UNRESTRICTED REPORT

Prepared for:
VPhase

Appliance Energy-Saving Test Report

Author: D. Siddorns

Project No: 83620
Report No: 6526 Issue 2

June 2012

Project No: 83620

Appliance Energy-Saving Test Report

EA Technology Limited, Capenhurst Technology Park, Capenhurst, Chester, CH1 6ES; Tel: 0151 339 4181 Fax: 0151 347 2404
http://www.eatechnology.com
Registered in England number 2566313

Appliance Energy-Saving Test Report

by

D. Siddorns

Summary

This report details the tests that were undertaken for VPhase, to determine the energy-saving brought about through the application of the VX1 Voltage Optimisation system to domestic appliances.

This report states the conditions and methodology employed for the tests, equipment used and details of the appliances tested. Energy-savings for each appliance, as well as the overall energy-saving for the basket of appliances are presented.

Contents

1 Introduction

1.1 Reason for tests

VPhase commissioned EA Technology to run a series of tests using the VX1 Voltage Optimisation systen, on a selection of domestic appliances that would be typically found in a modern domestic property. The tests were designed to determine the level of energy-saving for each appliance.

The tests were organised so that the appliances would be operated first without the VX1, at 245 V and then with the VX1 in-circuit. The VX1 regulates the output voltage to 220 V. The difference in energy-consumption between the tests would then demonstrate the energy savings possible by application of the VX1.

1.2 What was done

The appliances supplied by VPhase, were arranged in an indoor room where the room temperature and supply voltage was controlled. The test-room has a ring main of power outlet sockets around the perimeter of the room. The appliances were plugged in using their normal power leads.

To measure the electrical energy consumed, 'Plogg' Class 0.5 metering devices were inserted in series with each appliance. The Plogg was also used as a timer, which could be programmed to switch the supply on and off to each appliance as required, to achieve exact operating durations for each appliance.

2 Methodology

2.1 Control of conditions

General

A number of calibration tests were carried out at 245 V with environmental parameters held constant, to confirm the chosen test regime, provide data with which to determine run-times for appliances and to determine the test-to-test accuracy for each appliance. The test-to-test accuracy provides a determination of the accuracy of the appliance energy-savings. This is determined by taking the set of energy-consumption readings from the calibration tests, calculating the standard-deviation of the set and applying the following formula to calculate the Confidence Intervl (CI)

$$= \pm \frac{ts}{\sqrt{n}}$$

where s is the standard deviation, n is the number of tests and t is a table value chosen according to the Confidence Level (CL). The CL was set-to 95%. CIs were calculated on the basis of a comparison between a single test at 245 V and a single test at 220 V. Thus the number of tests was set-to two.

Details of all equipment used for the tests are presented in Section 3.2. Further details of the calibration tests and CIs can be supplied on request.

Voltage

Voltage was controlled using a variable-voltage power supply with set-point. At the beginning of each test, the voltage set-point was checked to ensure that 245 V was being supplied. For the 245 V tests, the supply was directly-connected to the ring-main supplying the appliances. For the VX1 tests, the 245 V supply was used to feed the VX1 and the output of the VX1 (220 V) was connected to the ring-main supplying the appliances. The voltage to each appliance was monitored to ensure that the VX1 and supply were correctly connected.

Air temperature

The air temperature of the test room was kept at a stable 20^0C throughout the tests.

Water temperature

Dishwashers and washing machines heat water to a set-point temperature. To ensure repeatable and reliable calculation of the energy-saving, the incoming cold water temperature should not change during the tests. Whilst the ideal condition would be to have a reservoir of water controlled to the correct temperature, this was not available for the tests. To provide control, water was drained at the start of each test to remove any standing water and until the temperature of the flow had ceased changing. For the tests presented, water-temperatures were 13.6°C (245 V) and 13.3°C (220 V).

Water used to fill the kettle was drawn from a number of vessels which were left standing in the room, so that they had assumed the room temperature. This was verified using a thermocouple.

Duration of appliance test periods

Each type of appliance was run on its own time schedule during the test, and repeated for each subsequent test (see Results table). Most appliances were operated according to time-schedules, but for some some appliances a fixed number of cycles was used (e.g. the kettle).

2.2 Operation of appliances

Operating Appliances in a ‘Reasonable’ Manner

To produce a credible testing regime, it is necessary for each appliance to be operated in a manner similar to typical use. To provide an overview of how much energy is saved on an annual basis for a home, it is necessary to relate the run-times and cycles-of-use of each appliance to annual totals. A previous assignment for VPhase, delivered by EA Technology, determined the typical annual energy consumptions of different appliances on a average basis for the UK.

These were converted into the equivalent daily run-times or cycles-of-use for the appliances supplied by VPhase, according to data from the calibration tests. In some cases the run-times for the supplied appliances were greater than 24 hours. In these cases, multiple appliances of the same type were operated at the same time, to ensure that the daily energy-consumption required from each appliance was met within the test-time available.

This applied to LED bulbs, the fridges and others. Quantities are detailed in Section 4. Further details about the operation of the appliances are presented below.

One test of each appliance was conducted at each voltage level.

Boiler Pump

A central heating boiler-pump was used, mounted on the top of a supply tank in it's own closed-circuit with both inlet and outlet pipes to and from the tank. The fluid circuit had been designed by VPhase to load the pump. Operation of the pump was enabled and disabled by the timer within the Plogg to ensure an exact run-time.

Kettle

The kettle was filled using the same measured amount of room-temperature fresh water for each cycle of each test. It was ensured that the same amount of water was used for each cycle by measuring the mass of the kettle on scales (kettle plus a fill of water = 2.28 kg ± 0.01kg).

The kettle was switched-on manually and switched-off automatically by it's own cutout for each test. The boiled water was disposed each time.

Microwave

Several potatoes were selected for cooking, to a mass >0.6kg and trimmed to weigh 0.60 kg ± 0.01kg. Power was made available to the microwave by via a Plogg. Since the built-in cooking timer had been found to be rather innaccurate, a Plogg was used to ensure that the potatoes were cooked for exactly 15 minutes at full-power.

The core temperature of the largest potato, one from each test, was taken using a thermometer probe after the cooking time was completed. For the tests completed, these temperatures were 97.1°C (245 V) and 97.3°C (220 V).

A fresh batch of potatoes were used for each test.

Lighting

The types of lighting used were several GLS bulbs drawing 224 W, 2x50 W halogen spotlights drawing 102 W, a selection of CFLs drawing 78 W, two fluorescent tubes drawing 96 W and three LEDs drawing a total of 4 W.

The selected types of lighting and numbers of bulbs were set up in a bench-mounted rig specially built to house all the lights in a safe open top enclosure. This allowed the lights to be exposed to the controlled temperature of the room.

Power to the lighting rig was controlled by a single Plogg, used to ensure an exact run-time. No measurement of luminous efficacy was made.

Computing equipment

A desktop computer, monitor and laptop were set up on a bench top in the test room. Each appliance had its own Plogg which allowed power to be made available to each appliance. As the equipment needed manual intervention, the Plogg was set to apply and remove power to the equipment at fixed times. The technician operating the appliances switched the equipment on at a specified time.

The Laptop was turned on prior to each test period to ensure the battery was fully charged at the start of each test.

Cold appliances

To provide a load, simulated standard loads at room temperature were put in to the larder refrigerators and upright freezer prior to the start of each test. Two refrigerators and one freezer were used.

A hand held digital thermometer with thermocouple was placed in to the middle shelf of the refrigerator before each test began. Each appliance would them be switched on via it's own Plogg at the desired time to start the test. At the same time part-way through each test, the temperature was noted from the digital thermometer. It was then removed from the refrigerater and placed in to the middle draw of the freezer. This temperature was also noted prior to the end of the test.

The temperatures recorded for the tests presented were -21.6°C (245 V) and -23.9°C (220 V) for the freezer, 5.8°C (245 V) and 6.0°C (220 V) for the refrigerator (temperature was only recorded for one of the refrigerators).

Wet appliances

The washing machine and dishwasher were supplied with cold water from a manifold connected to the mains supply located in the test room. Prior to the operation of the washing machine and dishwasher, the cold water mains was run off until the supply temperature to each machine was stable, as described in Section 2.

Prior to each cycle of the washing machine and tumble drier, the clothes used to wash and dry were weighed. The washing machine and the tumble drier were set to a 40^0C wash cycle and 40-minute drying period at the high heat setting repectively for each test.

The dishwasher was set to Programme 6 ("3 in 1") setting for each test.

Power to all three wet-appliances was made available through Ploggs. The tumble-dryer internal timer was not found to be accurate, so a Plogg was used to create an exact run-time of 35 minutes.

The weights of the clothes put into the washing machine were 4.65 kg (245 V) and 4.60 kg (220V) ±0.01 kg respectively for each test. These weighed 4.63 kg and 4.63 kg ±0.01 kg respectively when placed into the tumble-dryer. On exit from the dryer they weighed 3.94 kg (245V) and 4.05 kg (220 V) ±0.01 kg i.e. they were 16% less-dry at 220 V.

Consumer electronics

The televisions (TV's), Set Top Box (STB), Personal Video Recorder (PVR), DVD player, games console and Power Supply Units (PSUs) were mounted on a bench-top in the test room. Power to the TV's, STB, PVR and DVD player was enabled through one Plogg to provide an exact run-time.

Power to the games console and PSUs were enabled by their own individual Ploggs, also by timer.

3 Equipment Used for the Tests

3.1 Appliances

Table 1 presents details of the appliances used for the tests and their power ratings, as determined during calibration tests.

Table 1: Appliance Details

Category	Devices in category	Make	Model	Power (W)	Energy Performance Rating (if available)
Boiler pumps	Boiler pumps	Wilo	Gold RS50	71	
Food preparation devices	Kettle	Proline	PJK3	3000	
	Microwave	Prestige	KS20	1300	
Lighting	GLS	ASDA	Pearl BC/B22	224	
	Halogen	Pluslite	GU10+C	102	
	CFL	Electronic	Flez0TBXT3/827	78	
	Fluorescent (a)	Wattmiser	F28W2D1835	96	
	Fluorescent (b)	Crompton	F58T8/White		
	3 x LED	Pluslite	GU10LED W	4	
Computing Equipment	Desktop	Acer Power	S285	66	
	Laptop	HP-Compaq	6735s	22	
	Monitor	IBM	9512-ABO	26	
Cold appliances	Upright freezer	Proline	PFZ115WA	59	A
	2 x Refrigerator	Proline	PLF140W	42	B
Wet appliances	Washing machine	Beko	WMA 510W	1200	
	Dishwasher	Proline	Logic	1200	
	Tumble-dryer	Hotpoint	TVM570 (UK)	1500	
Consumer Electronics	2 x TV	Daewoo	14CB 2TP	94	
	STB	Panasonic DV3	TU-CT20		
	PVR	Inverto	IDL-7000		
	DVD	Nikkai	A32JC		
	Games consoles	Sony Playstation 2	SCPH-39003	27	
	4 x Power supply units	Uniross	C0152020-8-3	32	

3.2 Equipment used for the tests

A. The appliances were located in a test room known as the “Indoor Temperature room” where the electrical power was fed via a ring main, from a “Watford Controls” stabilised power supply, type EMS21EOH-1P-R25 X2968 Input -11%+11% Output 230V +/- 0.5% (set-point was adjustable). This was located approximately 10m from the test room.

B. Electrical power to each appliance was supplied from the ring-main in the test room through individual wall sockets via Ploggs. The Ploggs monitored and recorded the supply voltage and the energy used by that appliance throughout each test. Ploggs are Class 0.5 meters (accurate to within ±0.5%) that were set to record voltage and accumulated energy-consumption at 1-minute periods.

C. The air temperature of the “Indoor Temperature Room” was controlled by 2 x Delchi air-conditioning units located in the Environmental Chamber adjacent to the test room, with the addition of a fan to aid the circulation of air through 2 vent slots in the adjoining wall.

D. The air temperature of the “Indoor Temperature Room” was monitored using a Telemetry type Squirrel logger (Type RX250EAT) using 2 x temperature transmitters (GC-05) located in mid position around the room.

E. The cold water feed temperature to the dishwasher and washing machine was measured using a further temperature transmitter (GS-34), equipped with a thermistor bonded to the copper water supply pipe in the test room.

F. Temperatures (of the water used for filling the kettle, the fridges and freezers, and the potatoes) were obtained by an Oakton Temp 6 RTD Thermometer.

G. The mass of water used to fill the kettle and the mass of washing were measured using an Avery 3359 Digital Scales range 0 – 30 kg.

4 Results

Table 2 presents the results of the tests in terms of the energy consumed and saved, together with the estimated accuracy of the tests.

Table 2: Results Table

Category	Devices in category	Energy at 245 V (kWh)	Energy at 220 V (kWh)	Energy Saving (%)	CI (+/-)	Runtime (Hr:Min)	Cycles
Boiler pumps	Boiler pumps	1.307	1.106	15%	0.1%	18:07	
Other food preparation devices	Kettle	0.671	0.682	-2%	0.4%		4
	Microwave	0.312	0.276	11%	0.5%		1
Lighting	GLS	1.057	0.916	13%	0.1%	4:41	
	Halogen	0.690	0.597	13%	0.1%	6:43	
	CFL	0.322	0.279	13%	0.1%	4:06	
	Fluorescent	0.208	0.173	17%	0.2%	2:08	
	LED	0.023	0.020	13%	0.1%	6:43	
Computing Equipment	Desktop	0.620	0.609	2%	0.1%	8:46	
	Laptop	0.104	0.104	0%	0.9%	4:49	
	Monitor	0.227	0.228	-1%	0.6%	8:32	
Cold appliances	Upright freezer	1.086	0.900	8%	5.0%	20:00	
	2 x Refrigerator	0.889	0.771	13%	18.3%	21:51	
Wet appliances	Washing machine	0.763	0.755	1%	1.6%		2
	Dishwasher	0.689	0.693	-1%	0.6%		1
	Tumble-dryer	0.684	0.563	18%	0.6%		1
Consumer Electronics	2xTV,STB,PVR & DVD	2.162	2.123	2%	0.0%	23:00	
	Games consoles	0.090	0.091	0%	0.4%	3:00	
	Power supply units	0.717	0.563	21%	0.1%	22:00	
Totals		12.619	11.545	8.5%	0.4%		

Table 2 shows that a reasonable level of accuracy was reached for the determination of individual appliance energy-saving, with the exception of the refrigerators and freezer. Options for improving the accuracy for these devices would include the use of multiple tests to yield an average energy-consumption for each voltage level, increased observation of temperature and electrical load so that a fixed number of compressor cycles could be used in the test period and/or increased run-times to create the same effect as a number of discrete tests.

The overall accuracy of the 8.5% energy-saving for the basket of appliances is ±0.4%. This was determined in the same manner as for the individual appliances listed above.

EA Technology Limited
Capenhurst Technology Park
Capenhurst, Chester UK
CH1 6ES

tel +44 (0) 151 339 4181
fax +44 (0) 151 347 2404
email sales@eatechnology.com
web www.eatechnology.com

Delivering Innovation in **Power Engineering**