# Test Report


## Himoinsa HYW-17 T5 Three Phase Diesel Generator

**Radial Flux Laboratories Pty. Ltd.**
**E-mail:** info@radialfluxlabs.com
**Web:** http://www.rflalternators.com/

2/7 Pritchard Pl,
Peakhurst, NSW, 2210
Phone: +61 2 9584 9970
Mobile: +61 408 504 842

# Contents

# RFL Alternator versus Stamford Alternator

*A comparison on the Yanmar 4TNV88 Diesel Engine (Himoinsa HYW-17 Gen-Set)*

The RFL Alternator RF-4 Series is a technologically advanced brushless single stator, single rotor permanent magnet design. The combination of novel winding techniques with innovative rotor and stator design gives the RF series significant advantage over current commercially available technologies.

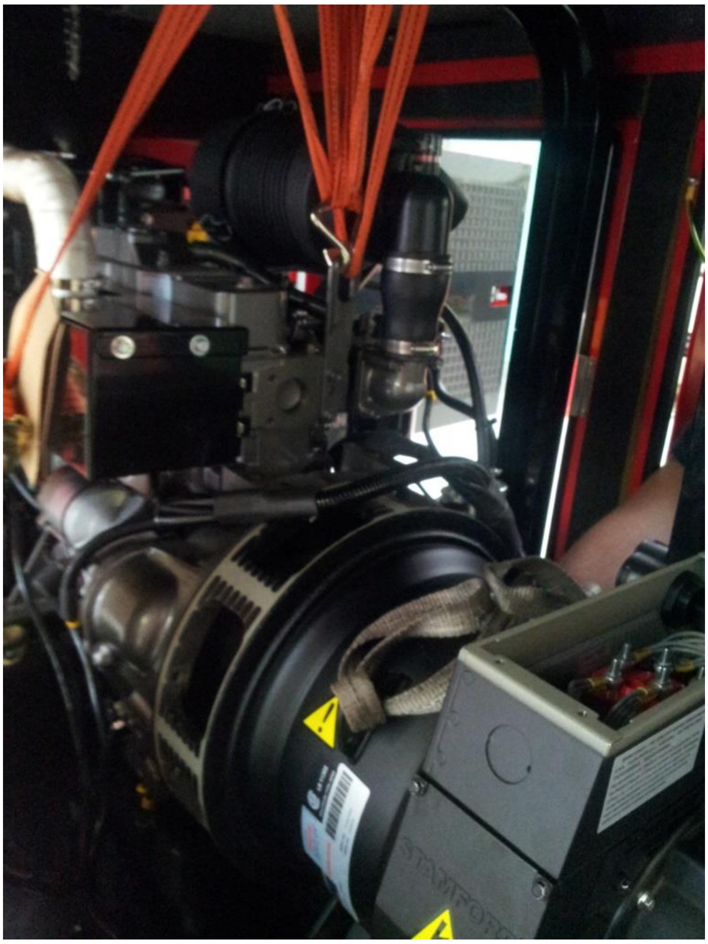
The RF4 series alternators are designed to be compact and lightweight with high efficiency. All materials used in construction are conventional, so as to minimize manufacturing cost whilst still providing the specified performance. Its PM design and natural electronic regulation means that possible points of failure are kept to a minimum by eliminating traditional brushes and AVRs.

The original Stamford PI044H Alternator was used as a comparison point for its similar high efficiency, brushless design. Tests results of fuel economy, motor starting capabilities and other physical factors were compared and the RFL alternator was found to be superior in most aspects.

# Technical Specifications

| |  |  |
|---|---|---|
| **Alternator** | **Stamford PI044H** | **RFL RF4-160-130-157** |
| | | |
| **Type** | Brushless Alternator with Exciter | PM Brushless Alternator |
| **Poles** | 4 Poles | 4 Poles |
| **Phase** | 3 Phase | 3 Phase |
| **Frequency** | 50Hz | 50Hz |
| **RPM** | 1500 RPM | 1500 RPM |
| **Voltage Range** | 415 V | 420 V |
| **Apparent Power** | 17.6 kVA | 20.7 kVA |
| **Power Factor** | 0.8 | 0.8 |
| **Standby Power** | 16.0 kW | 20.0 kW |
| **Continuous Power** | 14.0 kW | 17.0 kW |
| **Regulation** | AVR Controlled + PM End | No AVR |
| **Stator Resistance** | 0.561 Ohms | 0.275 Ohms |
| **Bearing** | Single | Single (removable cassette) |
| **Enclosure** | IP23 | IP23 |
| **Insulation Class** | H | H |
| **Length** | 555mm | 300mm |
| **Weight** | 107 kg | 58 kg |
| **Transients, Load Rejection 24.0 A** | -11.0%, +13.0% | -6.0% +0.0% |
| | | |

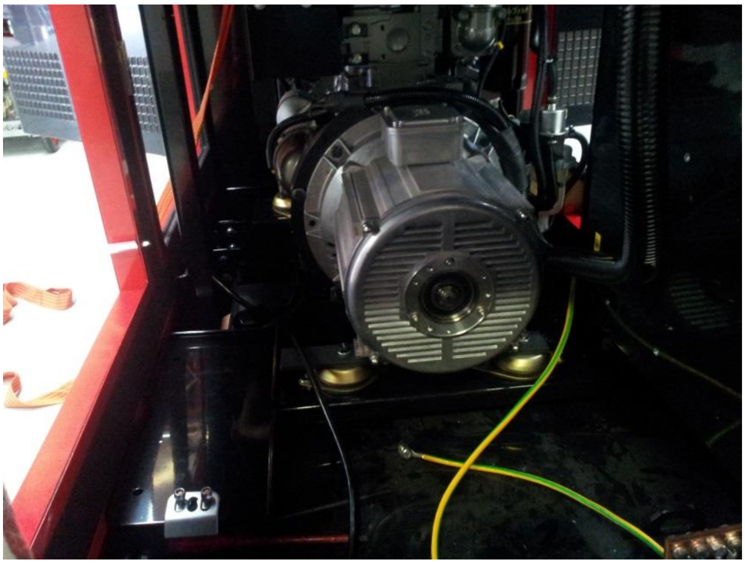
## Switch-over Procedure



The back covers of the gen-set were removed and side doors were opened to allow access to the engine and alternator. Before removing the alternator, the bolts holding the alternator legs down were removed and a wrench strap was wound several times around the engine lifting hook and the top of the metal frame of the gen-set. This was tightened until it held the weight of the alternator side of the engine and tilted it slightly upwards. The electrical connections between the alternator and main switchboard panel were also disconnected.

After unscrewing the alternator grill covering the SAE connection, the flywheel bolts were unbolted with great difficulty by putting a hand in the large holes in the alternator flange. The engine flywheel was rotated slightly several times in order to reach all eight bolts. Once this was done, most of the bolts joining the engine housing to the alternator flange were removed except for two, which were left there to stabilise the alternator. A forklift hook was then inserted through the door of the gen-set and took the weight of the alternator using a smaller strapping. After removing the two remaining bolts, as well as the battery, the forklift picked up the alternator and was guided out of the gen-set doorway.

To install the RFL alternator, the taper shaft coupling was first bolted to the engine flywheel and the alternator lifted into position with the forklift. The inwards adjustment distance between the feet mounts on the gen-set was not sufficient and also too low for the smaller size of the RFL alternator so a temporary bar was made to be able to bolt the alternator legs to the leg mounts. Bolts fastened the alternator flange to the engine housing and the central engine bolt fitted with a torque of 50N.m. In order to achieve this, the engine flywheel was locked so it could not spin by inserting a screwdriver in the side of the Yanmar engine to make contact with the ring gear.



The battery was then refitted, strapping released, ground wire connected and the electrical connections were made.

## Physical Comparisons

Figure 1 - Front view size comparison

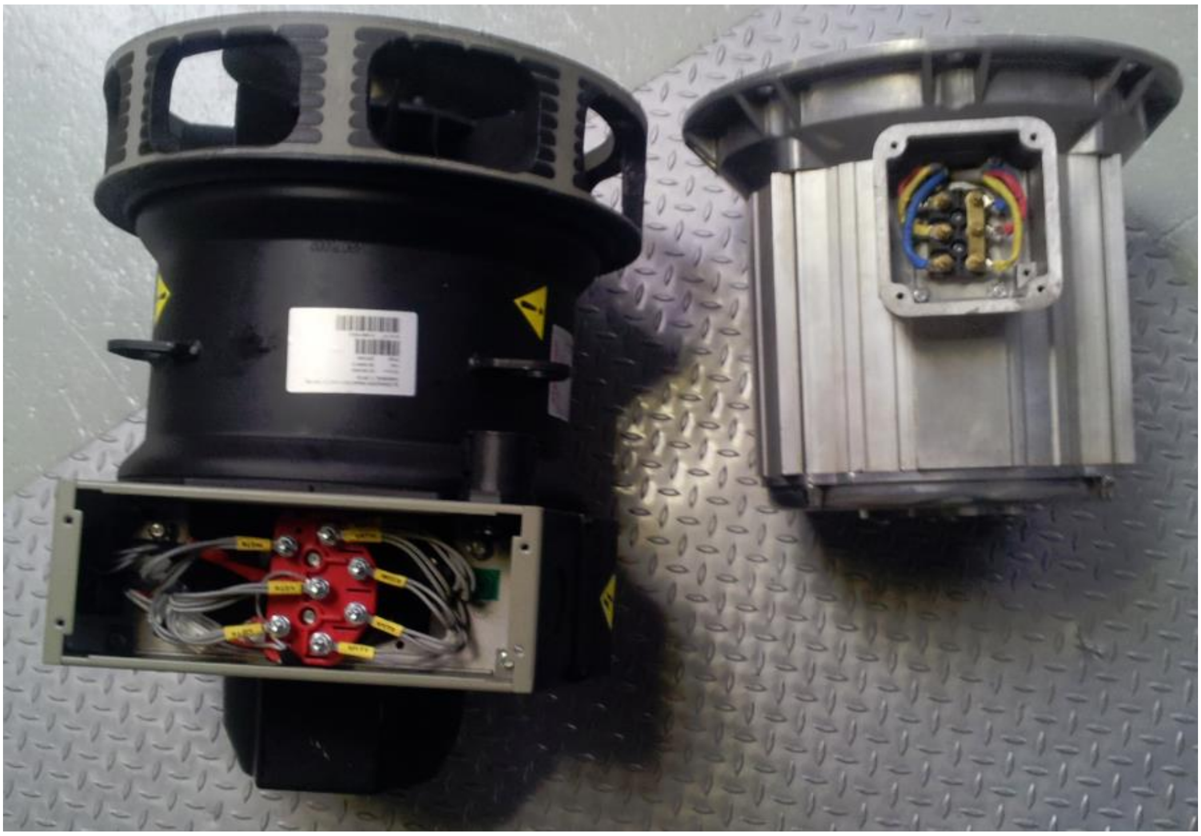


Figure 2 - Top view size comparison

Figure 3 - Stamford AVR Electronics

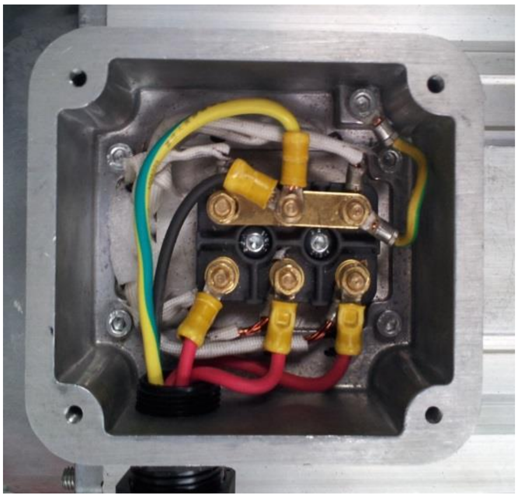


Figure 4 - RFL electric terminals

| Alternator Comparison | | | |
|---|---|---|---|
| | Stamford | RFL | RFL % Reduction |
| **Weight (Kg)** | 107 | 58 | -45.79% |
| **Resistance (Ohms)** | 0.561 | 0.257 | -54.19% |
| **Length(mm)** | 500 | 300 | -40.00% |
| **Efficiency** | 87% | 95% | +9.20% |

# Test Procedure

Tests were conducted on the HYW-17 T5 with the Stamford alternator to establish base line data using resistive load and motor start loads. Temperature sensors were placed on the alternator and on the inside of the gen-set box. These were named as; T1 Alternator Air In, T2 Alternator Air Out, T3 Alternator Case Temp, T4 Air inside Gen Set Box . A HIOKI Power Analyser was used to measure volts, amps, Pf, watts and kVA. A Digital Oscilloscope (PicoScope 3425) was used to look at and record the wave forms and measure the transient voltages. A Pico USB TC-08, with K type thermocouple, was used to measure and record the temperature.

Fuel usage was measured using a graduated glass column and a stop watch, scaled to measure in Litres/h. The fuel tubes to the tank were removed and the input and output fuel pipes were re-routed to the glass column, so that fuel volume could be measured.

The Stamford P .I044H1 alternator was then removed and replaced with the RFL RF4-160-130-157-3P alternator and the same tests were repeated

Our original testing along with the data taken from the HIMOINSA Web site was used for the comparisons.

The maximum load testing point (SBY) was taken when the engine speed dropped to 49.8 Hz, and could be maintained for 30 Minutes. The rated power (PRP) was taken when the engine speed dropped to 50.0Hz and could be maintained for at least 1.5 Hours


# Performance Test Results

When the Alternator was changed from the Stamford P.I044H1 to the RF4-160-130-157-3P RFL Alternator, the tests showed an improvement of around 1,800 Watts extra from the engine at Continuous rating and 2,300 watts in standby rating. The table below shows the new rating for the HYW-17-T5 when it is fitted with a RFL Alternator. The testing was conducted at 17°C ambient.

## Straight resistive loads:

| | | Gathered | | | | | | | | Calculated | | | Temperature | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours | Time (Sec) | Power (W) | RMS Voltage (V) | RMS Current (A) | Frequency (Hz) | THD (%) | PF | KVA | Voltage Drop | Voltage Drop % | Frequency Drop (%) | Ambiant Temp | (T1) Alt Air In | (T2) Alt Air Out | (T3) Alt Case Temp | (T4) Air Inside Box | Alt Temp Rise | Mag Safty | Comments |
| 0.00 | 0 | 0 | 432.8 | 0 | 52.18 | 2.9/4.0 | | | 0 | 0.00% | 0.00% | 15 | 15 | 15 | 15 | 15 | 0 | 85 | |
| 0.06 | 200 | 17,500 | 394 | 25.4 | 50 | 1.5/5.0 | | | 38.8 | -8.96% | -4.18% | 15 | 19 | 25 | 38 | 15 | 19 | 75 | |
| 0.11 | 400 | 17,660 | 392 | 25.7 | 49.95 | 1.5/5.08 | | | 40.8 | -9.43% | -4.27% | 15 | 20 | 27 | 42 | 15 | 22 | 73 | |
| 0.22 | 800 | 17,350 | 390.8 | 25.6 | 49.9 | 1.5/5.08 | | | 42 | -9.70% | -4.37% | 15 | 22 | 32 | 53 | 16 | 31 | 68 | |
| 0.33 | 1200 | 17,200 | 390 | 25.57 | 49.9 | 1.5/5.08 | | | 42.8 | -9.89% | -4.37% | 15.7 | 24 | 37 | 61.7 | 17.6 | 37.7 | 63 | Max Rating (Standby) |
| 0.44 | 1600 | 17,100 | 387.5 | 25.5 | 49.8 | 1.5/5.0 | | | 45.3 | -10.47% | -4.56% | 16 | 23.6 | 40.2 | 66.8 | 17 | 43.2 | 59.8 | |
| 0.46 | 1650 | 16,730 | 388 | 24.7 | 50 | 1.5/5.0 | | | 44.8 | -10.35% | -4.18% | 16 | 24.3 | 41 | 68.1 | 17 | 43.8 | 59 | Load Down |
| 1.25 | 4500 | 16,200 | 383.9 | 24.45 | 49.8 | 1.5/5.0 | | | 48.9 | -11.30% | -4.56% | 17 | 27 | 52 | 80 | 17 | 53 | 48 | Cont Rating |
| 1.28 | 4600 | 15,480 | 387 | 23 | 49.9 | 1.6/5.0 | | | 45.8 | -10.58% | -4.37% | 17 | 28 | 51 | 81 | 17 | 53 | 49 | Load Down |
| 1.49 | 5360 | 16,300 | 384 | 24.4 | 49.8 | 1.6/5.0 | | | 48.8 | -11.28% | -4.56% | 17 | 27 | 50 | 80 | 18 | 53 | 50 | |
| 1.53 | 5500 | 16,200 | 383 | 24.4 | 49.8 | 1.6/5.0 | | | 49.8 | -11.51% | -4.56% | 17 | 27 | 49.8 | 80.8 | 17.5 | 53.8 | 50.2 | Cont Rating |
| 1.58 | 5700 | 0 | 425 | 0 | 52.1 | 2.6/3.8 | | | 7.8 | -1.80% | -0.15% | 17 | 27 | 49 | 81 | 18 | 54 | 51 | Load Off |
| | | | | | | | | | | | | | | | | | | | Temp After stablise stop |

| 20.86 Amp un-balanced load ( RFL Alt) | | | | |
|---|---|---|---|---|
| | Volts | Amps | Volt Err | |
| U | 391.8 | 21.4 | -23.2 | -5.59% |
| V | 422.8 | 0 | 7.8 | 1.88% |
| W | 434 | 0 | 19 | 4.58% |
| | | | | |
| U-N | 233.16 | 21.4 | -6.84 | -2.85% |
| V-N | 236.7 | 0 | -3.3 | -1.38% |
| W-N | 250 | 0 | 10 | 4.17% |

The resistive load run showed that a new rating could be given for the HYW-17-T5

| New Rating For HYW-17-T5 | | |
|---|---|---|
| PRP | 15.5 Kw | |
| SBY | 17.2 Kw | |
| KVA | 19.5 KVA | |
| Current | 27.1 | |

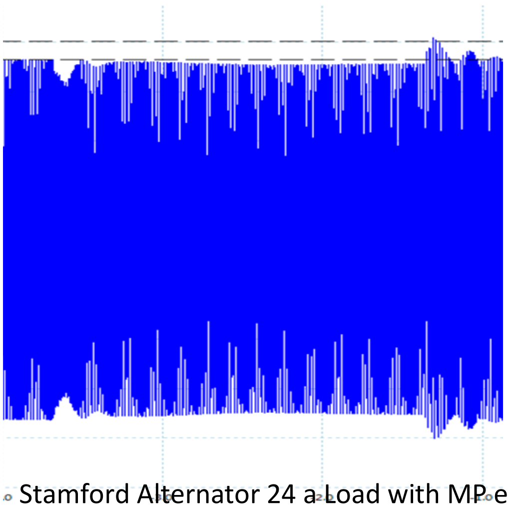
# Voltage regulation:

The main difference between the Stamford alternator and the RFL Alternator is in its voltage response under load. The RFL alternator having a full PM rotor, is affected by 2 variables, load and engine speed. This is because the RFL alternator does not have an AVR and the voltage is affected by the changes in engine RPM. In our testing the engine speed dropped by around 4.5% from No load to full load. This is a 20V voltage drop due to the engine droop. The voltage is also affected by alternator load; this is a further 5% drop, giving a further 20V droop. The voltage droop between no load and engine full load is around 40V (10%). The RFL Alternator is manufactured to run at the high end of the voltage range when the engine is under no load (430V). This gave it a voltage range between no load and full load of 430V to 385V.

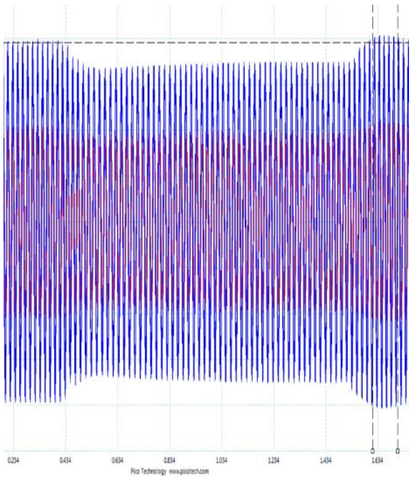
The Stamford maintains an almost constant voltage of (415 V) over the full load range, but has a much higher transient on sudden load changes and during DOL motor start. The steady voltage regulation was +-1%, but the transient voltage change with resistive load changes (No Load to Full load 24 amp), was 468 – 368. This is a range of +13% to -11%. This was even greater with motor start (5.5 Kw 2 pole 3 phase) even with the PM End fitted, reaching values of 260V to 478V which is a range of -36% + 15%.

The RFL alternator on the other hand was much better during DOL motor start (5.5Kw 2 pole 3 phase). The voltage went from 380 to 432 -26% to +4.0%.  At no time during any load changes did the upper voltage go above the 440 volts for normal line voltage supplies.  On the other hand the Stamford alternator fitted with a PM end had an overshoot significantly over 478V.

For appliances and sensitive electronic equipment, they are more likely to be damaged by over voltage spikes rather than low voltage dips, as all equipment is designed to work over the normal electrical line voltage range (440V – 376V). The AU line voltage is 400V +10% to -6%.  So despite the fact that the RFL alternator has a larger voltage regulation range, it is less likely to cause any damage to equipment, and will run all motors and other equipment normally.



Stamford Alternator 24 a Load with MP end



RFL Alternator 25.5A load change

Resistive load transients

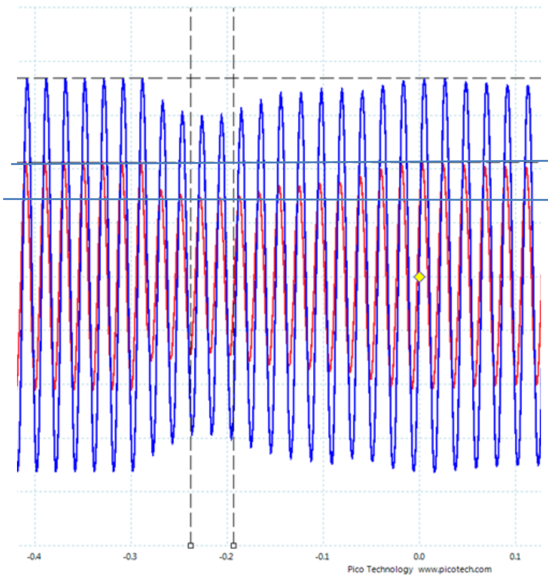
# Motor Starting Test Results

4 types of motor start and loads were conducted

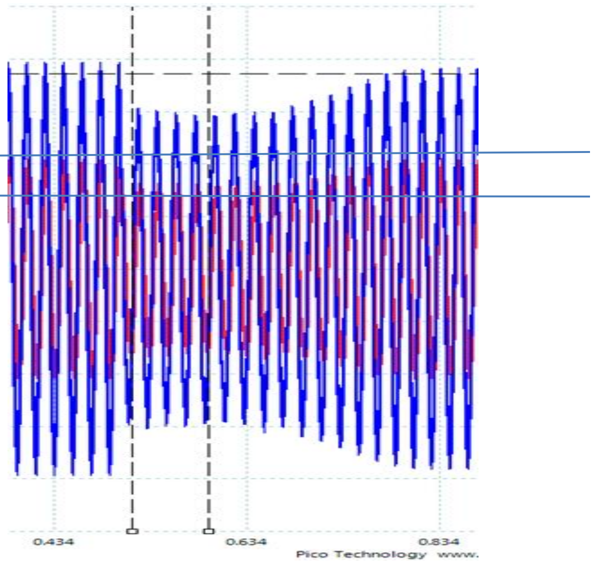
1. 1 Phase 2.2 kW motor start air compressor at full pressure
2. 3 Phase DOL 5.5 kW 2 pole,  and 5.5 kW 2 pole + 5.5 Kw 4 Pole Together
3. 3 phase 9.2 kW 2 pole connected in star with full load on shaft
4. 3 phase 37 kW 2 pole motor started with a WEG VF drive

## 1 Phase 2.2 kW motor start of compressor at full pressure

The 1 phase motor was a Teco ML90L-2, 2.2 Kw. It was able to start a 2 cylinder reciprocating compressor at full tank pressure of 90 PSI. The motor started normally with no hesitation. The line voltage wave forms for both the Stamford with PM end and the RFL alternator are shown below. You can see that the RFL Alternator transient voltage did not drop as far on motor start. The blue is the 3 phase line to line voltage and the red is the 1 phase voltage line to neutral.



Stamford, 2.2 Kw Motor start
1 Phase volts at start = 182.3 V AC

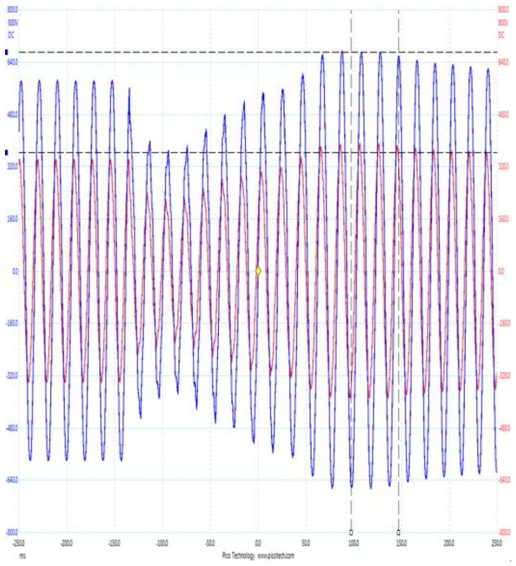



RFL 2.2 Kw Motor Start
1 Phase Volts at start = 192.0 V AC

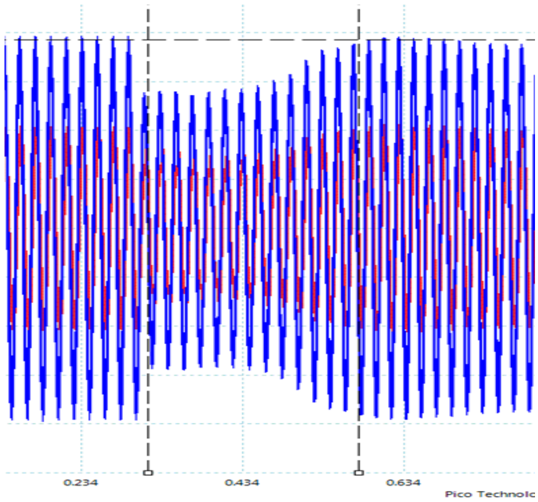
## 3 Phase DOL 5.5 kW, 2 pole, and 5.5 kW 2 pole + 5.5 kW 4 Pole Together

The second test involved starting a 5.5 kW 3 Phase 2 pole Motor DOL and starting transient wave forms were analysed. The start waveforms for the Stamford and the RFL alternators are shown below.

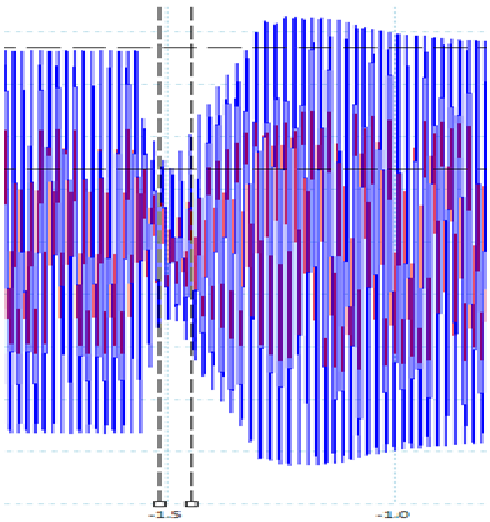
You can see that there was a larger drop in voltage and a substantial over shoot in voltage, with the Stamford alternator. The Stamford with PM end alternator had a voltage drop of 36% and a voltage overshoot of 15%, whereas the RFL alternator had only a 26% drop and a 4% overshoot. An even greater voltage transient was evident with the starting of the 2 motors together



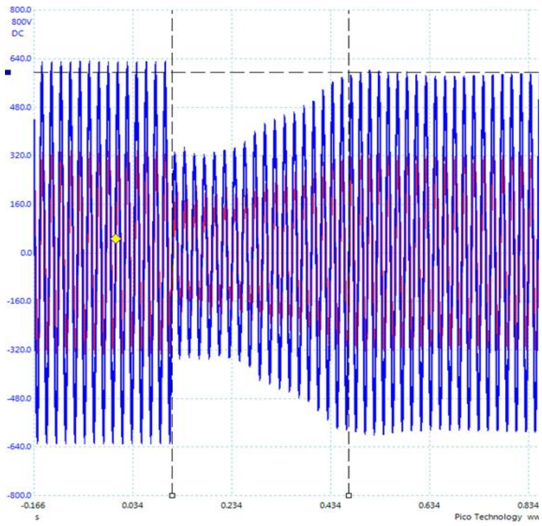
Stamford with PM End 5.5 kW DOL motor start
Volts drop to 266.6V Transient 478.8V




RFL 5.5 kW DOL motor start
Volts Drop to 308.5V Transient 432.6 V



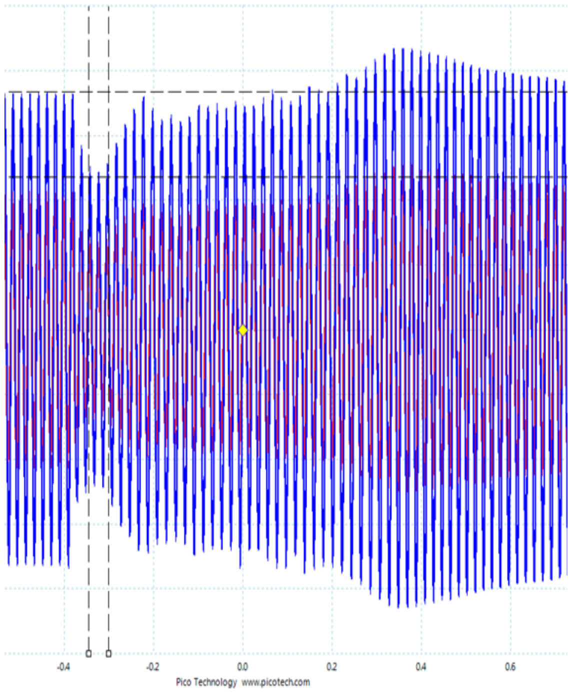

Stamford with PM End, 5.5 +5.5 kW DOL motor start
Volts drop to 160.0V Transient 498.8V



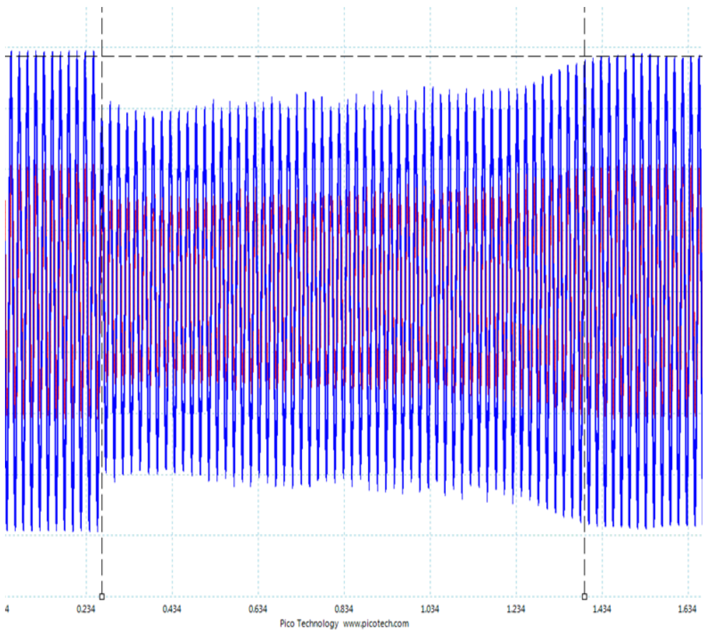

RFL 5.5 + 5.5 kW DOL motor start
Volts Drop to 234.0V Transient 416.5 V

### 3 phase 9.2 kW 2 pole connected in star with full load on shaft

The final test involved starting a 9.2 kW 2 pole motor connected in Star to reduce the start current. The motor was driving a load of 5.0 Kw at full speed (typical high inertia fan type load). The Stamford alternator did start the load quicker but with a large voltage drop and a very high over voltage spike




Stamford with PM End, 9.2 kW DOL motor start
Volts Drop to 230.0V Transient 493.0V



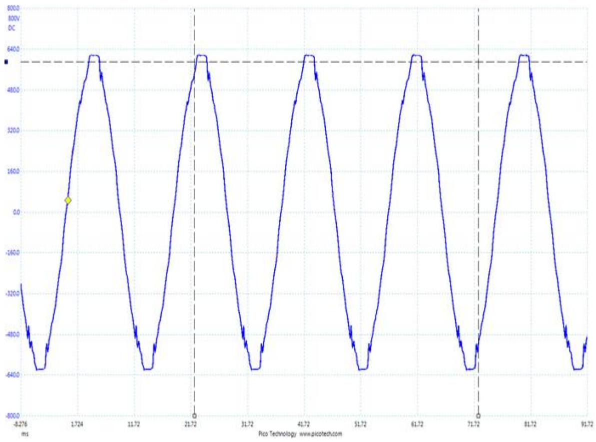

RFL 9.2 kW star connection DOL motor start
Volts drop to 275V Transient 434V

# Waveform Test Results
## VF Drives:

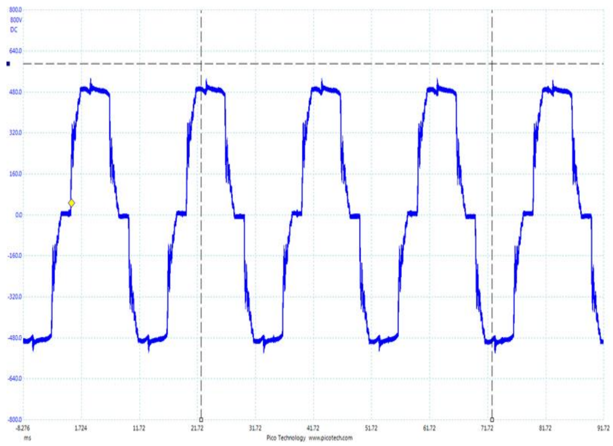
The RFL alternator was used to start and run a large AC induction motor (37 Kw 3 phase 2 pole), using WEG CFW-11 drive. The loads are shown below in the table. The WEG Drive was rated at 73 Amps 380V to 480V.

| Loads | | | | |
|---|---|---|---|---|
| Kw | Amps | Volts | | |
| 0 | 0 | 426 | | |
| 2.2 | 3.14 | 437.5 | | |
| 8.94 | 13.4 | 410.3 | | |
| 12.76 | 19.7 | 398.6 | | |
| 15.35 | 23.99 | 390 | PRP | Continues rating |
| 16.89 | 27.2 | 381.2 | | |
| 17.38 | 28.3 | 377.4 | SBY | Max Stand by loading |
| | | | | |

The 37 kW motor was started with a 16.8 kW load with no problems. The waveforms seen by the RFL Alternator were rather distorted due to the high frequency chopping of the drive, but this did not affect the performance of either the VF drive or the AC motor.  As the RFL alternator has no electronics or diodes, the high frequency chopping caused by the VF Drive cannot affect the alternator or cause failures. The same applies to other loads such as 3 phase MIG welders and battery chargers. The waveforms seen by the alternator are shown below.



No load waveform



16.89 kW waveform

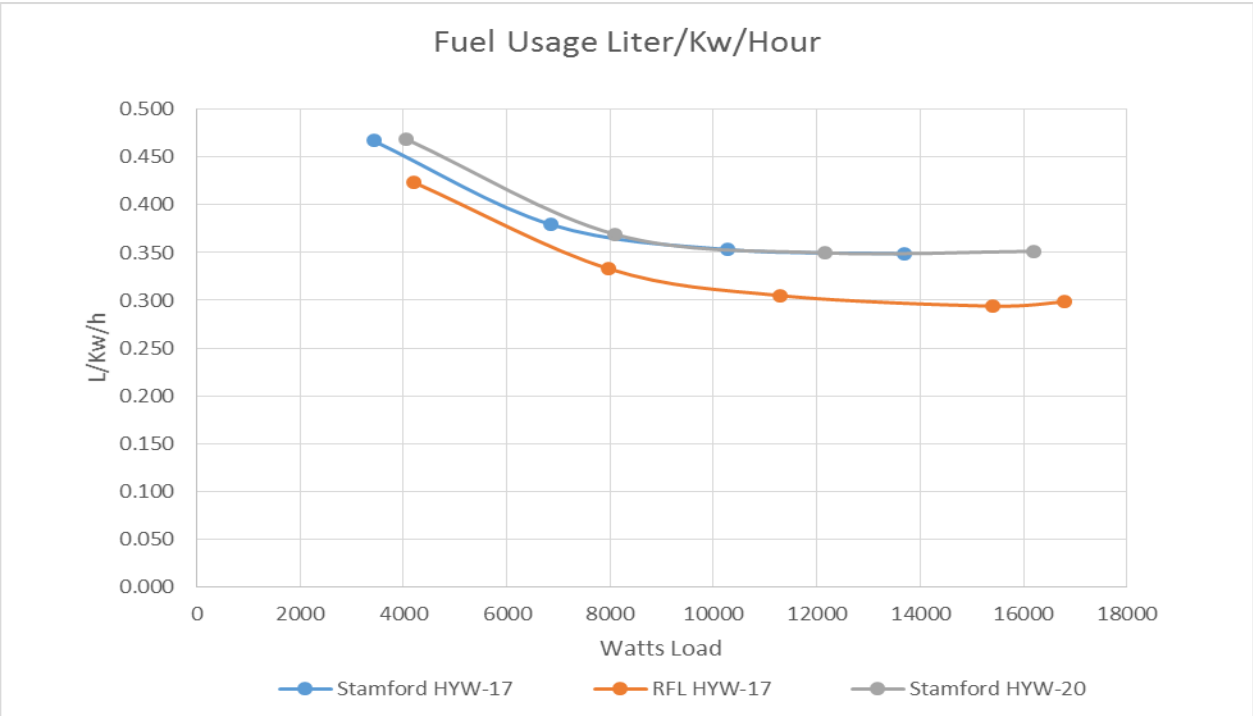
# Fuel Test Results

Fuel Usage testing results

| HYW-17-T5 using RFL RF4-160-130-157-3P | | | | | |
|---|---|---|---|---|---|
| Load | 25% | 50% | 75% | 100% | 110% |
| L/h | 1.78 | 2.657 | 3.447 | 4.525 | 5.016 |
| L/Kw/h | 0.424 | 0.333 | 0.305 | 0.294 | 0.299 |
| Load | 4200 | 7,980 | 11,300 | 15,400 | 16800 |

| HYW-17-T5 U With Stamford Alternator | | | | |
|---|---|---|---|---|
| Taken from Data Sheets | | | | |
| Load | 25% | 50% | 75% | 100% |
| L/h | 1.6 | 2.6 | 3.63 | 4.78 |
| L/Kw/h | 0.467 | 0.380 | 0.353 | 0.349 |
| Load | 3425 | 6,850 | 10,275 | 13,700 |

| HYW-20-T5 With Stamford Alternator | | | | |
|---|---|---|---|---|
| Taken from Data Sheets | | | | |
| Load | 25% | 50% | 75% | 100% |
| L/h | 1.9 | 2.99 | 4.25 | 5.694 |
| L/Kw/h | 0.469 | 0.369 | 0.350 | 0.351 |
| Load | 4,050 | 8,100 | 12,150 | 16,200 |




Comparison between the HYW-17, HYW-20 and the HYW-17 fitted with a RFL Alternator

The graph above shows that the fuel consumption is improved by between 11% and 14% for the same output, reflecting the outcomes of the RFL Alternator's higher efficiency.

**Fuel Cost savings Stamford changed to RFL** ***(Diesel Price $1.20/L)***

| Load % | Load Kw | Stamford L/h | RFL L/h | Saving L/h | Saving $/h | Saving $ 1000h | Saving $ 2500h | Saving $ 5000h |
|---|---|---|---|---|---|---|---|---|
| 25% | 4.05 | 1.9 | 1.78 | 0.12 | $0.14 | $144.00 | $360.00 | $720.00 |
| 50% | 8.1 | 2.99 | 2.6973 | 0.2927 | $0.35 | $351.24 | $878.10 | $1,756.20 |
| 75% | 12.2 | 4.26749 | 3.721 | 0.54649 | $0.66 | $655.79 | $1,639.47 | $3,278.94 |
| 100% | 16.2 | 5.694 | 4.7628 | 0.9312 | $1.12 | $1,117.44 | $2,793.60 | $5,587.20 |

When the HYW-17 T5 has its alternator changed to a RFL Alternator, it can be rated at 20 KVA

The table above shows savings in $ for 1000h , 2500h, and 5000h run time for the average loads 25% to 100%. This is based on the current diesel fuel cost of $1.20 per L. If the fuel cost is higher, the savings would also be higher.

# Performance Test Results with New RFL Speed controller fitted

The HYW-17-T5 with the RFL RF4-160-130-157-3P alternator was fitted with aRFL Speed controller, and a new set of load test results were recorded. The test result tables on the following page shows the new rating for the HYW-17-T5 genset when it is fitted with a RFL Alternator and the RFL Speed controller. The testing was conducted at 30°C ambient temperature.

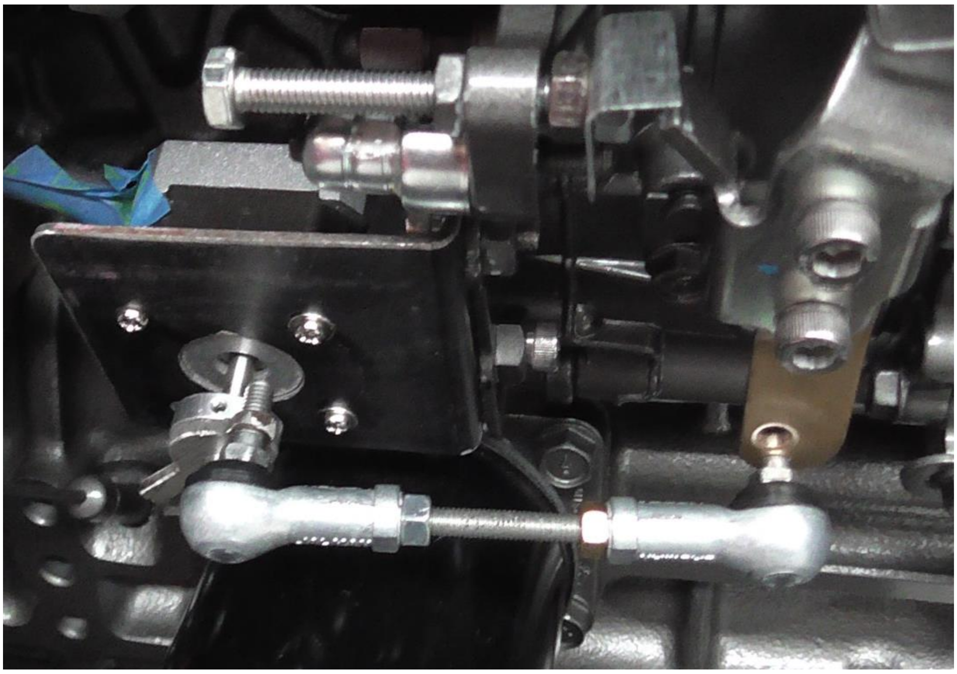


Figure 5 - Stepper Motor Throttle Control

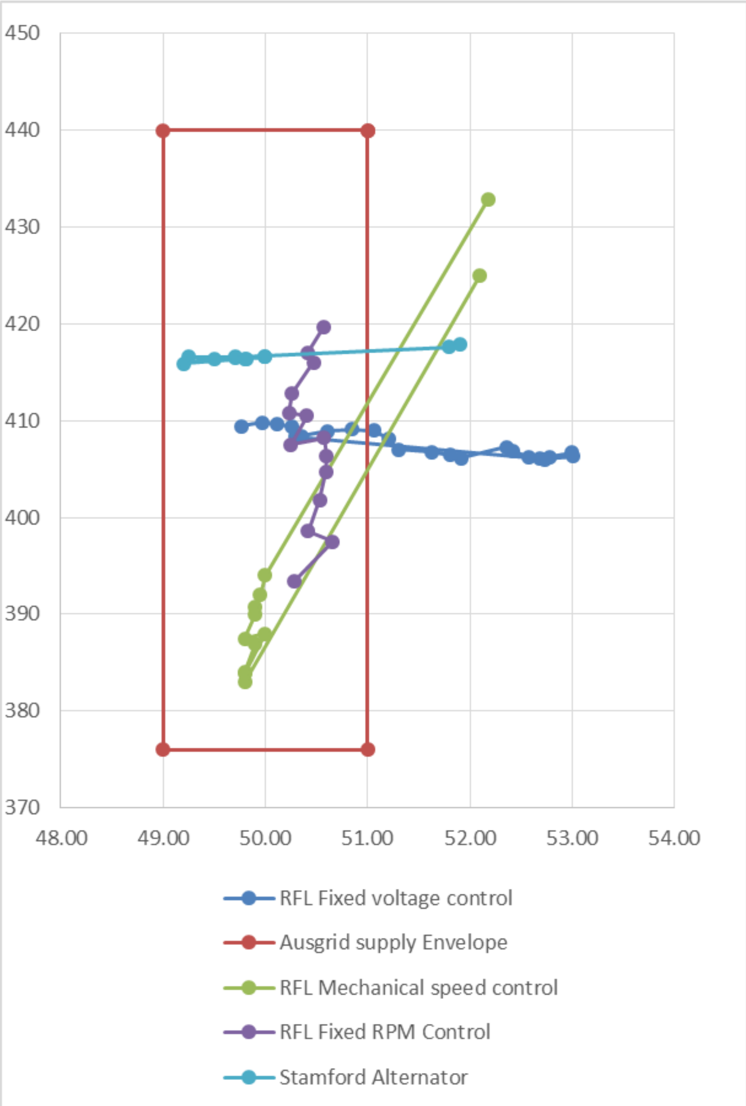
## Test results: Straight resistive loads with RFL Speed controller

**RFL Fixed Voltage control**

| Run Hours | Time | Power (W) | RMS Voltage (V) | RMS Current (A) | Frequency (Hz) | THD (%) | PF | KVA Power | Voltage Drop | Voltage Drop % | Frequency Drop (%) | Ambiant Temp | Adjusted voltage | Volt Drop Corr | % Volt Drop Corr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.35 | 0 | 409.41 | 0.0 | 49.77 | 2.48 | 0.00 | | 0.00 | 0.00% | -0.47% | | 409.41 | 0.00 | 0.00% |
| 0.01 | 1.36 | 1,472 | 409.8 | 2.1 | 49.97 | 2.40 | 1.00 | | -0.39 | -0.10% | -0.06% | | 409.8 | -0.39 | -0.10% |
| 0.05 | 1.4 | 3,071 | 409.64 | 4.3 | 50.12 | 2.40 | 1.00 | | -0.23 | -0.06% | 0.23% | | 409.64 | -0.23 | -0.06% |
| 0.05 | 1.4 | 4,517 | 409.41 | 6.4 | 50.26 | 2.30 | 1.00 | | 0.00 | 0.00% | 0.51% | | 409.41 | 0.00 | 0.00% |
| 0.05 | 1.4 | 6,360 | 408.39 | 9.0 | 50.35 | 2.19 | 1.00 | | 1.02 | 0.25% | 0.70% | | 408.39 | 1.02 | 0.25% |
| 0.06 | 1.41 | 7,812 | 408.92 | 11.0 | 50.61 | 2.09 | 1.00 | | 0.49 | 0.12% | 1.22% | | 408.92 | 0.49 | 0.12% |
| 0.07 | 1.42 | 9,399 | 409.09 | 13.3 | 50.85 | 2.00 | 1.00 | | 0.32 | 0.08% | 1.69% | | 409.09 | 0.32 | 0.08% |
| 0.10 | 1.45 | 10,839 | 408.96 | 15.3 | 51.06 | 1.93 | 1.00 | | 0.45 | 0.11% | 2.12% | | 408.96 | 0.45 | 0.11% |
| 0.10 | 1.45 | 12,530 | 408.15 | 17.7 | 51.20 | 1.89 | 0.99 | | 1.26 | 0.31% | 2.41% | | 408.15 | 1.26 | 0.31% |
| 0.10 | 1.45 | 13,478 | 407.04 | 19.2 | 51.30 | 1.78 | 1.00 | | 2.37 | 0.58% | 2.60% | | 407.04 | 2.37 | 0.58% |
| 0.10 | 1.45 | 14,954 | 406.77 | 21.3 | 51.63 | 1.70 | 0.99 | | 2.64 | 0.65% | 3.25% | | 406.77 | 2.64 | 0.65% |
| -0.19 | 1.16 | 16,340 | 406.43 | 23.3 | 51.81 | 1.71 | 0.99 | | 2.98 | 0.73% | 3.62% | | 406.43 | 2.98 | 0.73% |
| 0.11 | 1.46 | 16,878 | 406.12 | 24.1 | 51.92 | 1.70 | 0.99 | | 3.29 | 0.81% | 3.83% | | 406.12 | 3.29 | 0.81% |
| 0.12 | 1.47 | 18,257 | 407.25 | 26.0 | 52.36 | 1.55 | 0.99 | | 2.16 | 0.53% | 4.72% | | 407.25 | 2.16 | 0.53% |
| 0.16 | 1.51 | 18,180 | 406.83 | 25.9 | 52.42 | 1.54 | 0.99 | | 2.58 | 0.63% | 4.85% | | 406.83 | 2.58 | 0.63% |
| 0.65 | 2 | 18,125 | 406.25 | 25.8 | 52.58 | 1.50 | 0.99 | | 3.16 | 0.78% | 5.15% | | 406.25 | 3.16 | 0.78% |
| 0.75 | 2.1 | 18,123 | 406.22 | 25.8 | 52.78 | 1.47 | 0.99 | | 3.19 | 0.79% | 5.57% | | 406.22 | 3.19 | 0.79% |
| 0.85 | 2.2 | 18,158 | 406.69 | 25.9 | 52.99 | 1.41 | 0.99 | | 2.72 | 0.67% | 5.98% | | 406.69 | 2.72 | 0.67% |
| 0.89 | 2.24 | 18,143 | 406.32 | 25.9 | 53.01 | 1.41 | 0.99 | | 3.09 | 0.76% | 6.02% | 21.7 KVA Rating | 406.32 | 3.09 | 0.76% |
| 0.90 | 2.25 | 16,869 | 406.04 | 24.1 | 52.69 | 1.55 | 0.99 | | 3.37 | 0.83% | 5.38% | 20 KVA Rating | 406.04 | 3.37 | 0.83% |
| 1.00 | 2.35 | 16,847 | 405.99 | 24.0 | 52.74 | 1.52 | 0.99 | | 3.42 | 0.84% | 5.47% | 20 KVA Rating | 405.99 | 3.42 | 0.84% |
| 1.04 | 2.39 | 0 | 408.35 | 0.0 | 50.30 | 2.48 | 0.99 | | 1.06 | 0.26% | 0.60% | Load Off after run | | | |

**RFL Fixed RPM Controll 09-12-2014** by Paul Lillington

| Hours | Run Time (Min) | Power (W) | RMS Voltage (V) | RMS Current (A) | Frequency (Hz) | THD (%) | PF | KVA Power | Voltage Drop | Voltage Drop % | Frequency change (%) | Ambiant Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 419.61 | 0 | 50.568 | 2.14 | 1 | 0 | 0 | 0.00% | 1.14% | 30 |
| | | 1,524 | 416.95 | 2.141 | 50.412 | 2.13 | 1 | 1,525 | 2.66 | 0.64% | 0.82% | 30 |
| | | 3,179 | 416.01 | 4.475 | 50.472 | 2.05 | 1 | 3,181 | 3.6 | 0.87% | 0.94% | 30 |
| | | 4,588 | 412.82 | 6.507 | 50.262 | 2.01 | 1 | 4,590 | 6.79 | 1.64% | 0.52% | 30 |
| | | 6,412 | 410.8 | 9.102 | 50.231 | 1.91 | 1 | 6,416 | 8.81 | 2.14% | 0.46% | 30 |
| | | 7,861 | 410.5 | 11.176 | 50.404 | 1.77 | 1 | 7,866 | 9.11 | 2.22% | 0.81% | 30 |
| | | 9,341 | 407.52 | 13.38 | 50.251 | 1.7 | 1 | 9,347 | 12.09 | 2.97% | 0.50% | 30 |
| | | 10,804 | 408.23 | 15.457 | 50.572 | 1.58 | 1 | 10,812 | 11.38 | 2.79% | 1.14% | 30 |
| | | 12,156 | 406.33 | 17.731 | 50.596 | 1.45 | 1 | 12,267 | 13.28 | 3.27% | 1.19% | 30 |
| | | 13,293 | 404.66 | 19.286 | 50.594 | 1.44 | 1 | 13,304 | 14.95 | 3.69% | 1.19% | 30 |
| | | 14,612 | 401.79 | 21.339 | 50.533 | 1.35 | 1 | 14,627 | 17.82 | 4.44% | 1.07% | 30 |
| | | 15,728 | 398.59 | 23.153 | 50.415 | 1.3 | 1 | 15,744 | 21.02 | 5.27% | 0.83% | 30 |
| | | 17,400 | 397.52 | 25.644 | 50.657 | 1.21 | 1 | 17,520 | 22.09 | 5.56% | 1.31% | 30 |
| | | 17,562 | 393.46 | 26.165 | 50.288 | 1.23 | 1 | 17,583 | 26.15 | 6.65% | 0.58% | 30 |




**Test result envelope of the HYW-17 T5 Gen set**

*The Red Envelope is the normal line supply guarantee from AusGrid, (Australian electricity supply authority)*
*The Light Blue Lines represents the Stamford Alternator fitted to the HYW-17 T5 (Standard Speed control)*
*The Green line represents the RFL Alternator fitted to the HYW-17 T5 (Standard speed control)*
*The Dark Blue line represents the RFL Alternator fitted to the HYW-17 T5 (With constant voltage control)*
*The Purple line represents the RFL Alternator fitted to the HYW-17 T5 (with constant speed control)*

As can be seen above, the only test results that maintains its output within the red envelope is the **RFL** Alternator when fitted with the constant speed control. The envelope encasing the purple line is much smaller than that of the mains power. This means that the RFL Alternator, with its much higher efficiency, better transient and motor starting, when fitted with a constant speed control, will run any loads at their rated load, voltage, and frequency without complications. The RFL speed controller is also able to maintain constant voltage similar to that of the Stamford alternator. However, as its range falls outside of the mains supply regulation, it is not recommended.

# Conclusion

When the HIMONSA HYW-17-T5 gen set is fitted with the RFL Alternator, it lifts its performance very close to that of the HYW-20-T5 Gen set. This is achieved while giving a reduction in overall weight and a potential reduction in cabinet size. Changing the alternator in the HYW-17-T5, from the Stamford to a RFL RF-160-130-157-P3 alternator would enable it to be rated at 19.5 kVA (HYW-19.5-T5) and achieve an 11% to 14% fuel saving over the current HYW-20-T5, 20 kVA. Motor starting ability is comparable to the HYW-20-T5 20 kVA gen set fitted with a PM referenced alternator.

The RFL Alternator's no Load Voltage is proportional to the speed of the engine, and engine droop has an effect on the output voltage. The 4.5% speed droop from no load to full load requires 5% extra voltage droop. The RFL alternator has a nominal 5% voltage droop between no load and full load, so this gives a 10% voltage droop overall.

**RFL Speed controller fitted:**

When the new RFL Speed controller was fitted to the (HYW-17-T5) we were able to run the unit is two new modes, fixed voltage control or fixed speed control.

For applications where the voltage is critical the fixed voltage control mode can keep the voltage within 1%, by varying the frequency between 49.7Hz and 53 Hz over the full load range. Using the fixed frequency (RPM) control mode the voltage dropped by 6% while the frequency stayed within 1%. This mode can be used when fixed frequency is critical, and for parallel or grid connected operation. The only mode of operation that stayed within the Ausgrid (supply authority) envelope was the RFL fixed frequency mode. With the RFL speed controller fitted, the gen-set KVA rating was increased by up to 10%.

**Cost Saving:**

Replacing the Stamford alternator with the RFL alternator, could potentially reduce the cost of the HYW-20 to the same cost as the HYW-17. Additionally operational costs savings of up 10% could also be recognised.

**Advantages in extreme duty application:**

The RF4-160-130-157-3P alternator has a special Dolphon CB1128 coating on both the winding and rotor. It is specially manufactured to withstand the grit and salt on European roads. This also makes it suitable for marine use and working in dusty environments where the dust is abrasive. The RFL Alternator can operate with no failures with light salt spray in the intake air. The special bearing cassette is the only wearing component and can be replaced without removing the alternator from the engine.