



Application Note

Burn-In Testing Using Regenerative Electronic Loads

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Introduction to Burn-In Testing

Burn-in testing is a critical step in verifying the reliability, performance, and durability of electrical and electronic products. By subjecting components to extended operation under elevated stress conditions, manufacturers can identify early-life failures and ensure that products meet stringent performance standards before deployment. This process is especially vital in industries like energy, automotive, military applications, telecommunications, where product failure can have significant operational or safety implications or can lead to costly quality or safety related product recalls.

Traditionally, resistive loads have been used for burn-in tests as they are simple and inexpensive. However, regenerative electronic loads offer a more energy-efficient, automated, and cost-effective alternative over time.

In this application note, we'll explore common applications of burn-in testing and discuss the benefits of using regenerative loads as well as their potential cost savings.

R&D vs. Production Burn-in Testing

Burn-in testing can occur during both the R&D and production stages of a product's lifecycle, but with different goals. R&D burn-in focuses on product design and evaluation, while production burn-in ensures the quality and reliability of mass-produced products.

R&D:

- **Purpose:** To understand product performance, identify design weaknesses, and validate reliability.
- **Focus:** Product design development, testing limits.
- **Test Conditions:** More varied testing conditions with longer durations.
- **Outcome:** Failures are expected and used to improve the design.

Production:

- **Purpose:** To ensure product quality and detect early failures (infant mortality).
- **Focus:** Quality control, ensuring only reliable units are shipped.
- **Test Conditions:** Standardized and higher volume.
- **Outcome:** Defective units are discarded or repaired.

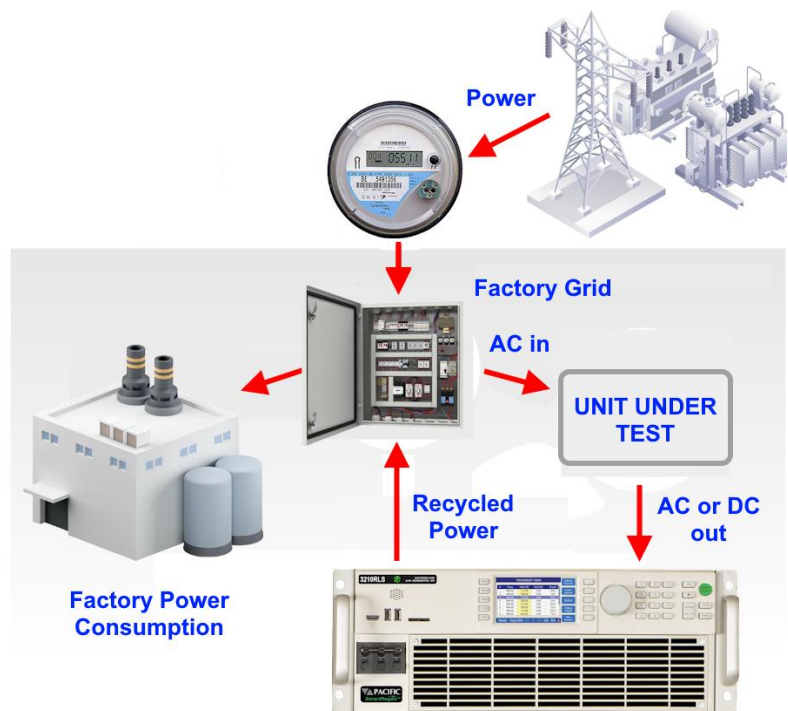


Diagram of energy recycled during test using a Regenerative Load

Common Burn-In Testing Applications

1. Energy Storage Systems (ESS)

Energy storage systems, including lithium-ion battery packs, are integral to renewable energy solutions and grid stabilization. Burn-in testing ensures these systems can handle prolonged charges and discharge cycles at varying temperatures.

While batteries are DC, the grid typically provides AC power, and AC-DC converters are used to charge the batteries. The same electronic loads can be used for both charging (AC) and discharging (DC) applications. In this case, the ability to use the same load for both charging (AC) and discharging (DC) for battery and power converter testing can be advantageous.



Home Energy Storage Unit

2. Electric Vehicle (EV) Power Electronics & Chargers

Key components in electric vehicles, such as inverters, onboard chargers, DC-DC converters, and EV chargers (Level 1, 2, 3) undergo burn-in testing to simulate real-world driving conditions. These tests evaluate performance under sustained thermal and electrical loads, ensuring reliability over the system's lifespan.



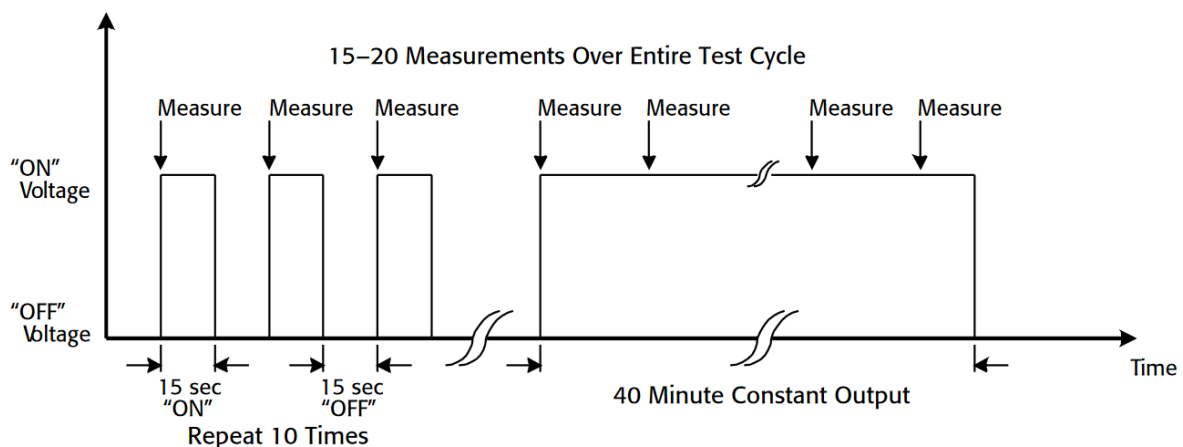
EV Chargers

3. Power Supplies

Most AC/AC or AC/DC power supplies including uninterruptible power supplies (UPS), military/ATE equipment and IT server power supplies used in data centers require stringent performance and burn-in testing to guarantee up-time. Burn-in tests can include simulated power sag and surges as well as steady-state operation to validate the resilience of power conversion equipment under maximum load and adverse AC grid conditions.



Data Server



Example of power supply burn-in on/off cycling diagram

4. Solar Inverters

Renewable energy systems rely heavily on inverters to convert and manage power. Burn-in testing these devices ensures they can withstand fluctuations in input and output loads, as well as environmental stresses and abnormal grid power conditions, ensuring reliable energy delivery.



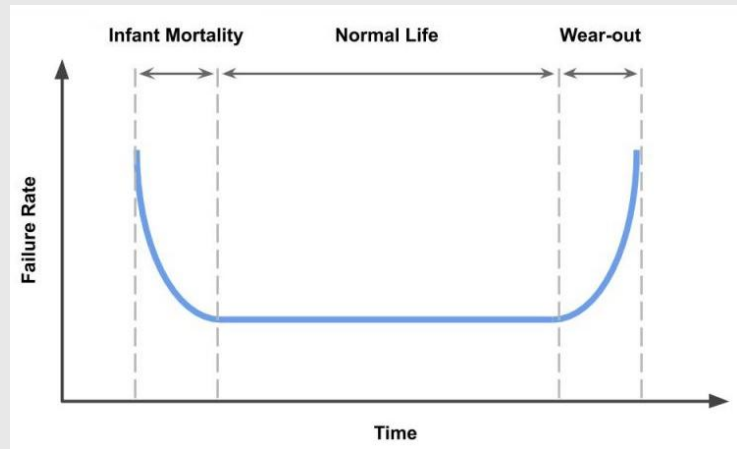
Solar PV Inverters

Characteristics of Burn-In Testing






Accelerated Life Testing (ALT)

Every device will eventually fail, whether from early defects or long-term wear.

A common burn-in test is accelerated life testing which simulates conditions to predict longevity. This type of testing accelerates failures in a controlled setting to enhance quality and reliability. These tests reveal failure patterns such as early manufacturing defects (infant mortality) and wear-out from aging and use.



Example of Accelerated Life Testing Stages

Example Challenges	
	High Stress Testing: High volume testing and prolonged operation under high voltage, current and temperature stress conditions generate significant heat that must be managed without damaging the equipment or affecting other units.
	Long Test Times: Burn-in tests are time-intensive, often lasting several hours to days. This increases costs and delays time-to-market. Effective accelerated life testing burn-in cycles may be used to reduce required burn in times.
	Accurate Stress Replication: It's important to replicate real-world stresses accurately without overloading the device and causing non-representative failures. Programmable AC or DC electronic loads can increase the effectiveness and accuracy of stress testing.
	High Volume Testing: Production testing can often involve high volumes of products being tested for quality assurance.
	Regulatory and Industry Compliance: Testing must align with industry-specific standards, such as IEC, UL, or MIL-STD, which influence the test conditions and reporting requirements.

Resistive Loads vs Regenerative Electronic Loads

Resistive loads dissipate electrical energy as heat. During burn-in testing, the power product under test delivers power to a resistive load, which converts it into heat. Traditionally, resistive loads have been the default choice for simple, basic burn-in testing. Resistive loads provide a consistent and linear response, meaning their power consumption is directly proportional to the applied voltage or current. This predictability ensures that test conditions remain stable.

However, for test applications that require dynamic and complex load profiles, resistive loads come with limitations including energy waste, difficulty changing load levels for cycle testing, high operating costs, and the need for significant cooling infrastructure. The time it takes to conduct these long tests using this highly manual process can introduce errors or be an inefficient use of the user's time.

Regenerative loads recycle **the absorbed energy back into the power grid or facility** instead of converting electrical energy into heat. Regenerative loads can offer a more sustainable, flexible, accurate, cost-efficient, and productive solution for more complex testing.



Regenerative Benefits

Regenerative loads feed the energy drawn during testing back into the grid or the facility resulting in significant cost savings, especially in large-scale operations or for long duration burn-in testing.

Burn-In Testing	Resistive Loads	Regenerative Electronic Loads
Energy Usage	High energy consumption; waste heat increases costs	Energy recovery reduces waste and lowers utility bills
Cooling Requirements	Significant cooling infrastructure requirements /HVAC costs	Minimal cooling needed due to energy recycling
Cost Implications	Lower initial costs but higher operational expenses	Higher upfront cost offset by long-term savings
Scalability	Limited; suitable for basic, smaller-scale applications	Highly scalable for diverse and large-scale operations
Testing Flexibility	Predictable, linear response. Limited to Static testing only; lacks dynamic load profile support	Programmable for dynamic and complex load profiles
Environmental Impact	Higher carbon footprint due to energy and cooling demands	Reduced emissions through efficient energy utilization improves sustainability
Operational Efficiency	Manual processes prone to errors	Automated, programmable systems for long, high volume testing can improve precision and reduce risk of errors

Comparative Analysis & Potential Cost Savings

Consider a burn-in test requiring 10 kW for 10 hours. In this simplified example, **the use of regenerative loads results in an energy savings of 189 kWh**, which significantly reduces electricity and HVAC costs. Depending on local utility rates, the cost savings can be quite substantial.



	Resistive Load	Regenerative Load
Energy Consumed	10 kW * 10 hours = 100 kWh	10 kW * 10 hours = 100 kWh
Energy Recycled	0kWh	90kWh Assuming 90% efficiency
Net Energy Consumed	100kWh	10kWh
HVAC Energy	100kW (Assuming 1:1 ratio for simplicity)	1 kWh Minimal due to low heat output
Total Energy Consumed	200kWh	Only 11kWh

The transition from resistive loads to regenerative electronic loads for burn-in testing of power products offers substantial savings in energy and HVAC costs. Regenerative loads not only improve energy efficiency by recycling electrical energy back into the grid but also minimize heat generation, reducing the burden on HVAC systems.



Energy Savings Calculator

To estimate your potential cost savings, use our free savings estimator spreadsheet: [Energy Cost Savings Regenerative AC and DC Loads.xlsx](#)

How to Select a Regenerative Load for Burn-In?

When selecting a regenerative load for burn-in testing, below are 10 top considerations to improve the reliability and efficiency of your testing process.

Top 10 Considerations	
	<p>Regenerative Power & Efficiency Regenerative power returns energy back to the facility or grid. Look for a regenerative load that has a high efficiency typically > 90%.</p>
	<p>Modularity & Scalability Modular and scalable power provides flexibility to scale as needed for futureproofing.</p>
	<p>Constant Power Voltage Range Test both higher current at lower voltage and higher voltage at lower current using a single voltage range. This eliminates potential loading interruption when having to switch between High and Low voltage input ranges.</p>
	<p>High Peak Current; Inrush Current Control Make sure the electronic load can support demanding load conditions involving high crest factor peak currents. Evaluate programmable crest factor load settings that can replicate adverse load conditions.</p>
	<p>Precision & Control The regenerative load should provide precise control over current and voltage settings to enable repeatability and accurate simulation of resistive, inductive, or capacitive loads and dynamic operating conditions.</p>
	<p>Flexible Output Configuration Simultaneous AC and DC load operation of modes per phase (or channel), and the automatic switching of input modes provides the highest degree of flexibility. AC, DC input configurations are available in single, split, three phase and multi-channels with optional isolated neutrals in AC and DC with the RLS and ELZ Series.</p>
	<p>Programmability for Custom Test Profiles Consider whether the load can simulate the expected load profile (real-world conditions) during the burn-in test, including dynamic load changes (e.g., step load, ramping, or cycling).</p>
	<p>Safety Protection Features Ensure the regenerative load is equipped with protection limits (overload, over-voltage, over-temp, short-circuit) to safeguard both the DUT and the load itself from sudden spikes in power. Full galvanic isolation also reduces safety risks for operators and prevents potential damage to the UUT by eliminating unwanted current loops, ground loops or line noise.</p>
	<p>Reliability and Long-Term Performance A regenerative load should be capable of withstanding long-duration testing without degradation. Look for a load that has advanced hardware performance such as SiC technology, as burn-in tests often involve continuous operation over days or weeks.</p>
	<p>Full Galvanic Isolation Choose a load that provides built-in galvanic isolation between Facility power and unit under test as well as Channel to Channel isolation. This ensures that there is no disturbance or interference between channels and provides higher accuracy for testing.</p>
	<p>Easy Communication, Integration, and Control The regenerative load should have communication capabilities (e.g., remote control via Ethernet, RS-485, or CAN bus, GPIB) to allow for automation and integration with test management systems.</p>

Pacific Power Source Test Solutions

Burn-in testing remains a cornerstone of test and validation, and quality assurance for energy-intensive products. The adoption of regenerative loads represents a shift in how manufacturers approach testing, offering tangible benefits in cost, efficiency, and sustainability. As industries continue to set sustainability goals and operational efficiency, regenerative loads are set to become the standard for burn-in testing applications.

If you're looking for a Regenerative Load Solution, consider the following products:

1. For high-power density **RLS Series 6kW parallelable up to 252kW.**
2. For higher power, learn about the **ELZ Series up to 30kW parallelable up to 550kW.**

Key Advantages include:

- Regenerative Power > 90%
- Modularity and Scalability
- High Power Density
- 4 Quadrant AC & DC Load
- High precision and programmability
- Wide test coverage (Voltage, Current, Frequency)
- Flexible Output Configuration
- Several Emulation Modes
- **SmartSource Suite** Browser for enhanced control and visualization on any web browser



RLS Series Regenerative Load Simulator



ELZ Series High Power Regenerative Load

Please contact Pacific Power Source at sales@pacificpower.com or visit our website www.pacificpower.com.