# Galileo Research, Inc. Initial Prototype Free-Piston Engine-Generator Testing.

## Test To Study The Effects Of Advancing Spark Ignition.

**Conditions:**

- **Full Throttle.**
- **2 Stroke Gas/Oil Mix.**
- **Start Engine at 28 Hz.**
- **Fixed 12.9 Ohm Resistive Load.**
- **Advancing Ignition Timing.**

**Spark in relation to Piston Reversal was accomplished by subtracting "Spark Ignition Distance From Center" from ½ the Stroke.**

**Results:**

| Data Points from Data Acquisition Record *(seconds)* | Operating Frequency *(Hz)* | Max Stroke *(Inches)* | Spark Ignition *Distance From Center (Inches)* | Spark Ignition *Distance from Piston Reversal (Inches)* | Average Cylinder Pressure *(PSI)* | Current Output *(Amps)* | Voltage Output (*Peak to Peak) (V)* | Voltage Output (RMS*) (V)* | Power Output (Watts) | Voltage *"Dead Zone"* [1] *over 1" Stroke (Inches)* | Voltage *"Dead Zone"*[1] *over 1" Stroke (seconds*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 to 1.1 | 26.0 | 1.251 | 0.500 | 0.1255 | 425 | 3.25 | 154 | 49.7 | 161.53 | 0.251 | 0.0050 |
| 20.0 to 20.1 | 25.5 | 1.185 | 0.449 | 0.1435 | 350 | 3.13 | 143 | 47.1 | 147.42 | 0.185 | 0.0038 |
| 30.6 to 30.7 | 25.0 | 1.157 | 0.407 | 0.1715 | 300 | 3.00 | 140 | 46.0 | 138.00 | 0.157 | 0.0035 |
| 46.9 to 47.0 | 24.5 | 1.043 | 0.321 | 0.2005 | 180 | 2.87 | 125 | 42.5 | 121.98 | 0.043 | 0.0005 |

[1] **Alternator designed for 1" stroke is being over stroked 0.25" (0.125" in either direction).**

**Observations:**

**Advancing timing resulted in reduced Stroke, Cylinder Pressure, Power Output and Operating Frequency.**

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## Test To Study The Effects Of Varying Resistive Load.

**Conditions:**

- **Full Throttle.**
- **2 Stroke Gas/Oil Mix.**
- **Start at 30 Hz.**
- **Increasing Resistive Load.**

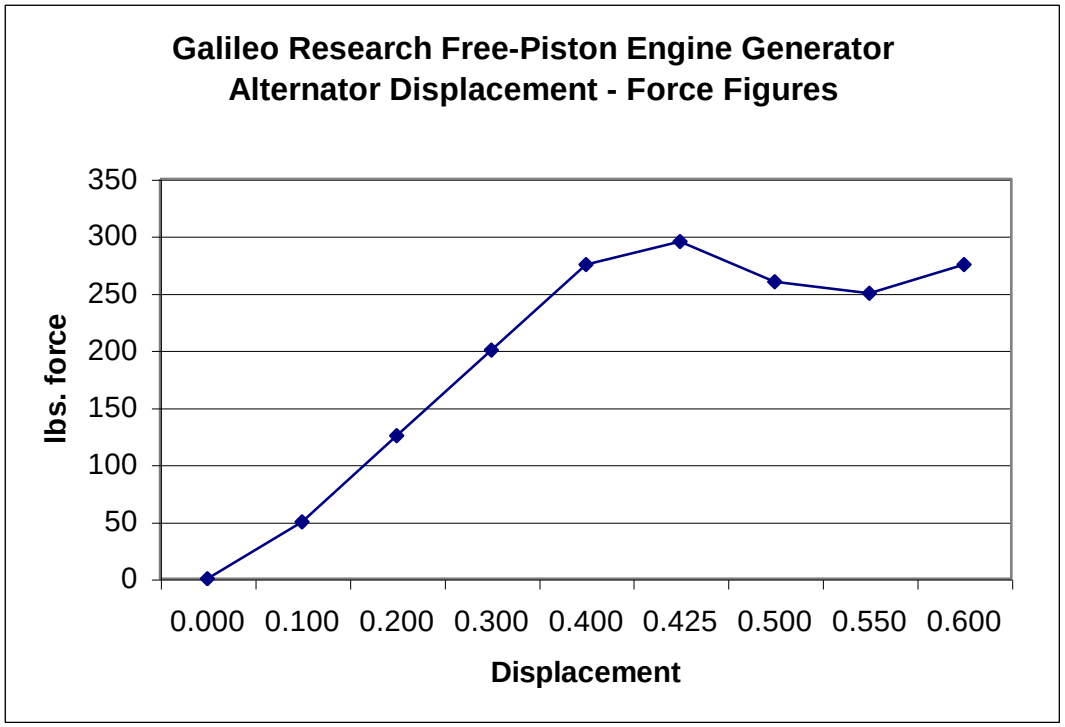
**Results:**

| Resistive Load | Time *(seconds)* | Operating Frequency *(Hz)* | Stroke *(Inches)* | Spark Ignition *Distance From Center (Inches)* | Peak Cylinder Pressure *(PSI)* | Voltage Output (*Peak to Peak) (V)* | Current Output *(Amps)* |
|---|---|---|---|---|---|---|---|
| No Load (Startup) | 17.00 to 17.10 | 29.5 | 1.255 | 0.4250 | 600 | 0 | 0 |
| Light Load | 23.46 to 23.56 | 29.5 | 1.266 | 0.4250 | 500 | 171 | 0.574 |
| Moderate Load | 36.00 to 36.10 | 29.5 | 1.259 | 0.4250 | 500 | 168 | 1.100 |
| Heavy Load | 51.96 to 52.06 | 29.5 | 1.230 | 0.4250 | 450 | 157 | 2.313 |

**Observations:**
**Increasing Resistive Load resulted in Reduced Stroke, Cylinder Pressure, Power Output and Operating Frequency.**

# Free-Piston Engine-Generator Operating Variables

| Changing Item | Items Influenced | | | | |
|---|---|---|---|---|---|
| | Running Frequency | Stroke | Ignition Timing | Throttle Position | Load (Power Output) |
| Increasing Throttle Position | ↑ Minimal Impact | ↑ | ↑ | ↑ | ↑ |
| Decreasing Throttle Position | ↓ Minimal Impact | ↓ | ↓ | ↓ | ↓ |
| Increasing Load (Power Output) | ↓ Minimal Impact | ↓ | ↓ | ↑ | ↑ |
| Decreasing Load (Power Output) | ↑ Minimal Impact | ↑ | ↑ | ↓ | ↓ |
| Increasing Ignition Timing (From Optimum Position) | ↓ | ↓ | ↓ | — | ↓ |
| Decreasing Ignition Timing (From Optimum Position) | ↑ | ↑ | ↑ | — | ↑ |
| Increasing Stroke | — | ↑ | ↑ | ↓ | X |
| Decreasing Stroke | — | ↓ | ↓ | ↑ | X |
| Increasing Reciprocating Mass | ↓ | ↓ | ↓ | — | — |
| Decreasing Reciprocating Mass | ↑ | ↑ | ↑ | — | — |




| Displacement | Lbs. Force |
|---|---|
| 0.000 “ | 0. |
| 0.100 “ | 50. |
| 0.200 “ | 125. |
| 0.300 “ | 200. |
| 0.400 “ | 275. |
| 0.425 “ | 295. |
| 0.500 “ | 260. |
| 0.550 “ | 250. |
| 0.600 “ | 275. |

Measurements were taken on a Instrom Force Measuring machine at a local Test Facility.

**Figure 5**

# Generac Distributed Generation 50 kW Generator-Set

**50 kW = 170,644 BTU / hr**

**Generac's Spec: Natural Gas has a LHV (Lower Heating Value) of 925 BTU / $ft^3$**

**Generac DG50 50 kW Generator Set**

**Fuel Consumption at 100% Load = 10.2 $ft^3$ / min.**

**10.2 $ft^3$ / min * 60 min = 612 $ft^3$ / hr**

**612 $ft^3$ / hr * 925 BTU / $ft^3$ = 566,100 BTU / hr**

**566,100 BTU / hr = 166 kW**

$$\frac{\text{50 kW}}{\text{166 kW}} = 0.30 = 30\ \%$$

**30% Total System Efficiency.**