White Paper on Acceptance Criteria --- Draft (0.3)

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AC-DC Working Group (hereafter AC-DC-WG) of the Climate Savers Computing Initiative (hereafter CSCI) performed a measurement project to define the acceptance criteria for the AC-DC power supply.

This white paper describes the findings through the measurement, the Acceptance Criteria, and the philosophy discussed and reached by the AC-DC-WG, which is behind the Acceptance Criteria.

1. Experimental Measurement

Power efficiencies were measured for 8 power supply models, 5 for multi-output and 3 for single-output, from mass production of 4 power supply manufacturing companies, with sample size ranging from 30 to 200.

The data were plotted against cumulative-normal-distribution curve, and it was confirmed that the distributions of all models followed normal-distribution.

The mean values and standard-deviation values were calculated, and are shown in Table.1.

The measured standard-deviations (Std-Dev) were found to be small. The largest value was 0.815%, second was 0.581%, and other values were between 0.350%and 0.046%. The average was 0.245% (% is the unit for power efficiency). The AC-DC-WG agreed that most of the mass produced power supplies in the industry are expected to have measured standard-deviations of 1% or smaller, when sample size is 30 or larger. Also, it was noted that sample size of 30 is a general number used to check the production capacity in the development phase, and would be acceptable to most of the power supply manufacturers and models.

Table.1. Measured Mean and Standard-Deviation of Power Supplies

Model *1	Sample Size	Mean			Standard-Deviation (unbiased)			note
		20%load	50%load	100%load	20%load	50%load	100%load	
M-A	30	84.483	87.843	87.478	0.581	0.137	0.245	
M-B	30	81.606	81.611	84.767	0.310	0.333	0.815	
M-C	30	82.027	83.880	83.963	0.134	0.254	0.262	
M-D1	30	83.284	87.691	86.427	0.350	0.156	0.119	230Vac
M-D2	30	82.298	85.893	83.826	0.281	0.154	0.129	115Vac
S-A	30	86.911	90.807	90.508	0.277	0.182	0.184	
S-B	200	77.815	86.903	86.045	0.267	0.206	0.213	
S-C	51	85.688	90.654	91.453	0.168	0.070	0.046	
average	---	---	---	---	0.296	0.186	0.252	
					0.245			

*1: M:Multi-output power supply
S: Single-output power supply
A, B, C... : in alphabetical order.
M-D1 and M-D2 are same model, measured at different input voltages.

The theory of statistics teaches that, when samples are taken from a large Total Population, and when the sample size N is 30, the estimation error for the mean is 0.380Std-Dev., with a confidence level of 95%. In other words, the true mean of the Total Population, which is unknown, is within the mean of the samples plus or minus 0.380Std-Dev. of the samples, with a confidence level of 95% :

$$\left(mean_{sample} - 0.380\sigma_{sample}\right) < mean_{Total\_Population} < \left(mean_{sample} + 0.380\sigma_{sample}\right)$$

Because the acceptance standard of power efficiency specifies only the lower limit (one side bounded), it can be said with confidence level of 97.5%, that the true mean of the Total population is equal to or larger than the mean minus 0.380Std-Dev. calculated from the samples :

$$mean_{Total} > \left(mean_{sample} - 0.380\sigma_{sample}\right)$$

When the standard-deviation is 1% or smaller, the estimation error is 0.380% or smaller (% is the unit for power efficiency), with a confidence level of 97.5%, toward the lower side of the true mean from the Total Population.

AC-DC-WG of CSCI agreed that this error is small enough to be neglected, which facilitates the qualification process, but the standard-deviation needs to be confirmed that it is small enough, smaller than or equal to 1%, in order to ensure the reliability of this standard.

2. The Basic Criterion

Based on the above discussion, AC-DC-WG of CSCI defined the basic acceptance criterion for the power efficiency of AC-DC power supply as follows :

$$\overline{\eta_{sample}} \geq \eta_{target}$$

$$\sigma_{sample} \leq \sigma_{target}$$

$$N \geq 30.$$

where,

η_{target} : Target Efficiency of CSCI (unit: %).

$\sigma_{target} = 1\%$, for $N \geq 30$ (% is the unit of Power Efficiency)

$\overline{\eta_{sample}}$: mean of measured power efficiencies η_i of the samples (unit: %).

(Excel function AVERAGE() may be used)

$$\overline{\eta_{sample}} = \frac{\sum_{i=1}^{N} \eta_i}{N}$$

σ_{sample} : unbiased-standard-deviation of measured power efficiencies η_i of the samples (unit: %).

(Excel function STDEV() may be used)

$$\sigma_{sample} = \sqrt{\frac{\sum_{i=1}^{N} \left(\eta_i - \overline{\eta}_{sample}\right)^2}{N-1}} = \sqrt{\frac{N\sum_{i=1}^{N} \eta_i^{\ 2} - \left(\sum_{i=1}^{N} \eta_i\right)^2}{N(N-1)}}$$

N : Sample Size (unitless value).

3. The meaning of the Basic Criterion.

What the Basic Criterion means is as follows :

1) the mean power-efficiency of mass produced model is expected to be greater than or equal to the Target Efficiency of CSCI (with an error of 0.380% or smaller neglected, and with a confidence level of 97.5%).
2) not all the power supply units in mass production are expected to have power-efficiencies greater than the Target Efficiency of CSCI.
3) the mass produced power supplies, as a whole, are expected to have positive contribution to energy saving and environmental improvement, to the degree the Target Efficiency of CSCI is expected to contribute.
4) the mean power-efficiency is a good representation of actual overall efficiency of the power supplies.

4. Extended Criterion.

CSCI AC-DC-WG discussed cases when the Basic Criterion is difficult to be performed, and the following Extended Criterion was provided. This Extended Criterion is intended to give same quality or confidence level of that of the Basic Criterion.

4.1 When the measured mean is smaller than the Target Efficiency.

Not accepted.

4.2 When the measured standard-deviation σ_{sample} is larger than 1%.

Not accepted.

4.3 When the sample size N is smaller than 30

When the sample size N is smaller than in the Basic Criterion, the following criterion may be used.
A negative compensating term is introduced in alignment with the Basic Criterion :

$$\overline{\eta_{sample}} - \max\left[0, \left(A\sigma_{sample\_b} - 0.380\right)\right] \geq \eta_{target}$$

$$\sigma_{sample} \leq \sigma_{target}$$

$$5 \leq N < 30$$

where,

$\overline{\eta_{sample}}$: mean of measured power efficiencies η_i of the samples (unit: %).
(Excel function AVERAGE() may be used)

$$\overline{\eta_{sample}} = \frac{\sum_{i=1}^{N} \eta_i}{N}$$

σ_{sample_b} : biased-standard-deviation of measured power efficiencies η_i of the samples. (unit: %).
(Excel function STDEVP() may be used)

$$\sigma_{sample\_b} = \sqrt{\frac{\sum_{i=1}^{N}\left(\eta_i - \overline{\eta_{sample}}\right)^2}{N}} = \sqrt{\frac{N\sum_{i=1}^{N}\eta_i^{\,2} - \left(\sum_{i=1}^{N}\eta_i\right)^2}{N^2}}$$

σ_{sample} : unbiased-standard-deviation of measured power efficiencies η_i of the samples (unit: %).
(Excel function STDEV() may be used)

$$\sigma_{sample} = \sqrt{\frac{\sum_{i=1}^{N}\left(\eta_i - \overline{\eta_{sample}}\right)^2}{N-1}} = \sqrt{\frac{N\sum_{i=1}^{N}\eta_i^{\,2} - \left(\sum_{i=1}^{N}\eta_i\right)^2}{N(N-1)}}$$

N : Sample Size (unitless value).

The A value is selected from Table.2, or calculated by the accompanying formula.
Sample size should not be smaller than 5, because deviation needs to be confirmed (unbiased-standard-deviation).

Table.2 Sample Size N and A value

N	A
5	1.388
6	1.150
7	0.999
8	0.894
9	0.815
10	0.754
12	0.664
14	0.599
16	0.550
18	0.512
20	0.480
22	0.454
24	0.431
26	0.412
28	0.395
30	0.380

$$A = \frac{TINV(\alpha, N-1)}{\sqrt{N-1}}$$

TINV : inverse of t-distribution
(Excel function : $TINV(\alpha, N-1)$)

α : reject level. (confidence level is
1-α for double side, 1-α /2 for single side).
use $\alpha = 0.05$ for calculation of A.

N : sample size (N-1 is freedom).

example 1 :

if measured values are N=10, $\overline{\eta}_{sample}$= 80.223%, and σ_{sample}= 0.8%, and the Target Efficiency= 80%, then

80.223% - max[0, (0.754*0.8% - 0.380%)] = 80.223% - max[0, (0.223%)] = 80.0%≥80%

and meets the criterion.

example 2 :

if measured values are N=10, $\overline{\eta}_{sample}$= 80.223%, and σ_{sample}= 0.3%, and the Target Efficiency= 80%, then

80.223% - max[0, (0.754*0.3% - 0.380%)] = 80.223% - max[0, (-0.1538%)] = 80.223%≥80%

and meets the criterion.

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