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ENGINEERING CONSULTANCY SERVICES

Effect of load on RCD test performance

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Interim Report

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1. Introduction

ERA is currently undertaking field testing of RCDs for the Electrical Safety Council as described in ERA's proposal reference 7EZ060044, ref. 1. This interim report describes tests undertaken in the laboratory at ERA to determine the effects of various domestic loads on the performance of RCDs. This initial task was undertaken so that a decision could be made on whether to isolate loads or leave loads connected during the RCD testing in domestic properties.

2. RCDs tested

In order to provide a performance comparison between various electromechanical, 30mA, Double Pole RCDs, 8 units were chosen from different manufacturers. Throughout this phase of the project, and the subsequent on site testing phase, the manufacturers were identified by code letters. The manufacturers' code letters, current rating and RCD types were as follows:

Sample 1, Manufacturer A, 63A, Type AC

Sample 2, Manufacturer B, 63A, Type AC

Sample 3, Manufacturer C, 63A, Type AC

Sample 4, Manufacturer D, 63A, Type AC

Sample 5, Manufacturer E, 63A, Type AC

Sample 6, Manufacturer F, 63A, Type A (AC plus pulsating DC)

Sample 7, Manufacturer G, 25A, Type AC

Sample 8, Manufacturer H, 25A, Type AC

All of the RCDs chosen were in new condition apart from sample 8 which had been in service.

3. Test Method

The 8 RCDs were mounted in an 8-way consumer unit and connected in parallel so that any one could be switched on to supply the various loads.

A number of loads were considered as possible sources of imbalance between the line and neutral conductors. Many domestic appliances are double insulated and do not have an earth conductor. Others have an earth conductor but do not create an imbalance between line and neutral. The loads which are likely to be present in a domestic property are discussed in more detail in section 5 below.

After considering these issues a combined load was selected which consisted of 3 desktop PCs with CRT monitors and one 3kW immersion heater. These loads, when energised together, created an imbalance

between the live and neutral conductors of 3.6mA measured by clipping an earth leakage current ammeter around both the line and the neutral conductor.

The RCDs were tested with an AVO MEGGER LCB2500/2 LOOP/RCD tester 3 times at 1In for a positive fault and 3 times for a negative fault. The procedure was then repeated at 5In. From the measured trip times, the averages for each test condition were calculated.

Initially each RCD was tested with no load to provide a reference for comparison when loaded. The tests were then repeated with all the loads energised. A single line circuit diagram for the test arrangement is shown in figure 1.

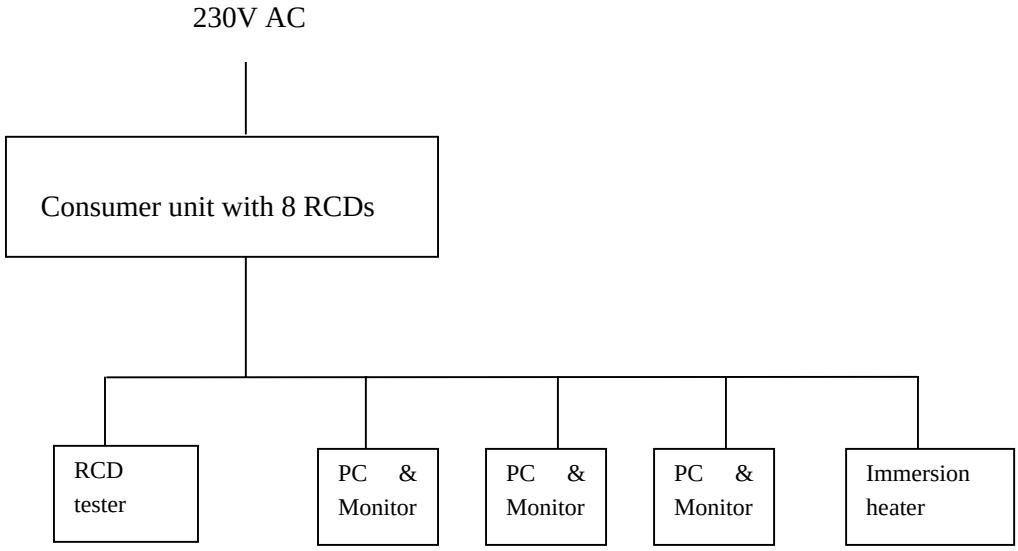

Figure 1: Test arrangement

4. Results

The test results are listed in the following tables:

Table 1: RCD tripping times with no load POW: Point On Wave.

Test current	1In 30mA	POW	O°				18O°			
			Test 1	Test 2	Test 3	Average	Test 1	Test 2	Test 3	Average
Make	Type	Rating A	ms	ms	ms	ms	ms	ms	ms	ms
A	AC	63	19.8	19.2	19.2	19.4	29.6	29.6	29.3	29.5
B	AC	63	29.2	29.8	29.7	29.6	19.0	19.0	19.5	19.2
C	AC	63	34.9	34.9	34.4	34.7	26.6	26.5	26.5	26.5
D	AC	63	18.2	18.9	18.9	18.7	18.4	9.5	18.8	15.7
E	AC	63	17.8	18.1	18.2	18.0	18.0	17.9	17.4	17.8
F	A	63	38.6	38.6	38.6	38.6	28.5	28.5	29.0	28.7
G	AC	25	28.6	28.3	27.8	28.2	17.5	17.5	18.0	17.7
H	AC	25	29.5	29.5	29.0	29.3	18.8	19.3	18.9	19.0
Test Current	5In 150mA	POW	O°				18O°			
			Test 1	Test 2	Test 3	Average	Test 1	Test 2	Test 3	Average
Make	Type	Rating A	ms	ms	ms	ms	ms	ms	ms	ms
A	AC	63	17.8	17.8	17.7	17.8	27.5	27.7	26.9	27.4
B	AC	63	7.1	6.8	6.4	6.8	16.4	16.7	16.8	16.6
C	AC	63	12.4	12.7	12.6	12.6	7.2	7.2	6.8	7.1
D	AC	63	16.4	6.9	16.3	13.2	7.1	16.3	7.0	10.1
E	AC	63	9.1	8.0	8.5	8.5	8.5	8.6	8.2	8.4
F	A	63	19.0	18.2	19.0	18.7	28.3	29.0	29.0	28.8
G	AC	25	5.8	5.4	5.4	5.5	15.3	15.7	15.8	15.6
H	AC	25	6.6	6.8	6.6	6.7	16.3	16.7	16.2	16.4

Table 2: RCD tripping times with 3.6mA imbalance between live and neutral

Test Current	1In 30mA	POW	O°				18O°			
			Test 1	Test 2	Test 3	Average	Test 1	Test 2	Test 3	Average
Make	Type	Rating A	ms	ms	ms	ms	ms	ms	ms	ms
A	AC	63	19.6	19.7	19.7	19.7	29.3	29.0	29.4	29.2
B	AC	63	9.5	9.6	9.8	9.6	19.4	18.8	19.2	19.1
C	AC	63	39.0	39.0	38.5	38.8	28.4	28.5	28.9	28.6
D	AC	63	9.2	18.7	9.3	12.4	18.8	19.2	19.2	19.1
E	AC	63	19.2	18.6	19.0	18.9	18.8	18.3	18.8	18.6
F	A	63	39.0	39.0	39.0	39.0	28.8	28.8	29.0	28.9
G	AC	25	28.9	28.8	28.8	28.8	18.3	18.6	18.7	18.5
H	AC	25	9.5	9.1	9.1	9.2	19.0	19.2	18.6	18.9
Test Current	5In 150mA	POW	O°				18O°			
			Test 1	Test 2	Test 3	Average	Test 1	Test 2	Test 3	Average
Make	Type	Rating A	ms	ms	ms	ms	ms	ms	ms	ms
A	AC	63	18.8	18.6	18.2	18.5	28.5	28.6	28.3	28.5
B	AC	63	8.9	8.7	9.1	8.9	18.6	18.3	18.6	18.5
C	AC	63	18.6	18.9	19.0	18.8	8.6	8.3	8.3	8.4
D	AC	63	8.7	8.1	8.8	8.5	8.8	18.2	8.3	11.8
E	AC	63	9.0	8.9	9.0	9.0	8.7	8.9	9.0	8.9
F	A	63	18.5	19.0	19.0	18.8	28.5	29.0	28.7	28.7
G	AC	25	8.7	8.7	8.6	8.7	18.5	18.2	18.0	18.2
H	AC	25	8.7	8.7	8.6	8.7	18.2	18.8	18.6	18.5
V	231V									
I	13.3A									

5. Discussion

5.1 Sources of leakage currents in domestic properties

The on-site RCD testing in the second phase of the project is being conducted in domestic properties owned by Housing Associations, Local Housing Authorities and a Student Accommodation Authority. ERA's engineers are testing during the day at times when the power circuits are likely to be lightly loaded. However there is a risk that energised electrical equipment in the domestic properties may generate leakage currents causing an imbalance between the line and neutral currents which will affect the results of the RCD tests.

Leakage currents can be generated by EMC filter safety capacitors, designated as class Y to IEC60384-14, fitted between line/neutral and earth in class 1 (earthed equipment) consumer appliances to suppress common mode electrical noise. Older equipment, which used linear power supplies, did not need these capacitors as the conducted emissions were low. However, switch mode power supplies have become much more common to increase power conversion efficiency, and these devices can potentially generate high levels of common mode noise unless suppressed with common mode filter capacitors. Typically, if the power consumption of the equipment is in excess of 25 W there is the potential that these EMC filter capacitors may be present.

The maximum leakage current that is permitted per appliance is set by the safety standards. For portable consumer equipment this is BS EN 60950. This standard specifies a maximum touch current (this equates to leakage current) of 3.5 mA peak for moveable non handheld equipment. Handheld equipment has a maximum touch current of 0.75 mA peak. In practice the maximum capacitor value that is usually used is 4.7 nF which, when excited by the 230 V rms mains voltage, gives a leakage current of approximately 0.5 mA peak, thus meeting the handheld touch current limit with a tolerance margin. High power moveable appliances can have larger capacitor values to result in the higher, 3.5 mA, peak touch current.

The International Electrotechnical Commission (IEC) recommends that the standing leakage current should not exceed 30% of the RCCB rating i.e. 10 mA for a 30 mA device. One major reason is that an RCCB with a 30 mA trip rating may trip anywhere between 15 and 30 mA due to component tolerances. Clearly this restricts the number of connected appliances that draw 3.5 mA peak leakage current to about three and handheld appliances drawing 0.75 mA peak leakage current to about 15.

Many modern appliances are class 2 i.e. they only have a live and neutral connection and do not have an earth connection so they cannot generate an earth leakage current as part of normal operation. They use double or reinforced insulation to protect the user from dangerous voltage. The largest number of home appliances: most Hi-Fi equipment, portable CD players/radios, mobile phone and camera chargers, plug-in lamps, electric blankets, games consoles, set top boxes, computer peripherals, food processors, video and DVD recorders/players, small televisions and DIY tools fall in this category. Gardening power tools also tend to be class 2 for safety reasons.

Potential class 1 earthed devices include home personal computers, PCs, (a home could have more than one), washing machines, tumble dryers, dish washers, fridges and freezers, microwaves, large television sets, electric heaters, immersion water heaters (often a high leakage device), heating boilers, electric showers, alarm systems, bread makers, electric pianos, toasters and irons. Of these, devices such as toasters and irons are simple heating devices and would not use Y class capacitors to earth unless electronic power control had been added to them. The immersion heater can be a moderate leakage device due to the wire wound heating element being tightly enclosed in a metal case creating a high winding to earth capacitance. Other potential moderate leakage (3.5 mA peak) devices are those that use thyristor motor control e.g. a washing machine, due to the levels of electrical noise such controls create, PCs due to the high power switch mode PSU that is used, and other devices using enclosed motors e.g. fridges, due to winding to earth capacitance.

5.2 Effect of background leakage current on RCD performance

The domestic properties where ERA is carrying out the RCD tests are classed as social housing and have relatively low levels of electricity usage, particularly during the day when ERA's tests are being carried out. The test circuit shown in figure 1 was chosen to generate a level of leakage current which might be encountered in such properties.

The results in Tables 1 and 2 show that for the majority of RCDs tested there was no difference in the operating times of the RCDs with and without the 3.6mA background leakage current. However for three RCDs, B, D and H, the RCD operated in the first half cycle with the leakage current rather than the third half cycle without the leakage current (i.e. within 10mS instead of 30mS).

6. Conclusion and Recommendations

The presence of leakage currents from electrical equipment in the domestic properties where ERA is testing could have an effect on the operating times of the RCDs.

For the RCD reliability testing in Task C of the project all circuits controlled by the RCD, except the circuit being used for the test, should be de-energised. Checks should be made to ensure that any equipment on the energised circuit likely to produce leakage current, such as PCs and washing machines, is switched off before the RCD is tested.

7. Reference

1 In-service reliability of RCDs, Phase 2 RCD testing, ERA Proposal EZ060044, Nov 2006