



TECHNICAL PERSPECTIVE

Prototype and Production Testing

INTRODUCTION

As one of the world's leading manufacturers of power generation equipment, Generac Power Systems is committed to a comprehensive program of research and development. Part of that R&D initiative is extensive product evaluation. Before a design goes into production, it is subjected to exhaustive prototype testing to evaluate every aspect of construction and performance. When it becomes part of the Generac product line, every unit undergoes a rigorous test before it leaves the factory. This regimen ensures that Generac gensets and transfer switches operate properly and provide years of reliable service.

Generac's Investment in Research and Development Proves its Commitment

Generac is at the forefront of innovation and product development. We lead the industry in the creation of unique products and technologies. Our commitment extends beyond a product focus as we also invest heavily in leading-edge facilities and expert personnel.

Our ability to quickly design or modify our equipment to meet the rapidly changing marketplace has been a cornerstone to our success. This would not be possible without the skills and talents of our electrical, mechanical and industrial engineering groups. With several design teams working in the United States and overseas, Generac engineering is truly a global endeavor that brings the best minds to every challenge.

KEY POINTS

- Generac's Investment in Research and Development Proves its Commitment
- Prototype Testing Ensures Performance and Reliability
- Production Testing Ensures Operability and Satisfaction



Generac has state-of-the-art research and development laboratories in each of our manufacturing facilities. Designs can be created, tested and evaluated for engine output, exhaust emissions, alternator performance and sound levels. The company's main R&D laboratory — at corporate headquarters in Waukesha, Wisconsin — features numerous computer design stations, a large fabrication workshop, individual test cells and an outdoor testing site. To ensure that our equipment lives up to Generac's reputation for durability, we subject our engines, alternators, controls and transfer switches to the industry's most punishing test routines. Once we're certain that these units are up to the task, we make them a part of our valued product line.

Prototype Testing Ensures Performance and Reliability

Our prototype testing is a lengthy process that includes the performance evaluation of individual components and complete gensets. We test new products to ensure they conform to numerous industry standards, including:

- UL Underwriters Laboratories Inc.
- EPA Environmental Protection Agency
- NEMA National Electrical Manufacturers Association
- CSA Canadian Standards Association
- CARB California Air Resources Board
- SCAQMD South Coast Air Quality Management District (California)

The UL Listing from Underwriters Laboratories has become increasingly important for power generation equipment. Because of this, we dedicate considerable engineering, manufacturing and testing resources to ensure we maintain the following UL Listings.

- UL 2200 Stationary generator sets
- UL 1008 Automatic transfer switches
- UL 891 Paralleling switchgear

Because so many tests are needed to obtain these Listings, **Generac built its own research and development facilities to allow us to self-certify our equipment.** We must follow stringent UL guidelines during testing to ensure we comply with

UL's uncompromising standards. All such work is subject to UL's oversight and audit procedures.

Prototype testing includes a full array of evaluation procedures covering a comprehensive range of performance aspects.

Gensets:

- **Maximum Power Level** – The unit is operated at its maximum capacity, which is greater than its listed rating, for a minimum of 5 minutes. The load is adjusted until maximum power is obtained at rated speed. Power is measured via the kilowatt output of the generator.
- **Torsional Analysis** – Engine/alternator combinations are verified to be free from damaging torsional stresses. While initial torsional vibration calculations may be performed during the development stages, all new products undergo prototype fatigue testing to confirm torsional compatibility of the engine/alternator system.
- **Transient Response** – Full load is applied at unity power factor with voltage and frequency recorded using a high-speed recorder. Engine/alternator must have the ability to accept application of the full load in a single step and recover fully to the rated voltage and frequency.
- **Engine Cooling Requirements** – Verification of the engine cooling system is performed by operating the genset with a sound attenuated enclosure at full rated load in a 110°F ambient. The cooling system is monitored to ensure that temperatures stabilize within acceptable levels. Horsepower deration is applied beyond 77°F on select engines.
- **Endurance Test** – The unit is tested to meet or exceed endurance requirements of Mil Spec 705. It is operated at full kVA load for up to 1000 hours at its standby rating without mechanical or electrical failure. At the end of endurance testing, key components are inspected and evaluated to ensure that any wear is within acceptable levels.
- **Mechanical Soundness** – The unit must be structurally sound and not have any resonant vibration in either rotating components or structural parts. Alternator rotor assemblies are dynamically balanced to minimize vibration.

Alternators:

- **Maximum Motor Starting** – Motor starting or instantaneous voltage curves are developed with an inductive load bank at 0.3 power factor. Individual loads are applied to the alternator and voltage dip is determined from a high-speed strip chart recorder. The load is incrementally increased until the voltage dip exceeds 35%.
- **Structural Soundness** – A three phase symmetrical short is applied and opened 10 times over a 60 second period. The alternator must build up and perform normally without intervention.
- **Temperature Rise** – Alternator temperature rise, at full kVA rating, is determined by the IEEE 115 resistance test. Maximum acceptable rise is 125°C per UL over a 40°C ambient.
- **Harmonic Analysis** – A full harmonic analysis is performed. Maximum acceptable total distortion is 3.5%. Telephone Influence Factor is calculated and must be < 50.
- **Voltage Regulator Test** – The voltage regulator must maintain output voltage within $\pm 1\%$ from no load to full load, and no damage to the alternator can occur if voltage sensing is removed from the regulator. The regulator must be able to withstand a 25% current overload for 30 minutes without damage.
- A variety of additional tests are conducted to evaluate performance:
 - Insulation resistance at 170°C temperature
 - High potential test at 1500 volts for five minutes
 - Shaft current measurement
 - Overspeed test at 140% of synchronous speed
 - Saturation curves are plotted
 - Transient response curves are plotted
 - Subtransient, transient, zero sequence, negative sequence and synchronous reactance values are calculated from test data

Transfer Switches:

- **Overload Tests** – Performed at 600% normal current, 0.4 - 0.5 power factor at rated voltage. Depending on switch ampere rating, up to 50 operations are performed at these conditions.
- **Temperature Rise Check** – Switch must continuously carry 100% load at rated voltage and current without exceeding specified temperature limits.
- **Endurance Test** – Switch is operated at 0.75 - 0.80 power factor and rated voltage. Depending on switch ampere rating, up to 3000 operations at rated current and 3000 operations at 2 times rated current are performed.
- **Withstand and Closing Test** – Performed at a minimum of 20 times rated current, in compliance with UL 1008. Switch must withstand the thermal and electromagnetic effects of this current until the circuit protective device (i.e., circuit breaker) opens up.

Once these prototype tests are completed and the unit is accepted for production, additional testing and evaluation may be conducted, as needed, to ensure that the product performs within its design parameters.

Production Testing Ensures Operability and Satisfaction

In addition to in-process component testing, every completed genset and transfer switch is fully tested before it leaves the factory. The production test consists of the following:

Gensets up to 200 Kilowatts

- The engine/generator is visually inspected before load wires and fuel lines are connected. The inspector verifies that all fasteners are tight, belts are secure, and guards are present and clear of any rotating parts.
- The fuel and load leads are connected, the engine is pre-lubricated, the governor and voltage regulator are disconnected, and the engine is started. After inspecting all rotating parts and listening for any unwanted noise, the engine is shut down, the governor and voltage regulator are reconnected, and the engine is restarted.
- The voltage and frequency are set and the voltage stability is adjusted along with voltage gain settings and the under-frequency cutoff.
- The generator is run at 25% load for 10 minutes, 50% load for 10 minutes, then 100% load for 10 minutes. The unit is constantly monitored for stability, noise, vibration, fluid leaks, engine temperature, oil pressure, exhaust temperature, engine timing and air/fuel ratio for gaseous engines.

- A test summary report is printed and packaged with the support literature to be shipped with the unit.
- The engine is shut down and examined for oil leaks, coolant leaks, loose fasteners and loose wiring. The genset is given a twenty-five point check that covers everything from data plate information to any special engineering items requested.
- If specified, the enclosure and basetank are fastened to the unit.
- The unit is moved into the final staging area where the paint finish is examined and manuals, decals, covers and shipping skids are applied.
- The unit receives a final inspection by quality control personnel for fit and finish, then it is prepared for shipping.

Gensets 230 To 6000 Kilowatts

Larger gensets undergo the same test procedures outlined above, plus the following:

- Strip charts are created showing the load application and load drop transients at six stages:
0 - 50% load 0 - 75% load 0 - 100% load
50 - 0% load 75 - 0% load 100 - 0% load
- Voltage, current, frequency and fuel consumption are documented on hard copy printouts at load points up to 100% and at two hours of run time.

- When low voltage switchgear (soft load) is provided, it is tested with the engine/generator through the complete operating cycle (Modular Power Systems).
- **All paralleled units are tested individually and as a complete system prior to shipment.**

Transfer Switches

- The undervoltage sensor and inphase monitor are calibrated.
- The switch is tested to verify utility fail operation.
- Fast and Normal Test operation is verified.
- All options are tested for proper function.
- All timer and sensor settings are adjusted to factory specifications.

Additional or customized tests (extended run time, more extensive load testing, etc.) may be ordered to meet the specifications of a particular application.

DEALER INFORMATION

GENERAC[®]
POWER SYSTEMS, INC.

Generac Power Systems, Inc.
Highway 59 & Hillside Rd.
P.O. Box 8
Waukesha, WI 53187
1-888-GENERAC
generac.com