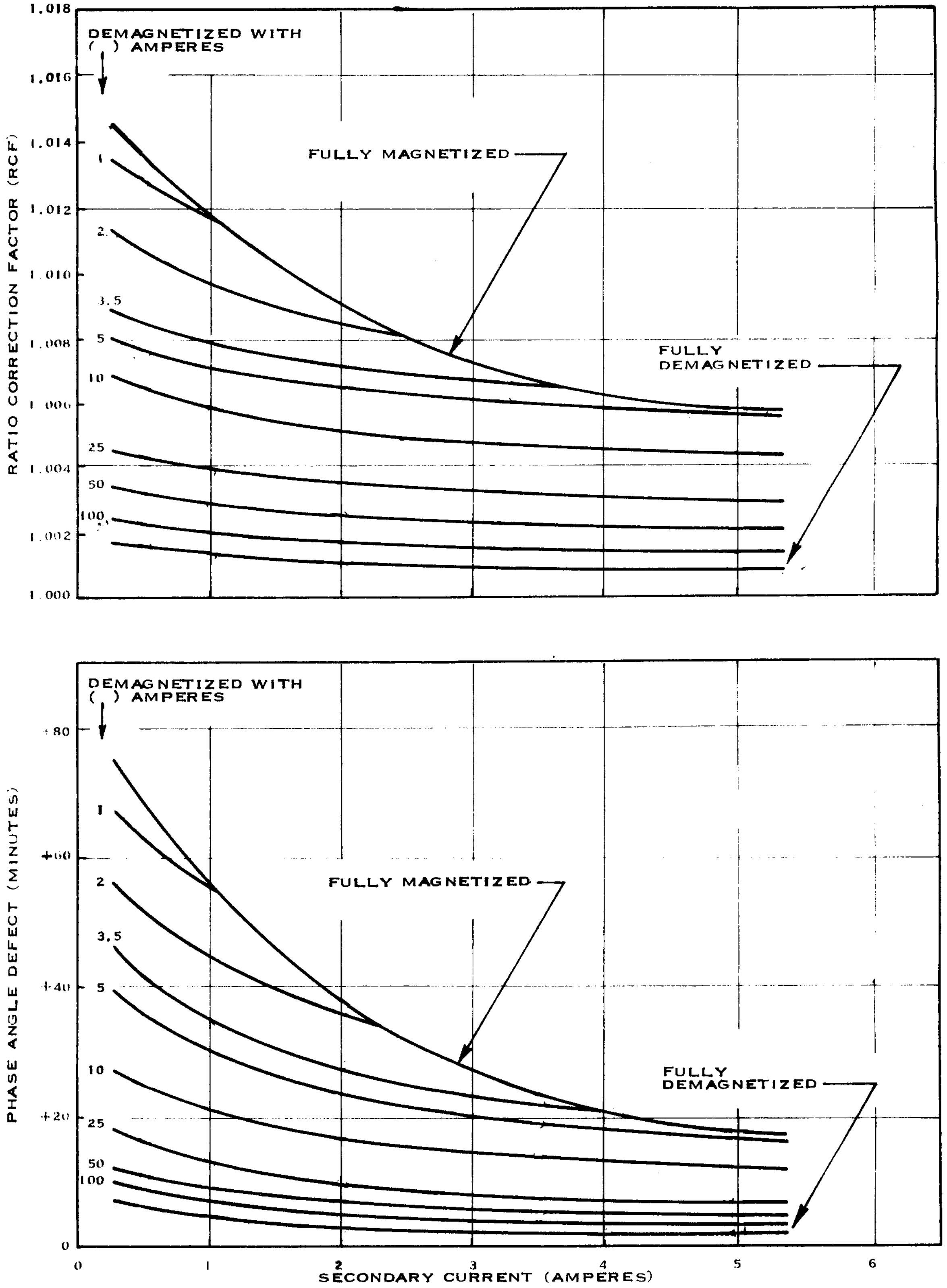

FIGURE I

VARIATION OF CURRENT TRANSFORMER ERRORS WITH RESIDUAL MAGNETISM

RATIO – 800 – 5 BURDEN B–1.8

129171–RD

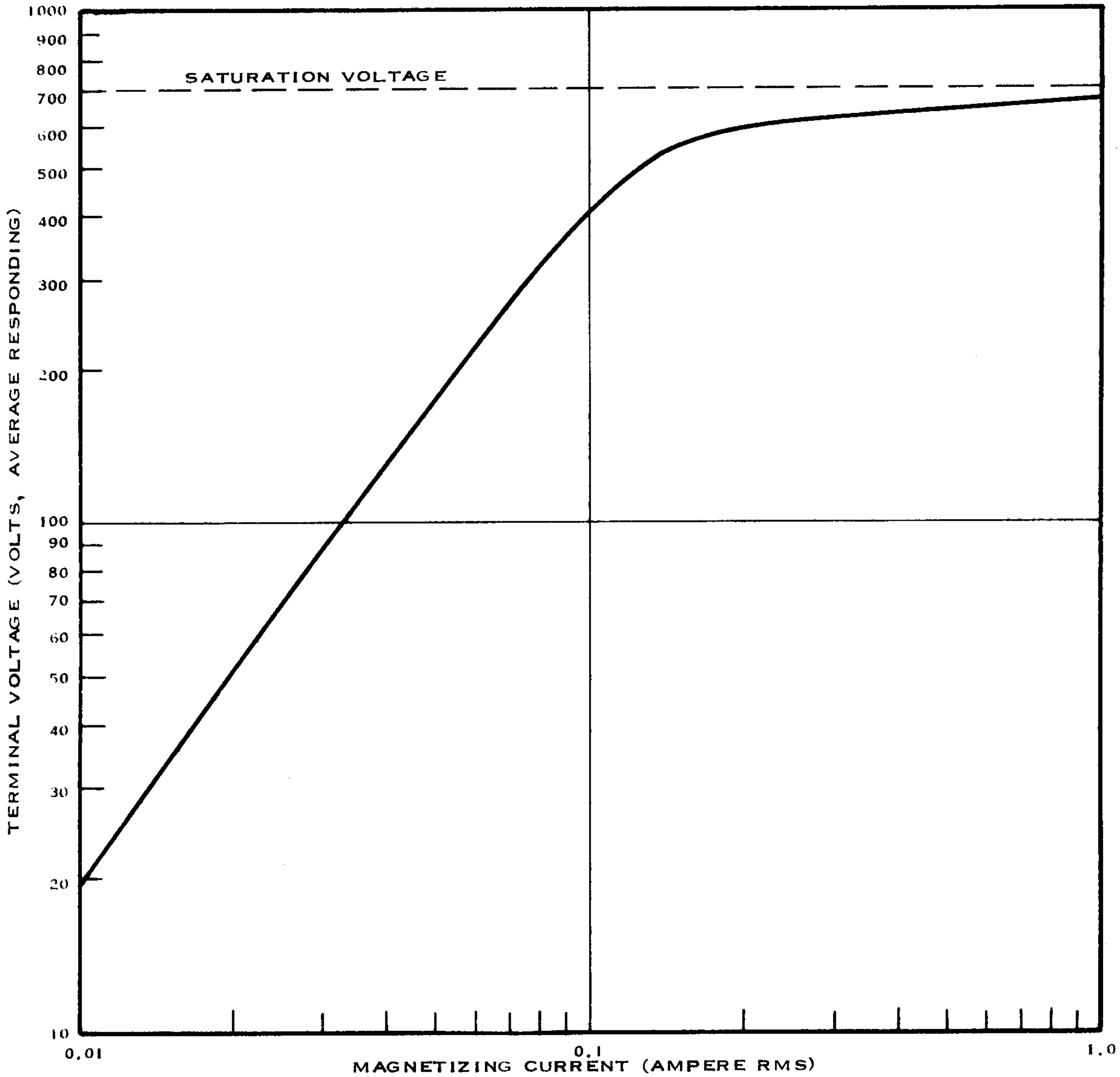

FIGURE 2

EXCITATION CHARACTERISTICS
WESTINGHOUSE TYPE OPC–230, SER NO 761588
RATIO 800–5

129278–RD

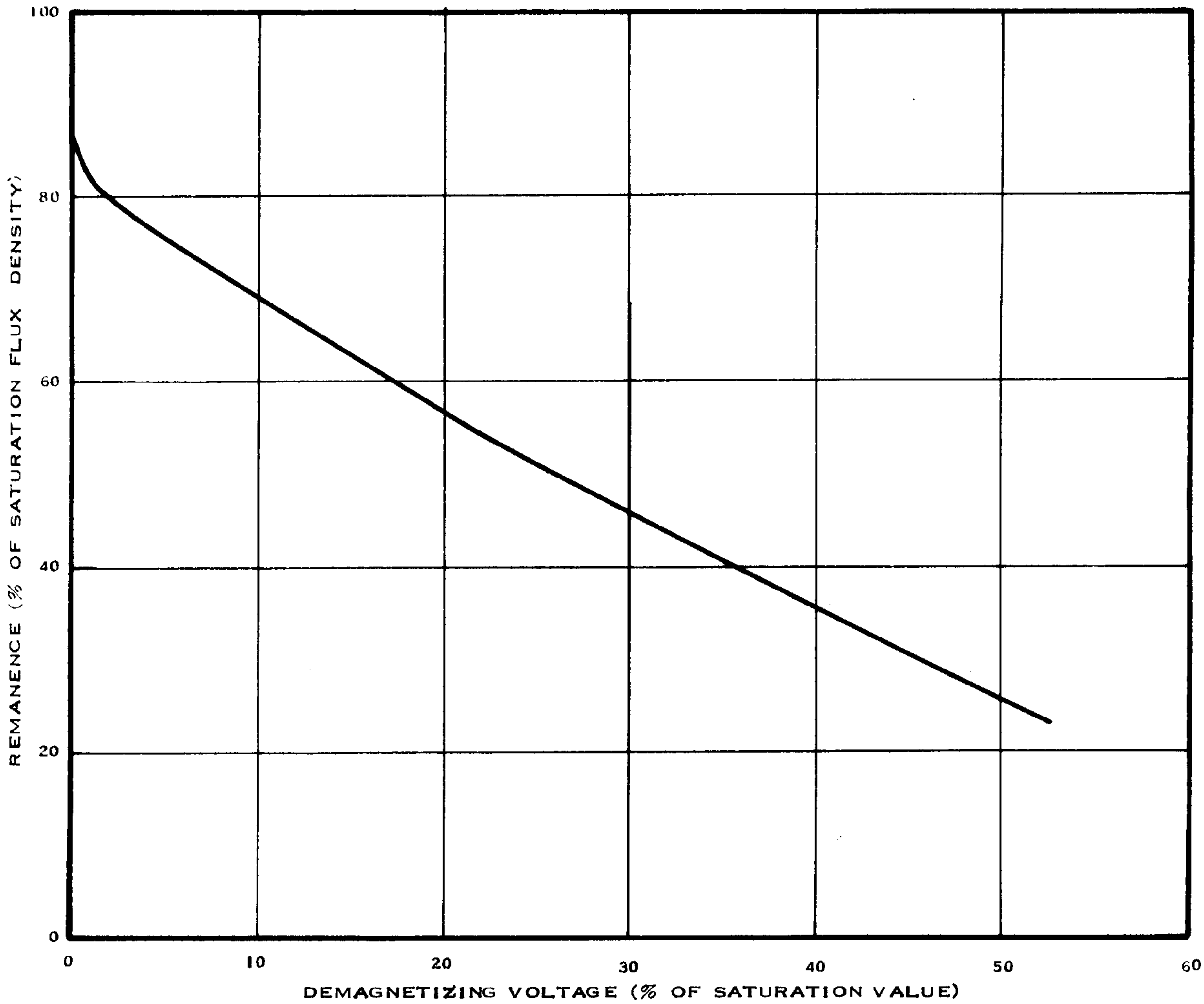

FIGURE 3

TYPICAL DEMAGNETIZATION CHARACTERISTICS FOR GRAIN–ORIENTED SILICON STEEL CORE

129276–RD