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Testing, Gauging and Lifting Curves Characteristic of Current Transformers and Protection Relays

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I - Introduction

The Brazilian electricity transmission system is highly interconnected and tends to expand interconnect, which brings numerous advantages for consumers, such as reliability, continuity, safety and economy. However, to achieve the desired reliability, it is necessary that each of the components of this system function properly, in order to prevent the collapse, and may generate blackouts on a national scale, as seen in October 2012, which affected a large part of states of the North and Northeast regions [1,2]. The size of the system is directly related to its complexity. Thus, with the interconnection characteristic of the Brazilian system, it is impossible for it to be immune to the disturbances that occur frequently, which may result in interruptions in supply and damage to the components that compose it. Given these conditions, protection must be planned in order to receive the information of electrical quantities in real time, to efficiently carry out the decision making for which it is responsible, since the main function of the protection is to ensure the disconnection of the portion of the electrical system subjected to any abnormality that makes it operate outside or part of the intended limits [3]. Therefore, to ensure a proper functioning of the system as a whole, protective equipment such as circuit breakers, TCs, potential transformers (TP) and relays are used. These are responsible for avoiding system failures, which can damage equipment, promoting the rapid restoration of energy, avoiding damage to consumers and providing better quality in the supply of energy to users.

In order for these equipments to fill in their role, that is, to deliver the correct information, acting satisfactorily within their protection zone, they are subjected to tests and tests. In view of the above, this work aims to present the test procedures and tests in TCs and digital relays, aiming to provide access to information and laboratory testing methodology. In addition, this work will present the main normalizations applied in this area, empirically demonstrating the main tests and their ways of measuring these equipments, before they are integrated into the electrical networks.

II – Methodology

2. Magnetization Curve

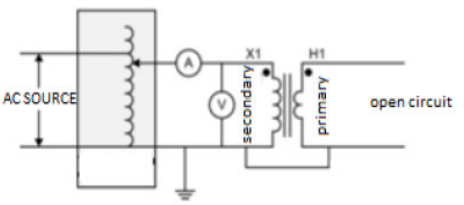
The current in the TC primary is responsible for generating a magnetic flow that circulates through the core and ties the secondary coils, promoting the current circulation in the same.

Thus, as the quantities present in the TC primary increase, there is a corresponding increase in the secondary voltage, due to the increase in magnetic flux. Therefore, there is a greater possibility of saturation [11].

This is due to the flow generated by the excitation current, which is responsible for the reading error in a TC, and that during saturation, presents a very sharp value, since the core is overloaded and requires greater current for maintenance circulating flow.

Therefore, it is necessary to have a greater knowledge about the excitation current, seeking to ensure that the TC does not saturate and thus does not interfere in the correct operation of the protection system. For this, some tests are carried out in order to survey this current.

Thus, with the primary open, a voltage level is injected into the TC secondary and its current is measured until a small increase in voltage generates a large current variation, as illustrated in Figure 1



The test is performed in the secondary, due to the small current value that needs to be applied, since this winding works with a higher voltage level. This situation is preferable, because the limiting factor for this case is the insulation of the equipment, which does not change its size. [12,13].

3. Tests Equipment for Relays

The CE-6006 was used for the relay tests. This is a hexaphasic equipment built for testing the electrical protection system. Because it is portable, it allows testing,
calibrating and measuring the most diverse types of relays, transducers and qualimeters. As for electromechanical relays, the CE-6006 provides high power for high impedance testing without the need for additional hardware.

4. Protection Relay

Relays applied to SEPs have the primary function of identifying and locating faults with the lowest possible error rate. In addition, it should alert the system operator if failures occur and command the performance of protective devices, such as circuit breakers, in order to isolate the defect. Therefore, relays act as sensors, constantly analyzing the operation of the network, and if any disturbance occurs, they are triggered [4].

Relays, over time, have evolved, however, the philosophy of protection remains the same [11]. With this, they must act according to some criteria, such as sensitivity, selectivity and reliability.

Although the goal of the protection is always the same, it is necessary specific relays for each type of equipment. The most relevant for this study are the overcurrent relay and the differential relay.

The overcurrent relay (50/51) acts when passing through it, a current of value greater than its adjustment value. It is an essential protection in all segments of the electrical system.

The differential relay, on the other hand, has as a principle, to compare the input current with the output current of a given equipment. Thus, if the current value found during the comparison is greater than the relay setting current, it will fire by opening the circuit breaker.

In general, it can be observed that relays are responsible for the logic of action, that is, through the information that is sent to their coils, through TCs or TPs, they decide whether or not to send an opening signal for the performance of a circuit breaker [12, 13, 14].

III – Results

1. Tests on TCs

1.1. Magnetization Curve

For the cm survey, the tc secondary feeding was limited to an application of 900 V and 1 A. Figure 2 shows the result obtained by this assay, which shows that the raised CM is within the range established by NBR 6856. In addition, the knee point is given by voltage, which in the face of a 10% increase, results in a 50% increase in current.

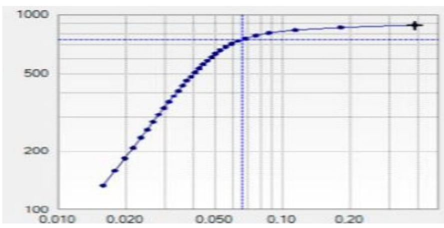


Fig. 2. Magnetization curve lifting

1.2. Winding Resistance

To measure the winding resistance by means of the equipment, the ambient temperature at the time of testing was set in the software. The time has been set to 10s, which is a considerable time for winding resistance to undergo variations. The adjusted parameters are displayed in Figure 3.

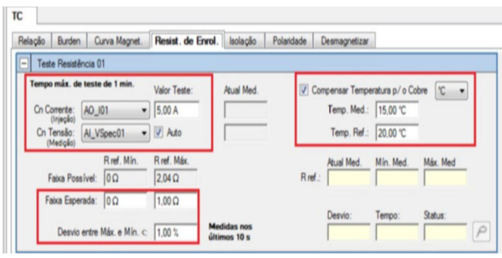


Fig. 3. Adjustments for winding resistance test

According to NBR 6856, the values obtained in this test must be equal to or lower than the limit values provided by the manufacturer [6]. Therefore, it is concluded that the response obtained is within the expected range of.

2. Tests in Relays

2.1. Differential Function

To measure the operation of the SIPROTEC 7UT relay with the differential function, 3 tests are required: configuration test, firing test and search.

The first is necessary to ensure that all parameters are correct, reducing the possibility of failures. The second test evaluates the operation of the relay and its firing time. While the search test, aims to find the pick-up region to define whether it conforms to what has been parameterized.

To adjust the software, you need to know the equipment that must be protected. In this case, the TP, the system TCs and their connection. Tables 3 and 4 show the transformer characteristics of 50 MVA and TCs respectively.

2.1.2. Shooting Test

As the configuration test showed that the parameters were adjusted correctly, the relay is tested. For this, the test points were selected as shown in Figure 10. It is noteworthy that points should not be selected in the region of uncertainty, which is represented by the region in blue.

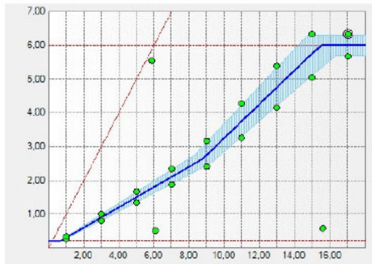


Fig. 3 Test chart Source: From the author, 2019.

For the selected points, table 8 obtained the status of the relay for a fault A-B-C in winding 02, approved or disapproved, as well as the time of operation of the relay. In order to synthesize the table and knowing that it would not compromise its understanding, the values from 1 to 6 were presented.

Table 1: Shooting Test Result

Pto	IRest	IDif	Reg	Acted	tOp Nom	tOp Real	Status
01	6,08 In	0,500 In	NOp.	No	-	-	Ap
02	15,57 In	0,578 In	NOp.	No	-	-	Ap
03	5,88 In	5,55 In	Op.	Yes	0s	25,80 ms	Ap
04	1,00 In	267,9m In	NOp.	No	-	-	Ap
05	1,00 In	333,9m In	Op.	Yes	0s	28,02 ms	Ap
06	3,00 In	0,804 In	NOp.	No	-	-	Ap

For all points exposed, the relay approval is observed, as it is within the tolerances provided by the manufacturer, as shown in Table 8. Thus, in the case of the operating regions and the firing times, the relay performance was acceptable.

IV - Conclusions

This paper presented the main fundamentals on TCs and protection relays, highlighting the overcurrent and differential functions. In addition, it covered in detail the main tests that are performed for the approval of the equipment before placing them in the field. Such tests are of great importance to ensure the good performance of the equipment, since they operate in the SEP and therefore, their poor performance can lead to numerous setbacks for customers and for the energy concessionaire itself.

Thus, the equipment used for these tests was presented and it was proved that, due to the high technology employed, the processes were automated, which allows faster analysis.

Through the above, it is expected to have contributed to those who study the SEPs, showing the importance of performing commissioning tests on protective equipment and performing routine tests, which aim to maintain the integrity of the equipment, ensuring the quality of preventive and predictive maintenance.