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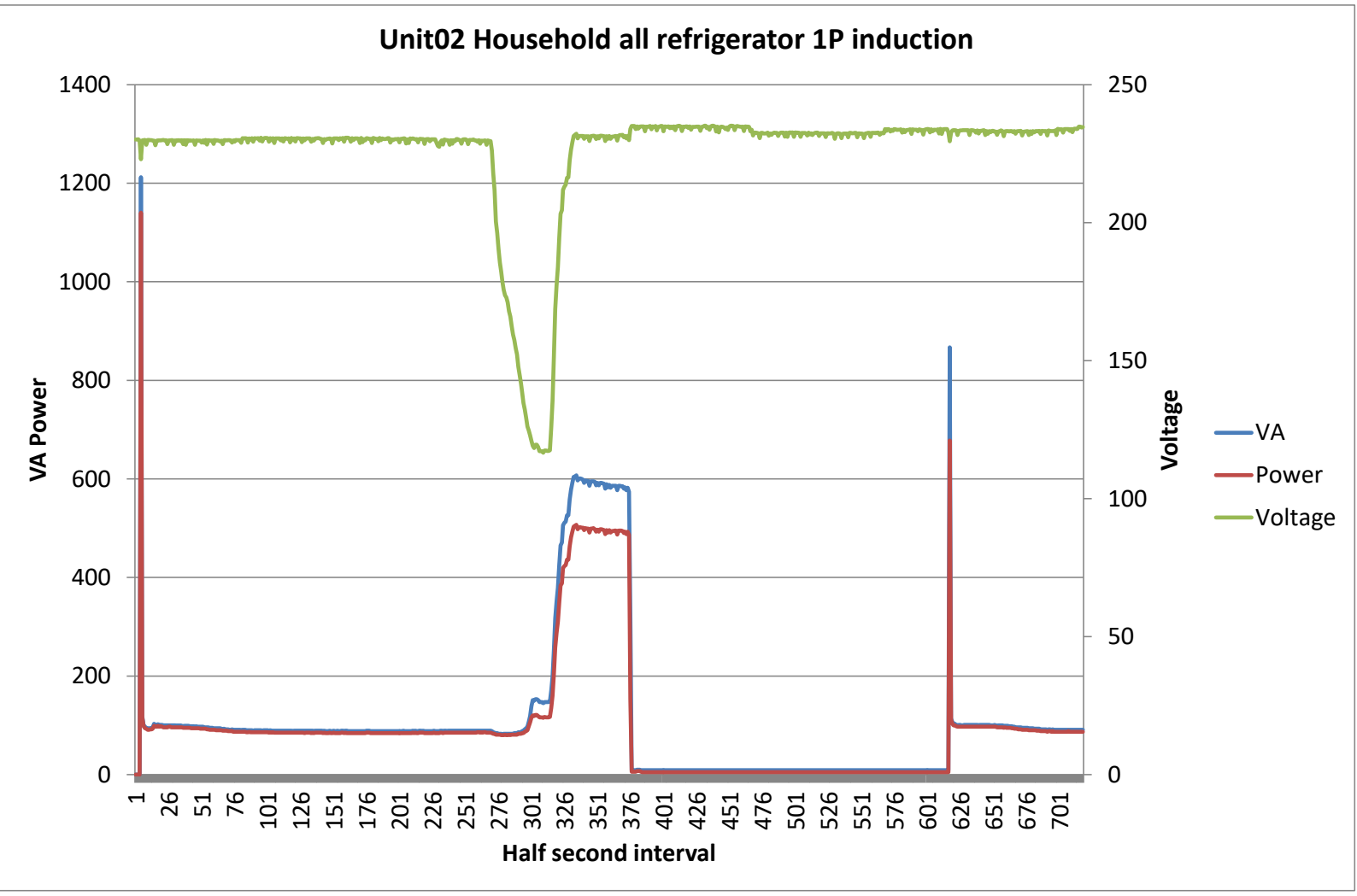
Final Report

Prepared for:

AEMO

Results of low voltage stall measurements on single phase induction motors and inverter systems



Prepared by Energy Efficient Strategies

Results of low voltage stall measurements on single phase induction motors and inverter systems

Report prepared for:
Australian Energy Market Operator

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Results of low voltage stall measurements on single phase Motor D and inverter systems

Background

This report provides some detailed analysis of the field measurements conducted on a range of household and commercial refrigerators as part of a larger AEMO project to better understand the composition of single phase induction motors used in refrigeration and air conditioners in the NEM. The objective of that project is to quantify the make-up of the load to allow better modelling of motor behaviour under fault and low voltage conditions. The main report from that project is titled *Single Phase Induction Motor Loads on the NEM from Refrigeration and Air Conditioners* (June 2020) and this should be consulted to better understand the context of this work.

AEMO is seeking information on the typical load type by region in order to model the behaviour of the grid during power system disturbances. The main focus of that study is to quantify typical loads from the so called “Motor D” category, which is made up of single-phase induction motors, primarily used in air conditioners and small refrigeration systems. Quantification of so called “Electronic Loads” is also desirable, which are made up of power electronic (inverter-based or electronically coupled) motor driven load components.

To provide a deeper insight into product behaviour under low voltage conditions, a series of single phase household refrigeration and commercial refrigeration systems were measured during operation to quantify their behaviour during low voltage conditions. This included 14 household refrigeration products, 27 commercial display refrigerators and 1 inverter driven pool pump.

Approach and equipment

In order to get a representative sample of products in use, the author recruited product owners from several sources in order to get access to products. The main sources of products measured were:

- Household refrigerators and freezers in private households (13)
- Household freezers in commercial premises (1)
- Commercial refrigerators and freezers in several commercial food operations (6)
- Commercial refrigerators and freezers on display in a commercial kitchen showroom (22)(mix of new and second hand products)
- One inverter driven pool pump in a private household
- One additional commercial refrigerator in a commercial food operation was measured but a valid result regarding motor protection could not be obtained due to electrical overload.

Owners generally allowed access to their products for measurement on a voluntary basis. The exception was the commercial kitchen showroom, where a fee was paid to access and measure the characteristics of products on display.

While these tests were not conducted in a laboratory setting, high quality measurement equipment was used. Energy measurements were recorded on a Yokogawa WT200 digital power analyser, which was connected via a GPIB interface to a laptop. Data was recorded at 0.5 sec intervals. A single phase variac was used to vary the supply voltage to the equipment during testing. Changes in supply voltage to the appliance only was recorded by the Yokogawa instrument.

The data fields recorded by the test equipment were:

- Date and time of measurement
- Voltage (RMS) (V)
- Current (RMS) (A)
- Active power (W)

- Reactive power (VAR)
- Apparent power (VA)
- Power factor
- Phase angle (degrees)
- Voltage peak value (V)
- Current peak value (A)
- Frequency (Hz)(mains).

Data was recorded at 0.5 sec intervals was written to a CSV format text file on a laptop. This was then later loaded into Excel for more detailed analysis. All raw data measurements have been provided in a separate Excel file with some tools to analyse and chart the data for each product, together with a detailed summary and field notes. Only a summary of the data and key findings is included in this report.

The following “test method” was discussed and agreed with Filip Brnadic of AEMO prior to conducting field measurements:

- Continuously record power, voltage, power factor and current (0.5 sec) throughout
- Start the unit at normal voltage and let it run to stabilise (approximately 2 to 3 minutes)
- Wind down the voltage to identify the stall voltage (thermal overload) or disconnect voltage (digital controllers) fairly quickly (over around 10 sec or less, down to around 140V or less) to identify the point where the unit stops (disconnects or stalls)
- Wait for up to 5 secs at stall/disconnect voltage, then quickly increase the voltage back to 230V nominal (over a sec or so)
- Leave to operate until:
    - 1) thermal overload trips then the product restarts normally, OR
    - 2) digital controller or inverter control restarts the unit.
- Once restarted, operate for around 1 min or more to establish that normal operation has resumed.

When operating through a GPIB serial interface, the Yokogawa software locks the meter auto-ranging function for voltage and current on the meter. A voltage range of 600V was selected and a current range of 5A was selected for household appliances and 10A for commercial appliances (a couple of larger commercial products required the 20A range to be selected). Care was taken not to reconnect power too quickly to an appliance once it been stopped as the refrigeration back pressure on the compressor could lead to additional stalling or possible damage.

The format of the data is effectively CSV (comma delimited) with a sample shown below:
Date of measurement, Time of measurement, Voltage, Current, Power, VA, VAR, PF, deg, Vpk, Apk, Frequency, Math,
13/06/2020,4:52:13 PM,231.1,0.069,4,16,15,0.255,75.2,-323,-1.42,50.01,No Data
13/06/2020,4:52:13 PM,231.2,0.026,4,6,4,0.67,47.9,-323,-0.08,50.01,No Data
13/06/2020,4:52:14 PM,231.2,0.027,4,6,5,0.687,46.6,-323,-0.09,50.02,No Data
13/06/2020,4:52:14 PM,225.4,4.666,993,1052,347,0.944,19.3,-316,7.13,50.03,No Data
13/06/2020,4:52:15 PM,225.2,4.716,1005,1062,343,0.946,18.9,-316,-7.01,50.02,No Data
13/06/2020,4:52:15 PM,228.9,1.356,286,310,121,0.921,22.9,-321,-3.58,50.03,No Data
13/06/2020,4:52:16 PM,230.1,0.905,184,208,98,0.883,27.9,-321,-1.35,50.03,No Data

The first row in each data block is the identification of the fields measured. Note the last field is a maths function that can be used to perform specific calculations during data recording (such as crest factor), but this was not configured for these tests. The time field only shows hh:mm:ss so there are two readings for each time stamp as the data recording interval was 0.5 sec.

A picture of the equipment used is shown in Figure 1.

Figure 1: Equipment used to measure electrical characteristics at low voltage

During measurements, the data recording was always started without the appliance connected so that the starting characteristics and exact start time were captured. This usually showed power of 0W plus an error for power factor and voltage angle. Occasionally during a compressor start the current range was exceeded, which shows “over range” in the raw data (usually for just one record). Two large commercial refrigeration products drew over 10A under low voltage conditions and blew a protection fuse in the variac. In one of these cases the data on the compressor protection was still usable. In the other case the data recording stopped before the compressor protection was activated so no valid data was obtained.

Where thermal overload protection for a motor is activated when the motor stalls at low voltage, it was sometimes difficult to ascertain exactly when the motor stopped rotating from the electrical characteristics alone. Typically the power consumed by the thermal overload protection when the motor stalled at low voltage was similar to the compressor operating power just before it stalled. Power factor was the most useful parameter to examine in this case. If the motor was stalled, the power consumed at the nominal supply voltage (230V) was typically more than five times the normal compressor operating power, so adjusting the voltage back to nominal provided the best indicator of whether the motor was stalled or not.

The readings in this report cover all of the appliances in the draft main report and many other appliances as well, so this report should be referenced as the most accurate source of data.

High level results

When subjected to low supply voltage levels (typically through a supply side disturbance) single phase motors in refrigeration systems can stall if the voltage dip is low enough and long enough and if there is significant load on the motor. However, depending on the product design and configuration, there are several possible outcomes from a low voltage event. Based on the field measurements collected for this project, there are three main cases that were documented:

1. The motor stalls: as the voltage drops to low levels, there is insufficient power available to keep the motor operating and it stalls and thermal overload protection is activated.
2. Control equipment disconnects the motor: as the voltage drops, the system controller senses the low voltage and/or motor operating condition and disconnects it before it stalls.
3. For inverter or electronically controlled equipment: the motor power adjusts to the voltage conditions and continues to operate through the disturbance (may disconnect at low V).

For the 43 products measured for this project, Table 1 summarises the key results.

Table 1: Overview of results of single phase motors subjected to low voltage conditions

Sector	Count	On power W	On Power Factor	Stall/ disconnect V	Protection	Stall Power at 230V	Stall Power Factor	Stall time sec	Off time to restart sec	Ratio Stall P to Operating Power
Household	9	98.4	0.80	112.1	Thermal	796.2	0.84	23.9	106.3	8.2
Household	5	117.2	0.76	18.2	No stall	#N/A	#N/A	#N/A	#N/A	#N/A
Household	1*	152.0	0.64	155.0	Disconnect	#N/A	#N/A	#N/A	11.0	#N/A
Commercial	8	304.1	0.62	113.1	Thermal	1736.6	0.88	15.4	60.6	7.3
Commercial	3	460.0	0.77	25.3	No stall	#N/A	#N/A	#N/A	#N/A	#N/A
Commercial	16	445.0	0.66	102.6	Disconnect	#N/A	#N/A	#N/A	112.6	#N/A

Notes: Measurements by the author, supply voltage to the appliance adjusted via a variac; power, voltage and power factor measured using a Yokogawa WT200. Household/Thermal were typical refrigerators with single speed compressors. Household/No Stall were inverter driven household refrigerators. Household unit marked * is an inverter driven pool pump. Commercial/Thermal were typical refrigeration units with single speed compressors. Commercial/Disconnect were typical commercial refrigerators with single speed compressors where the digital controller disconnected the compressor in low voltage conditions. Commercial/No Stall were units that appeared to be able to operate through very low voltage conditions without stalling. It is unclear how this was achieved. Where the motor stalled, the stall power was typically found to be 7 to 8 times the normal operating power (equivalent to the motor start in-rush current)(varied from 2 to 13 times).

Household refrigerators

All household refrigerators that were not inverter driven had typical thermal overload protection to protect the motor when it stalled under low voltage conditions. The average stall voltage was found to be 112V and the average power when stalled was found to be 800W, which is more than 8 times the normal operating power. The operating power factor varied for household systems from 0.5 to 0.98. However, when stalled, the power factor for most units was around 0.84 and this was remarkably consistent. The average stall time before disconnection was 24 sec and the average off time before reconnecting was 106 sec (range from 0 sec to 387 sec).

Inverter driven household refrigerators were very adaptable and all units tested appeared to happily operate at a supply voltage as low as 50V AC, at least for a short time. Some of these units disconnected for a few seconds once the supply voltage dropped to less than 30V but restarted to normal operation once the voltage had returned to nominal within a few seconds. There was no power surge on restarting or at the time of disconnection.

Commercial refrigerators

The vast majority of commercial refrigerators now have digital controllers of some description. Only a limited number of systems in the stock appear to have analogue controls and certainly almost no new products would have analogue controls. From the products tested it appears that many (but not all) digital controllers offer some additional protection to compressors and disconnect them at low voltage conditions before they stall. This appears to be slightly more prevalent on units with larger compressors. Once the normal compressor input power exceeds about 800W, the stall power (which typically could exceed 5kW) is likely to cause electrical problems with overloading on switchboards. The maximum compressor on power that had thermal overload protection was around 650W. Digital controllers that disconnected the load operated on compressors of all sizes (smallest 80W, largest 2.3kW). It is likely that all single phase compressors will still have thermal overload protection as a backup to prevent motor damage if the controller fails (but in practice this is not normally used).

Of the 27 commercial refrigerator systems measured, around 60% had digital controllers that disconnected the compressor in low voltage conditions. A further 30% had traditional thermal overload protection that activated when the single phase motor stalled in low voltage conditions. Around 10% (3 units) did not seem to stall on even very deep low voltage events. It is unclear how these units were able to do this. One unit was quite old and certainly had no special control or technology and a previous test did seem to indicate stalling (but this was not recorded). One of the units was a 2012 single door display refrigerator and the other unit was a new cake display unit. Both were able to operate through voltage dips as low as 15V AC without stopping or activation of thermal protection. It may be possible that permanent magnet ECM motors may be more resilient in low voltage conditions, but it is unclear whether any of these units used this type of technology. It may be that the voltage profile applied to these particular units and their operating state at the time allowed them to continue operating. It seems clear at this stage than inverter driven compressors are not used in any single phase commercial refrigeration systems and are not likely to be used to any significant extent in the next 5 years.

The average operating power of the commercial refrigeration systems measured was 3 to 4 times more than household refrigerators, which is unsurprising given that many are large units and most have much higher heat gains (glass doors are common). For commercial refrigeration systems with thermal overload protection, the average stall voltage was 113V, which is almost the same as household systems (commercial product stall voltage varied

from 87V to 149V). The stall time before overload protection was slightly shorter on average for commercial refrigeration systems at 15 sec and the average restart time was 61 sec (range 0 sec to 171 sec). The average power when stalled was found to be 1740W, which is more than 7 times the normal operating power (similar to household refrigeration).

For commercial refrigeration systems with digital controllers that disconnected the compressor before the motor stalled in low voltage conditions, the average disconnect voltage was 103V. The average off time before reconnecting was 113 sec (range from 7 sec to 240 sec).

Discussion of low voltage motor test results

These test results were commissioned as a variation to the original project brief to provide insights to single phase induction motor behaviour under low voltage conditions. Firstly, the behaviour of household refrigeration systems is as expected. Most single speed compressors have thermal overload protection when the motor stalls and typically these motors stall when the supply voltage drops to around 110V. The minimum start voltage was not tested, but industry engineers believe that these products could continue to operate "normally" at around 180V to 190V. Once stalled at low voltage, however, the power consumed by the motor is similar to the operating power, but when the voltage reverts back to nominal, the power consumed by the stalled motor is typically 7 to 8 times the normal operating power. Note for several household and commercial refrigeration systems that went into thermal overload, the motor did not restart normally after the first thermal trip once the supply voltage was back to normal. Of the 17 models that activated thermal overload protection once the motor had stalled, three entered overload protection twice before the motor started normally and three entered overload protection three times before the motor started normally (i.e. about one third experienced multiple thermal overloads before resuming normal operation). When a compressor stops, there is significant refrigerant gas back pressure from the condenser which takes some minutes to dissipate. If a single phase induction motor attempts to start too quickly after any sort of interruption, the motor load may be too large to allow a normal start. This obviously depends on a number of factors such as the motor starting characteristics, the time between motor stalling and the attempted restart as well as the refrigeration system characteristics.

The testing approach for these additional measurements was agreed with AEMO to reflect a more typical supply fault scenario of a short duration voltage drop for a second or two (sufficient for the motor to stall) and then reversion to the normal supply voltage (nominally 230V). Common historic disturbances analysed by AEMO's DER team include short duration single-phase-ground faults resulting in an under-voltage event, which may or may not cause the motor D type equipment to stall.

Five inverter driven household refrigerators were tested. These were all remarkably robust and the compressor motor did not stall or the controller disconnect, even when the supply voltage was reduced to 50V AC. The input power was generally in proportion to the supply voltage, but the unit immediately reverted to normal operation once the voltage was returned to normal. There was no increase in consumption under a very low voltage condition.
An inverter driven pool pump was tested. This kept a constant input power with reduced voltage and the controller pulled the motor off line once the voltage dropped to around 155V. The unit commenced operation again once the voltage resumed to >220V. There were no surges or increases in power at any time under a low voltage condition. It was not possible to test inverter driven air conditioners as these are almost always hard wired at the switchboard. However, it is expected that they will behave in a similar manner to the inverter driven refrigerators (the unit will operate through many low voltage conditions at reduced power and the controller will pull the motor off line once a critical low voltage is reached with no power surges).

The commercial refrigeration examples were very revealing. Around 30% of the models tested had single speed induction motors (Motor D) that stalled at low voltage. The thermal protection on these units disconnected the compressor after a short period. Around 60% of units tested had single speed induction motors (Motor D) with digital controllers that protected the motor. Under low voltage conditions, the digital controller disconnected the compressor before it stalled, so there was no surge current. The digital controller restarted the compressor again after a short period that varied considerably across units. A further 10% of units did not appear to stall under even very low voltage conditions and did not exhibit any surge in power. Given the configuration and vintage of these particular units, this appears to be a fortunate combination of product configuration, voltage profile and operating state at the time of the test that allowed this to happen, rather than any specific design attribute or control equipment.

While most small commercial refrigeration units still use single speed induction motors (Motor D), it would appear that most digital controllers are able to protect the compressor under low voltage conditions by disconnecting it without any surge currents. If the sample of 27 units tested is representative of the market, this suggests that the majority of newer commercial refrigeration products will have these features that avoid motor stalling and thermal overload, but with a significant minority of products still using thermal overload protection in low voltage conditions. Some of the suppliers interviewed are aware of these features in at least some digital controllers, but they were unsure whether the specific configuration of the controller is required for each model to allow it to disconnect the compressor before the motor stalls. Based on the measured data, changes in the stock share of commercial refrigeration with thermal overload protection and with digital controllers that disconnect the motor has been estimated, noting that most of the units measured in this sample were new or fairly new. These estimates are documented in the main report.

Summary of test results for individual units

This section provides a summary of the test results for each individual unit. This includes a description of the product and measured data, as well as a chart of the data, together with any measurement notes. Please refer to the separate spreadsheet supplied for access to all raw 0.5 sec interval data for all electrical parameters. For household refrigerators, the Group in accordance with AS/NZS4474 is shown in brackets. Pictures have generally been provided for commercial refrigeration units as they have a wide range of configurations. Household refrigerators all look very similar so pictures were not taken. An index of all units tested is shown in Table 2.

Table 2: List of refrigeration products subjected to low voltage conditions

Unit	Sector	Product	Motor	Controller	Brand	Model
Unit01	Household	refrigerator-freezer	1P induction	Electronic	F&P	E522B
Unit02	Household	all refrigerator	1P induction	Electronic	F&P	E450
Unit03	Household	chest freezer	1P induction	Mechanical	Westinghouse	WCM5000WC
Unit04	Household	chest freezer	1P induction	Mechanical	Kelvinator	H210S
Unit05	Household	all refrigerator	1P induction	Electronic	F&P	E373
Unit06	Commercial	2 door display refrigerator	1P induction	Digital	Novachill	P1000
Unit07	Commercial	1 door display Freezer	1P induction	Digital	Novachill	SM600GZ
Unit08	Commercial	1 door display refrigerator	1P induction	Digital	Artisan	M1101
Unit09	Commercial	under bench 3 door refrigerator	1P induction	Digital	FED	GN3100TN

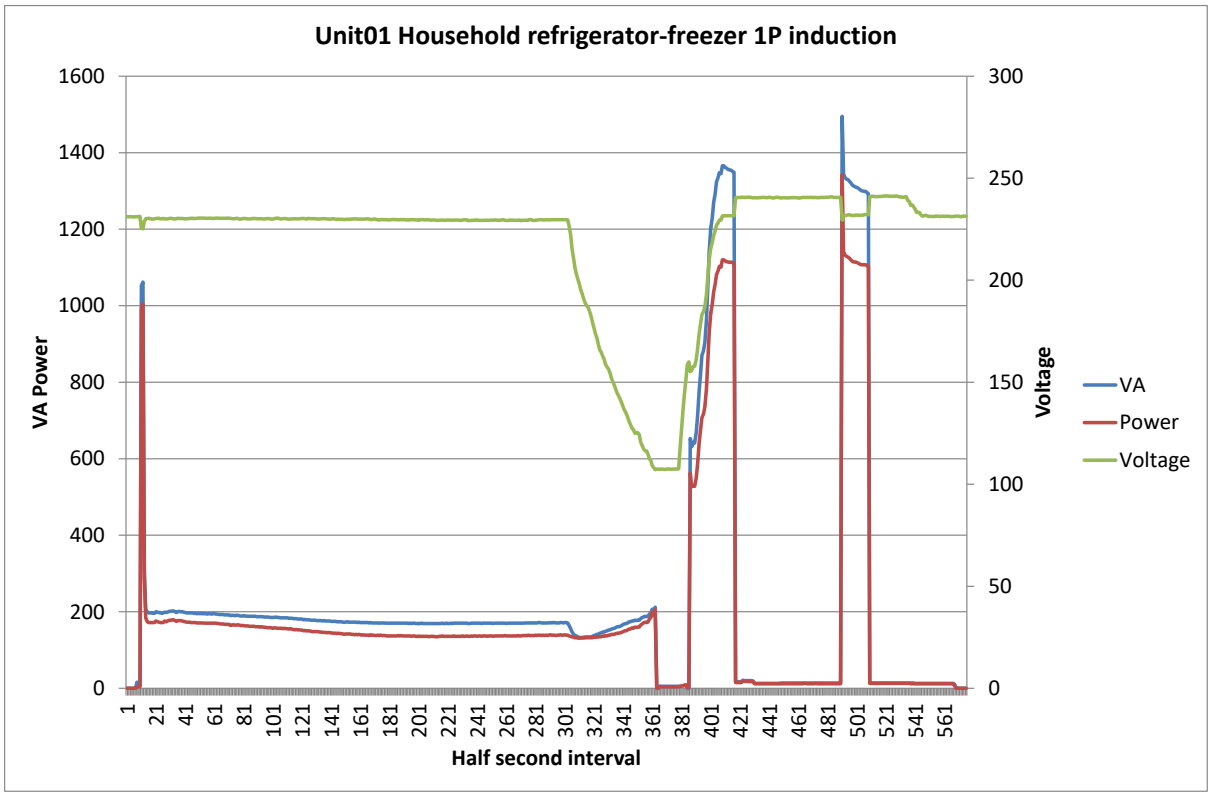
Unit	Sector	Product	Motor	Controller	Brand	Model
Unit10	Commercial	single door display refrigerator	1P induction	Digital	FED	LG220
Unit11	Commercial	2 door under bench refrigerator	1P induction	Digital	Coolking	TNG2100
Unit12	Commercial	bench top mini display cabinet	1P induction	Digital	ICS	Venice 80
Unit13	Commercial	1 door under bench refrigerator	1P induction	Digital	FED	LG138HC
Unit14	Commercial	2 door under bench refrigerator	1P induction	Digital	FED	LG220HC
Unit15	Commercial	solid door under bench freezer	1P induction	Mechanical	FED	HF200SS
Unit16	Commercial	bench top milk dispenser	1P induction	Digital	Autonumis	
Unit17	Commercial	4 sided cake display cabinet	1P induction	Digital	ICS	Como
Unit18	Commercial	under bench refrigerator with pizza top	1P induction	Digital	Snowman	1.3m pizza bar
Unit19	Commercial	salad bar with 2 door under counter	1P induction	Digital	Fresh Refrigeration	1.5m salad bar
Unit20	Commercial	benchtop cake display	1P induction	Digital	Anvilaire	1.5m cake fridge
Unit21	Commercial	1.8m cake display fridge (floor)	1P induction	Digital	FED	SG180FA3XB
Unit22	Commercial	salad bar	1P induction	Mechanical	ROBAND	ERX25
Unit23	Commercial	back bar 3 door under bench refrigerator	1P induction	Digital	FED	BC3100G
Unit24	Commercial	bench top salad bar	1P induction	Digital	Atosa	VRX1500
Unit25	Commercial	4 door under bench refrigerator	1P induction	Digital	Snowman	GN4100TN
Unit26	Commercial	deli display refrigerator	1P induction	Digital	Derigo	2.5m deli
Unit27	Commercial	open top freezer	1P induction	Digital	Derigo	2m open top
Unit28	Commercial	1 door display freezer	1P induction	Digital	Novachill	SM600GZ
Unit29	Commercial	1 door display freezer	1P induction	Digital	Novachill	SM600GZ
Unit30	Commercial	1 door display freezer	1P induction	Digital	Bromic	
Unit31	Commercial	4 door display refrigerator	1P induction	Digital	Orford	Carel controller
Unit32	Commercial	reach in open vertical display cabinet	1P induction	Digital	Derigo	
Unit33	Commercial	2 door display refrigerator	1P induction	Digital	Skope	BME1200A
Unit34	Household	Vertical freezer (7)	1P induction	Electronic	Westinghouse	WFB4204WA
Unit35	Household	refrigerator-freezer French door (5B)	1P induction	Electronic	F&P	RF522ADX4
Unit36	Household	chest freezer (6C)	1P induction	Mechanical	F&P	H275
Unit37	Household	refrigerator-freezer (5B)	Linear inverter	Electronic	LG	GB-450UPLX
Unit38	Household	refrigerator-freezer (5T)	1P induction	Electronic	Simpson	STM5200WA
Unit39	Household	refrigerator-freezer (5S)	Linear inverter	Electronic	LG	GS-B679PL
Unit40	Household	refrigerator-freezer (5B)	Inverter	Electronic	Electrolux	EBE5307SA
Unit41	Household	refrigerator-freezer (5B)	Inverter	Electronic	Electrolux	EBE4507SA
Unit42	Household	refrigerator-freezer (5T)	Inverter	Electronic	Electrolux	ETE4607SA
Unit43	Household	pool pump	Inverter (3 speed)	Electronic	Onga	Eco8

Unit01

Unit: Unit01
Sector: Household
Product: refrigerator-freezer (5B)
Motor type: 1P induction
Control: Electronic
Brand: F&P
Model: E522B

Measurement notes: Alarm started beeping and power went to zero at 107V (appeared to disconnect for 12 sec), unable to start when compressor reconnected, recorded stall power is at 155V in thermal overload. Alarm continued and second stall event at 230V so disconnected, started normally later, second stall event was 11 sec. This is the only household refrigeration system measured that disconnected.

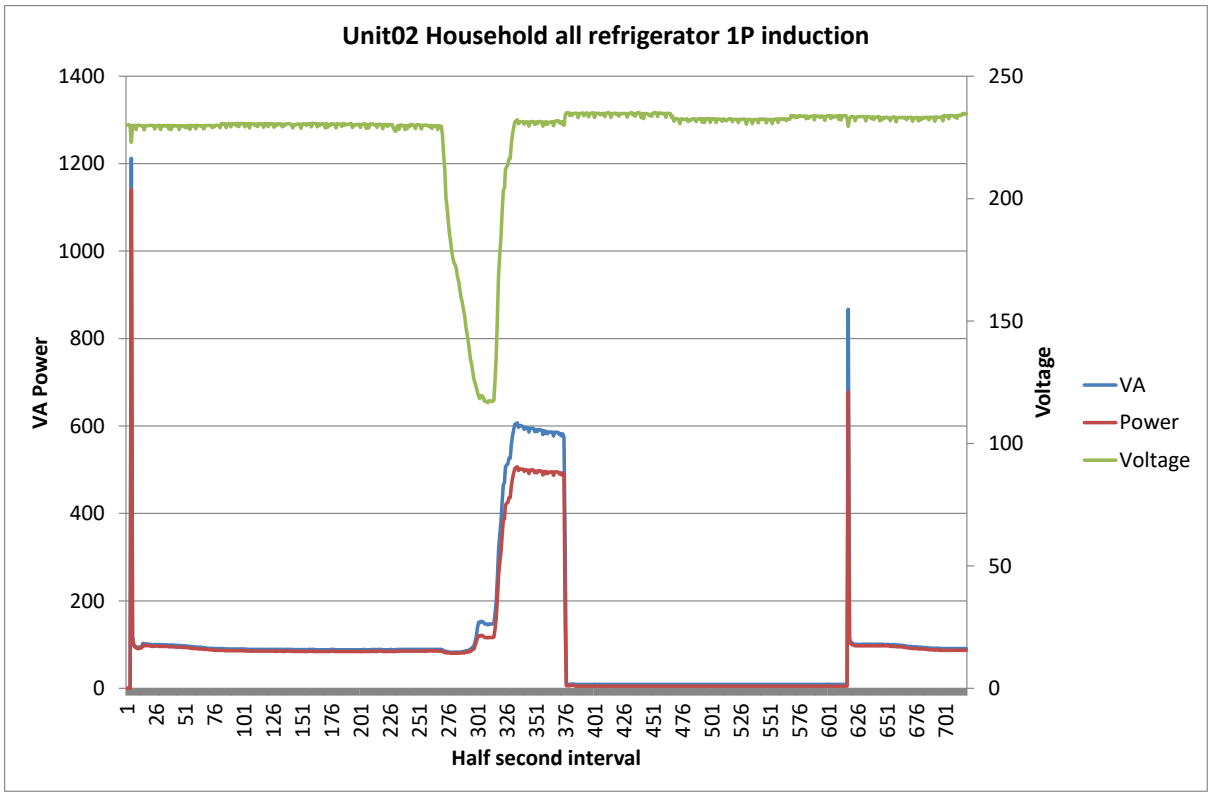
Parameter	Value
Year:	2004
On power W:	139
On Power Factor:	0.804
Stall/disconnect Voltage:	107
Stall Power @ stall Voltage W:	530
Protection type:	Thermal
Stall Power @ 230V W:	1120
Stall Power Factor:	0.840
Stall time before protection disconnects sec:	16
Off time after disconnect before restart sec:	37
Ratio Stall Power/Operating Power:	8.058



Unit02

Unit: Unit02
Sector: Household
Product: all refrigerator (1)
Motor type: 1P induction
Control: Electronic
Brand: F&P
Model: E450
Measurement notes: Nothing unusual

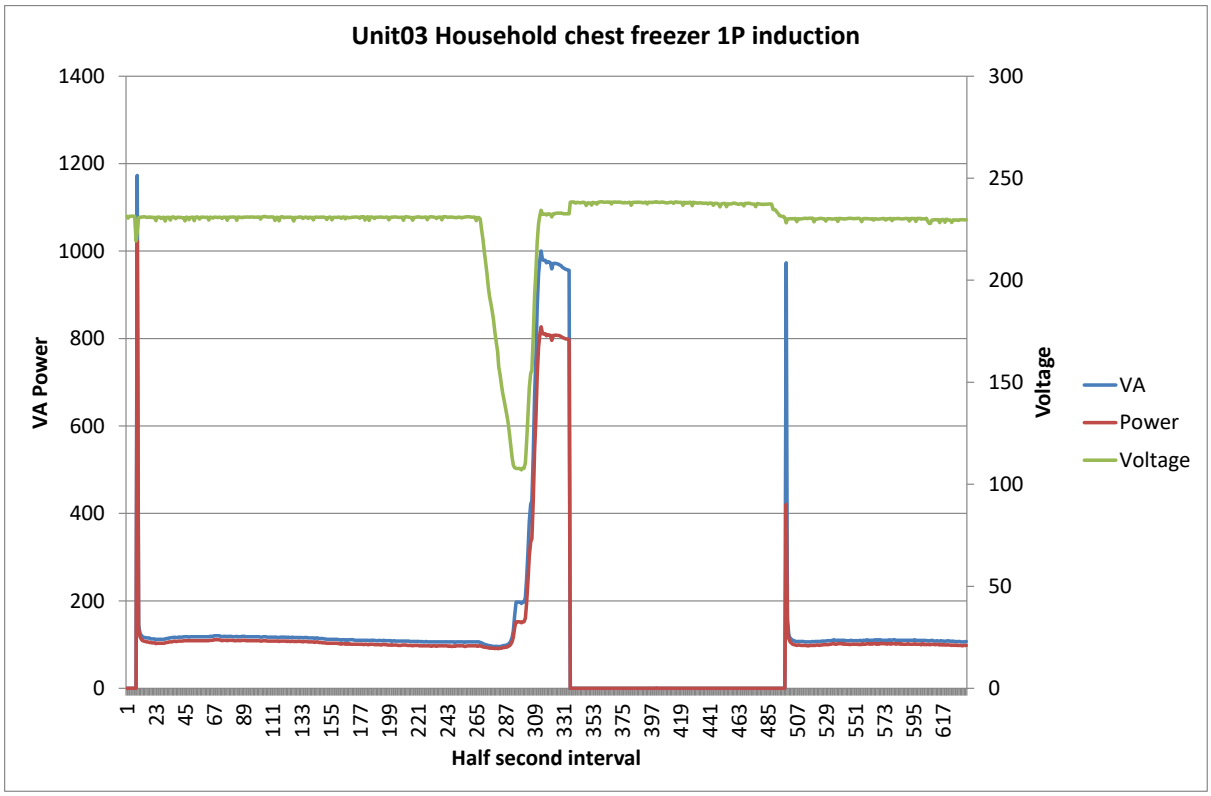
Parameter	Value
Year:	2010
On power W:	85
On Power Factor:	0.955
Stall/disconnect Voltage:	125
Stall Power @ stall Voltage W:	121
Protection type:	Thermal
Stall Power @ 230V W:	496
Stall Power Factor:	0.846
Stall time before protection disconnects sec:	39
Off time after disconnect before restart sec:	121
Ratio Stall Power/Operating Power:	5.835



Unit03

Unit: Unit03
Sector: Household
Product: chest freezer (6C)
Motor type: 1P induction
Control: Mechanical
Brand: Westinghouse
Model: WCM5000WC
Measurement notes: Nothing unusual

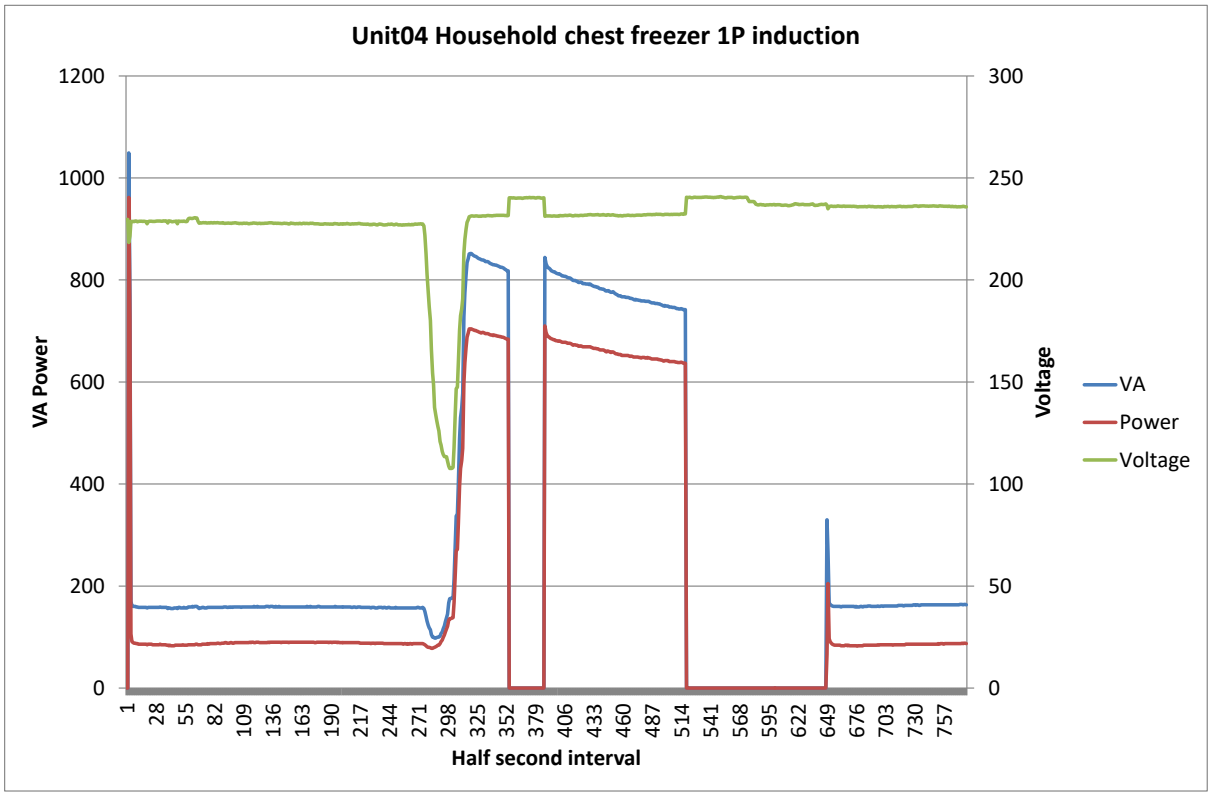
Parameter	Value
Year:	2013
On power W:	97
On Power Factor:	0.91
Stall/disconnect Voltage:	108
Stall Power @ stall Voltage W:	140
Protection type:	Thermal
Stall Power @ 230V W:	805
Stall Power Factor:	0.830
Stall time before protection disconnects sec:	21
Off time after disconnect before restart sec:	82
Ratio Stall Power/Operating Power:	8.299



Unit04

Unit: Unit04
Sector: Household
Product: chest freezer (6C)
Motor type: 1P induction
Control: Mechanical
Brand: Kelvinator
Model: H210S
Measurement notes: Second stall event of 66 sec duration (old unit, possible high back pressure on compressor), second off interval was 65 sec then started normally

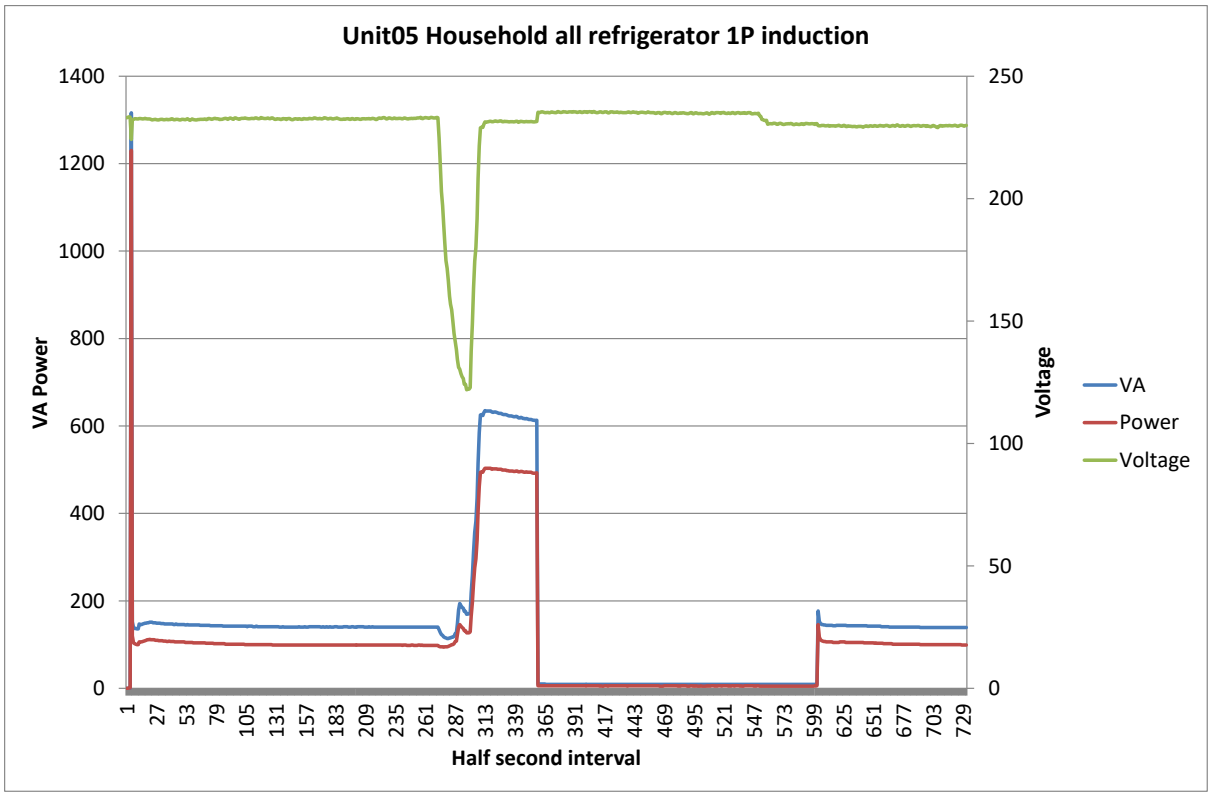
Parameter	Value
Year:	1989
On power W:	85
On Power Factor:	0.557
Stall/disconnect Voltage:	113
Stall Power @ stall Voltage W:	110
Protection type:	Thermal
Stall Power @ 230V W:	830
Stall Power Factor:	0.835
Stall time before protection disconnects sec:	30
Off time after disconnect before restart sec:	17
Ratio Stall Power/Operating Power:	9.765



Unit05

Unit: Unit05
Sector: Household
Product: all refrigerator (1)
Motor type: 1P induction
Control: Electronic
Brand: F&P
Model: E373
Measurement notes: Nothing unusual

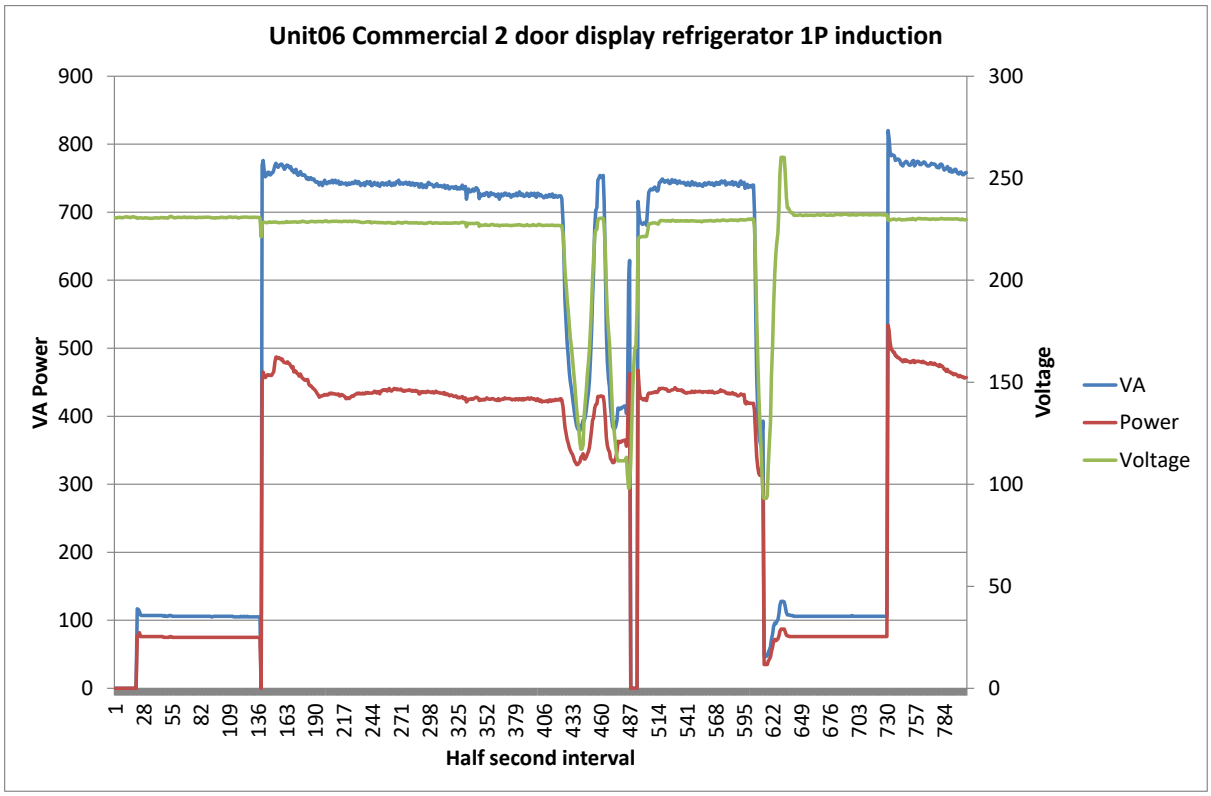
Parameter	Value
Year:	2008
On power W:	99
On Power Factor:	0.702
Stall/disconnect Voltage:	131
Stall Power @ stall Voltage W:	140
Protection type:	Thermal
Stall Power @ 230V W:	495
Stall Power Factor:	0.803
Stall time before protection disconnects sec:	35
Off time after disconnect before restart sec:	122
Ratio Stall Power/Operating Power:	5.000



Unit06

Unit: Unit06
Sector: Commercial
Product: 2 door display refrigerator
Motor type: 1P induction
Control: Digital
Brand: Novachill
Model: P1000
Measurement notes: First part meter set on 5A range so overloaded, 59 sec until compressor on. Kept running at 98V, disconnected on second attempt at 94V

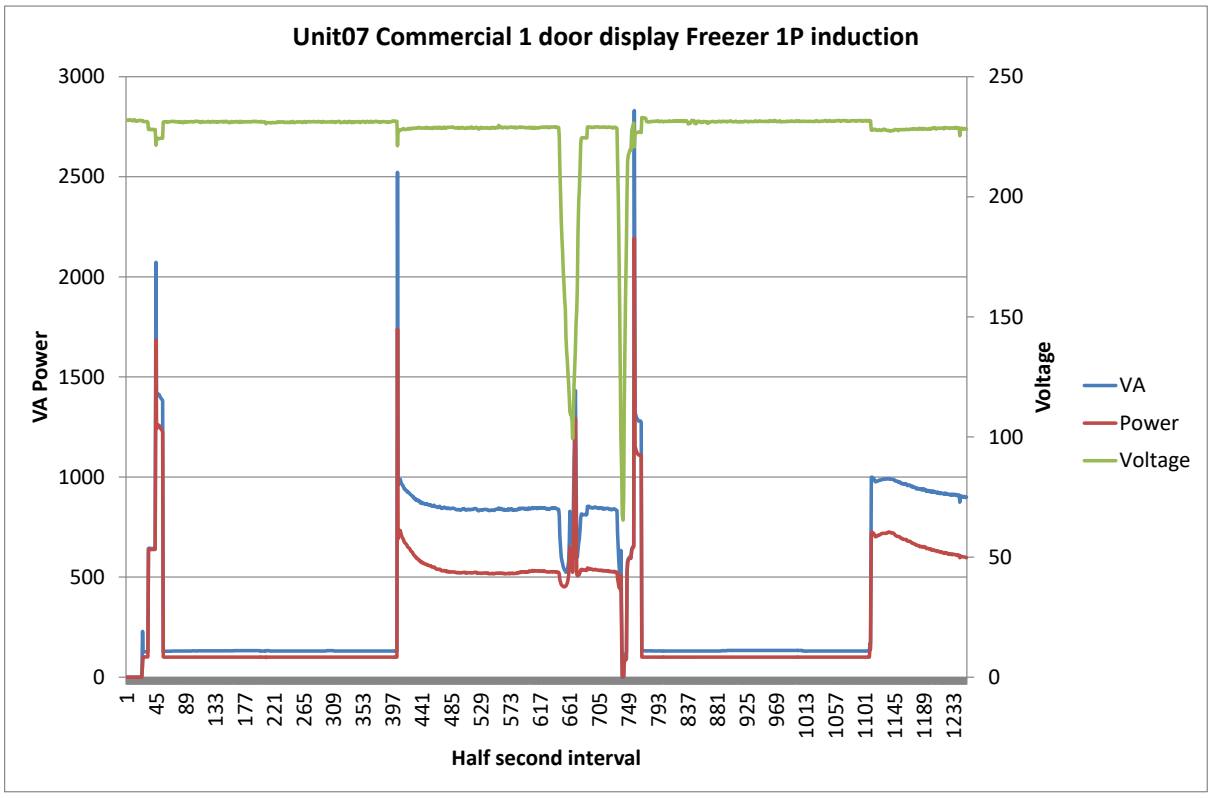
Parameter	Value
Year:	new
On power W:	433
On Power Factor:	0.59
Stall/disconnect Voltage:	94
Stall Power @ stall Voltage W:	35
Protection type:	Disconnect
Stall Power @ 230V W:	85
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	59
Ratio Stall Power/Operating Power:	#N/A



Unit07

Unit: Unit07
Sector: Commercial
Product: 1 door display Freezer
Motor type: 1P induction
Control: Digital
Brand: Novachill
Model: SM600GZ
Measurement notes: Some activity after power on, unclear, compressor start 190 sec, kept running with a dip to 99V, disconnected at 87V, then a resistive load equal to compressor power came on for 5 sec, unclear what caused the short power surge after disconnect (same as when power first connected)

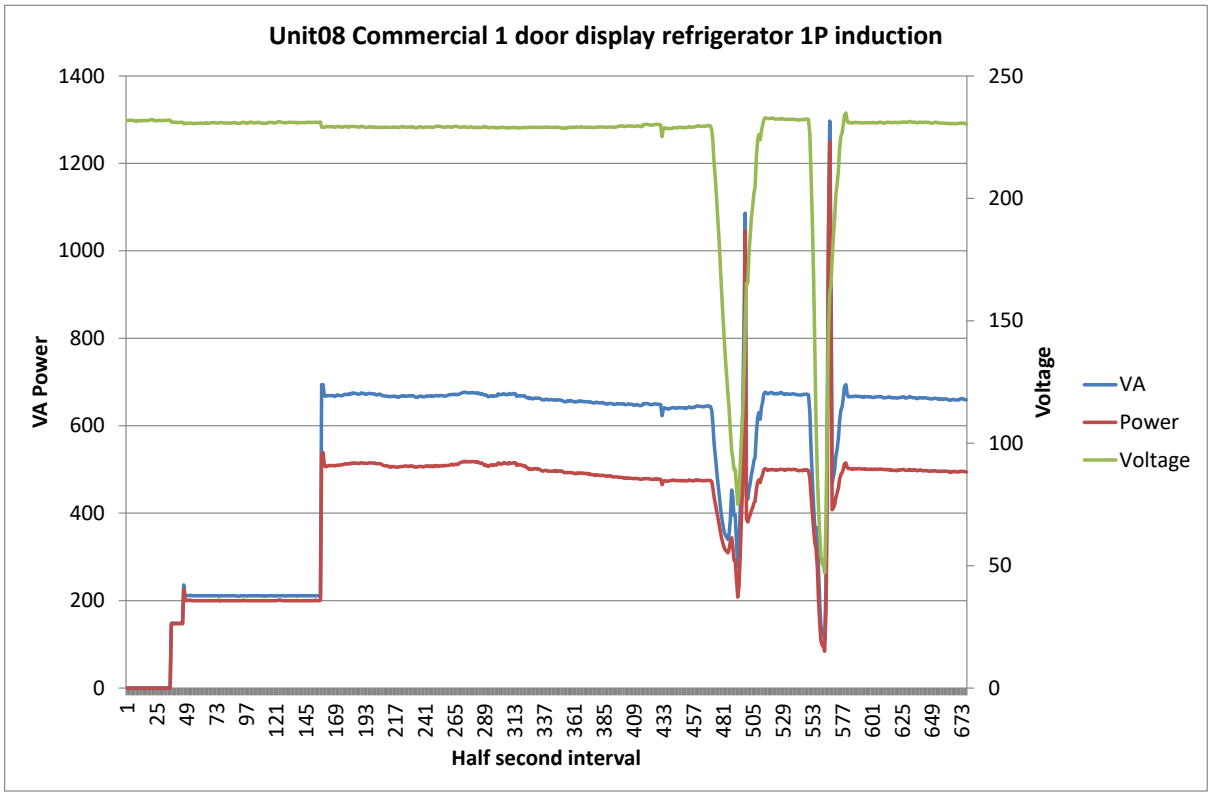
Parameter	Value
Year:	new
On power W:	520
On Power Factor:	0.63
Stall/disconnect Voltage:	87
Stall Power @ stall Voltage W:	#N/A
Protection type:	Thermal
Stall Power @ 230V W:	1125
Stall Power Factor:	0.870
Stall time before protection disconnects sec:	5
Off time after disconnect before restart sec:	171
Ratio Stall Power/Operating Power:	2.163



Unit08

Unit: Unit08
Sector: Commercial
Product: 1 door display refrigerator
Motor type: 1P induction
Control: Digital
Brand: Artisan
Model: M1101
Measurement notes: 73 sec to compressor on initially, would not stall down to 47V, small 0.5 sec power spike when voltage set back to 230V

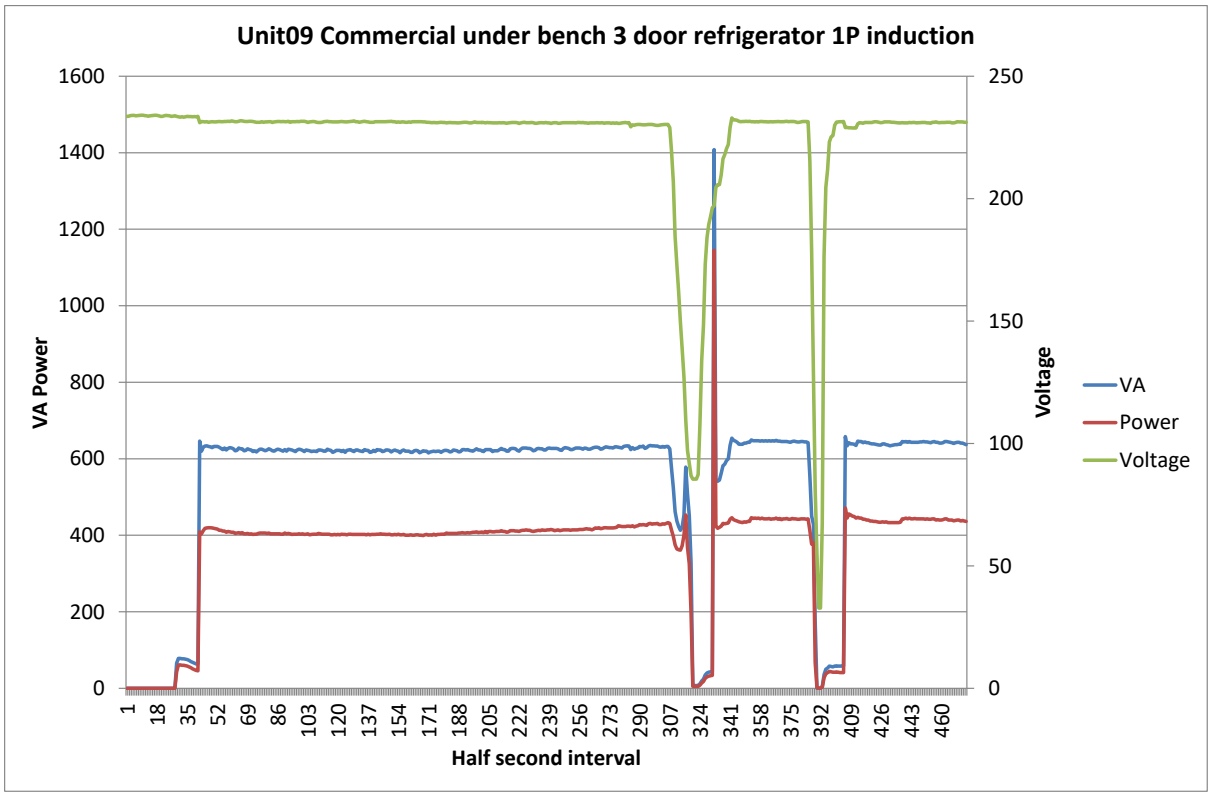
Parameter	Value
Year:	2012
On power W:	508
On Power Factor:	0.76
Stall/disconnect Voltage:	47
Stall Power @ stall Voltage W:	#N/A
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A



Unit09

Unit: Unit09
Sector: Commercial
Product: under bench 3 door refrigerator
Motor type: 1P induction
Control: Digital
Brand: FED
Model: GN3100TN
Measurement notes: Nothing unusual

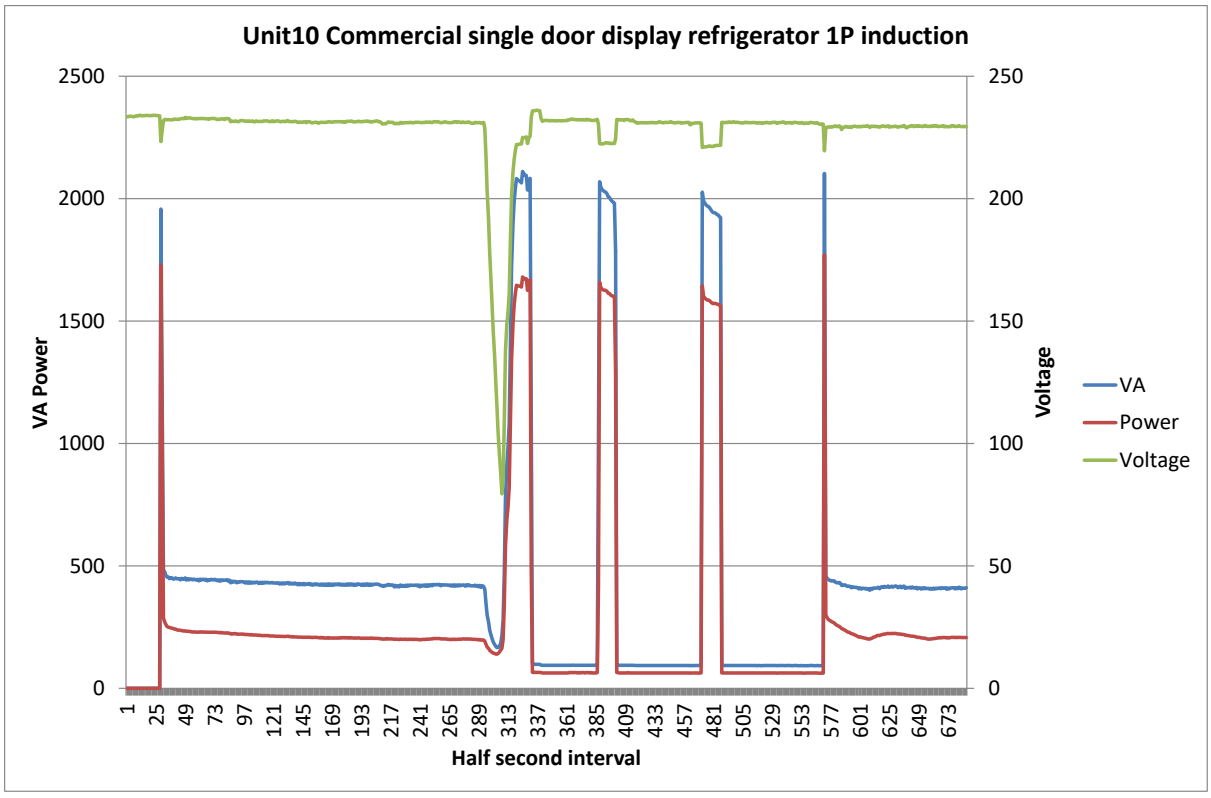
Parameter	Value
Year:	2019
On power W:	402
On Power Factor:	0.65
Stall/disconnect Voltage:	86
Stall Power @ stall Voltage W:	5
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A



Unit10

Unit: Unit10
Sector: Commercial
Product: single door display refrigerator
Motor type: 1P induction
Control: Digital
Brand: FED
Model: LG220
Measurement notes: 3 consecutive stalls with gaps of 27 sec, 35 sec and 42 sec before restarting normally, subsequent stall times were around 7 sec long

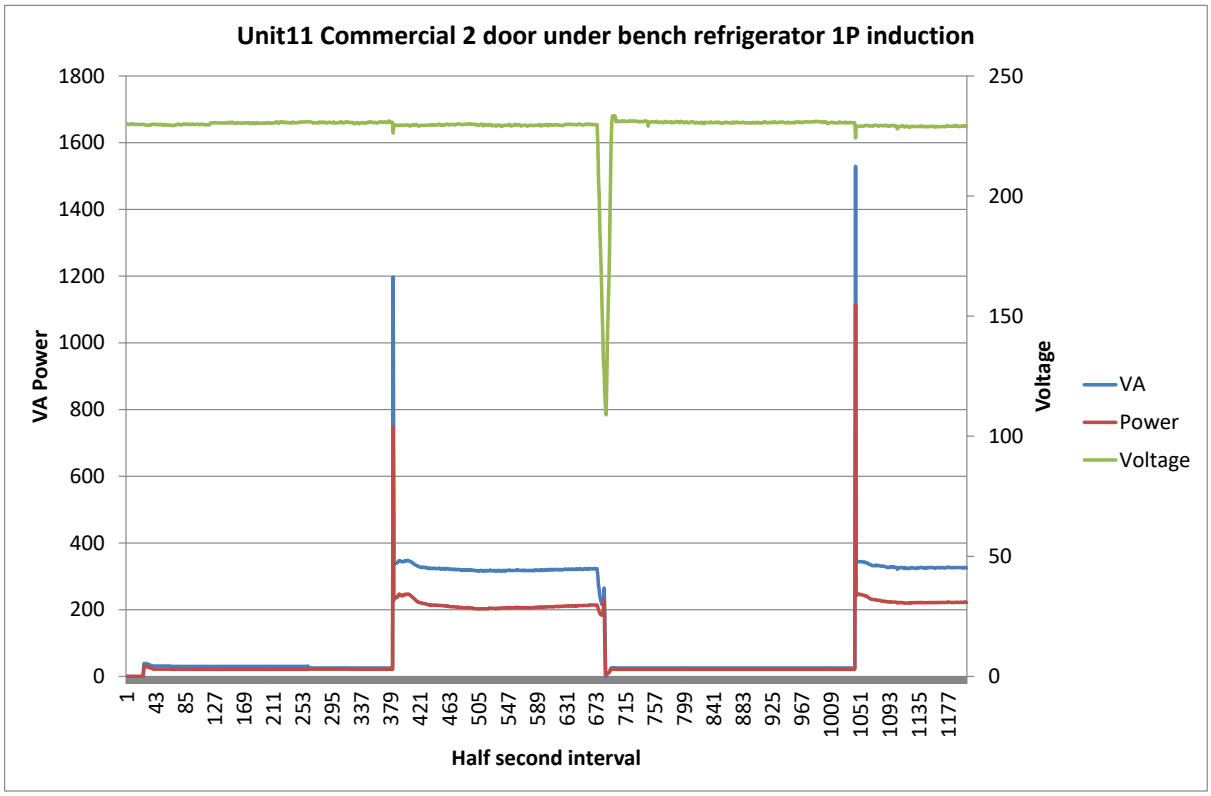
Parameter	Value
Year:	new
On power W:	201
On Power Factor:	0.48
Stall/disconnect Voltage:	96
Stall Power @ stall Voltage W:	148
Protection type:	Thermal
Stall Power @ 230V W:	1950
Stall Power Factor:	0.807
Stall time before protection disconnects sec:	12
Off time after disconnect before restart sec:	35
Ratio Stall Power/Operating Power:	9.701



Unit11

Unit: Unit11
Sector: Commercial
Product: 2 door under bench refrigerator
Motor type: 1P induction
Control: Digital
Brand: Coolking
Model: TNG2100
Measurement notes: 180 sec to compressor on when power on or after protection disconnected compressor

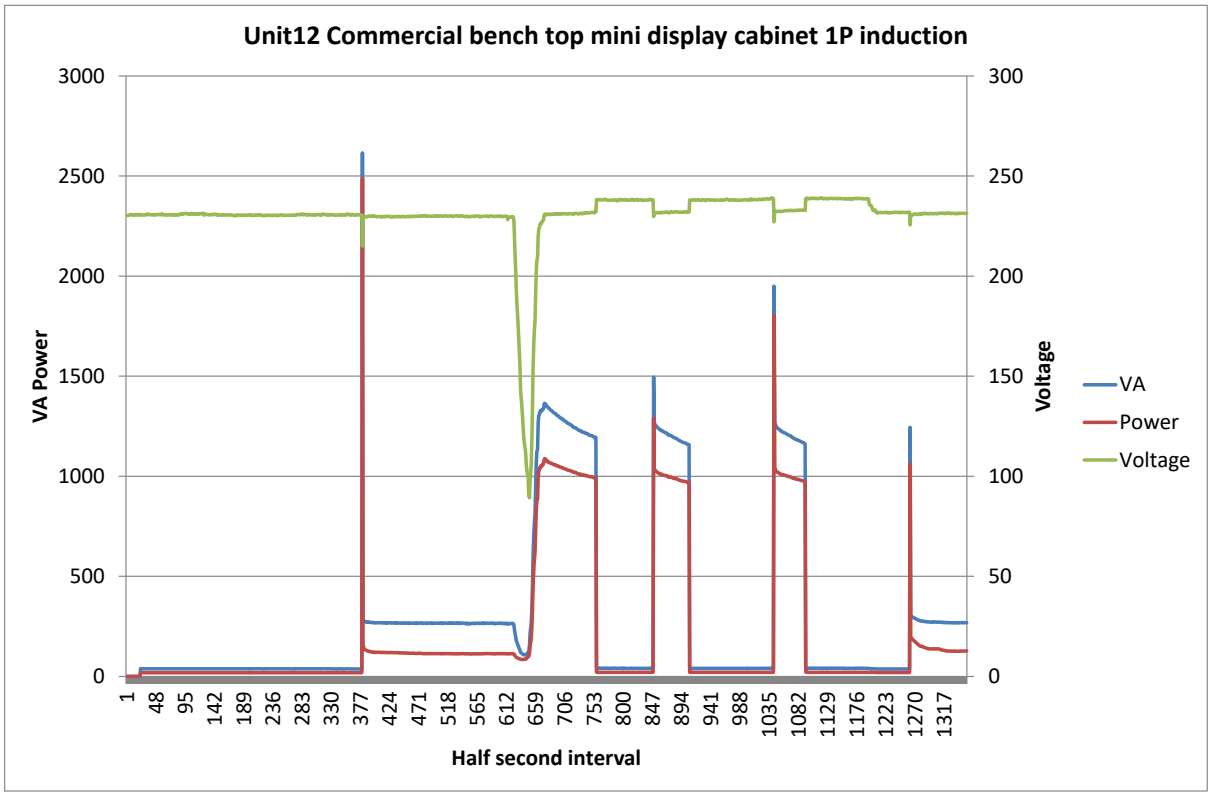
Parameter	Value
Year:	new
On power W:	206
On Power Factor:	0.65
Stall/disconnect Voltage:	118
Stall Power @ stall Voltage W:	4
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	180
Ratio Stall Power/Operating Power:	#N/A



Unit12

Unit: Unit12
Sector: Commercial
Product: bench top mini display cabinet
Motor type: 1P induction
Control: Digital
Brand: ICS
Model: Venice 80
Measurement notes: 180 sec to compressor start from power on, 3 consecutive stall events with duration of 54 sec, 29 sec and 26 sec, the subsequent off times of 46 sec, 68 sec and 84 sec

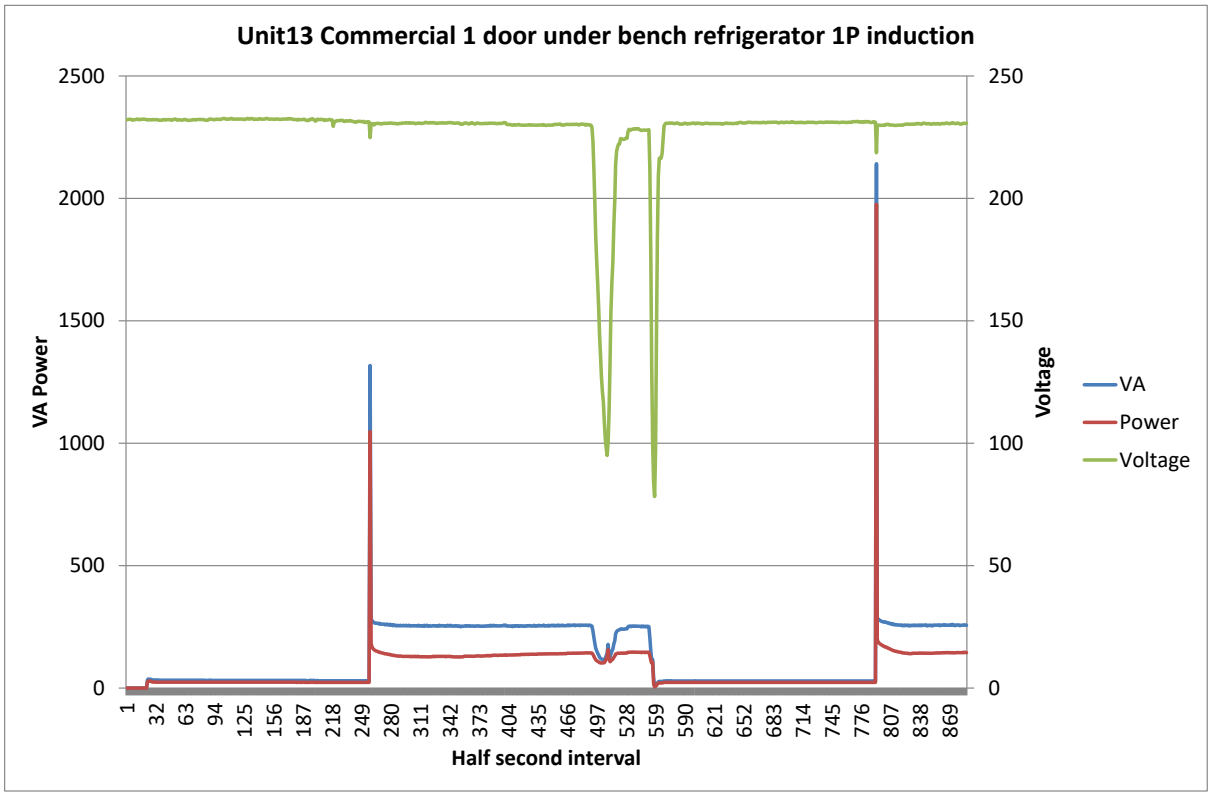
Parameter	Value
Year:	new
On power W:	114
On Power Factor:	0.43
Stall/disconnect Voltage:	89
Stall Power @ stall Voltage W:	116
Protection type:	Thermal
Stall Power @ 230V W:	1086
Stall Power Factor:	0.796
Stall time before protection disconnects sec:	54
Off time after disconnect before restart sec:	46
Ratio Stall Power/Operating Power:	9.526



Unit13

Unit: Unit13
Sector: Commercial
Product: 1 door under bench refrigerator
Motor type: 1P induction
Control: Digital
Brand: FED
Model: LG138HC
Measurement notes: 118 sec to compressor start from power on or disconnect, kept running with a voltage dip to 95V

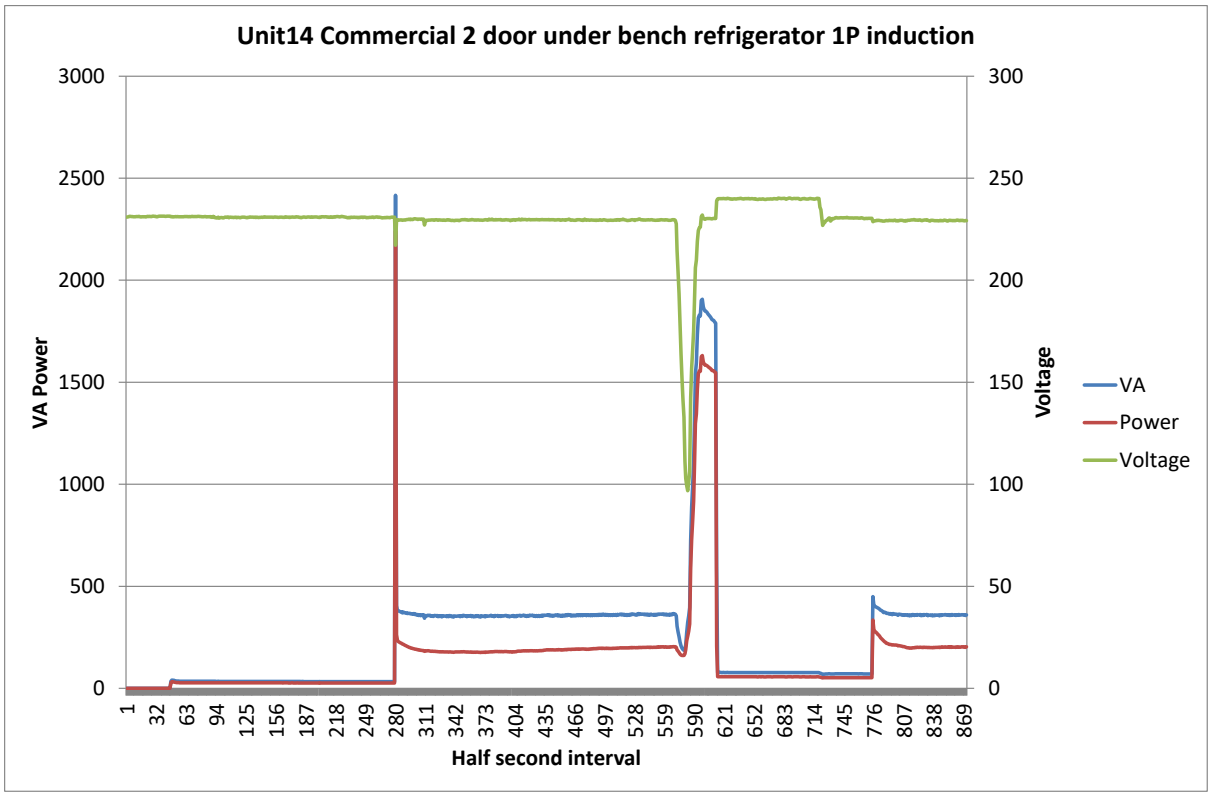
Parameter	Value
Year:	new
On power W:	134
On Power Factor:	0.528
Stall/disconnect Voltage:	84
Stall Power @ stall Voltage W:	5
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	118
Ratio Stall Power/Operating Power:	#N/A



Unit14

Unit: Unit14
Sector: Commercial
Product: 2 door under bench refrigerator
Motor type: 1P induction
Control: Digital
Brand: FED
Model: LG220HC
Measurement notes: 116 sec to compressor start from power on

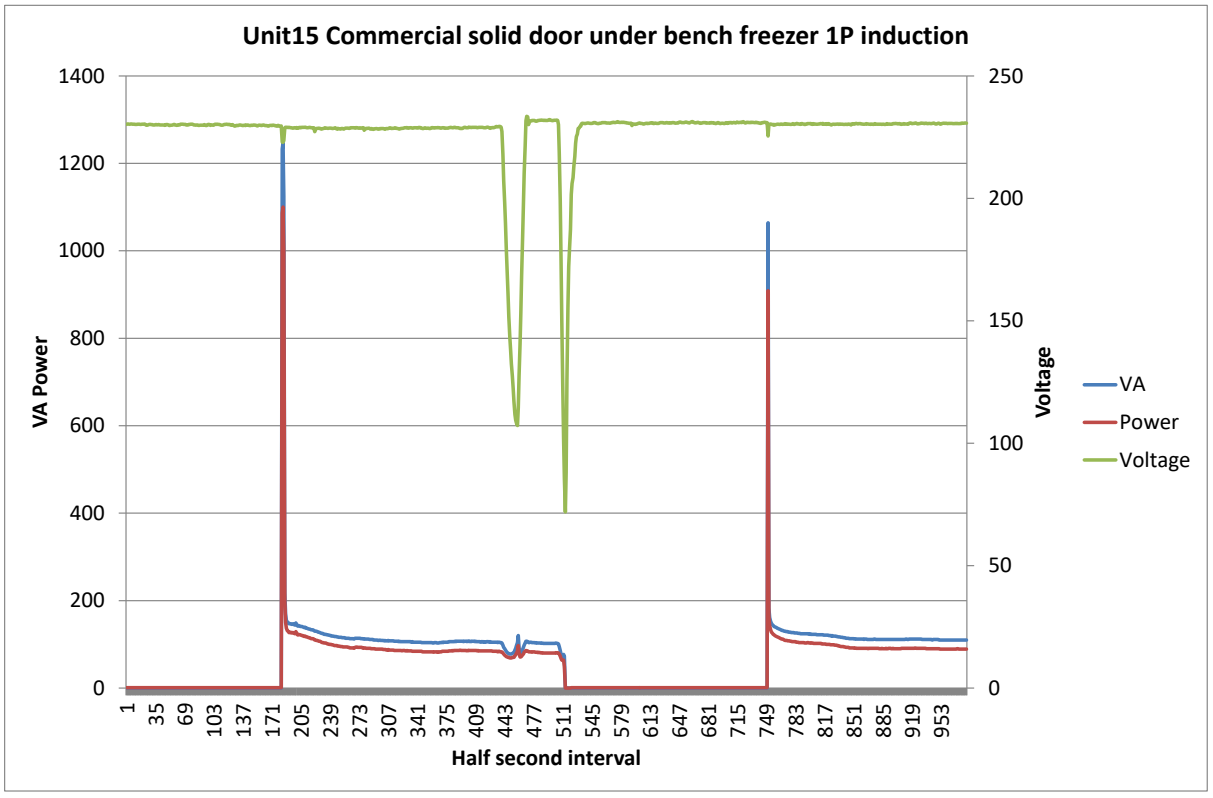
Parameter	Value
Year:	new
On power W:	200
On Power Factor:	0.55
Stall/disconnect Voltage:	111
Stall Power @ stall Voltage W:	170
Protection type:	Thermal
Stall Power @ 230V W:	1560
Stall Power Factor:	0.860
Stall time before protection disconnects sec:	17
Off time after disconnect before restart sec:	80
Ratio Stall Power/Operating Power:	7.800



Unit15

Unit: Unit15
Sector: Commercial
Product: solid door under bench freezer
Motor type: 1P induction
Control: Mechanical
Brand: FED
Model: HF200SS
Measurement notes: 118 sec to compressor start from power on or disconnect, voltage dip to 108V did not stall, clearly some electronics involved despite mechanical thermostat

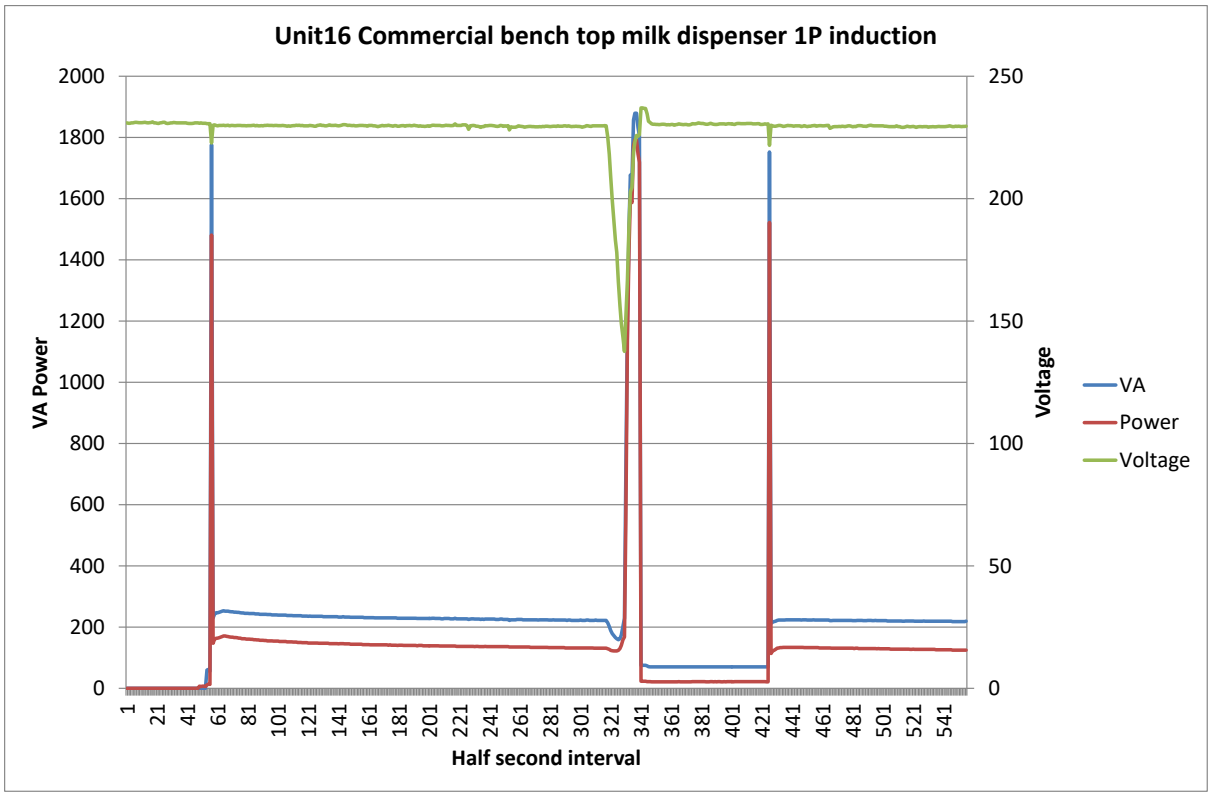
Parameter	Value
Year:	new
On power W:	83
On Power Factor:	0.8
Stall/disconnect Voltage:	80
Stall Power @ stall Voltage W:	0
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	118
Ratio Stall Power/Operating Power:	#N/A



Unit16

Unit: Unit16
Sector: Commercial
Product: bench top milk dispenser
Motor type: 1P induction
Control: Digital
Brand: Autonumis
Model:
Measurement notes: High power factor in thermal overload

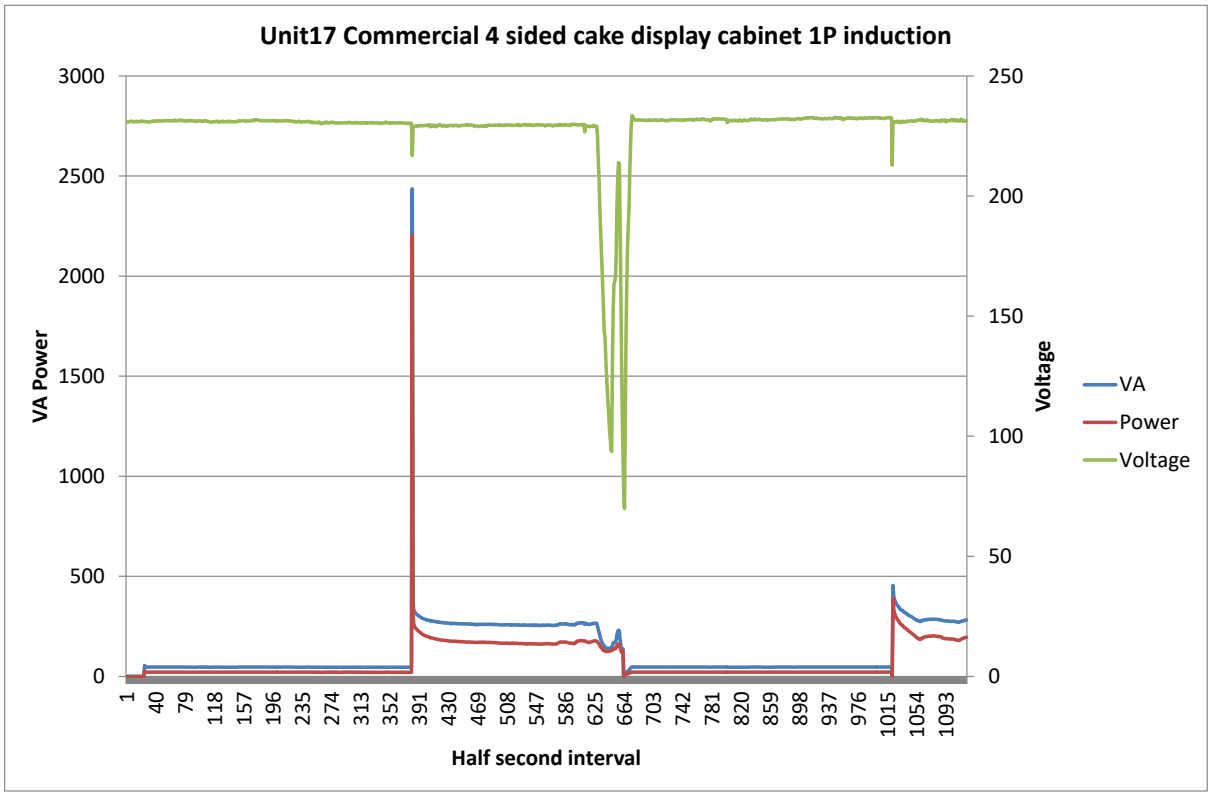
Parameter	Value
Year:	new
On power W:	138
On Power Factor:	0.606
Stall/disconnect Voltage:	144
Stall Power @ stall Voltage W:	145
Protection type:	Thermal
Stall Power @ 230V W:	1792
Stall Power Factor:	0.954
Stall time before protection disconnects sec:	7
Off time after disconnect before restart sec:	43
Ratio Stall Power/Operating Power:	12.986



Unit17

Unit: Unit17
Sector: Commercial
Product: 4 sided cake display cabinet
Motor type: 1P induction
Control: Digital
Brand: ICS
Model: Como
Measurement notes: 180 sec to compressor on when power on or after protection disconnected compressor

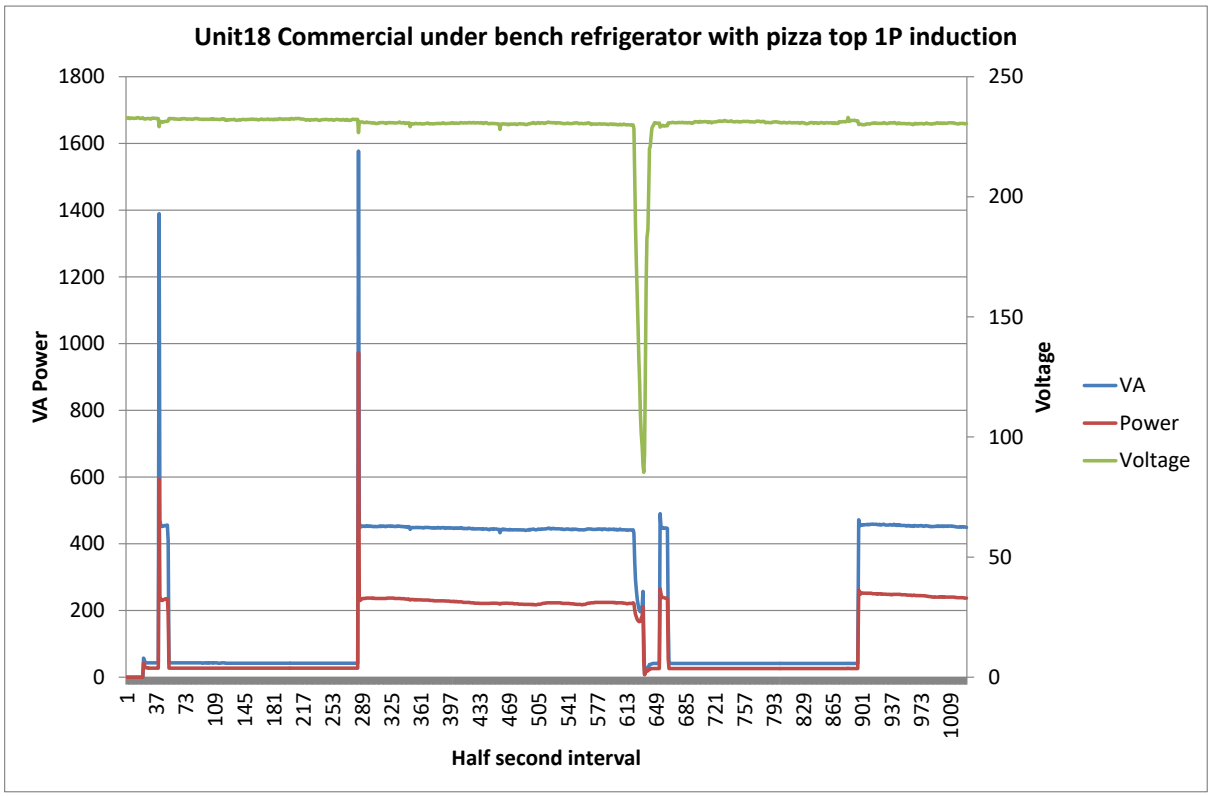
Parameter	Value
Year:	new
On power W:	179
On Power Factor:	0.67
Stall/disconnect Voltage:	85
Stall Power @ stall Voltage W:	2
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	180
Ratio Stall Power/Operating Power:	#N/A



Unit18

Unit: Unit18
Sector: Commercial
Product: under bench refrigerator with pizza top
Motor type: 1P induction
Control: Digital
Brand: Snowman
Model: 1.3m pizza bar
Measurement notes: 130 sec to compressor on when power on or after protection disconnected compressor, appears to have a short compressor start when power connected (or some other activity)

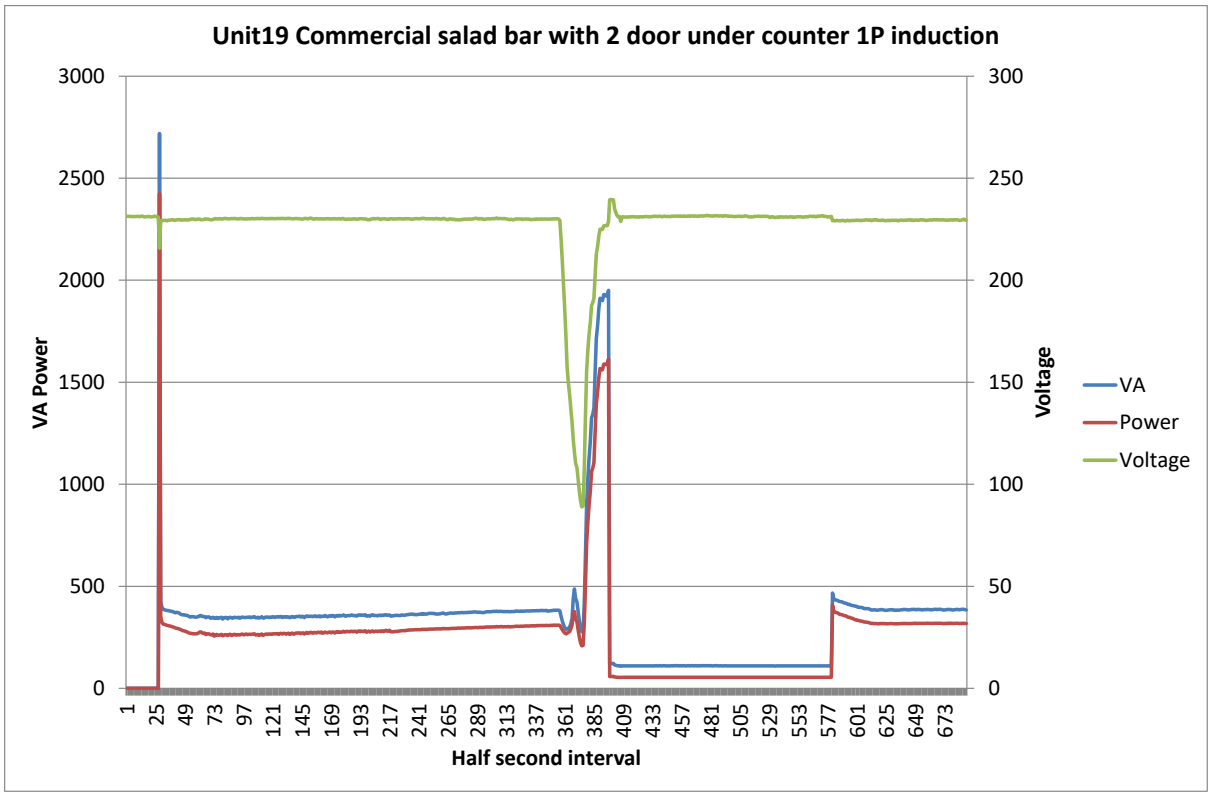
Parameter	Value
Year:	new
On power W:	224
On Power Factor:	0.504
Stall/disconnect Voltage:	85
Stall Power @ stall Voltage W:	26
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	130
Ratio Stall Power/Operating Power:	#N/A



Unit19

Unit: Unit19
Sector: Commercial
Product: salad bar with 2 door under counter
Motor type: 1P induction
Control: Digital
Brand: Fresh Refrigeration
Model: 1.5m salad bar
Measurement notes: Nothing unusual

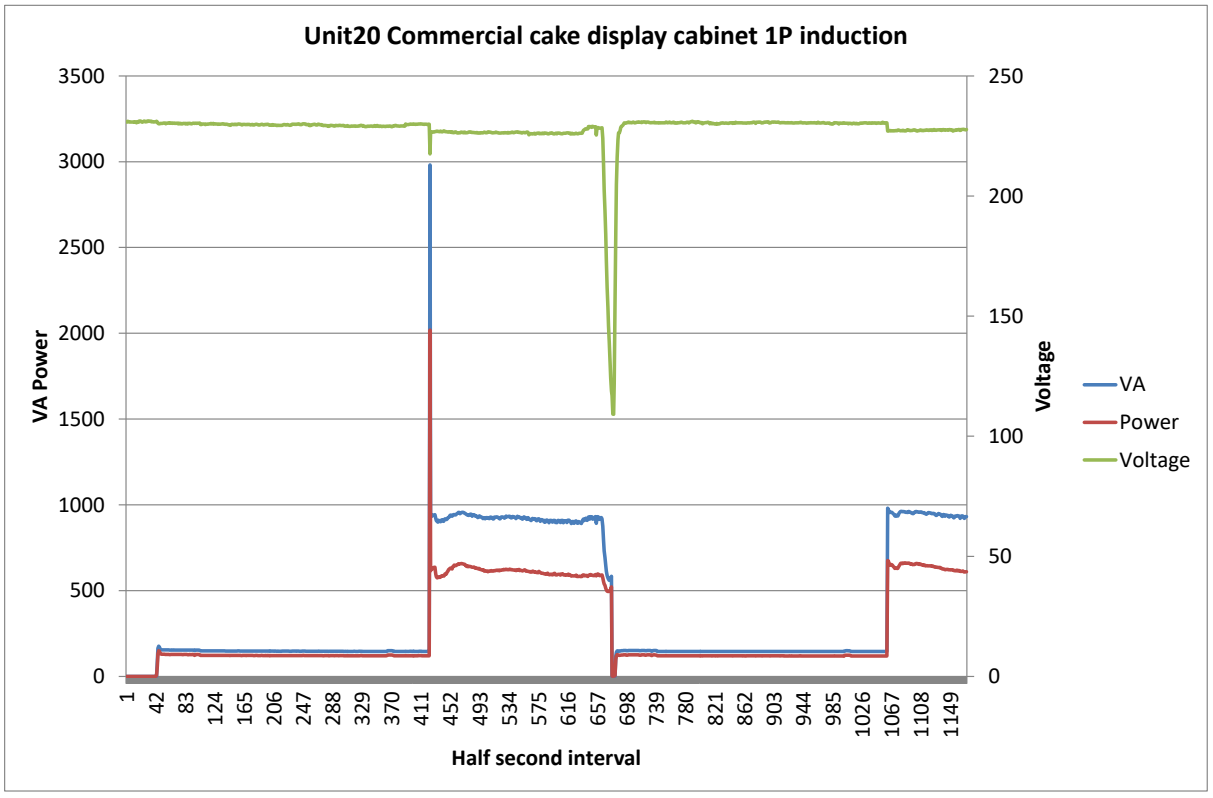
Parameter	Value
Year:	new
On power W:	310
On Power Factor:	0.809
Stall/disconnect Voltage:	116
Stall Power @ stall Voltage W:	376
Protection type:	Thermal
Stall Power @ 230V W:	1590
Stall Power Factor:	0.824
Stall time before protection disconnects sec:	10
Off time after disconnect before restart sec:	92
Ratio Stall Power/Operating Power:	5.129



Unit20

Unit: Unit20
Sector: Commercial
Product: cake display cabinet
Motor type: 1P induction
Control: Digital
Brand: Anvilaire
Model: 1.5m cake fridge
Measurement notes: 190 sec to compressor on when power on or after protection disconnected compressor

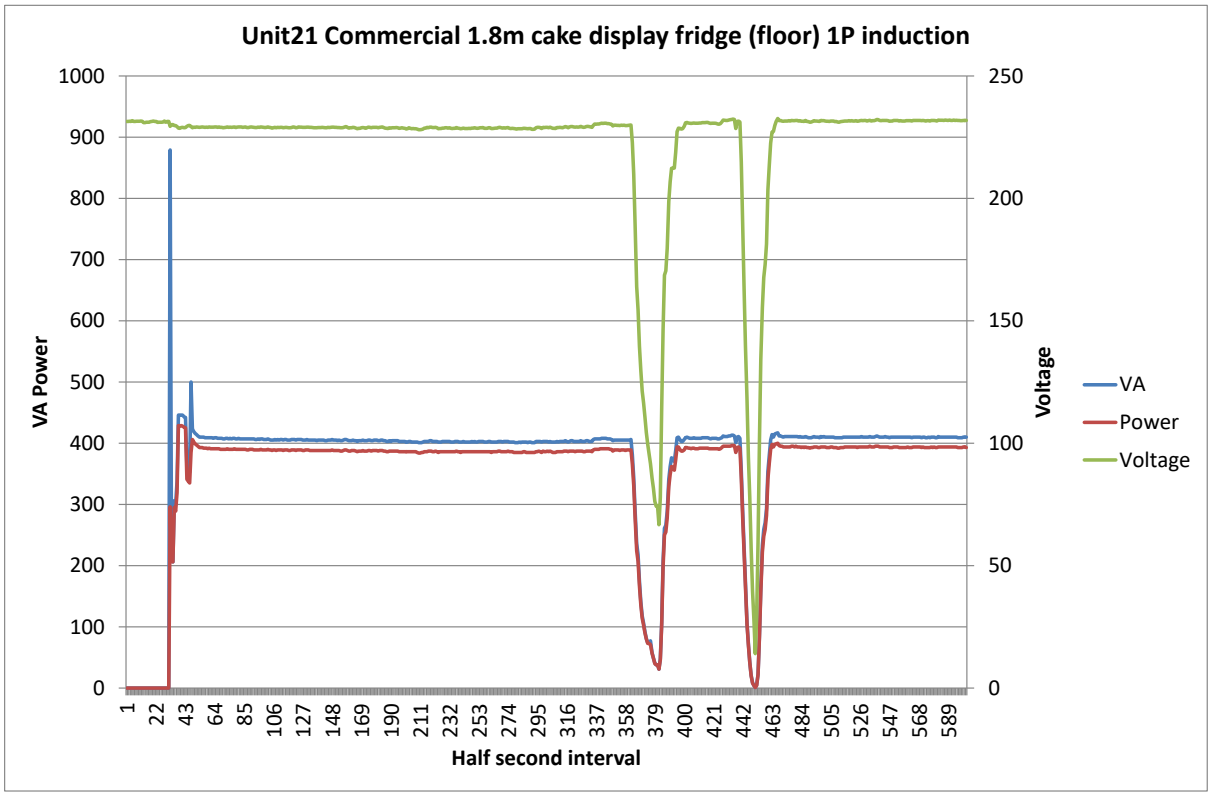
Parameter	Value
Year:	new
On power W:	586
On Power Factor:	0.65
Stall/disconnect Voltage:	117
Stall Power @ stall Voltage W:	2
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	192
Ratio Stall Power/Operating Power:	#N/A



Unit21

Unit: Unit21
Sector: Commercial
Product: 1.8m cake display fridge (floor)
Motor type: 1P induction
Control: Digital
Brand: FED
Model: SG180FA3XB
Measurement notes: Unit would not stall even at 14V AC, compressor kept operating as normal (does not appear to be an inverter)

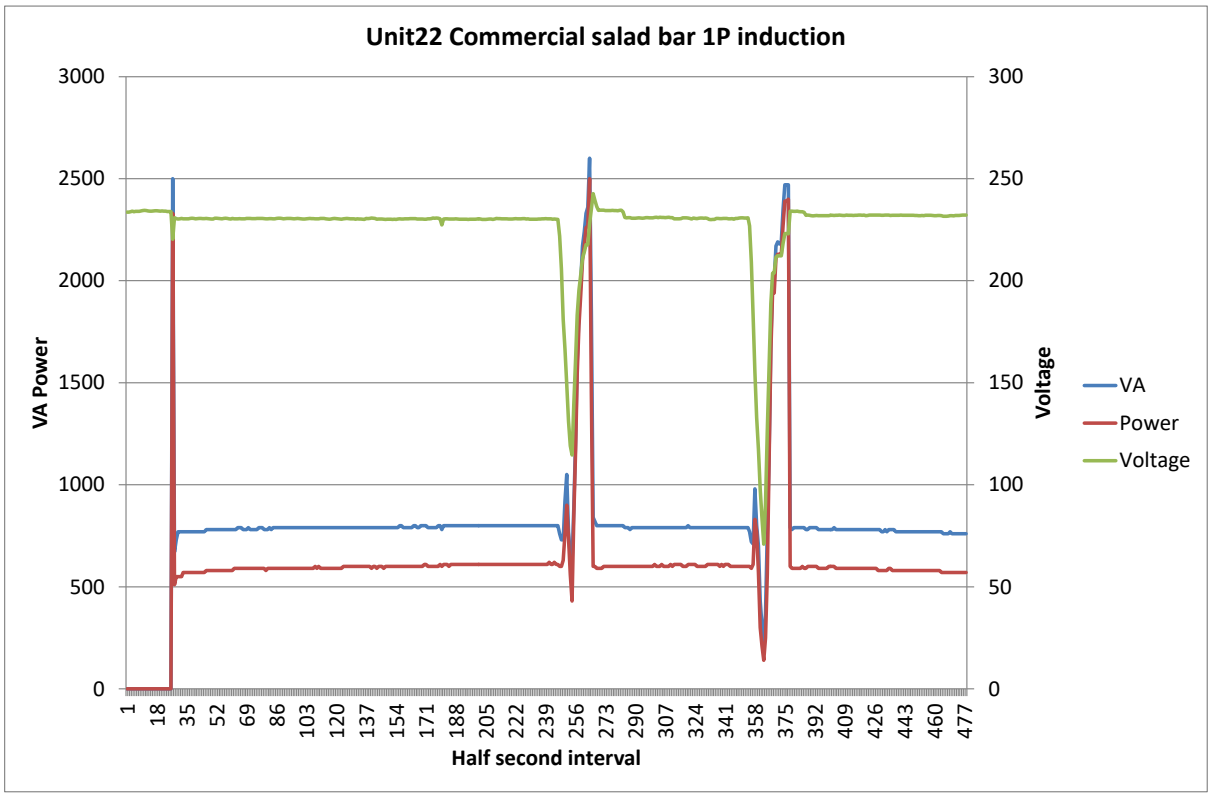
Parameter	Value
Year:	new
On power W:	388
On Power Factor:	0.958
Stall/disconnect Voltage:	14
Stall Power @ stall Voltage W:	#N/A
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A



Unit22

Unit: Unit22
Sector: Commercial
Product: salad bar
Motor type: 1P induction
Control: Mechanical
Brand: ROBAND
Model: ERX25
Measurement notes: Stalled at 130V (not that clear that it did stall or when as stall power and operating power very similar at low volts), seem to have a short overload period then resumed normal operation without a trip, 2 voltage dips attempted (same behaviour for both)

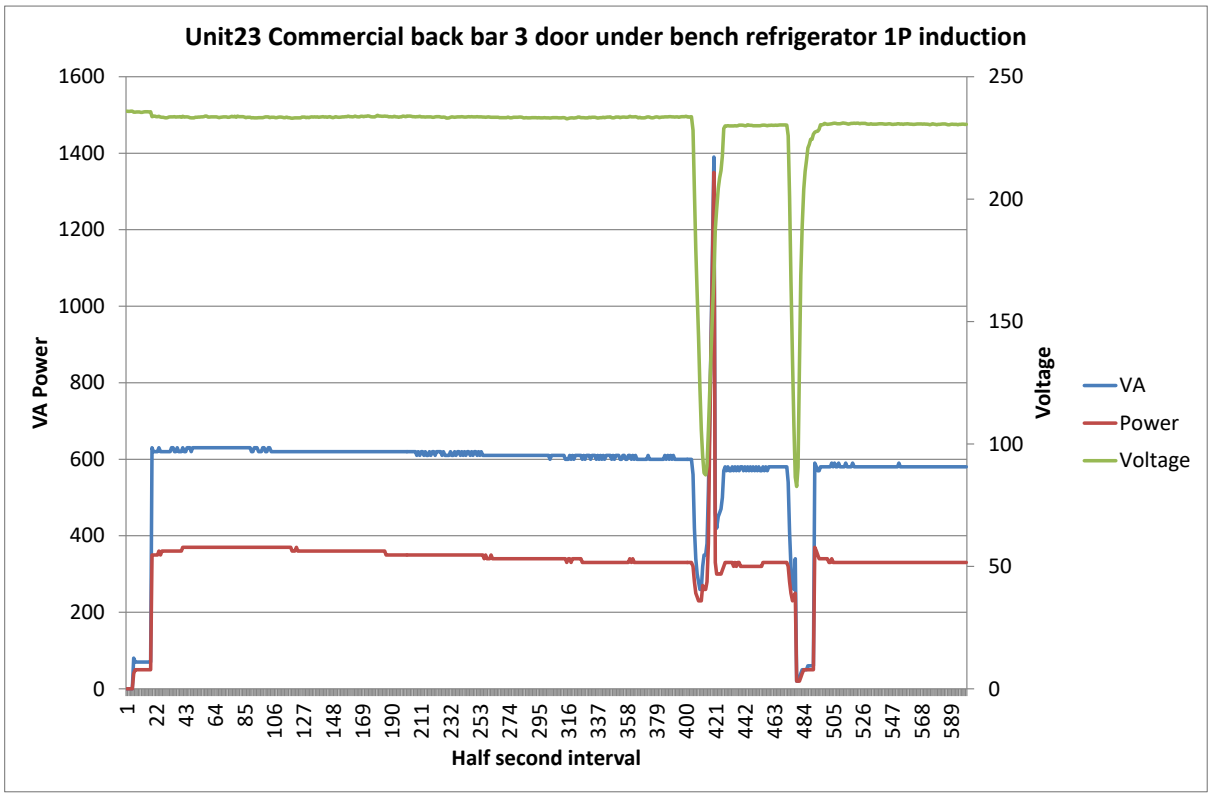
Parameter	Value
Year:	new
On power W:	610
On Power Factor:	0.765
Stall/disconnect Voltage:	149
Stall Power @ stall Voltage W:	900
Protection type:	Thermal
Stall Power @ 230V W:	2270
Stall Power Factor:	0.961
Stall time before protection disconnects sec:	7
Off time after disconnect before restart sec:	0
Ratio Stall Power/Operating Power:	3.721



Unit23

Unit: Unit23
Sector: Commercial
Product: back bar 3 door under bench refrigerator
Motor type: 1P induction
Control: Digital
Brand: FED
Model: BC3100G
Measurement notes: First attempt dipped to 87V and did not stall and there was a small power spike for a second or two, second attempt disconnected at lower voltage 84V (small steps in power over time?)

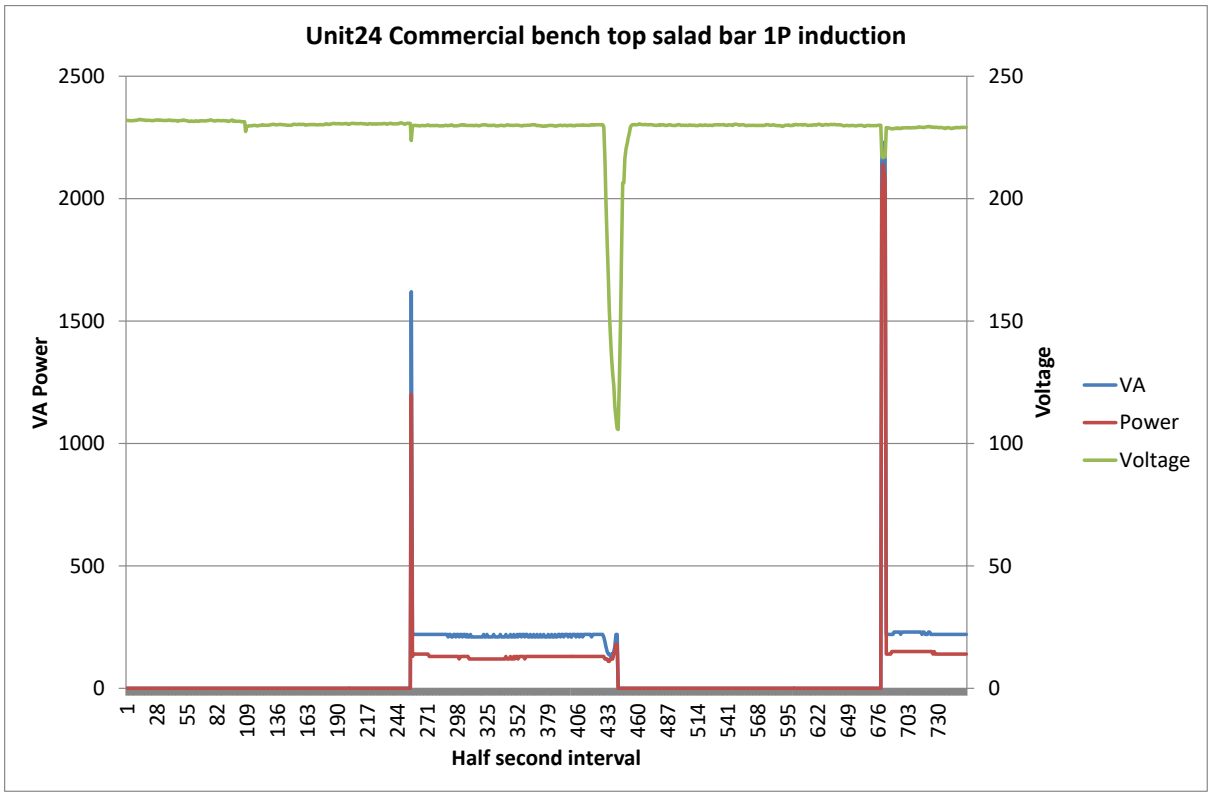
Parameter	Value
Year:	new
On power W:	330
On Power Factor:	0.556
Stall/disconnect Voltage:	84
Stall Power @ stall Voltage W:	20
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A



Unit24

Unit: Unit24
Sector: Commercial
Product: bench top salad bar
Motor type: 1P induction
Control: Digital
Brand: Atosa
Model: VRX1500
Measurement notes: Approx 125 sec from power connection to compressor start

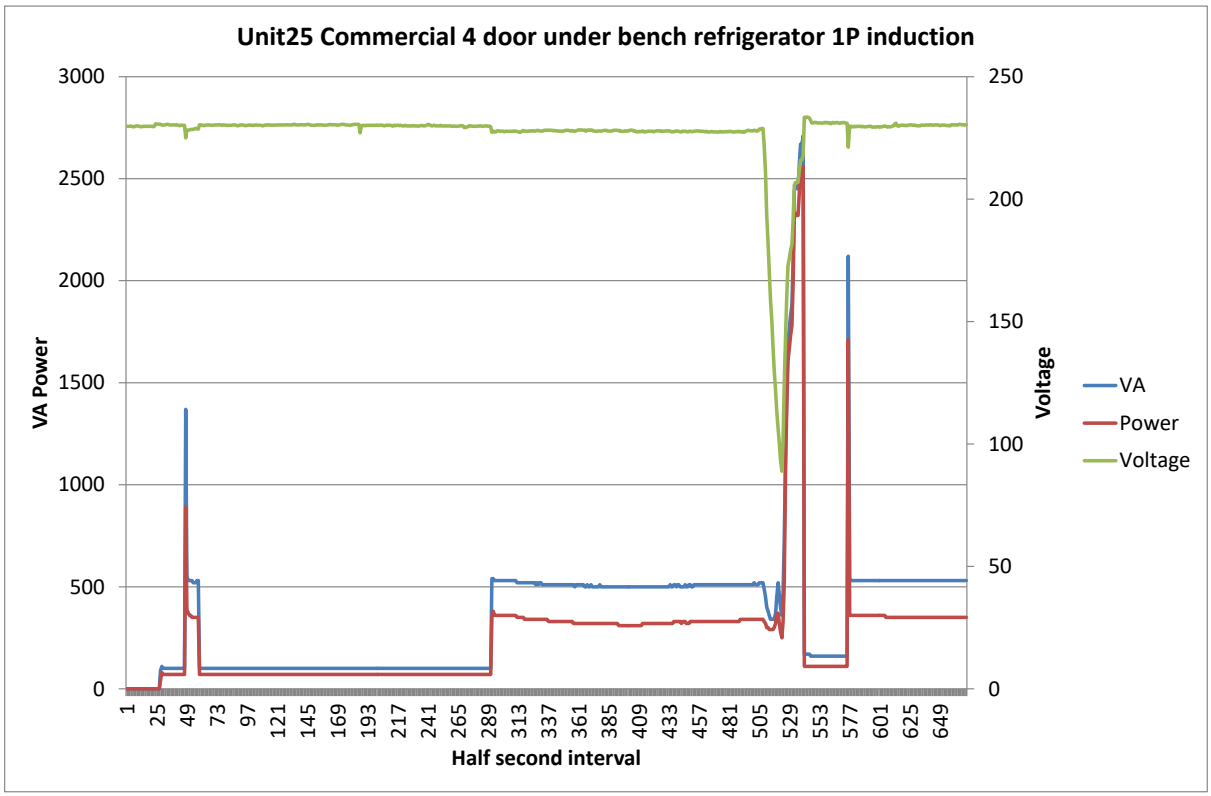
Parameter	Value
Year:	new
On power W:	130
On Power Factor:	0.604
Stall/disconnect Voltage:	105
Stall Power @ stall Voltage W:	0
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	119
Ratio Stall Power/Operating Power:	#N/A



Unit25

Unit: Unit25
Sector: Commercial
Product: 4 door under bench refrigerator
Motor type: 1P induction
Control: Digital
Brand: Snowman
Model: GN4100TN
Measurement notes: 130 sec to compressor on when power on or after protection disconnected compressor, seems to be short compressor operation 10 sec after power connected

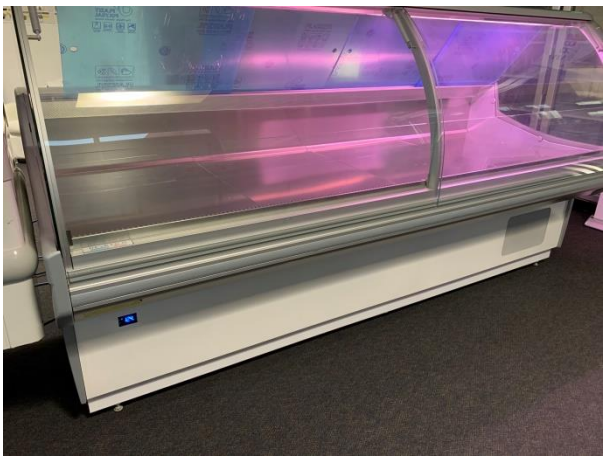
Parameter	Value
Year:	new
On power W:	340
On Power Factor:	0.653
Stall/disconnect Voltage:	113
Stall Power @ stall Voltage W:	370
Protection type:	Thermal
Stall Power @ 230V W:	2520
Stall Power Factor:	0.945
Stall time before protection disconnects sec:	11
Off time after disconnect before restart sec:	18
Ratio Stall Power/Operating Power:	7.412

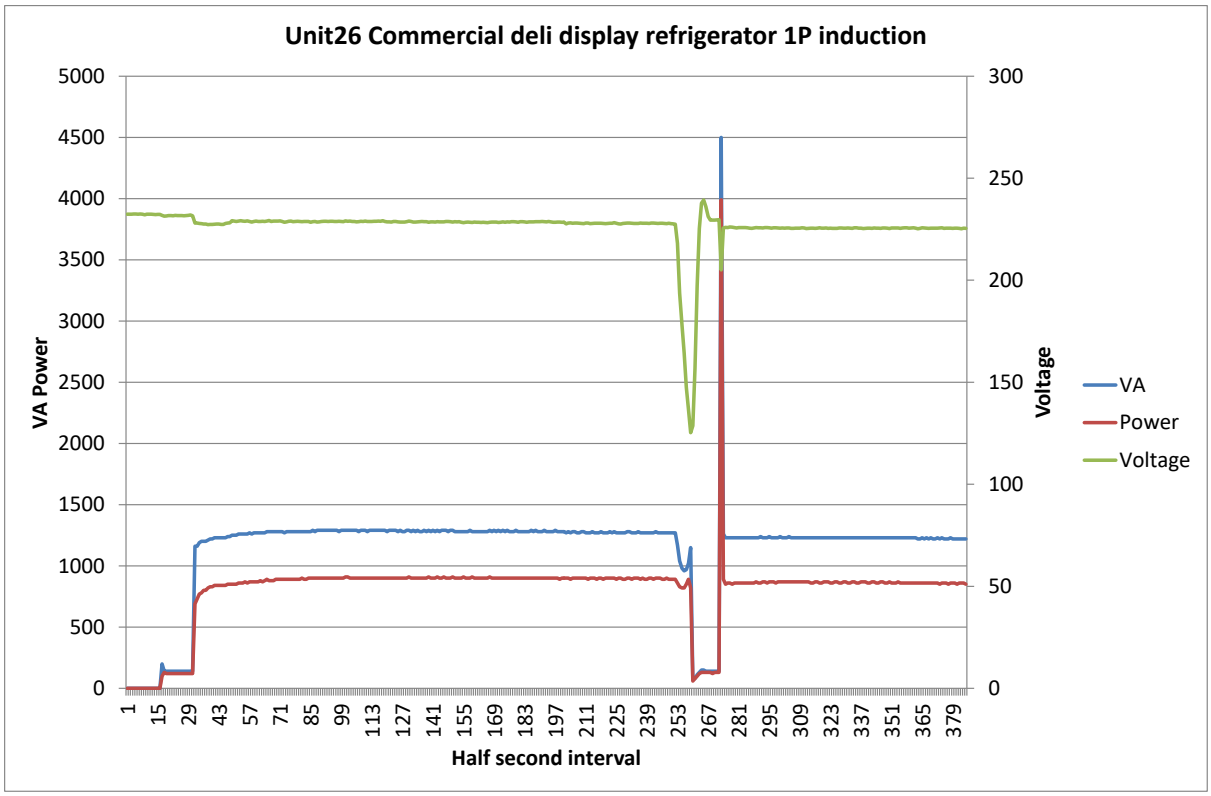


Unit26

Unit: Unit26
Sector: Commercial
Product: deli display refrigerator
Motor type: 1P induction
Control: Digital
Brand: Derigo
Model: 2.5m deli
Measurement notes: Nothing unusual

Parameter	Value
Year:	new
On power W:	900
On Power Factor:	0.702
Stall/disconnect Voltage:	126
Stall Power @ stall Voltage W:	60
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A

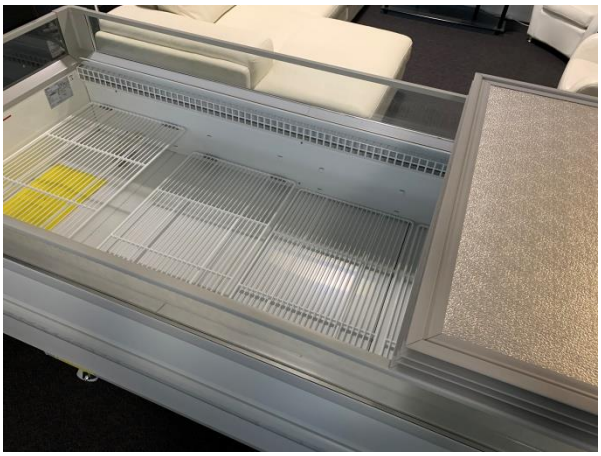


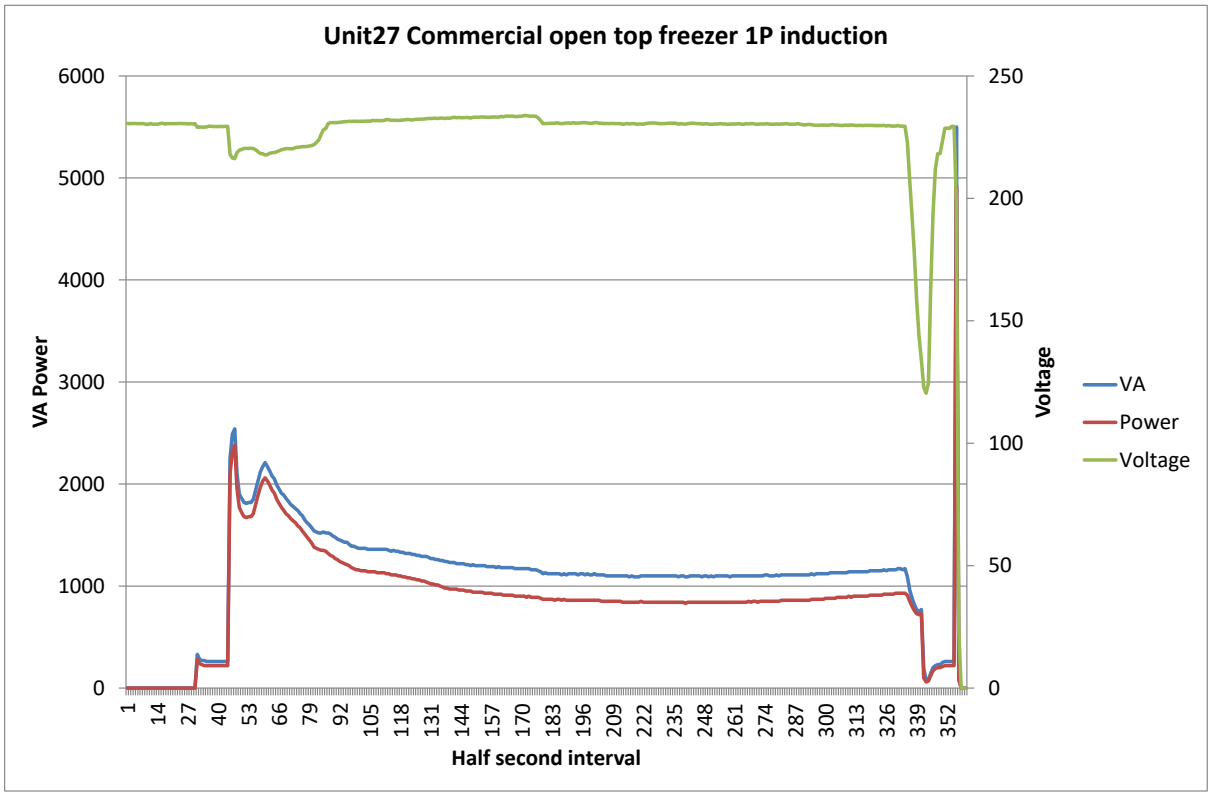


Unit27

Unit: Unit27
Sector: Commercial
Product: open top freezer
Motor type: 1P induction
Control: Digital
Brand: Derigo
Model: 2m open top freezer
Measurement notes: Compressor restart drew 20 A and blew 10A fuse on variac so readings stopped, still obtained valid result

Parameter	Value
Year:	new
On power W:	900
On Power Factor:	0.788
Stall/disconnect Voltage:	125
Stall Power @ stall Voltage W:	60
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A

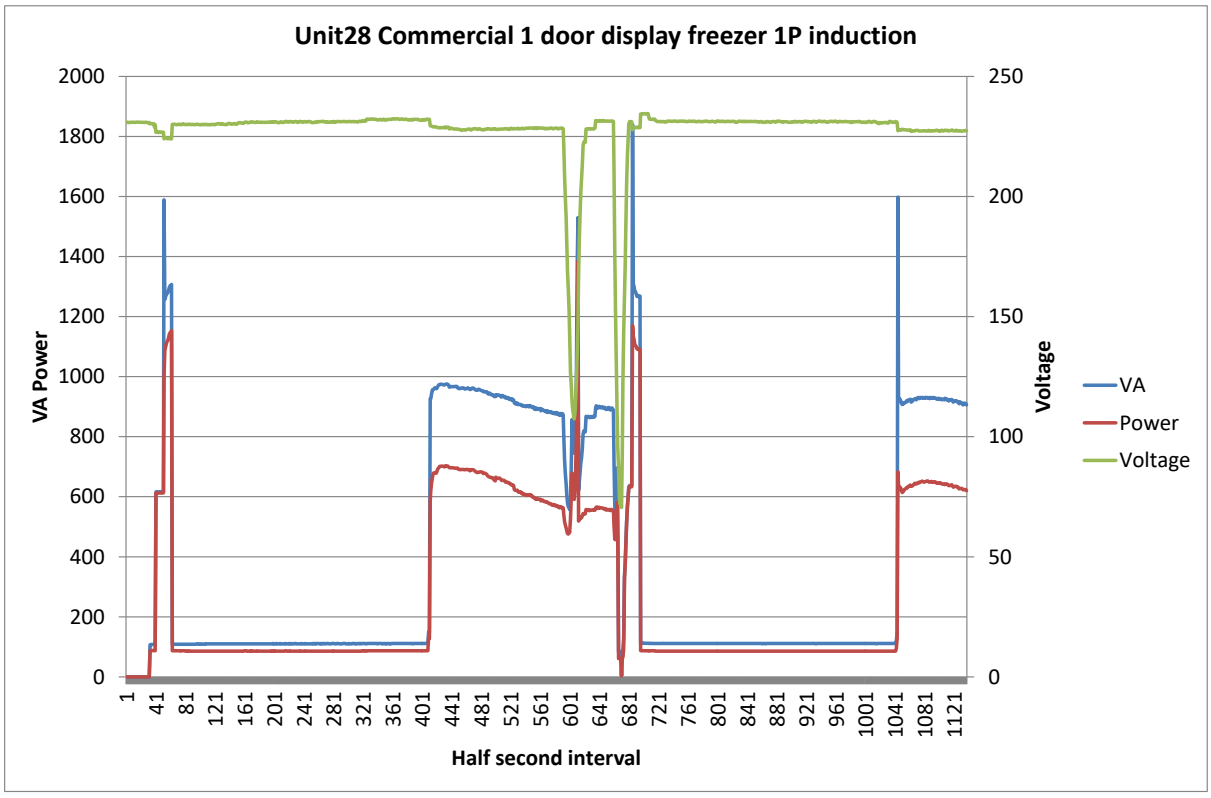




Unit28

Unit: Unit28
Sector: Commercial
Product: 1 door display freezer
Motor type: 1P induction
Control: Digital
Brand: Novachill
Model: SM600GZ
Measurement notes: 190 sec to compressor on when power on or after protection disconnected compressor, seems to be short compressor operation (or some other activity for 11 sec) 10 sec after power connected, 2 voltage dips - disconnected on second dip, see Unit07

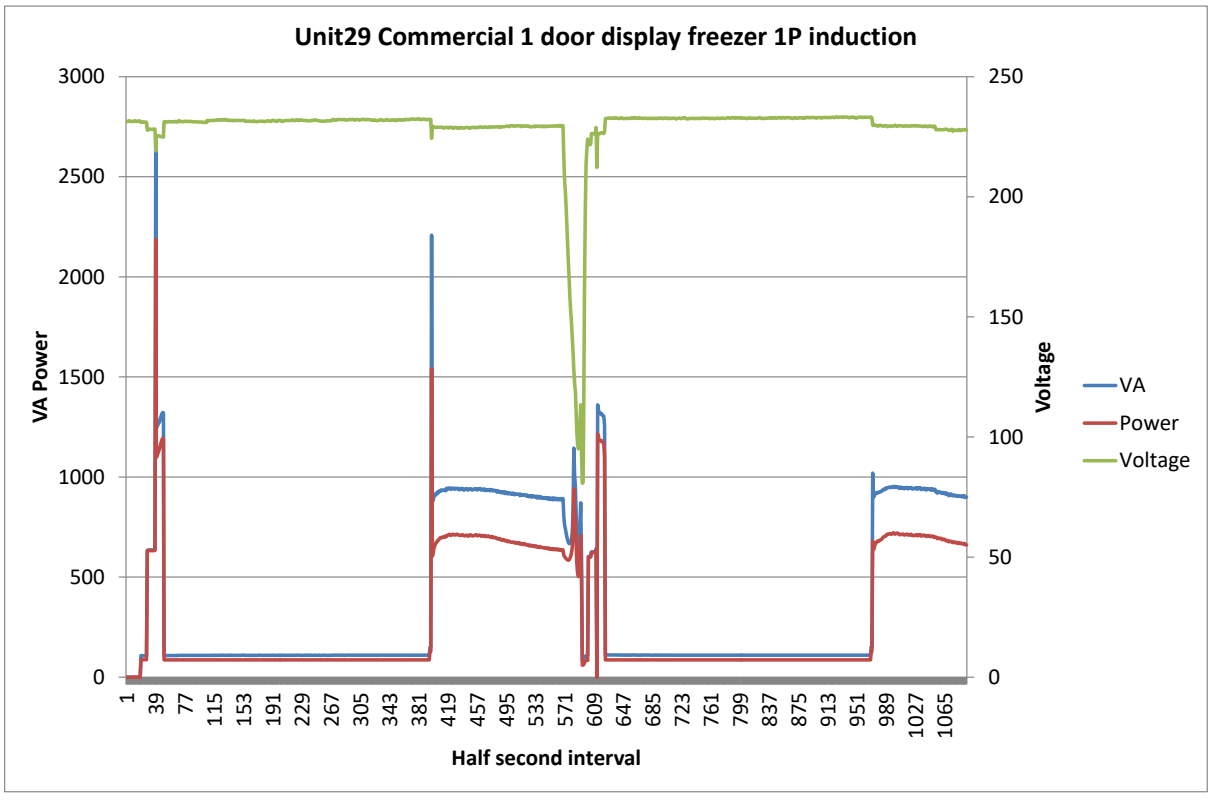
Parameter	Value
Year:	2019
On power W:	586
On Power Factor:	0.661
Stall/disconnect Voltage:	87
Stall Power @ stall Voltage W:	61
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	190
Ratio Stall Power/Operating Power:	#N/A



Unit29

Unit: Unit29
Sector: Commercial
Product: 1 door display freezer
Motor type: 1P induction
Control: Digital
Brand: Novachill
Model: SM600GZ
Measurement notes: 190 sec to compressor on when power on or after protection disconnected compressor, seems to be short compressor operation (or some other activity for 11 sec) 10 sec after power connected, see Unit07

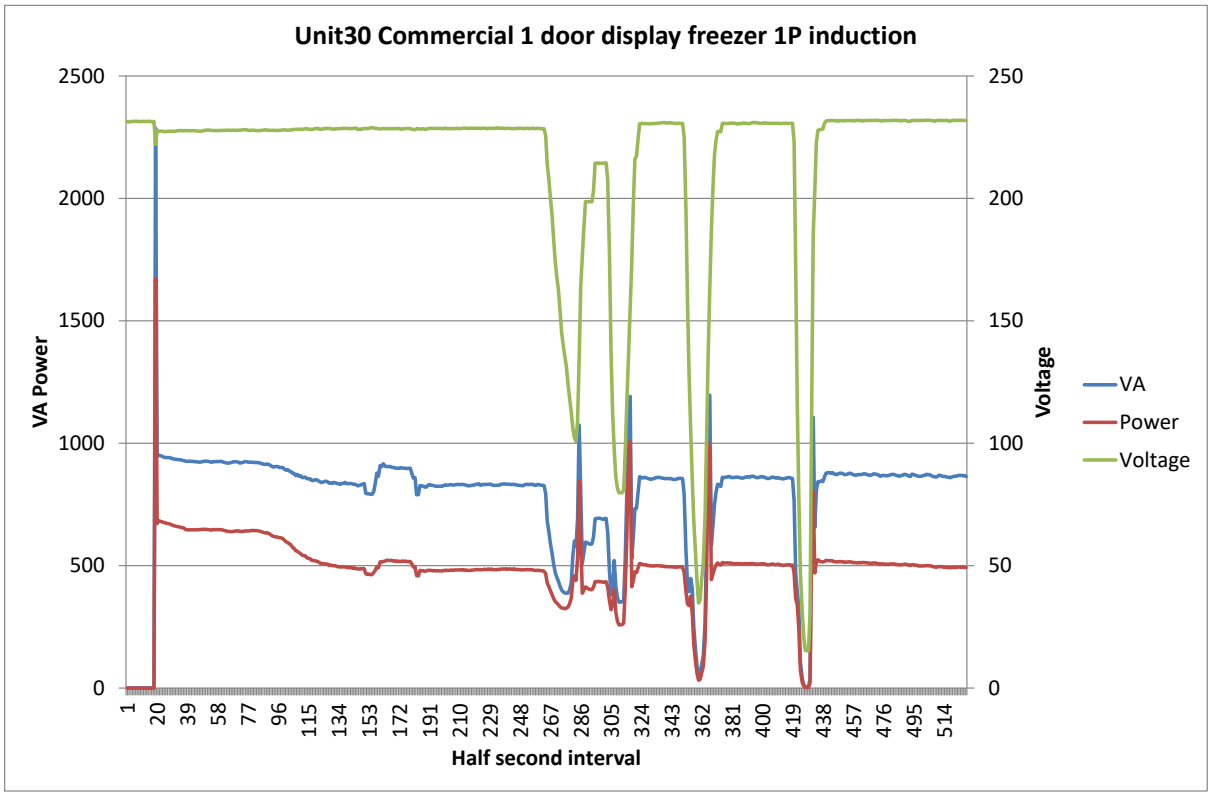
Parameter	Value
Year:	2020
On power W:	636
On Power Factor:	0.712
Stall/disconnect Voltage:	85
Stall Power @ stall Voltage W:	60
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	188
Ratio Stall Power/Operating Power:	#N/A



Unit30

Unit: Unit30
Sector: Commercial
Product: 1 door display freezer
Motor type: 1P induction
Control: Digital
Brand: Bromic
Model:
Measurement notes: 4 attempts at lower voltage but did not appear to stall, <1 sec power surge to 1000W as voltage increased

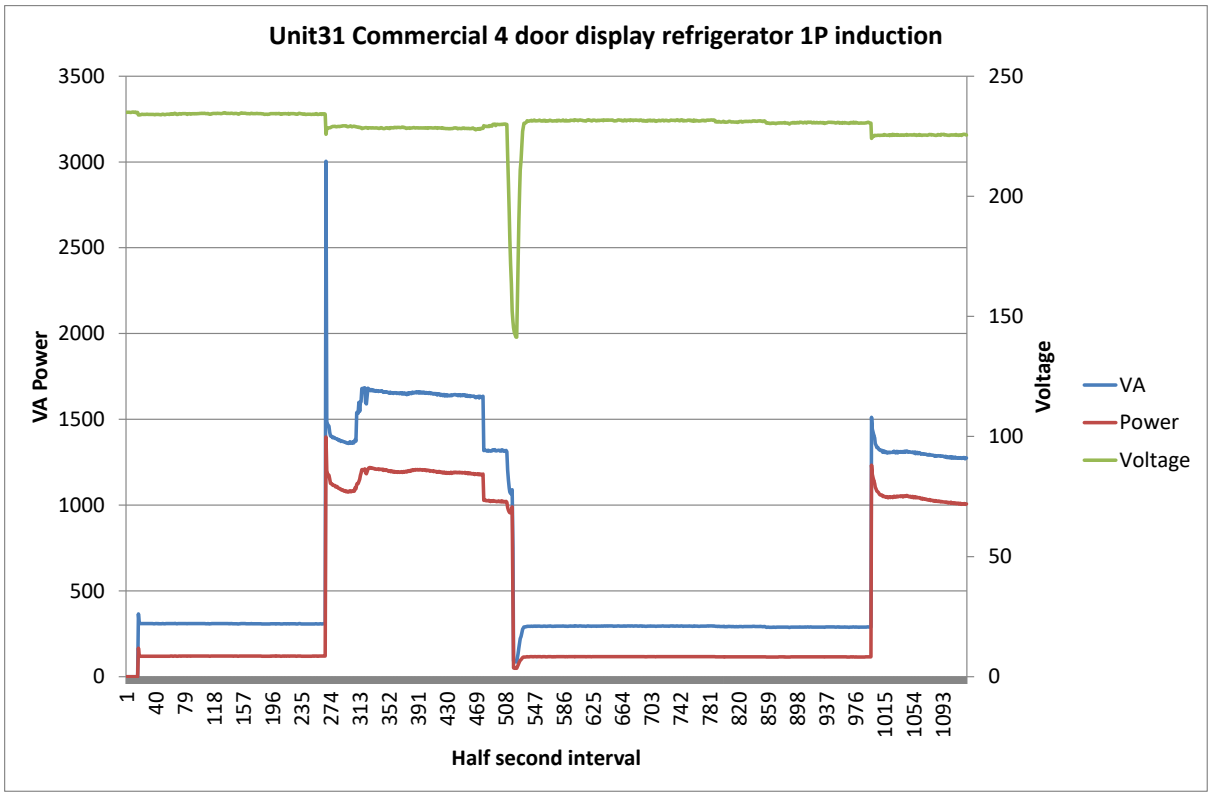
Parameter	Value
Year:	2008
On power W:	484
On Power Factor:	0.585
Stall/disconnect Voltage:	15
Stall Power @ stall Voltage W:	0
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A



Unit31

Unit: Unit31
Sector: Commercial
Product: 4 door display refrigerator
Motor type: 1P induction
Control: Digital
Brand: Orford
Model: Carel controller
Measurement notes: 125 sec to compressor on when power on

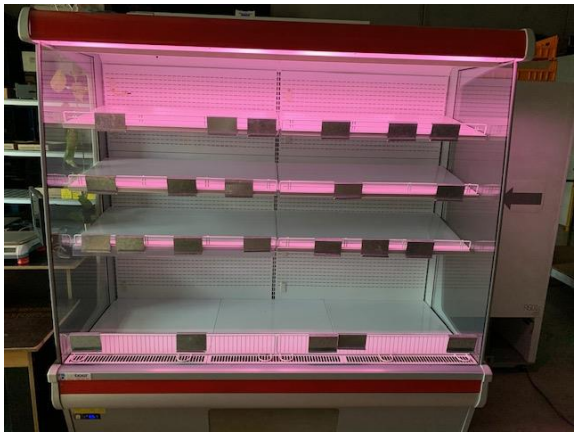
Parameter	Value
Year:	2010
On power W:	1025
On Power Factor:	0.776
Stall/disconnect Voltage:	146
Stall Power @ stall Voltage W:	51
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	240
Ratio Stall Power/Operating Power:	#N/A

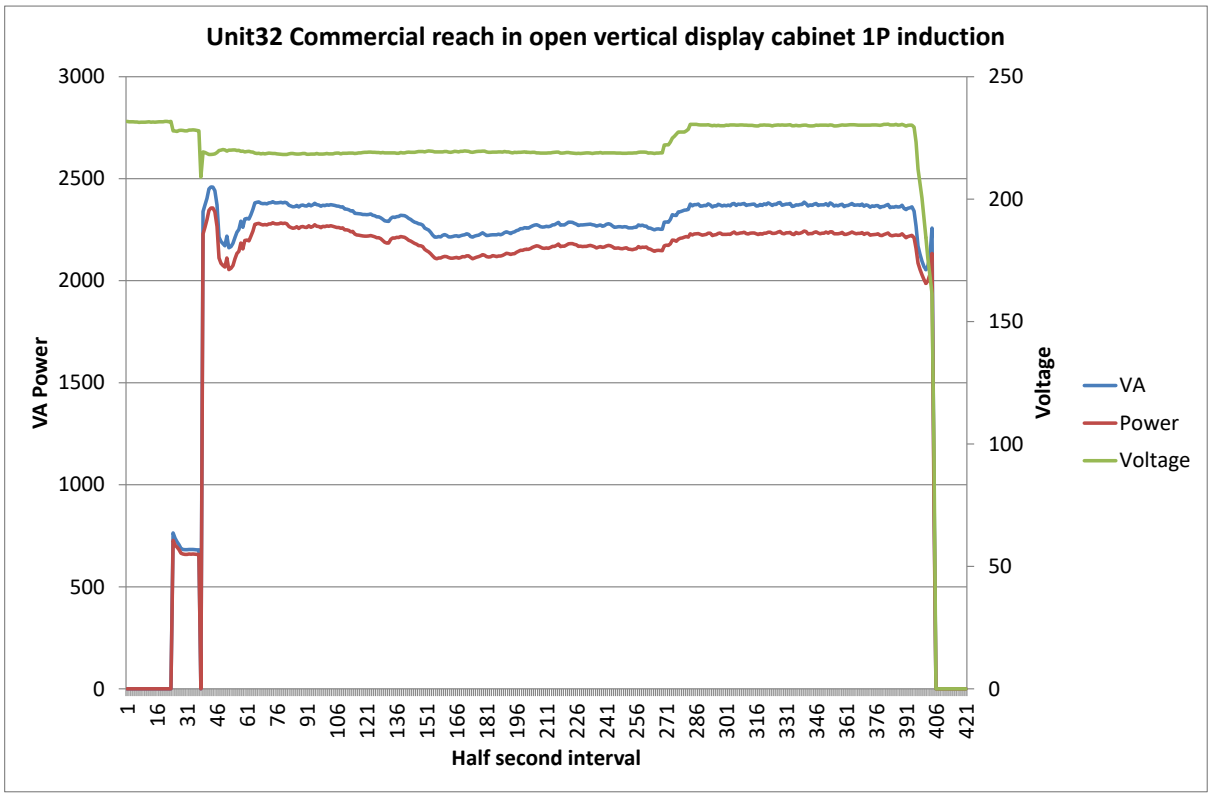


Unit32

Unit: Unit32
Sector: Commercial
Product: reach in open vertical display cabinet
Motor type: 1P induction
Control: Digital
Brand: Derigo
Model: 2.4m wide
Measurement notes: Compressor increase in current on low voltage drew 20A and blew fuse on variac so readings stopped before stall or disconnect, no conclusive data on protection

Parameter	Value
Year:	2020
On power W:	2230
On Power Factor:	941
Stall/disconnect Voltage:	#N/A
Stall Power @ stall Voltage W:	#N/A
Protection type:	#N/A
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A

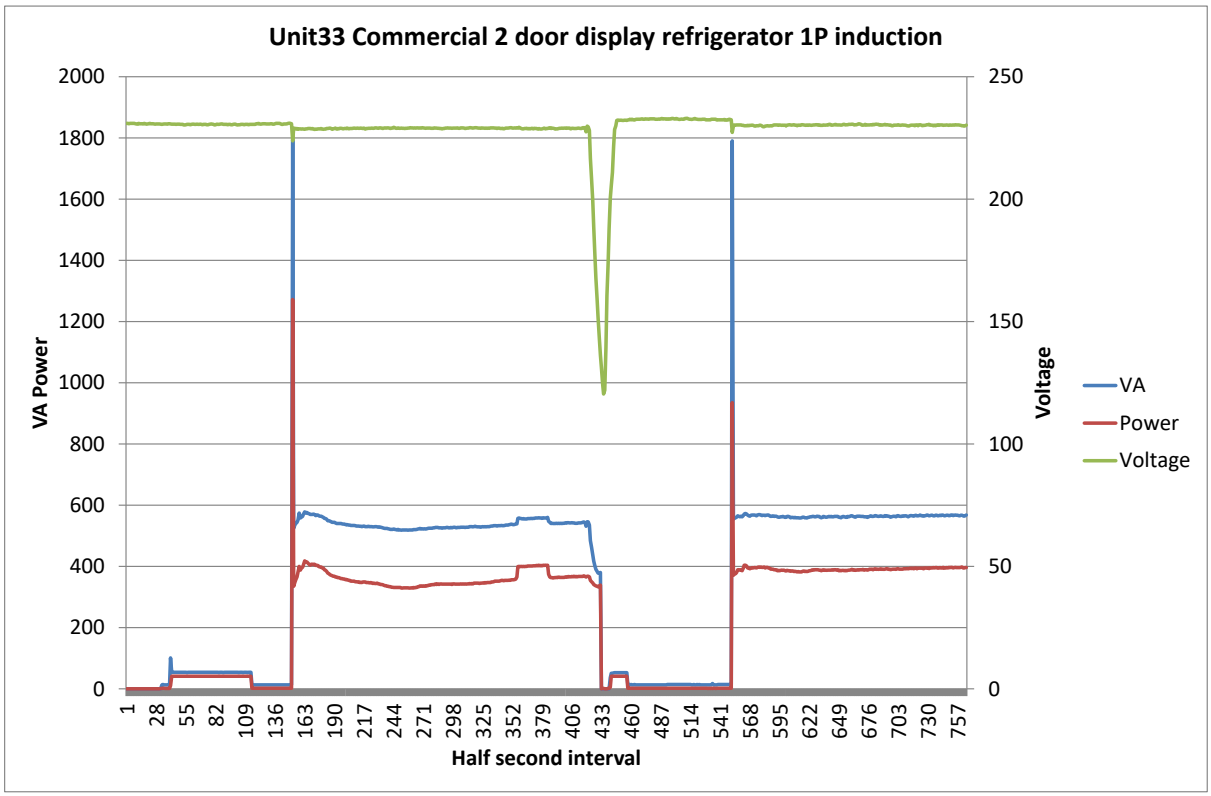




Unit33

Unit: Unit33
Sector: Commercial
Product: 2 door display refrigerator
Motor type: 1P induction
Control: Digital
Brand: Skope
Model: BME1200A
Measurement notes: 60 sec to compressor on when power on or after protection disconnected compressor, Carel S4 digital controller, lights came on after power on and after compressor disconnect (manually turned off)

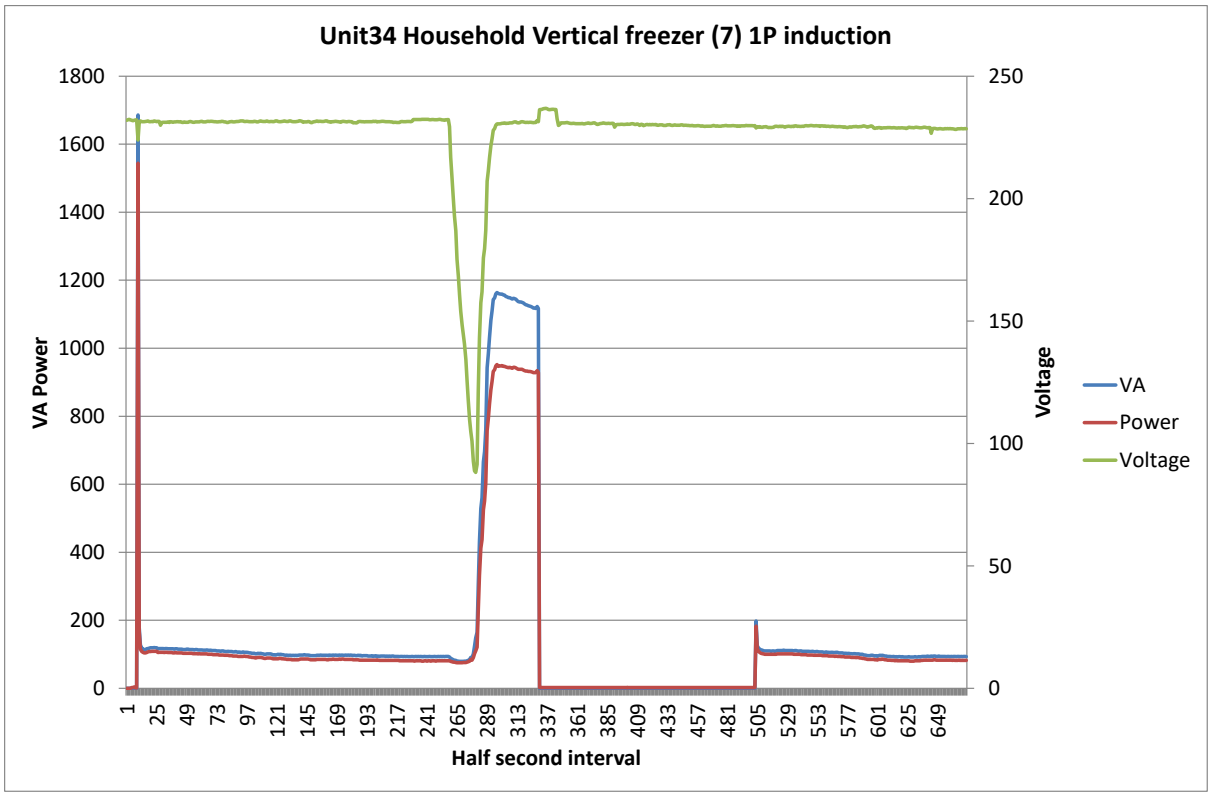
Parameter	Value
Year:	2015
On power W:	366
On Power Factor:	0.674
Stall/disconnect Voltage:	134
Stall Power @ stall Voltage W:	0
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	59
Ratio Stall Power/Operating Power:	#N/A



Unit34

Unit: Unit34
Sector: Household
Product: Vertical freezer (7)
Motor type: 1P induction
Control: Electronic
Brand: Westinghouse
Model: WFB4204WA
Measurement notes: Nothing unusual

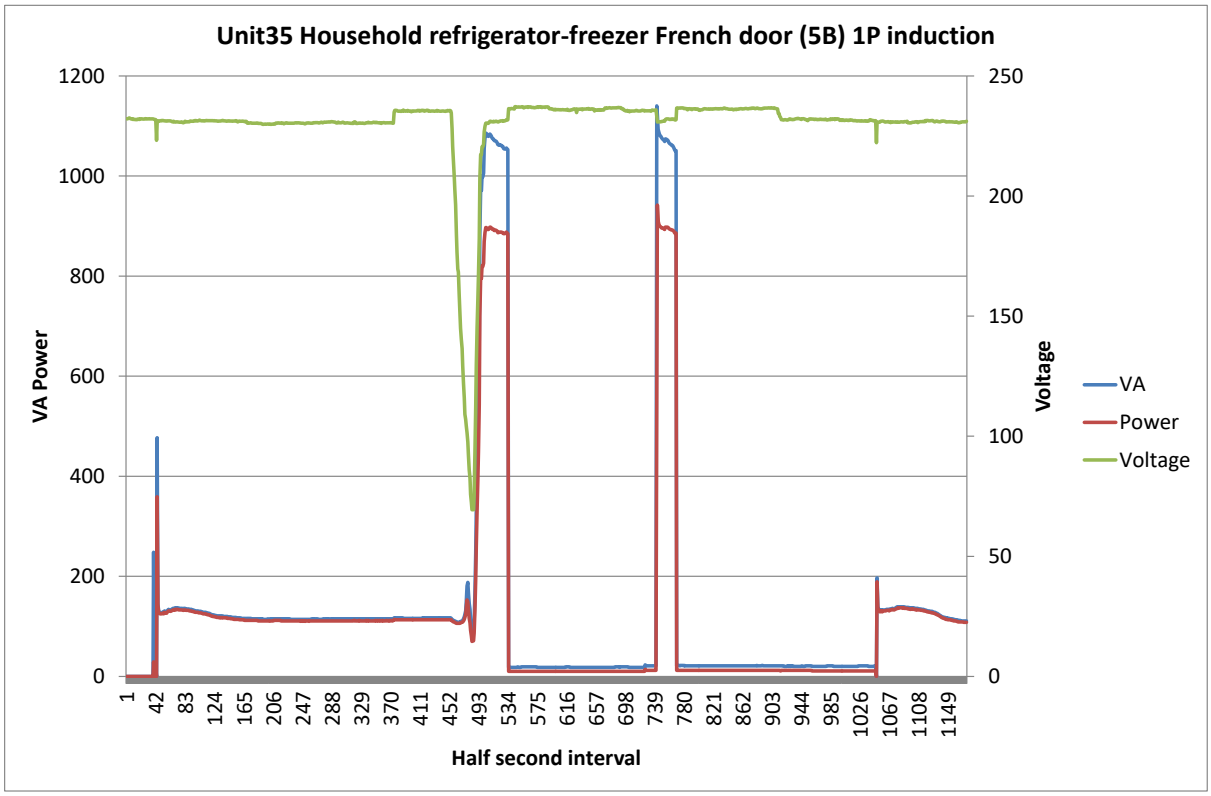
Parameter	Value
Year:	2018
On power W:	80
On Power Factor:	0.868
Stall/disconnect Voltage:	89
Stall Power @ stall Voltage W:	102
Protection type:	Thermal
Stall Power @ 230V W:	932
Stall Power Factor:	0.828
Stall time before protection disconnects sec:	26
Off time after disconnect before restart sec:	87
Ratio Stall Power/Operating Power:	11.650



Unit35

Unit: Unit35
Sector: Household
Product: refrigerator-freezer French door (5B)
Motor type: 1P induction
Control: Electronic
Brand: F&P
Model: RF522ADX4
Measurement notes: Two thermal overload events before restarting normally, first overload time was 34 sec due to lower voltage, second was 14 sec

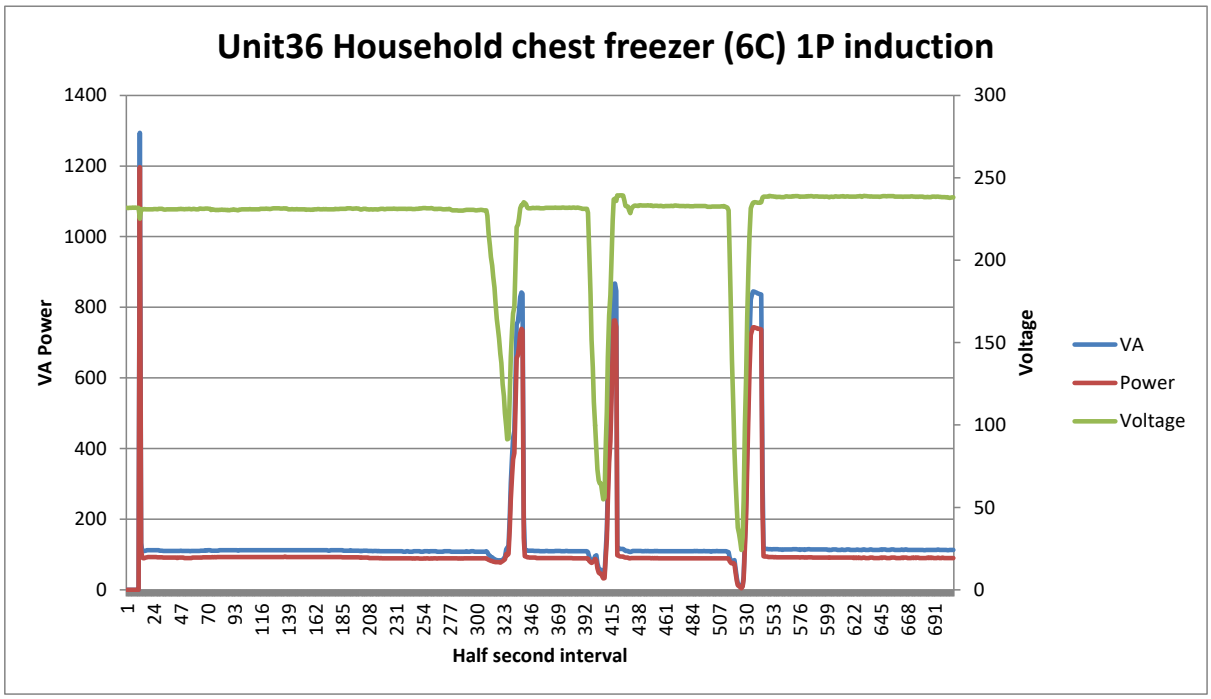
Parameter	Value
Year:	2013
On power W:	113
On Power Factor:	0.97
Stall/disconnect Voltage:	122
Stall Power @ stall Voltage W:	111
Protection type:	Thermal
Stall Power @ 230V W:	888
Stall Power Factor:	0.837
Stall time before protection disconnects sec:	14
Off time after disconnect before restart sec:	104
Ratio Stall Power/Operating Power:	7.858



Unit36

Unit: Unit36
Sector: Household
Product: chest freezer (6C)
Motor type: 1P induction
Control: Mechanical
Brand: F&P
Model: H275
Measurement notes: 3 attempts to stall, was a few sec of higher power at 750W after voltage reset but then resumed normal operation without a gap, may be overload protection without disconnect after reset

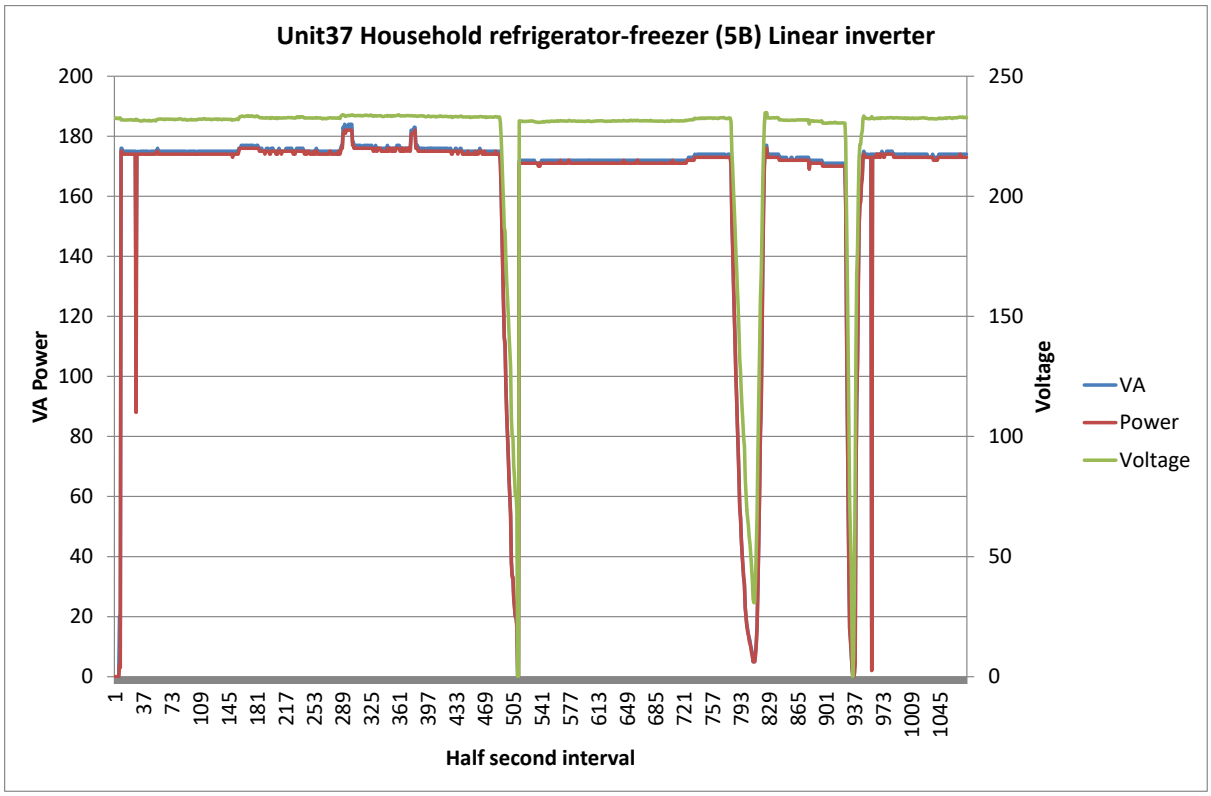
Parameter	Value
Year:	2013
On power W:	89
On Power Factor:	0.822
Stall/disconnect Voltage:	99
Stall Power @ stall Voltage W:	105
Protection type:	Thermal
Stall Power @ 230V W:	740
Stall Power Factor:	0.877
Stall time before protection disconnects sec:	8
Off time after disconnect before restart sec:	0
Ratio Stall Power/Operating Power:	8.315



Unit37

Unit: Unit37
Sector: Household
Product: refrigerator-freezer (5B)
Motor type: Linear inverter
Control: Electronic
Brand: LG
Model: GB-450UPLX
Measurement notes: Power scales with voltage to 0V, very high power factor

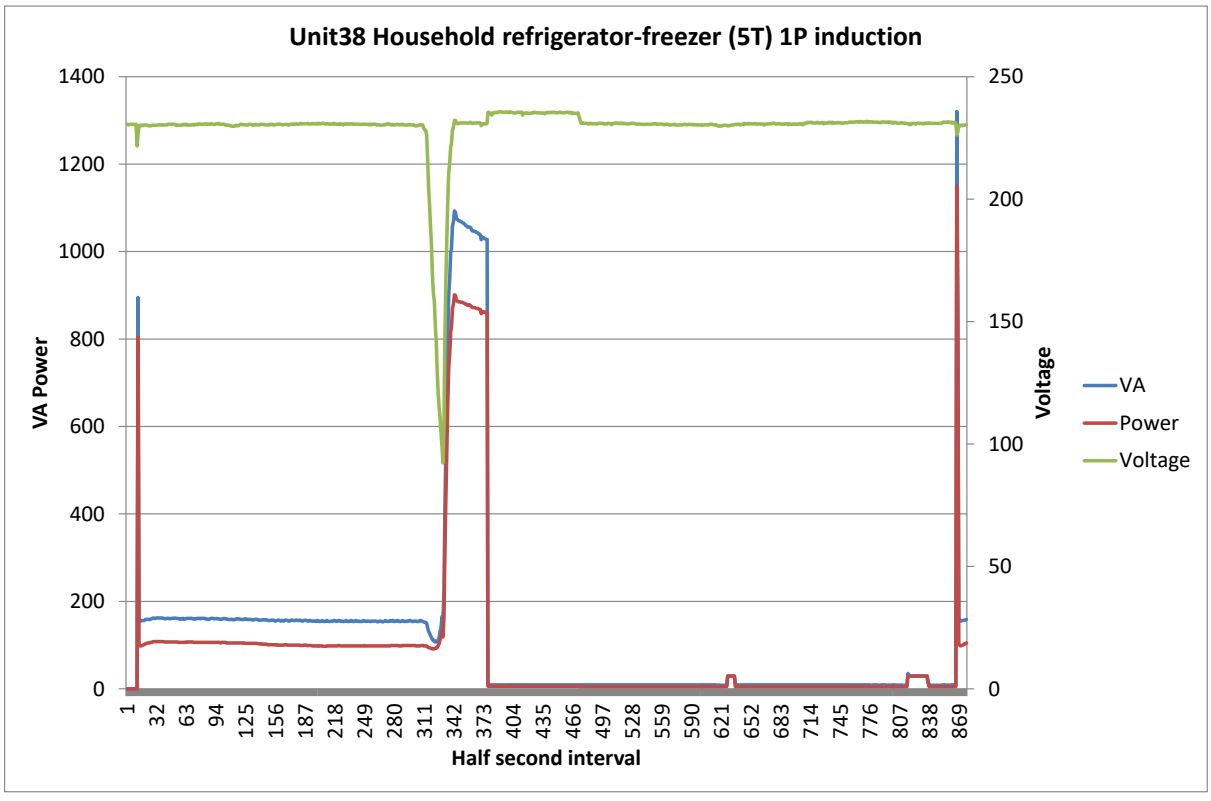
Parameter	Value
Year:	2019
On power W:	175
On Power Factor:	0.995
Stall/disconnect Voltage:	0
Stall Power @ stall Voltage W:	0
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A



Unit38

Unit: Unit38
Sector: Household
Product: refrigerator-freezer (5T)
Motor type: 1P induction
Control: Electronic
Brand: Simpson
Model: STM5200WA
Measurement notes: Some issues with laptop shutting down during recording so some data discontinuities in raw data, very long time to resume compressor after thermal protection, thermostat may have been at suitable temperature already so door opened twice

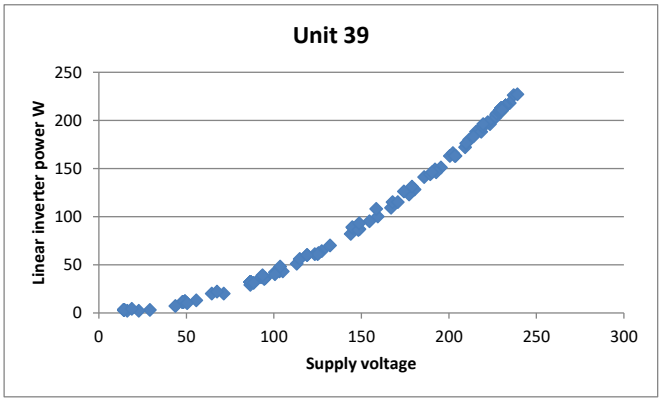
Parameter	Value
Year:	2007
On power W:	99
On Power Factor:	0.634
Stall/disconnect Voltage:	115
Stall Power @ stall Voltage W:	103
Protection type:	Thermal
Stall Power @ 230V W:	860
Stall Power Factor:	0.837
Stall time before protection disconnects sec:	26
Off time after disconnect before restart sec:	387
Ratio Stall Power/Operating Power:	8.687

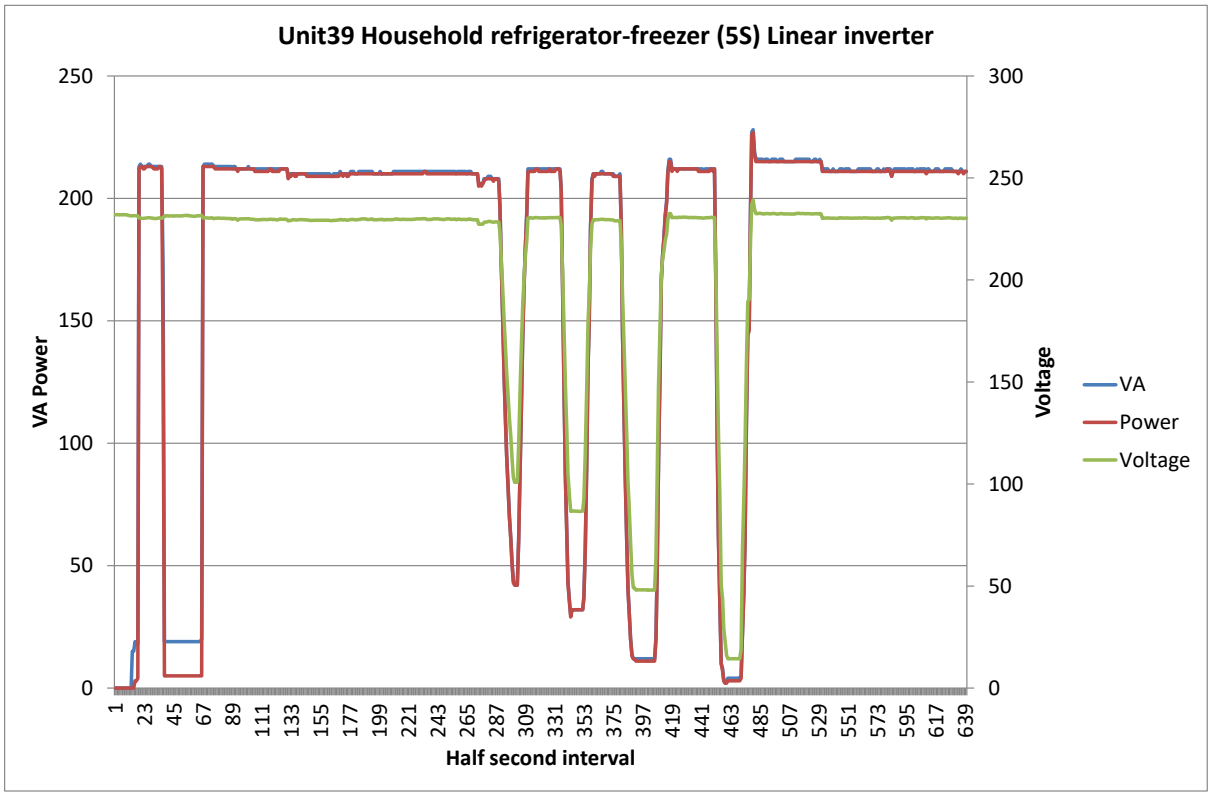


Unit39

Unit: Unit39
Sector: Household
Product: refrigerator-freezer (5S)
Motor type: Linear inverter
Control: Electronic
Brand: LG
Model: GS-B679PL
Measurement notes: Power scales with voltage to very low volts, 4 voltage dips, very high power factor

Parameter	Value
Year:	2017
On power W:	210
On Power Factor:	0.997
Stall/disconnect Voltage:	15
Stall Power @ stall Voltage W:	3
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	#N/A
Ratio Stall Power/Operating Power:	#N/A

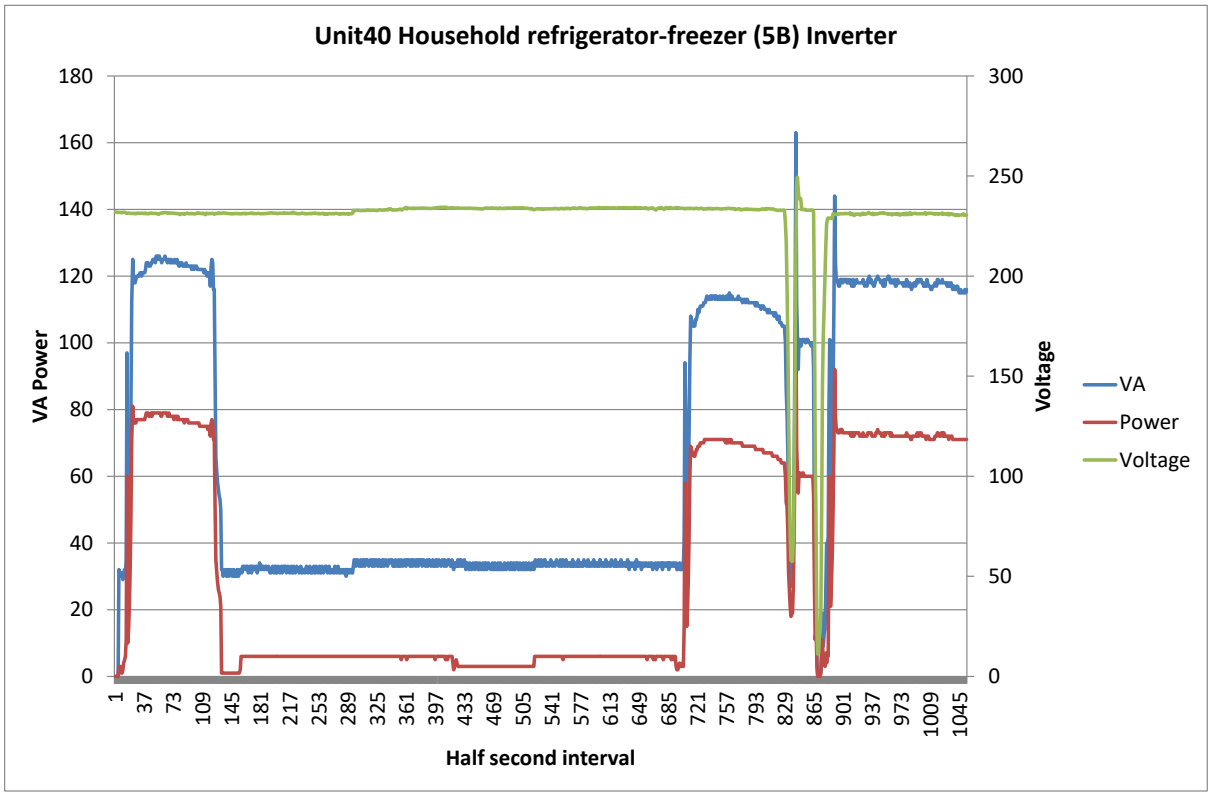




Unit40

Unit: Unit40
Sector: Household
Product: refrigerator-freezer (5B)
Motor type: Inverter
Control: Electronic
Brand: Electrolux
Model: EBE5307SA
Measurement notes: 2 voltage dips, disconnects at 15V for 7 sec then resumes, power more or less scales with voltage

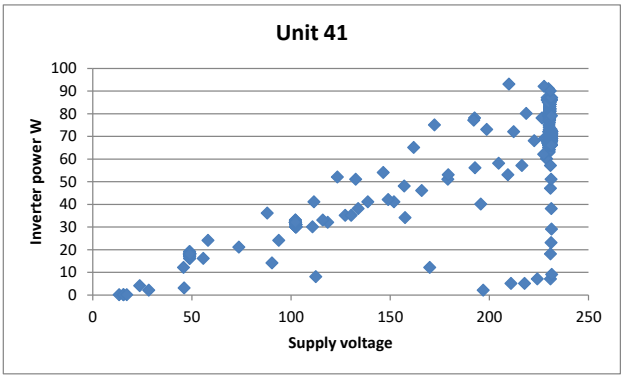
Parameter	Value
Year:	2019
On power W:	68
On Power Factor:	0.611
Stall/disconnect Voltage:	21
Stall Power @ stall Voltage W:	0
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A

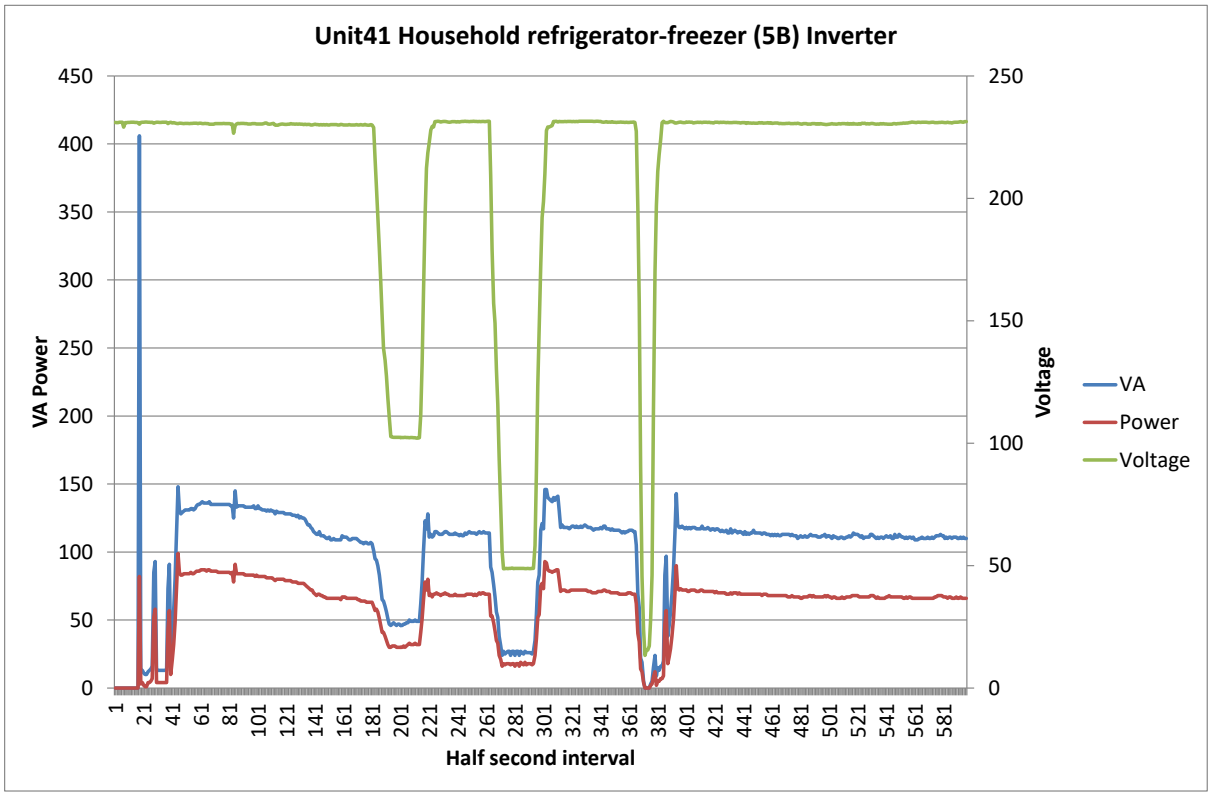


Unit41

Unit: Unit41
Sector: Household
Product: refrigerator-freezer (5B)
Motor type: Inverter
Control: Electronic
Brand: Electrolux
Model: EBE4507SA
Measurement notes: 3 voltage dips, operates at 50V, disconnects at 20V for 7 sec then resumes, power more or less scales with voltage

Parameter	Value
Year:	2019
On power W:	64
On Power Factor:	0.6
Stall/disconnect Voltage:	20
Stall Power @ stall Voltage W:	0
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	7
Ratio Stall Power/Operating Power:	#N/A

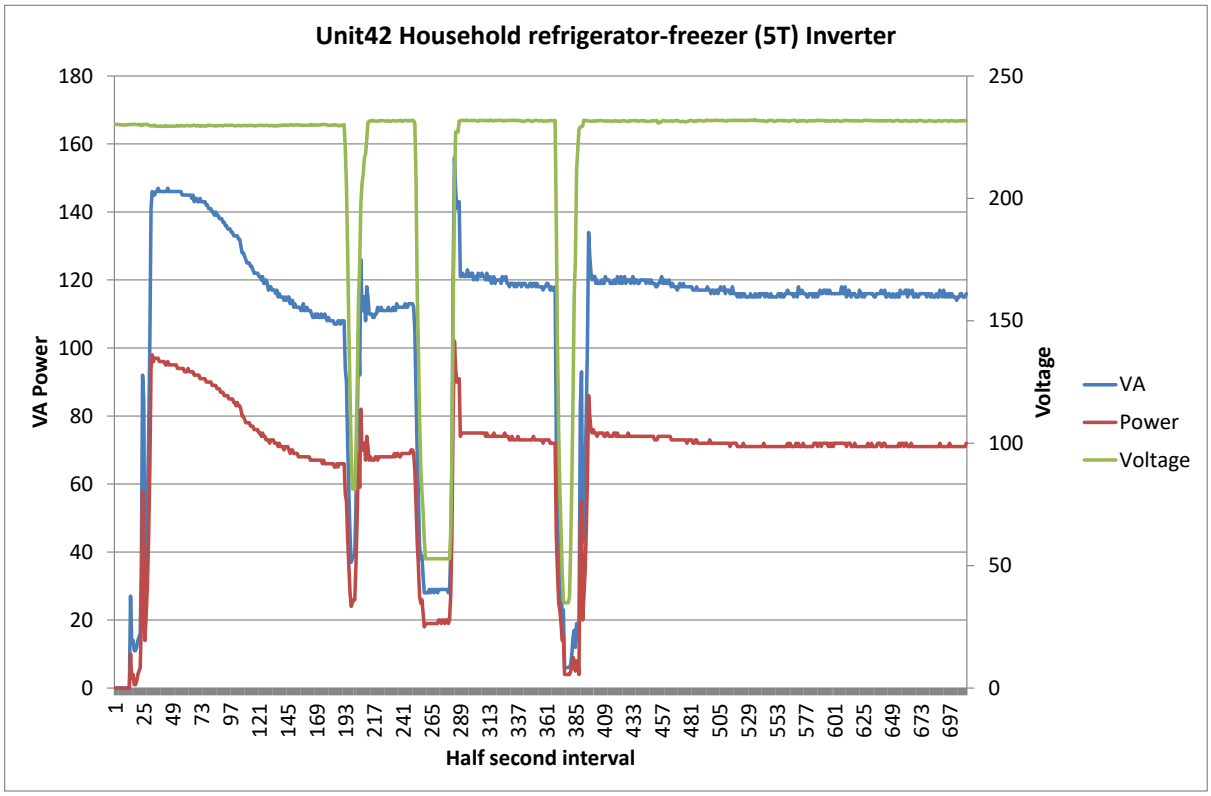




Unit42

Unit: Unit42
Sector: Household
Product: refrigerator-freezer (5T)
Motor type: Inverter
Control: Electronic
Brand: Electrolux
Model: ETE4607SA
Measurement notes: 3 voltage dips, operates at 50V, disconnects at 35V for 6 sec then resumes, power more or less scales with voltage

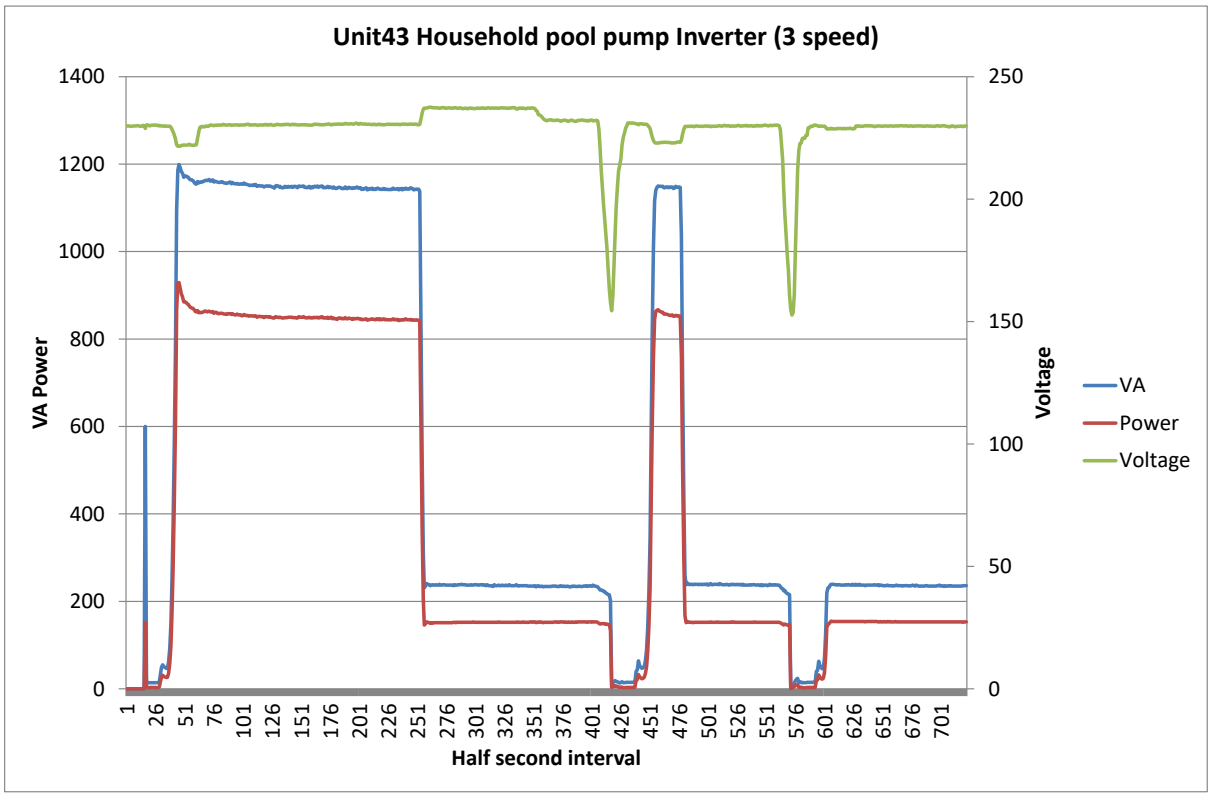
Parameter	Value
Year:	2018
On power W:	69
On Power Factor:	0.614
Stall/disconnect Voltage:	35
Stall Power @ stall Voltage W:	4
Protection type:	No stall
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	6
Ratio Stall Power/Operating Power:	#N/A



Unit43

Unit: Unit43
Sector: Household
Product: pool pump
Motor type: Inverter (3 speed)
Control: Electronic
Brand: Onga
Model: Eco8
Measurement notes: Soft start slowly increases speed, pool pump operates at highest speed for 112 sec when starting as pump priming cycle then drops back to selected speed, short priming cycle on first restart after low V, no priming cycle on second restart after low V

Parameter	Value
Year:	2016
On power W:	152
On Power Factor:	0.641
Stall/disconnect Voltage:	155
Stall Power @ stall Voltage W:	3
Protection type:	Disconnect
Stall Power @ 230V W:	#N/A
Stall Power Factor:	#N/A
Stall time before protection disconnects sec:	#N/A
Off time after disconnect before restart sec:	11
Ratio Stall Power/Operating Power:	#N/A



Report end