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ADDENDA

ANSI/ASHRAE Addendum h to
ANSI/ASHRAE Standard 90.4-2019

Energy Standard for Data Centers

Approved by the ASHRAE Standards Committee on September 23, 2022; by the ASHRAE Board of Directors on October 14, 2022; and by the American National Standards Institute on November 8, 2022.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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© 2022 ASHRAE ISSN 1041-2336

Approved American National Standard
ANSI
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FOREWORD

Uninterruptable power supplies (UPSs) have become more efficient since the 2016 publication of this standard and their efficiency curves have become flatter over the full load range. SSPC 90.4 believes it is the responsibility of any standard to encourage the use of equipment meeting the improved performance standards available from manufacturers today. This has resulted in increased efficiency requirements for the UPS segment of the electrical loss component (ELC).

Transformers have also become more efficient as a result of the 2016 publication of transformer efficiency standards by the U.S. Department of Energy (DOE). These standards require compliance only at 35% loading, which is below the design levels of most data center power distribution units (PDUs). PDU manufacturers have recognized this and provide transformers in their equipment that not only meet or exceed the DOE 35% load efficiency minimums but are also more efficient than standard building transformers at higher load levels. The committee believes it is our responsibility to encourage the use of equipment that not only meets legal mandates but also performs well under relevant conditions beyond those that federal authorities prescribe. We have, therefore, adjusted the minimum efficiency (maximum loss) requirements for the information technology equipment (ITE) distribution segment of the ELC to correspond to the loading levels more common to data centers (80% for nonredundant systems and 40% to 45% for redundant systems). The result is increased ITE distribution segment efficiency requirements at load levels above and below the federally prescribed 35% level, as well as adherence to the maximum loss values prescribed in electrical codes for feeders and branch circuit conductors.

The mechanical load component (MLC) has always required calculation of mechanical loads at 25%, 50%, 75%, and 100% of the ITE design load. The ELC required calculations at only 25%, 50%, and 100%, which related to fully redundant, nonredundant, or minimally redundant UPS designs. In order to parallel the MLC, the ELC has now been adjusted to require compliance at all four load levels. This also eliminates the need for distinctions among UPS redundancy configurations. The ELC maximum loss (minimum efficiency) tables have been revised to reflect these changes.

Section 8.2.2 has been removed because of more stringent electrical distribution efficiency requirements in data centers. As a result, the alternative method is no longer available in Standard 90.4.

Lastly, the incoming service segment of the ELC has been eliminated from the ELC calculation. A thorough examination of multiple incoming service designs has revealed that too many combinations of utility transformers (utility or privately owned), voltages, and feeder designs are now being used in data centers for tables to realistically cover all possibilities. Further, the two major elements of the incoming service segment (transformers and feeders) are all covered by federal transformer regulations and electrical code dictums. Therefore, the standard now simply requires adherence to those standards and regulations and restricts the ELC calculation to the UPS and distribution segments where the standard can realistically require designs meeting efficiency levels that can be reasonably achieved with technologies available today.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum h to Standard 90.4-2020

Revise Section 3.2 as shown.

3.2 Definitions

[. . .]

design electrical loss component (design ELC): the *design electrical loss component* for the *data center* or *data center addition* shall be the combined *losses* (or the *losses* calculated from efficiencies) of ~~three~~ two segments of the electrical chain: ~~*incoming electrical service segment,*~~ *UPS segment* and *ITE distribution segment*. The *design ELC* shall be calculated using the ~~worst case~~ highest loss (lowest efficiency) parts of each segment of the power chain in order to demonstrate a minimum level of electrically efficient design. The *design ELC* does not, and is not intended to, integrate all electrical *losses* in the facility.

[. . .]

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incoming electrical service segment: the *incoming electrical service segment* ~~of the design ELC~~ shall include all elements of the electrical power chain ~~delivering power~~ prior to the *UPS segment*, beginning with the load side of the *incoming electrical service point* supplying the *building*, continuing through all other intervening *transformers*, wiring, and switchgear, and ending at the *manufacturer*-provided input *terminals* of the *UPS* or its equivalent location in the circuit. ~~Although the mechanical *equipment* is normally powered from the same *incoming electrical service point*, its path and *losses* are not part of the *ELC* and, therefore, not part of the *incoming electrical service segment* calculation.~~

[. . .]

ITE distribution segment: the segment of the *design ELC* that includes all elements of the power chain, beginning at the *manufacturer*-provided output-load *terminals* of the *UPS segment*, extending through all *transformers*, wiring, and switchgear; and continuing to and including the receptacles to which *ITE* or power distribution strips for connection of multipole pieces of *ITE* to a circuit are intended to be connected. The *ITE distribution segment* shall not include the actual *ITE*, its power cords, or any accessory part of the *ITE*. In cases where power is to be hardwired into self-contained, *manufacturer* configured *cabinets*, the calculation path shall terminate at the power input *terminals* provided by the manufacture within that *equipment*. The *ITE distribution segment* used to calculate the *design ELC* shall be the highest *loss* (lowest *efficiency*) path. This is normally the longest path that also contains the largest numbers of *loss*-producing devices such as *transformers*.~~, switchgear and/or panelboards.~~

[. . .]

uninterruptible power supply (UPS): also known as an "uninterruptible power *system*," a *system* primarily intended to continue delivering power to the critical load after a utility power interruption. It may also serve to deliver stable power ~~to the critical load~~when anomalies occur in the incoming power source, which may be the utility or an alternate power source such as a *generator*. *UPS systems* are defined by three internationally recognized classifications:

> ***voltage and frequency dependent (VFD) systems:*** also known as "off-line" or "standby" *UPS systems*, which are off-line until a power interruption occurs and then rapidly switch into the circuit to maintain power to the critical load.
>
> ***voltage independent (VI) systems:*** also known as "line interactive," which are similar to *VFD systems* in that they rapidly switch backup power to the critical load when a power interruption occurs. However, a *VI UPS* continually passes incoming power to the output while also using the stored energy source to filter incoming power, suppress voltage spikes, and provide a degree of voltage regulation.
>
> ***voltage and frequency independent (VFI) systems:*** also known as "double conversion," "dual conversion" or "full time" *UPS*, which use incoming utility or generator power solely to drive an electronic or mechanical mechanism that regenerates power and delivers it to the critical load without the need to switch anything into or out of the circuit. This results in total isolation of the critical load from incoming power and no break of any duration in the delivered power.

~~The majority of modern *UPS systems* are of two fundamental types.~~ Two physical types of *UPS systems* are in general use:

a. ~~"static," in which incoming alternating current (AC) power is rectified to direct current (DC) and then inverted back to AC, with batteries in the DC portion that assume the load when incoming power fails or anomalies occur, and~~ Battery *UPS* in which incoming AC power maintains battery charge, and an AC to DC converter, known as an "inverter," delivers power to the critical load on either a continuous or noncontinuous basis.

b. ~~"rotary,"~~ Rotary *UPS*, in which incoming AC power drives a propulsion unit that turns a generating device, with a heavy flywheel storing kinetic *energy* that continues to turn the generating portion when incoming power fails or anomalies occur. Batteries are also sometimes used to supplement the kinetic energy storage to extend "ride-through" time. Rotary *UPS systems* may also include a driven engine for emergency backup (commonly referred to as a Diesel Rotary *UPS* or "DRUPS", regardless of fuel type), which is decoupled from the rotary *UPS* components during normal operation and is not included in *efficiency* calculations.

Either type of *UPS* can be made up of one or more modules running in parallel to add capacity, *redundancy*, or both. DC *UPS* systems which eliminate the inverter and deliver DC power to the *ITE* are also used.

[. . .]

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Revise Section 8 as shown.

~~**8.2.2 Electrical Distribution *systems* Alternative for Section 8.4.** Electrical *distribution systems* shall comply either with provisions of ANSI/ASHRAE/IES Standard 90.1, Section 8, or with Section 8.4 of this standard.~~

[. . .]

8.4.1 Electrical Distribution S*ystems* for Mechanical Loads. The electrical *distribution systems* serving mechanical loads shall be designed with ~~pathway~~ *transformers* complying with U.S. Department of Energy (DOE) 2016 efficiency levels or comparative international standards, and conductor *losses* not exceeding ~~2%~~ 3%. However, these *losses* shall not be incorporated into the design ELC calculations set forth in Section 8 of this standard.

[. . .]

8.4.1.4 *Incoming Electrical Service Segment*. ~~A segment *loss* value shall be calculated for the incoming electrical service segment of the *design ELC*. This value shall be based on all *equipment efficiencies* and resulting *losses* in this segment at the design load for all down-stream *equipment* served.~~ The *incoming electrical service segment* is not part of the *ELC* calculation. However, all components in the incoming power chain shall meet or exceed published U.S. DOE minimum efficiencies for transformers or the equivalent international standards, and U.S. *National Electrical Code*® (NEC) maximum losses for service conductors or the equivalent international electrical codes.

Exception to 8.4.1.4: Emergency or stand-by power *systems* are not considered a part of the *incoming electrical service segment*, with the exception of individual elements such as associated transfer switches, *transformers*, or other devices that are also included between the *design ELC demarcation* and the *UPS*. DRUPS *systems* shall be calculated as part of the *UPS Segment* with the engine element decoupled.

8.4.1.5 *UPS Segment Efficiency*. *Efficiency* and resulting *loss* through the *UPS segment* of the ELC shall be calculated at both full and partial loads~~, depending on configuration,~~ as follows:

a. ~~For *N, N+1, or N+n*~~ *UPS* configurations~~,~~ *losses* shall be based on the *manufacturer's* stated *efficiencies* at 100%, 75%, 50% and 25% of the *UPS operational design load*.
b. For 2*N*, 2*N*+1, 2(*N*+1), or other dual-fed *UPS* configurations~~, the *systems* are each intended to normally operate at no more than half capacity. Therefore, the *UPS losses* shall be based on the *manufacturer's* started *efficiencies* at 50% and 25% of the *UPS operational design load*. W~~where *UPS systems* are identical, only one of the *systems* shall be used in the calculation. Where *UPS systems* are not identical, both *systems* shall be calculated, and the *system* with the lowest *efficiency* shall be used to compute the *UPS segment* of the *design ELC*.
c. Where a *UPS* has more than one mode of operation (e.g., normal and *UPS economy* modes), the mode used in these calculations shall be the same as the mode used as the Basis of Design and shall be so designated on the approved *construction documents*.
d. Where nonrated *UPS systems* are used, the *efficiencies* and *losses* shall be as published or otherwise provided in writing by the *manufacturer*.

[. . .]

8.4.1.7 ~~Combined *UPS* and Pathway *Loss* Calculations~~ ELC Calculation. The *design ELC* shall be ~~calculated as~~ the result of the calculated ~~*incoming electrical service segment loss*, the~~ *UPS segment loss*~~,~~ and the *ITE distribution segment losses* shall be separately reported at each of four (4) load levels: 100%, 75%, 50%, and 25% of *the ITE design load*. The electrical *system* shall meet or exceed the *ELC* minimum requirements at each of the *ITE design load* levels.

Informative Notes:

1. If the *ELC* cannot be met at one or more load levels, see Section 11 for directions on meeting the standard requirements by designing a more efficient mechanical system.
2. See Informative Appendix C, Section C1 "Examples—*Design ELC* Calculations," for method of combining *ELC* segment values.

8.4.1.8 *Alternate Designs*. In the event that a *UPS* is not used in the design, the incoming and distribution segments shall meet at the point(s) where a *UPS* would logically be inserted under normal operating conditions. Where another power conditioning device, such as a rectifier, voltage regulator, or harmonic neutralizing *transformer*~~,~~ is used either in place of ~~a~~the *UPS* or in combination with the *UPS*, or where a DRUPS *system* is used, the *efficiency* and *loss* for that device shall be included in the UPS segment *efficiency* and *loss* calculation as if it is taking the place of, or is part of, the *UPS* ~~used in the *efficiency* calcula-~~

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~~tion~~ in the same manner as that defined for a *UPS*. In the case of a DRUPS *system*, this calculation shall be performed with the engine decoupled. DRUPS operation under engine-generator power shall be considered a short-term emergency condition and is excluded from the requirements of the Standard in the same manner as are other on-site emergency of standby generators (See Exception under 8.4.1.4). Where no power conditioning device is utilized, the *system* shall meet the *distribution component* requirements of the *ELC*.

Table 8.5 Maximum *Design Electrical Loss Component* (*Design ELC*) and ELC Segments *Systems* (IT Design Load <100 *kW*) [a]

UPS Redundancy Configuration	Single-Feed *UPS* (*N*, *N+1*, etc.) or ~~No *UPS*~~[b] Active Dual-Feed *UPS* (*2N*, *2N+1*, etc.)[c] (See informative note below.)			
Calculation Percentage	100% of IT design load segment ELC	50% of IT design load segment ELC	50% of IT design load segment ELC	25% of IT design load segment ELC
Segments of ELC and Overall ELC	*Loss* / *efficiency*	*Loss* / *efficiency*	*Loss* / *efficiency*	*Loss* / *efficiency*
~~***Incoming Electrical Service Segment***~~	~~15.0% / 85.0%~~	~~11.0% / 89.0%~~	~~11.0% / 89.0%~~	~~10.0% / 90.0%~~
UPS Segment	8.0% / 92.0%	~~10.0% / 90.0%~~ 8.5% / 91.5%	~~10.0% / 90.0%~~ 8.5% / 91.5%	~~13.5% / 86.5%~~ 9.5% / 90.5%
ITE Distribution Segment	~~6.0% / 94.0%~~ 6.7% / 93.3%	~~4.0% / 96.0%~~ 5.0% / 95.0%	~~4.0% / 96.0%~~ 4.5% / 95.5%	~~3.0% / 97.0%~~ 2.9% / 97.1%
Electrical *Loss* / *Efficiency* Total	~~26.5% / 73.5%~~ 14.2% / 85.8%	~~23.1% / 76.9%~~ 13.1% / 86.9%	~~23.1% / 76.9%~~ 12.6% / 87.4%	~~24.5% / 75.5%~~ 12.1% / 87.9%
ELC	~~0.265~~ 0.142	~~0.231~~ 0.131	~~0.231~~ 0.126	~~0.245~~ 0.121

a. ***Informative Note:*** Example calculations are shown in Informative Appendix C.

~~b. *Informative Note:* These columns apply to electrical configurations resulting in a single output feed from the *UPS* irrespective of the number of *UPS* modules that may be paralleled prior to the output feed or the number of branches or subfeeders into which that output feeder may be divided.~~

~~c. *Informative Note:* These columns apply to electrical configurations made up of two distinct and electrically separated *UPS systems* resulting in two distinct and electrically separate output feeds, either of which is capable of independently supporting the total design load. *Systems* that meet these criteria may be made up of any number of *UPS* modules that are paralleled prior to each output feed. Crossties and/or transfer switches downstream of the independent feeds shall not continually tie the two output sections together.~~

Table 8.6 Maximum *Design Electrical Loss Component* (*Design ELC*) and ELC Segments *Systems* (IT Design Load ≥ 100 *kW*)

UPS Redundancy Configuration	Single-Feed *UPS* (*N*, *N+1*, etc.) or ~~No *UPS*~~[b] Active Dual-Feed *UPS* (*2N*, *2N+1*, etc.)[c] (See informative note below.)			
Calculation Percentage	100% of IT design load segment ELC	~~50~~75% of IT design load segment ELC	50% of IT design load segment ELC	25% of IT design load segment ELC
Segments of ELC and Overall ELC	*Loss* / *efficiency*	*Loss* / *efficiency*	*Loss* / *efficiency*	*Loss* / *efficiency*
~~***Incoming Electrical Service Segment***~~	~~15.0% / 85.0%~~	~~11.0% / 89.0%~~	~~11.0% / 89.0%~~	~~10.0% / 90.0%~~
UPS Segment	~~6.5% / 93.5%~~ 5.5% / 94.5%	~~8.0% / 92.0%~~ 5.5% / 94.5%	~~8.0% / 92.0%~~ 6.0% / 94.0%	~~11.0% / 89.0%~~ 7.0% / 93.0%
ITE Distribution System	~~5.0% / 95.0%~~ 5.8% / 94.2%	~~4.0% / 96.0%~~ 4.6% / 95.4%	~~4.0% / 96.0%~~ 3.6% / 96.4%	~~3.0% / 97.0%~~ 2.5% / 97.5%
Electrical *Loss* / *Efficiency* Total	~~24.5% / 75.5%~~ 11.0% / 89.0%	~~18.9% / 81.1%~~ 9.8% / 90.2%	~~18.9% / 81.1%~~ 9.4% / 90.6%	~~22.3%/77.7%~~ 9.3% / 90.7%
ELC	~~0.245~~ 0.110	~~0.189~~ 0.098	~~0.189~~ 0.094	~~0.223~~ 0.093

Informative Note: Example calculations are shown in Informative Appendix C.

~~b. *Informative Note:* These columns apply to electrical configurations resulting in a single output feed from the *UPS*, irrespective of the number of *UPS* modules that may be paralleled prior to the output feed, or the number of branches or subfeeders into which that output feeder may be divided.~~

~~c. *Informative Note:* These columns apply to electrical configurations made up of two distinct and electrically separated *UPS systems* resulting in two distinct and electrically separate output feeds, either of which is capable of independently supporting the total design load. *Systems* that meet these criteria may be made up of any number of *UPS* modules that are paralleled prior to each output feed. Crossties and/or transfer switches downstream of the independent feeds shall not continually tie the two output sections together.~~

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Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

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The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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