



Energy Efficiency Requirements by Levels



AN-G-001/15

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As early as 1992, the U.S. Environmental Protection Agency started a voluntary program to promote energy efficiency and reduce pollution, which eventually became the Energy Star program. However, it was not until 2004 that the first mandatory regulations dictating average efficiency minimums and no-load power consumption maximums were put into place.

As different countries enacted stricter requirements and moved from voluntary to mandatory programs, the Energy Star program defined the International Efficiency Marking Protocol to minimize confusion between regions and their similar standards. The defined markings set minimum average efficiency and maximum no-load power consumption levels for external power supplies:

- **Level I:** Power supply does not meet any of the standards defined.
- **Level II:** Power supply meets minimum efficiencies that were required by China in November 2005.
- **Level III:** Power supply meets Energy Star Tier 1, CEC Tier 1, and Australian MEPS standards.
- **Level IV:** Power supply meets EISA 2007, CEC Tier 2, and the Australian MEPS High Efficiency category.
- **Level V:** Power supply meets CEC Tier 3 and EU phase 2 standards.
- **Level VI:** Power supply meets DOE new standards effective in the US on February 10, 2016.

Table I below shows the countries or regions mandating that all external power supplies (EPS) shipped across their borders meet the specified efficiency level (prior to 2/10/2016):

LEVEL	COUNTRY
IV	United States
IV	Canada
V	European Union

TABLE I. Efficiency Level Requirements

Level VI Requirement:

The new DOE Level VI efficiency standard mandates that No-Load power consumption does not exceed 0.100 W for EPS ranging from <1 W to ≤ 49 W and does not exceed 0.210W for EPS >49 W to ≤ 250 W. It boosts the mandatory average efficiency by about 1%, and has set standards for EPS with power ratings above 250 W for the first time. The new regulations apply to all direct and indirect operation EPS. The regulations also extend their scope to encompass lower voltage DC-output EPS, multiple-output voltage EPS, and EPS with nameplate output power ratings exceeding 250 watts. The compliance date for the new requirements is February 10, 2016.

The nameplate of single voltage AC-DC EPS are marked with a Roman numeral from the sequence I (least efficient) to VI (most efficient) that corresponds to specific minimum Active average efficiency and No-Load power levels. The performance requirements for each Roman numeral are shown in Table II below.

Performance Requirements* – Single-Output EPS					
Level	Nameplate Output Power (Pno)	Minimum Average Efficiency in Active Mode (expressed as a decimal)	Maximum Power in No-Load Mode (W)	Power Factor	
I	Used if none of the other criteria are met				
II	<1 watt	≥0.39xPno	≤0.75	Not Applicable	
	1 to ≤10 watts	≥0.107 x Ln(Pno) + 0.39			
	>10 to 49 watts	≥0.107 x Ln(Pno) + 0.39	≤1.0		
	>49 watts	≥0.82			
III	≤1 watt	≥0.49xPno	≤0.5	Not Applicable	
	>1 to <10 watts	≥0.09 x Ln(Pno) + 0.49			
	10 to 49 watts	≥0.09 x Ln(Pno) + 0.49	≤0.75		
	>49 to 250 watts	≥0.84			
IV	<1 watt	≥0.5xPno	≤0.5	Not Applicable	
	1 to 51 watts	≥0.09 x Ln(Pno) + 0.50			
	>51 to 250 watts	≥0.85			
V	≤1 watt	Basic Voltage ¹ : ≥0.480 x Pno + 0.140	≤0.3	≥0.9 at 115Vac/60Hz for power supply with input power ≥100 watts	
		Low Voltage ² : ≥0.497 x Pno + 0.067			
	>1 to ≤49 watts	Basic Voltage ¹ : ≥0.0626 x Ln(Pno) + 0.622			≤0.5
		Low Voltage ² : ≥0.0750 x Ln(Pno) + 0.561			
	≥50 to ≤250 watts	Basic Voltage ¹ : ≥0.870	≤0.5		
		Low Voltage ² : ≥0.860			
VI	≤1 watt	Basic Voltage ¹ : ≥0.5 x Pno + 0.160	≤0.100	≥0.9 at 115Vac/60Hz for power supply with input power ≥100 watts	
		Low Voltage ² : ≥0.517 x Pno + 0.087			
	>1 to ≤49 watts	Basic Voltage ¹ : ≥0.071 x Ln(Pno) - 0.0014 x Pno + 0.67			≤0.210
		Low Voltage ² : ≥0.0834 x Ln(Pno) - 0.0014 x Pno + 0.609			
	>49 to ≤250 watts	Basic Voltage ¹ : ≥0.880	≤0.500		
		Low Voltage ² : ≥0.870			
	>250 watts	Basic Voltage ¹ : ≥0.875	≤0.500		
		Low Voltage ² : ≥0.875			

TABLE IIa. Efficiency Level Requirements: Single-Output

* Excluding any device that requires Federal Food and Drug Administration (FDA) listing and approval as a medical device. Consult DoE 10 CFR Part 430 for more details.

1) Basic Voltage: nameplate voltage $\geq 6V$.

2) Low Voltage: nameplate output voltage < 6V and nameplate output current $\geq 550mA$.

Performance Requirements – Multiple-Voltage External AC-DC Power Supply			
Level	Nameplate Output Power (P _{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal)	Maximum Power in No-Load Mode (W)
VI	<1 watt	$\geq 0.497 \times P_{no} + 0.067$	≤ 0.300
	1 to ≤ 49 watts	$\geq 0.075 \times \ln(P_{no}) + 0.561$	
	>49 watts	≥ 0.860	

TABLE IIb. Efficiency Level Requirements: Multiple-Output

Definitions:

Direct operation external power supply: an external power supply (EPS) that functions in its end product without the assistance of a battery.

External Power Supply (EPS): is an external power supply circuit with its own housing used to convert line voltage AC input into lower voltage AC or DC output electric current, intended to be used with a separate end-use product and connected via either hardwired or connectorized cable or wiring.

Indirect operation external power supply: an external power supply that cannot operate the end product without the assistance of a battery and is not a battery charger.

P_{no}: nameplate output power.

Ln: natural logarithm.

Active mode: The condition in which the input of a power supply is connected to line voltage AC and the output is connected to a DC load drawing a fraction of the power supply's nameplate power output greater than zero.

No-load mode: The condition in which the input of a power supply is connected to an AC source consistent with the power supply's nameplate AC voltage, but the output is not connected to a product or any other load.

Power Factor (true): The true power factor is the ratio of the active, or real, power (P) consumed in watts to the apparent power (S), drawn in volt-amperes (VA).

Basic voltage external power supply: an EPS with a nameplate output voltage of greater than or equal to 6 volts.

Low voltage external power supply: an EPS with a nameplate output voltage of less than 6 volts and a nameplate output current greater than or equal to 550 milliamps.

Test Methodology:

The unit under test (UUT) shall be tested at two voltage and frequency combinations: 115Vac, 60 Hz and 230Vac, 50 Hz, if its nameplate input voltage and frequency indicate

that it can operate safely under both conditions. The input voltage source shall be capable of delivering at least 10 times the nameplate input power of the UUT (as specified in IEEE 1515-2000). Regardless of the AC source type, the THD (total harmonic distortion) of the supply voltage when supplying the UUT in the specified mode shall not exceed 2%, up to and including the 13th harmonic (as specified in IEC 62301). The peak value of the test voltage shall be within 1.34 and 1.49 times its RMS value (as specified in IEC 62301).

The power measurement instrument shall have a resolution of 0.01W or better for power measurements of 10W or less, 0.1W or better for power measurements of greater than 10W up to 100W, and 1W or better for power measurements of greater than 100W.

The UUT shall be tested at the load conditions shown in Table III:

LOAD CONDITION	OUTPUT CURRENT
1	100% $\pm 2\%$
2	75% $\pm 2\%$
3	50% $\pm 2\%$
4	25% $\pm 2\%$
5	0%

TABLE III. Percentage of Nameplate Output Current

The UUT shall be operated at 100% of nameplate output current for at least 30 minutes. After this warm-up period, if the power level does not drift by more than 5% from the maximum value observed, the UUT can be considered stable and the measurements can be recorded. If AC input power is not stable over a 5 minute period, the guidelines established by IEC 62301 for measuring average power or accumulated energy over time for both AC input and DC output are followed.

Efficiency measurements shall be conducted in sequence from Load Condition 1 to Load Condition 5 as indicated in the table above. Efficiency shall be calculated by dividing the UUT's measured DC output power at a given load condition by the true AC input power measured at that load condition. Average efficiency shall also be calculated as the arithmetic mean of the efficiency values calculated at Load Conditions 1, 2, 3, and 4.

It is critical to use a short and properly sized test cable to reduce cable power loss as much as possible. It is also recommended to measure the output voltage right at the output connector, not through a mating connector. Significant losses may result from the mating connector.

Compliance Date:

The compliance date for the DOE Level VI regulations is February 10, 2016. Compliance will be based on the date of manufacture and/or date of import into the United States. Any power supply manufactured after this date must comply with the new regulations.

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