BSR/ASHRAE Standard 90.4P

3rd ISC Public Review Draft

Energy Standard for Data Centers

Third ISC Public Review (January 2016)
(Independent Substantive Chance Draft for Review)

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Note to Reviewers: This draft has been recommended for a third independent substantive change public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at https://www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. Apart from acknowledging receipt of each comment, communication with commenters by the authoring project committee is optional but may be undertaken to clarify a comment's intent or to invite further participation in the standard's development process. **Please note that only the changes that are in strike through and underline are open for public review comments.**

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FOREWORD

We would like to thank all of the people who registered comments on the second Public Review draft. The feedback has been very valuable in identifying improvements to the proposed Standard and the Committee believes it has successfully made changes to resolve the majority of the comments.
Here are some of the significant changes that were made in response to public comments:

- Revised the definition section to remove definitions used in ASHRAE Standard 90.1 and to instead reference the definitions.
- Revised several additional definitions to provide further clarity.
- Revised Section 4.2 to reference the Alternate Compliance Option
- Deleted Section 6.3 Alternative Compliance Path and created a revised Alternative Compliance Path in Section 11.
- Revised the numbers in Tables 8.2.1.1 and 8.2.1.2.
- Revised portions in Section 8
- Revised Figures in Informative Appendix C and the Examples in C5
- Updated the Normative and Informative References
- Added Additional Sample Submittal Forms to Informative Appendix B

Reviewers of this draft should understand that the Committee intended for this standard to allow innovation while still saving energy in data centers. There is also a related document that is out concurrently for public review. This is Addendum *cz* to ANSI/ASHRAE/IES Standard 90.1-2013 to eliminate scope overlap between 90.1 and 90.4.

Please be advised that the committee intends to put Standard 90.4, when published, on continuous maintenance to allow the committee to make changes in real time with the IT industry.

Ron Jarnagin, Chairman Standard 90.4 Committee

Title: BSR/ASHRAE Standard 90.4P, *Energy* Standard for *Data Center*s

1. PURPOSE

The purpose of this standard is to establish the minimum *energy* efficiency requirements of *Data Center*s for:

a. design, *construction*, and a plan for operation and maintenance, and
b. utilization of on-site, or off-site renewable *energy* resources

2. SCOPE

2.1 This Standard applies to:

a. new *Data Center*s or portions thereof and their *system*s,
b. new additions to *Data Center*s or portions thereof and their *system*s, and
c. modifications to *system*s and *equipment* in existing *Data Center*s or portions thereof

2.2 The provisions of this standard do not apply to:

a. *telephone exchange(s)*
b. *essential facility(ies)*
c. *information technology equipment (ITE)*

2.3 Where specifically noted in this standard, certain other *building*s or elements of *building*s shall be exempt.

2.4 This Standard shall not be used to circumvent any safety, health, or environmental requirements.

3. DEFINITIONS

3.1 General. Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. These definitions are applicable to all sections of this standard. ~~Terms that are not defined shall have their ordinary accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based upon standard American English language usage as documented in an unabridged dictionary accepted by the *adopting authority*.~~

3.1.1 Coordination. Where terms are not defined in this standard, but are defined in ASHRAE Standard 90.1, those terms shall have the meanings as assigned to them in ASHRAE Standard 90.1. Where terms are not defined in either document they shall have their ordinary accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based upon standard American English language usage as documented in an unabridged dictionary accepted by the *adopting authority*.

3.2 Definition

~~***adopting authority:*** the agency or agent that adopts this standard~~.

air; ambient: the air surrounding a *building* or *space*; the source of *outdoor air* brought into a *building*.

air; exhaust: air removed from a *space* and discharged to outside the *building* by means of mechanical or *natural ventilation system*s.

air, recirculated: air removed from a *space* and reused as *supply air*.

air, return: air removed from a *space* to be then *recirculated* or exhausted.

air, supply: air delivered by mechanical or *natural ventilation* to a *space*, composed of any combination of *outdoor air*, *recirculated air*, or *transfer air*.

alteration: a replacement not in kind or addition to a *building* or its *system*s and *equipment*. Routine maintenance, *repair*, replace in kind, and *service* or a change in the *building*'s use classification or category shall not constitute an *alteration*. Alterations exclude *ITE adds, moves and changes*

annualized mechanical load component (annualized MLC): the sum of all cooling, fan, pump, and heat rejection annual *energy* use divided by the *Data Center ITE energy*.

~~***authority having jurisdiction (AHJ):*** the agency or agent responsible for enforcing this standard.~~

automatic: self-acting, operating by its own mechanism when actuated by some non-*manual* influence and without human intervention, such as a change in current strength, pressure, temperature, or mechanical configuration. (See *manual*.)

~~***branch circuit:*** the circuit conductors between the final *overcurrent* device protecting the circuit and the outlet(s); the final wiring run to the load.~~

~~***building:*** a structure wholly or partially enclosed within exterior *wall*s, or within exterior and party *wall*s, and a *roof*, affording shelter to persons, animals, or property.~~

~~***building envelope:*** the exterior plus the semi-exterior portions of a *building*.~~

~~***building official:*** the officer or other designated representative authorized to act on behalf of the *authority having jurisdiction*.~~

cabinet: A container that encloses connection devices, terminations, apparatus, wiring, and *equipment*.

circuit breaker: a device designed to open and close a circuit by non-*automatic* means and to open the circuit *automatically* at a predetermined *overcurrent* without damage to itself when properly applied within its rating.

computer room**:** A room or portions of a *building* serving an *ITE* load less than or equal to10 *kW,* or 20 watts/sf (215 Watts/m^2) or less of *conditioned floor area.*

conditioned floor area: *floor area* of a *building* or structure that is *conditioned space*. See *space*, conditioned.

construction: the fabrication and erection of a new *building* or any addition to or *alteration* of an *existing building*.

construction documents: drawings and specifications used to construct a *building, building system*s, or portions thereof.

~~***control:*** to regulate the operation of *equipment*.~~

~~***cooled space:*** *space, conditioned*.~~

Cooling energy (kWh): the sum of all site energy required to provide cooling via vapor- compression, ventilation, dehumidification, humidification, evaporation, absorption, adsorption, or other means.

data center: A room or *building*, or portions thereof, including computer rooms being served by the data center systems, serving a total *ITE* load greater than 10 *kW* and 20 watts/sf (215 Watts/m^2) of *conditioned floor area.*

data center energy: annual *energy* use of the *data center* including all *IT equipment energy* plus *energy* that supports the IT *equipment* and *data center space*.

~~***data center ITE design power (kW):*** the sum of all power for the *ITE. ITE power* is not assumed to be seasonably variable in this Standard. Therefore, *ITE energy* can be calculated by multiplying *ITE power* by 8,760, the number of hours in a normal year.~~

~~***design***~~ ***data center ITE design power~~load~~:*** The combined ~~load~~ power, in *kW* ~~or~~ ~~*kVA*~~, of all the *ITE* loads for which the *ITE system* was designed. The *data center* ~~*design*~~ *ITE* ~~*Load*~~ *power* ~~shall be specified on the construction documents, and~~ shall not include any additional loads such as *cabinet* fans or other devices that are not inherent parts of the *ITE*, even if ~~they~~ the loads are part of the *UPS Operational Design Load*.

data center ITE energy (kWh): the sum of all *energy* consumed by the *ITE* on an annual basis.

data center point of presence (PoP**):** The location where the common carrier connects to the data center telecommunication equipment.

~~***design conditions:*** specified environmental conditions, such as temperature and light intensity, required to be produced and maintained by a *system* and under which the *system* must operate.~~

Data center ~~design~~ systems: HVAC systems, electrical systems, equipment, or portions thereof, used to condition ITE or electrical systems~~, which~~Data center systems may also be shared serving other data center additions or non-data center loads. ~~portions of a building or portions thereof~~.

design electrical loss component (design ELC): the *design electrical loss component* ~~of the *ITE room efficiency*~~ for the data center or data center addition shall be the combined losses (or the losses calculated from efficiencies) of three segments of the electrical chain: *incoming service segment*; *UPS segment* and *ITE distribution segment*. The *design electrical Loss component* shall be calculated using the worst case 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.

design ELC demarcation: The *incoming service point* as defined by the National Electrical Code (NFPA 70).

design mechanical load component (design MLC): the sum of all cooling, fan, pump, and heat rejection design power divided by the *data center ITE design power*.

~~***design power usage effectiveness (PUE):*** *total* data center power or energy divided by total IT equipment power or energy as calculated by a design professional in accordance with industry-accepted standards.~~

- ~~***design power usage effectiveness – category 0 (PUE0):*** peak electric demand power (kW), as designed, for the entire data center, including IT equipment and supporting infrastructure, divided by peak electric demand power (kW) of the IT equipment.~~
- ~~***design power usage effectiveness – category 1 (PUE1):*** annual energy consumption (kWh), as designed, for the entire data center, including IT equipment and supporting infrastructure, divided by annual energy consumption (kWh) of the IT equipment.~~

~~***design professional:*** an architect or engineer licensed to practice in accordance with applicable state licensing laws.~~

dew point: the temperature to which air must be cooled (assuming constant air pressure and moisture content) to reach a relative humidity of 100% (i.e. saturation).

~~***distribution system:*** conveying means, such as ducts, pipes, and wires, to bring substances or *energy* from a source to the point of use. The *distribution system* includes such auxiliary *equipment* as fans, pumps, and *transformers*.~~

efficiency: performance at specified rating conditions, usually expressed as a percentage or as a decimal factor of 1.0 or less.

~~***enclosed space:*** a volume substantially surrounded by solid surfaces such as *walls*, floors, *roofs*, and openable devices such as doors and operable windows.~~

~~***energy:*** the capacity for doing work. It takes a number of forms that may be transformed from one into another such as thermal (heat), mechanical (work), electrical, and chemical. Customary measurement units are British thermal units (Btu) and kilowatt hours (kWh).~~

equipment: devices for conditioning of electric power and *information technology equipment* (*ITE*)

essential facility: Those portions of a ~~*building*~~ *data center* whether on the same site or at a remote location, serving one of the following functions:
a. Hospitals and other health care facilities having surgery or emergency treatment facilities
b. Fire, rescue, and police stations and emergency vehicle garages
c. Designated earthquake, hurricane, or other emergency shelters
d. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response
e. Power-generation, transmission and distribution stations, and other public utility facilities required as emergency backup facilities for other essential facilities

f. Structures containing highly toxic materials where the quantity of the material exceeds the maximum allowable quantities
g. Aviation *control* towers, air traffic *control* centers, and emergency aircraft hangars
h. ~~*Buildings*~~ *Data centers* and other structures having critical national defense functions
i. Those spaces having a mechanical cooling or electrical design of Rating IV as defined by ANSI/TIA-942.
j. Those spaces classified under NFPA 70 Article 708 – Critical Operations Power Systems (COPS); or
k. Those spaces where core clearing and settlement services are performed such that failure to settle pending financial transactions could present systematic risk as described in "The Interagency Paper on Sound Practices to Strengthen Resilience of the Financial System, April 17, 2003."

~~***existing building:*** a *building* or portion thereof that was previously occupied or approved for occupancy by the *authority having jurisdiction*.~~

~~***existing equipment:*** *equipment* previously installed in an *existing building*.~~

~~***existing system:*** a *system* or *systems* previously installed in an *existing building*.~~

fan brake ~~horse~~power: the ~~horse~~power delivered to the fan's shaft. Brake ~~horse~~power (b~~h~~p) does not include the mechanical drive losses (e.g., belts, gears).

~~***floor area:*** the sum of the *floor areas* of the *spaces* within the *building*, including basements, mezzanine and intermediate-floored tiers, and penthouses with a headroom height of 7.5 ft. or greater. It is measured from the exterior faces of exterior *walls* or from the centerline of *walls* separating *buildings*, but excluding covered walkways, open roofed-over areas, porches and similar *spaces*, pipe trenches, exterior terraces or steps, chimneys, *roof* overhangs, and similar features.~~

~~***fossil fuel:*** *fuel* derived from a hydrocarbon deposit such as petroleum, coal, or natural gas derived from living matter of a previous geologic time.~~

~~***fuel:*** a material that may be used to produce heat or generate power by combustion.~~

~~***historic:*** a *building* or *space* that has been specifically designated as *historic*ally significant by the *adopting authority* or is listed in The National Register of *Historic* Places or has been determined to be eligible for such listing by the US Secretary of the Interior.~~

~~***HVAC system:*** the *equipment*, *distribution systems*, and *terminals* that provide, either collectively or individually, the processes of heating, ventilating, or *air conditioning* to a *building* or portion of a *building*.~~

Incoming electrical service point: The *terminal* at which the Public Utility hands-off the incoming power to the Owner, as defined by the National Electrical Code (NFPA 70).

incoming electrical service segment: the *incoming electrical service segment* of the *design electrical loss component (ELC)* shall include all elements of the electrical power chain ~~system~~ delivering power to the *UPS* ~~and mechanical equipment~~, 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* ~~and mechanical equipment~~. 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.

~~***incoming service segment:*** The segment of the *electrical loss component* (ELC) that shall include all elements of the power chain delivering power to the *UPS*, beginning at the design *ELC demarcation* and continuing through all intervening devices and switchgear to the input load *terminals* of the *UPS segment*.~~

information technology equipment ("ITE"): IT Equipment includes computers, data storage, servers and network/communication equipment.

ITE adds, moves and changes: The normal and somewhat perpetual additions, moves, and changes to *ITE* ~~*equipment*~~ such as a server moving from one *ITE enclosure* to another.

ITE distribution segment: The segment of the *electrical loss component* that includes all elements of the power chain beginning at the manufacturer-provided output load *terminals* of the *UPS segment*, through all *transformers*, wiring and switchgear, and up to and including the receptacles to which *information technology equipment (ITE)* or power distribution strips for connection of multiple 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 hard-wired into self-contained, *manufacturer*-configured *cabinets*, the calculation path shall terminate at the power input *terminals* provided by the *manufacturer* within that equipment. The *ITE distribution segment* used to calculate the *electrical loss component* shall be the longest path that also contains the largest numbers of *loss* producing devices such as *transformers*, switchgear and/or panelboards.

ITE enclosure: A rack, *cabinet*, or chassis that is designed to mount and enable appropriate ventilation of ITE.

IT equipment energy: annual *energy* used for computer, data storage and network *equipment* along with supplemental *equipment* represented by the uninterruptible power supply (*UPS*) output.

ITE room: A room dedicated for *ITE*.

~~***ITE room efficiency:*** the total *efficiency* of the electrical, mechanical and lighting systems serving the *ITE Room*, combined mathematically and used in the computation of the data center's *design PUE*.~~

~~***kilovolt-ampere (kVA):*** where the term *kilovolt-ampere* (*kVA*) is used in this standard, it is the product of the line current (amperes) times the nominal *system* voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, *kVA* is the product of the line current (amperes) times the nominal *system* voltage (kilovolts).~~

kilowatt (kW): the basic unit of electric power, equal to 1000 W. For Alternating Current circuits and single-phase equipment it is the ~~*kVA*~~product of the voltage times the ampage times the Power Factor (pf) of the connected *equipment*.

~~***labeled:*** *equipment* or materials to which a symbol or other identifying mark has been attached by the *manufacturer* indicating compliance with specified standards or performance in a specified manner.~~

~~***lighting power density (LPD):*** the maximum lighting power per unit area (Watts/square foot or Watts/square meter) of a *building* classification of *space* function.~~

loss: The difference between the power or *energy* entering a device or system segment and the power or *energy* leaving that device or system segment. The *loss* may be measured in physical units (volts, watts, psi, etc.) or may be calculated as one minus the *Efficiency* of the device or *system* segment.

~~***manual (non-automatic):*** requiring personal intervention for *control*. Non-automatic does not necessarily imply a *manual* controller, only that personal intervention is necessary. (See *automatic*.)~~

~~***manufacturer:*** the company engaged in the original production and assembly of products or *equipment* or a company that purchases such products and *equipment* manufactured in accordance with company specifications.~~

~~***mechanical cooling:*** reducing the temperature of a gas or liquid by using vapor compression, absorption, desiccant dehumidification combined with evaporative cooling, or another *energy*-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered *mechanical cooling*.~~

mechanical switchboard: the switchboard or *circuit breaker* panel from which sub-mains and/or *branch circuits* emanate to deliver power to the mechanical elements of the *ITE* Room cooling *equipment*.

N:* see *redundancy.

~~***outdoor (outside) air:*** air that is outside the *building envelope* or is taken from outside the *building* that has not been previously circulated through the *building*.~~

proposed design: a computer representation of the actual proposed *building* design or portion thereof used as the basis for calculating the *design energy cost*.

~~***record drawings:*** drawings that record the conditions of the project as constructed. These include any refinements of the *construction* or bid documents.~~

redundancy: ~~the duplication of critical~~ deliberate duplication of components, equipment, controls or systems and their interconnections to enable continued operations at needed functional capacities during and after the loss of the primary components, equipment, controls or systems due to failure, maintenance, servicing or other modification activities. ~~or functions of a system with the intention of increasing reliability of the system , usually in the form of a backup or fail-safe~~

N **=** Base ~~System~~ Number of capacity components needed to provide design system functional capacity
N+1, N+2, etc. **=** ~~Parallel Redundant~~ single system redundancy having one or more additional capacity components
2N, 2N+1 or 2(N+1), etc. **=** ~~Complete *Redundancy*~~ dual systems redundancy having one or more additional capacity components

~~***repair:*** the reconstruction or renewal of any part of an *existing building* for the purpose of its maintenance.~~

~~***roof:*** the upper portion of the *building envelope*, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal.~~

~~***service:*** the *equipment* for delivering *energy* from the supply or *distribution system* to the premises served.~~

service point: The point of connection between the facilities of the serving utility and the premises wiring. The *service point* can be described as the point of demarcation between where the serving utility ends and the premises continuation begins. The serving utility generally specifies the location of the *service point* based on the conditions of service.

~~***service water heating:*** heating water for domestic or commercial purposes other than *space* heating and process requirements.~~

~~***single-line diagram:*** a simplified schematic drawing that shows the connections among two or more *ite*ms. Common multiple connections are shown as one line.~~

skylight: an area of the *building envelope* that lets in light that has a slope of less than 60 degrees from the horizontal plan.

~~***space:*** an *enclosed space* within a *building*. The classifications of *space*s are as follows for the purpose of determining *building envelope* requirements:~~

~~***conditioned space:*** a *cooled space*, *heated space*, or *indirectly conditioned space* defined as follows:~~

~~**1. *cooled space:*** an *enclosed space* within a *building* that is cooled by a cooling *system* whose sensible output capacity exceeds 5 Btu/h·ft² of *floor area*.~~

~~2. ***heated space:*** an *enclosed space* within a *building* that is heated by a heating *system* whose output capacity relative to the *floor area* is greater than or equal to the criteria in Table 3.1.~~

~~3. ***indirectly conditioned space:*** an *enclosed space* within a *building* that is not a *heated space* or a *cooled space*, but which is heated or cooled indirectly by being connected to adjacent *space*(s) provided:~~

~~a. the product of the U-factor(s) and surface area(s) of the *space* adjacent to connected *space*(s) exceeds the combined sum of the product of the U-factor(s) and surface area(s) of the *space* adjoining the outdoors, *unconditioned space*s, and to or from *semi-heated space*s (e.g., corridors) or~~

~~b. that air from heated or *cooled space*s is intentionally transferred (naturally or mechanically) into the *space* at a rate exceeding 3 ach (e.g., atria).~~

~~***semi-heated space:*** an *enclosed space* within a *building* that is heated by a heating *system* whose output capacity is greater than or equal to 3.4 Btu/h·ft² of *floor area* but is not a *conditioned space*.~~

~~**Table 3.1 Heated Space Criteria**~~

~~**Heating Output (Btu/h·ft2)**~~	~~**Climate Zone**~~
~~**5**~~	~~1 and 2~~
~~**10**~~	~~3~~
~~**15**~~	~~4 and 5~~
~~**20**~~	~~6 and 7~~
~~**25**~~	~~8~~

system: a combination of *equipment* and auxiliary devices (e.g., *control*s, accessories, interconnecting means, and *terminal* elements) by which *energy* is transformed so it performs a specific function such as HVAC, *service water heating*, powering *ITE*, or lighting.

~~***system, existing:*** see *existing system*~~

telephone exchange: A telecommunication service facility which provides telecommunications services to the public that has operations regulated via Title II (Common Carriers) of the Telecommunications Act of 1934 and Chapter 1 of the Code of Federal Regulations (CFR) Title 47 by the Federal Communications Commission (FCC)” <u>See Informative Appendix D for additional guidance.</u>

terminal: a device by which *energy* from a *system* is finally delivered (e.g., registers, diffusers, lighting *fixture*s, faucets) terminating prior to the interface with the *ITE enclosure*.

~~***transformer:*** a piece of electrical *equipment* used to convert electric power from one voltage to another voltage.~~

~~***unconditioned space:*** see *space*.~~

uninterruptable power supply (UPS): a *system* intended to deliver continuous, stable power to the critical load. The majority of modern *UPS* systems are of two fundamental types: "~~Double conversion~~ static" in which incoming AC power is rectified to 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 "~~flywheel~~ rotary" in which incoming AC power drives a propulsion unit that turns a generating device, with a ~~large~~heavy flywheel storing kinetic *energy* that continues to turn the generating portion when incoming power fails or anomalies occur. Either type can be made up of one or more modules running in parallel to add capacity or *redundancy* or both. Direct Current *UPS systems*, which eliminate the inverter and deliver DC power to the *ITE* are also used.

UPS "economy mode": a mode of *UPS* operation in which power is normally fed to the load without going through power conversions within the *UPS* for the purpose of reducing *loss* during normal operation so as to save *energy*. Circuitry is incorporated to rapidly switch the load to the rectifier/battery/inverter in the event of a power failure or voltage drop below a preset threshold. "*Economy Mode*" is normally a configurable option that can be utilized or overridden at user discretion.

UPS operational design load: The load in *kW* ~~or *kVA*~~ at which the *UPS* is intended to operate by design. This will be the ~~*Design*~~ *data center* *ITE* ~~*Load*~~ *design power* plus any other loads such as *cabinet* door fans or refrigerant pumps that will be connected to the *UPS*. The *UPS operational design load* is typically less than the *UPS rated capacity*.

UPS rated capacity: The maximum load in *kW* or *kVA* at which an individual *UPS* is designed and specified by the *manufacturer* to operate on a continuous basis under specified environmental conditions. The *UPS rated capacity* does not include the capacity of any redundant *UPS* components or *systems*.

UPS segment: the *UPS segment* of the *design electrical loss component* (*design ELC*)shall include the *manufacturer*-provided *UPS system* from the input *terminals* to the output *terminals*, including all *transformers*, switchgear, rectifiers, inverters ~~flywheel~~ rotary propulsion units and wiring provided by the *manufacturer* between those two points. *Transformers* and switchgear provided by the *UPS manufacturer* but housed in different *cabinets* from the actual *UPS capacity components* shall be considered parts of the *UPS segment* along with associated wiring. *Transformers* and switchgear functioning as parts of the *UPS*, but installed separately and not provided by the *UPS manufacturer* (such as custom-configured bypass) shall not be considered part of the *UPS segment*. All such associated components shall be included with the *incoming service segment* and/or the *ITE distribution segment* in accordance with their specific design logic.

~~***ventilation:*** the process of supplying air to or removing air from a *space* for the purpose of controlling air contaminant levels, humidity, or temperature within the *space*.~~

~~***wall:*** that portion of the *building envelope*, including opaque area and fenestration, that is vertical or tilted at an angle of 60 degrees from horizontal or greater. This includes above and below grade *walls*, between floor spandrels, peripheral edges of floors, and foundation *walls*.~~

4. ADMINISTRATION AND ENFORCEMENT

4.1 General

4.1.1 Scope

4.1.1.1 New Data Centers. New *Data Center*s shall comply with the standard as described in Section 4.2.

Informative Note: Refer to Figure C.1 for Building Areas Subject to the Provisions of Standard 90.4

4.1.1.2 Additions to Existing Data Centers. An extension or increase in the floor area or height of a *data center* outside of the existing *data center* envelope shall be considered additions to existing *data center*s and shall comply with the standard as described in Section 4.2.

4.1.1.3 Alterations of Existing Data Centers. *Alterations* of existing *data center*s shall comply with the standard as described in Section 4.2.

4.1.1.4 Replacement of Portions of Existing Data Center. Portions of a *data center* envelope, heating, ventilating, air-conditioning, service water heating, power, lighting, and other *system*s and *equipment* that are being replaced shall be considered as *alterations* of existing *data center*s and shall comply with the standard as described in Section 4.2.

4.1.1.5 Changes in Space Conditioning. When unconditioned or semi-heated spaces in a *data center* are converted to *conditioned space*s, such *conditioned space*s shall be brought into compliance with the requirements of this standard that apply to the *data center* envelope, heating, ventilating, air-conditioning, service water heating, power, lighting, and other *system*s and *equipment* of the *space* as if the *data center* was new.

4.1.2 Administrative Requirements. Administrative requirements relating to permit requirements, enforcement by the authority having jurisdiction, locally adopted energy standards, interpretations, claims of exemption, and rights of appeal are specified by the authority having jurisdiction.

4.1.3 Alternative Materials, Methods of Construction, or Design. The provisions of this standard are not intended to prevent the use of any material, method of construction, design, *equipment*, or *data center system* not specifically prescribed herein.

4.1.4 Validity. If any term, part, provision, section, paragraph, subdivision, table, chart, or referenced standard of this standard shall be held unconstitutional, invalid, or ineffective, in whole or in part, such determination shall not be deemed to invalidate any remaining term, part, provision, section, paragraph, subdivision, table, chart, or referenced standard of this standard.

4.1.5 Other Laws. The provisions of this standard shall not be deemed to nullify any provisions of local, state, or federal law. Where there is a conflict between a requirement of this standard and such other law affecting *construction* of the *data center,* precedence shall be determined by the authority having jurisdiction.

4.1.6 Referenced Standards. The standards referenced in this standard and listed in Section 12 shall be considered part of the requirements of this standard to the prescribed extent of such reference. Where differences occur between the provision of this standard and referenced standards, the provisions of this standard shall apply. Informative references are cited to acknowledge sources and are not part of this standard. They are identified in Informative Appendix A.

4.1.7 Normative Appendices. The normative appendices to this standard are considered to be integral parts of the mandatory requirements of this standard, which, for reasons of convenience, are placed apart from all other normative elements.

4.1.8 Informative Appendices. The informative appendices to this standard and informative notes located within this standard contain additional information and are not mandatory or part of this standard.

4.2 Compliance

4.2.1 Compliance Paths

4.2.1.1 New Data Centers. New *data center*s shall comply with the provisions of Sections 5, ~~6~~, 7, ~~8~~, 9, and 10 ~~and 11~~. and one of the following:

a. Sections 6 and 8 or
b. Section 11.

Informative Note: See informative reference C.1 for an illustrative diagram.

4.2.1.2 Additions to Existing Data Centers. Additions to existing *data center* shall comply with the provisions of Sections 5, ~~6,~~ 7, ~~8,~~ 9, and 10 and ~~11.~~ and one of the following:

a. Sections 6 and 8 or
b. Section 11.

Exception:

1. Additions that result in less than a 10% increase in area or less than a 10% increase in connected load (*kW*) are excluded.
2. When an addition to an existing *data center* ~~cannot comply by itself, trade-offs will~~ is unable to demonstrate compliance the facility shall be allowed to demonstrate through trade-offs via ~~be allowed by~~ modification to one or more of the ~~existing~~ components of the existing *data center*. ~~Modeling of the modified components of the existing data center addition shall employ the procedures in Section 11 of ANSI/ASHRAE/IES Standard 90.1~~.

4.2.1.3 Alterations of Existing Data Centers. *Alterations* of existing *data center*s shall comply with the provisions of Sections 5, ~~6~~, 7, 8, ~~9~~, and 10 ~~and 11~~ and with either Sections 6 and 8 or Section 11, provided such compliance will not result in the increase of energy consumption of the building.

Exceptions:

1. *ITE adds, moves and changes* are excluded.
2. *ITE enclosures* are excluded.
3. A *data center* that has been specifically designated as *historic*ally significant by the *adopting authority*, listed in The National Register of *Historic* Places or has been determined to be eligible for listing by the US Secretary of the Interior, need not comply with these requirements.
4. Where one or more components or portions of an existing data center mechanical, electrical or lighting *system* is being replaced without changing capacities; the annual energy consumption of the of the system in which replacements are made shall not be greater than the annual energy consumption of the existing system. Compliance can be demonstrated using manufacturer's published efficiency data for the new and existing devices, or by comparative calculations of the annual energy consumptions of the existing and revised systems, performed by a design professional using calculation methods commonly accepted in the industry.

   Component or system replacements or modifications that result in changes in either capacity or type of technology require compliance with the applicable sections and versions of this Standard in accordance with 4.2.2.4.

~~**4.2.1.4 Compliance Standard Review Reference.** For alterations or additions to an *existing building* the version used for compliance shall be the most current version of the standard or that as specified in Table 4.2.1.4.~~

~~TABLE 4.2.1.4 Compliance Standard for Project Plan Review~~

~~Build Type~~	~~ENVELOPE~~	~~MECHANICAL SYSTEMS~~	~~MECHANICAL INDIVIDUAL COMPONENTS~~	~~LIGHTING~~	~~POWER SYSTEMS~~	~~POWER INDIVIDUAL COMPONENTS~~
~~•4.2.1.1 New~~						
~~Full Build-out~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~
~~Initial Phase Scaled Build~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~	~~C~~
~~Initial Phase Modular Build~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~	~~C~~
~~Initial Modular SHELL Build~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~
~~Shell and Core Build~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~	~~M~~
~~•4.2.1.2 Additions to existing~~						
~~Phase Scaled Build~~	~~C~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~Phase Modular Build~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~
~~Modular SHELL Build~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~
~~Core Build~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~	~~C~~
~~•4.2.1.3 Alterations to Existing~~						
~~All~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~• 4.2.1.3b Replacement of Portions of Existing~~						
~~Full Build-out~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~Phase Scaled Build~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~Phase Modular Build~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~Modular SHELL Build~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~
~~Shell and Core Build-out~~	~~M~~	~~M~~	~~C~~	~~C~~	~~M~~	~~C~~

~~(C) Current edition of the Standard~~
~~(M) Master plan standard edition, the edition of the standard used to create the original data center plan~~

Informative Note: Refer to Figures C.3, C.4 and C.5 for guidance on applicability.

4.2.2 Compliance Documentation

4.2.2.1 Construction Details. Compliance documents shall show all the pertinent data and features of the *data center*, *equipment*, and *systems* in sufficient detail to permit a determination of compliance by the building official and to indicate compliance with the requirements of this standard.

4.2.2.2 Supplemental Information. Supplemental information necessary to verify compliance with this standard, such as calculations, worksheets, compliance forms, vendor literature, or other data, shall be made available when required by the building official. Compliance may be documented using mechanical and electrical calculations to complete each required path shown below. If compliance is to be shown for mechanical systems only; designer performs calculation 6.2.1.1 or 6.2.1.2. If compliance is to be shown for electrical system only, designer performs calculation 8.2.1.1. Calculation 6.2.1.2 can be used to take credit for existing mechanical system efficiencies, when compliance is to be shown for electrical system only. Calculation 8.2.1.1 and 6.2.1.2 can be used to take credit for existing electrical system efficiencies, when compliance is to be shown for mechanical system only.

Informative Note: See Informative Figure C.2 Mechanical and Electrical Compliance Path.

4.2.2.3 Manuals. Operating and maintenance information shall be provided to the *data center* owner. This information shall include, but not be limited to, the information specified below:

a. Submittal data stating *equipment* size.

4.2.2.4 Version Applicability. Previous or subsequent versions of this Standard 90.4 may apply to data center expansions and modifications, depending on how they were designed and occur. The version used for compliance shall be the most current version of the standard or as specified in Table 4.2.2.4.

Informative Note: See informative reference C.2, C.3 and C.4 for illustrative diagrams.

TABLE 4.2.12.4 Compliance Standard for Project Plan Review

Build Type	ENVELOPE	MECHANICAL SYSTEMS	MECHANICAL INDIVIDUAL COMPONENTS	LIGHTING	POWER SYSTEMS	POWER INDIVIDUAL COMPONENTS
•4.2.1.1 New						
Full Build-out	M	M	M	M	M	M
Initial Phase Scaled Build	M	M	M	M	M	C
Initial Phase Modular Build	M	M	M	M	M	C
Initial Modular SHELL Build	M	M	M	M	M	M
Shell and Core Build	M	M	M	M	M	M
•4.2.1.2 Additions to existing						
Phase Scaled Build	C	M	C	C	M	C
Phase Modular Build	C	C	C	C	C	C
Modular SHELL Build	C	C	C	C	C	C
Core Build	C	C	C	C	C	C
•4.2.1.3 Alterations to Existing						
All	M	M	C	C	M	C
• 4.2.1.3b Replacement of Portions of Existing						
Full Build-out	M	M	C	C	M	C
Phase Scaled Build	M	M	C	C	M	C
Phase Modular Build	M	M	C	C	M	C
Modular SHELL Build	M	M	C	C	M	C
Shell and Core Build-out	M	M	C	C	M	C

(C) – Current edition of the Standard
(M) – Master plan standard edition, the edition of the standard used to create the original data center plan

Informative Note: Refer to Figures C.3, C.4 and C.5 for guidance on applicability.

4.2.3 Labeling of Material and *Equipment*. Materials and *equipment* shall be labeled in a manner that will allow for a determination of their compliance with the applicable provisions of this standard.

4.2.4 Inspections. All *data center* construction, additions, or *alterations* subject to the provisions of this standard shall be subject to inspection by the building official, and all such work shall remain accessible and exposed for inspection purposes until approved in accordance with the procedures specified by the building official. Items for inspection include at least the following:

a. wall insulation after the insulation and vapor retarder are in place but before concealment
b. roof/ceiling insulation after roof/insulation is in place but before concealment
c. slab/foundation wall after slab/foundation insulation is in place but before concealment
d. fenestration after all glazing materials are in place
e. continuous air barrier after installation but before concealment
f. mechanical *system*s and *equipment* and insulation after installation but before concealment
g. electrical *equipment* and *system*s after installation but before concealment

5. BUILDING ENVELOPE

5.1 General

5.1.1 Scope: This section defines the minimum requirements of the *data center* building envelope.

5.2 Compliance Paths

5.2.1 Compliance. Provisions of this section shall comply with Section 5 of ANSI/ASHRAE/IES Standard 90.1, or demonstrate energy efficiency improvement compared to a data center designed to comply with Section 5 of ANSI/ASHRAE/IES Standard 90.1.

6. HEATING, VENTILATING, AND AIR CONDITIONING

6.1 General

6.1.1 Scope

6.1.1.1 New *~~Buildings~~* *Data Centers*. Mechanical *equipment* and systems serving the heating, cooling, ventilating needs of new *~~buildings~~* *data centers* shall comply with the requirements of this section as described in Section 6.2 or Section 6.3.

6.1.1.2 Additions to *Existing* *~~Buildings~~* *Data Centers*. Mechanical *equipment* and systems serving the heating, cooling, or ventilating needs of additions to *existing* *~~buildings~~* *data centers* shall comply with the requirements of this section as described in Section 6.2 or Section 6.3.

Exception: Where conditioned air is provided to a~~n~~ a *data center* addition by using the *HVAC systems* and *equipment* ~~of the *existing building*~~, such *existing systems* and *equipment* shall not be required to comply with this standard.

6.1.1.3 Alterations to Heating, Ventilating, Air Conditioning, and Refrigeration (HVACR) in *Existing* *~~Buildings~~* *Data Centers*

6.1.1.3.1 Replacing existing HVAC *equipment* with new HVAC *equipment* shall comply with the specific minimum *efficiency* requirements applicable to that *equipment* in ANSI/ASHRAE/IES 90. 1 or Table 6.3.1.1.

Exceptions:

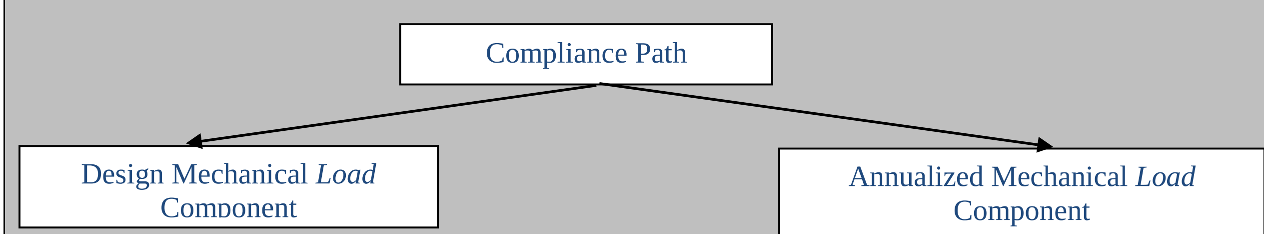
1. for *equipment* that is being modified or *repaired* but not replaced, provided that such modifications and/or *repairs* will not result in an increase in the annual *energy* consumption of the *equipment* using the same *energy* type;
2. where a replacement or alteration of *equipment* requires extensive revisions to other systems, *equipment*, or elements of a *building*, and such replaced or altered *equipment* is a like-for-like replacement;
3. for a refrigerant change of existing equipment;
4. for the relocation of existing equipment.

6.1.1.3.2 New cooling systems installed to serve previously uncooled spaces shall comply with this section as described in Section 6.2.

6.2 Definition of Compliance Paths.

See section 4.2.2.2.

Informative Note ~~for Reviewers~~: See informative appendix C for additional trade-offs



6.2.1 Mechanical system.

6.2.1.1 Maximum *Design Mechanical Load Component* (*MLC*). *Design MLC* shall be ~~as~~ calculated using ~~by~~ Equation 6.2.1.1 and the resultant values shall be less than or equal to values shown~~,~~ where

~~when~~ evaluated at 100% *design ITE* load~~,~~ at the outdoor weather condition ~~described,~~ for the appropriate climate zone in table 6.2.1.1. The design *MLC* shall also be less than or equal to the corresponding table 6.2.1.1 *MLC* value when evaluated at 50% of design load:

Table 6.2.1.1 Maximum *Design Mechanical Load Component*

Climate Zones as listed in ASHRAE Standard 169	Dry Bulb ASHRAE ^{0}F (^{0}C) (use for compliance)	WB Mean Coincident DB (use for compliance)	Design *MLC* at 100% and at 50% IT Load
1A	91.8 (33.2)	79.5/86.8	0.46
2A	97.2 (36.2)	79.3/88.2	0.48
3A	93.9 (34.4)	76.2/86.5	0.45
4A	94.0 (34.4)	76.8/86.5	0.45
5A	91.4 (33.0)	76.1/85.2	0.44
6A	90.9 (32.7)	74.9/84.3	0.43
1B	112.5(44.7)	70.1/99.3	0.55
2B	110.3 (43.5)	75.2/95.8	0.53
3B	108.4 (42.4)	71.2/94.7	0.51
3B, coast	83.7 (28.7)	~~96.0/76.1~~76.1/96.0	0.44
4B	95.3 (35.2)	64.5/81.3	0.46
5B	98.6 (37.0)	65.0/90.0	0.48
6B	92.9 (33.8)	59.2/77.5	0.41
3C	82.8 (28.2)	64.0/74.9	0.38
4C	85.3 (29.6)	64.8/78.8	0.40
5C	77.3(25.2)	66.3/75.2	0.38
7	84.3 (29.1)	70.3/78.4	0.40
8	81.3 (27.4)	61.5/73.9	0.38

Informative Note: These *MLC* values were developed to be generic and allow multiple *system*s to use this methodology and qualify for this path. The values were generated using current *system*s available on the market from multiple manufacturers.

Informative Note: The *MLC* does not directly compare to a data center's design PUE; the *MLC* doesn't take any electrical distribution losses into account. The above *system*s are not being rated using a certification program. This method requires a *system* approach and a *system* comparison. This requires a certain amount of due diligence from the professional engineer to rate the entire *system* including the pumps, fans etc. at part load condition. The committee believes this is the best way to drive performance of the *system* as opposed to the individual components. Perhaps in the future a rating program may be developed to rate these *system*s at specific rating conditions.

Equation 6.2.1. 1:

$$Design\ Mechanical\ Load\ Component\ (MLC) = \frac{(Cooling\ Design\ Power\ (kW) + Pump\ Peak\ Power\ (kW) + Heat\ Rejection\ Peak\ Fan\ Power\ (kW) + Air\ Handler\ Unit\ (AHU)\ Fan\ Design\ Power\ (kW))}{(\ Data\ Center\ Design\ ITE\ Power\ (kW))}$$

Exceptions: The following power use shall be excluded from the calculation

a. Cooling tower basin heaters
b. *Space* heaters
c. Well pumps not part of the building mechanical *system*; if the facility is supplied water from a utility, it can be assumed that normal utility water pressures are present.
d. The denominator should not include power to be distributed to any IT *equipment* that is cooled by a separate *system*.

Where,

Cooling Design Power (*kW*) = the sum of all site power required to provide cooling and humidification via vapor-compression, *ventilation*, dehumidification, evaporation, absorption, adsorption or other means at the weather conditions in Table 6.2.1.1 ~~ASHRAE 0.4% design *ambient outdoor air* temperature~~. In the case of cooling provided by a *source* other than electricity the fossil fuel or thermal *energy* shall be converted to *kW*. For data center designs that provide cooling for *UPS* and *data center* transformers that cooling design power must be included in this term.

> **Informative Note**: An annual demand credit may be taken for on-site renewable generation or on-site recovered *energy* that reduces the daily peak demand and is included in the data center design.

Pump Peak Power (*kW*) = the sum of all pump power used to distribute fluids for cooling and heat rejection. Actual motor input power shall be used to derive the Pump Power calculation as in the example below, including direct and indirect coolers that use pumps.

Pump Peak Power (*kW*) = Σ [Pump brake ~~horse~~power x 0.746 / (pump motor *efficiency* at design conditions)]

Heat Rejection Peak Fan Power (*kW*) = the sum of all heat rejection fan power (eg. *outdoor* cooling towers, fluid coolers, condensing units) at or above the design ambient *outdoor* condition shown in table 6.2.1.1. Actual heat rejection fan motor power shall be used in the Heat Rejection Fan Power calculation. Credit may be taken for operating available redundant *equipment*, if calculated using partially loaded efficiencies.

Exception: Heat rejection power that is included in the Cooling Power.

AHU Fan Design Power (*kW*) = the sum of all fan power used to distribute air for cooling and *ventilation*. Brake fan ~~horse~~power shall be used in the Fan Power calculation. For data center designs that provide cooling for *UPS* and *transformers*, that AHU fan design power must also be included in this term. Credit may be taken for operating available redundant fans, if calculated using partially loaded efficiencies. To take this credit instructions must be included in the approved design documents.

AHU Fan Design Power (*kW*) = Σ [*Fan brake horsepower* x 0.746 / (fan motor *efficiency* at *design conditions*)]

Data Center ~~(IT only)~~ Design Power (*kW*) = ~~the sum of all power used to power the IT *equipment* in the *space*. This includes all *equipment* downstream of the *UPS* (uninterruptible power supply).~~ See definitions.

> **Informative Note**: Brake ~~horse~~power (in IP units) was used in the above calculations to account for design *energy* use, and does not account for the sizing of the motor on the *system*. This

eliminates issues with a design that is close to the motor nameplate being less efficient than a motor that is oversized compared to the nameplate.

6.2.1.2 – Maximum Annualized *Mechanical Load Component* (*MLC*). ~~Calculated a~~Annual *MLC* as calculated in 6.2.1.2.1 shall be less than or equal to the value in Table 6.2.1.2 Maximum Annualized Mechanical *Load* Component, when evaluated at 100% *ITE* load, for the appropriate climate zone. The calculated *MLC* shall also be less than or equal to the corresponding table 6.2.1.2 *MLC* value when evaluated at 50% of design *ITE* load.

Table 6.2.1.2 Maximum Annualized *Mechanical Load Component* (*MLC*)

Climate Zones as listed in ASHRAE Standard 169	**HVAC maximum annualized *MLC* at 100% and at 50% *ITE* load:**
1A	0.36
1B	0.38
2A	0.35
3A	0.33
4A	0.33
5A	0.33
6A	0.32
2B	0.36
3B	0.35
3B-Coast	0.32
4B	0.35
5B	0.33
6B	0.34
3C	0.32
4C	0.32
5C	0.32
7	0.32
8	0.32

Informative Note: The calculated *MLC* does not directly compare to a data center's annual measured design PUE; the calculated *MLC* doesn't take any electrical distribution losses into account. These maximum MLC values were developed using *equipment* currently available from multiple manufacturers.

Informative Note: These values were based on 20°F (11°C) Delta T, for air pulled through *ITE*; and a Design Return Air Temperature (RAT) of 85°F (29°C).

Informative Note: Mechanical *system*s can be calculated to operate at any temperature, with or without an *automatic* reset schedule, however the fluid and air temperatures used in the calculation must not exceed the conditions specified for *equipment* selection by the design (i.e. the scheduled coil entering and leaving temperatures, the fan capacities, the presence or absence of variable speed drives or compressor unloading features).

6.2.1.2.1 Annual Energy. Annual Energy of each component shall be determined by following:

$$(Annualized\ Mechanical\ Load\ Component) =$$

$$\frac{(Cooling\ Energy\ (kWh) + Pump\ Energy\ (kWh) + HeatRejection\ Fan\ Energy\ (kWh) + AHU\ Fan\ Energy\ (kWh))}{(\ Data\ Center\ ITE\ Energy\ (kWh))}$$

where,

Cooling *Energy* (*kW*h) = the sum of all site *energy* required to provide cooling and humidification via vapor-compression, ventilation, dehumidification, evaporation, absorption, adsorption, or other means. In the case of cooling provided by a source other than electricity, the energy consumption shall be converted to *kW*h. For data center designs that provide cooling for *UPS* and transformers, that cooling design power must be included in this term. When evaluating the cooling design energy at 50% load, any change in *UPS* or transformer efficiency at that reduced load must be included in the 50% load cooling design energy.

Informative Note: An annual energy credit may be taken for on-site renewable generation or on-site recovered energy included in the data center design.

Pump Energy (*kW*h) = the sum of all pump energy used to distribute fluids for cooling and heat rejection. Brake horsepower energy shall be used to derive the Pump energy calculation as in the example below, including direct and indirect coolers that use pumps.

Pump Energy (*kW*h) = Σ [Pump brake ~~horse~~power x 0.746 / (pump motor *efficiency*)] x hours of annual operation

Informative Note: Brake ~~horse~~power may be used in the MLC calculation to account for *energy* use, and does not account for the sizing of the motor on the *system*. This eliminates issues with a design that is close to the motor nameplate being less efficient than a motor that is oversized compared to the nameplate.

Heat Rejection Fan Energy (*kW*h) = the sum of all heat rejection fan energy (e.g., outdoor cooling towers, fluid coolers, condensing units). Heat rejection brake fan power may be used in the Heat Rejection Fan energy calculation.

Heat Rejection Fan Energy *kW*h = Σ [*Fan brake ~~horse~~power* x 0.746 / (fan motor efficiency)] x hours of annual operation

Exception: Heat rejection fan *energy* that is included in the Cooling energy.

AHU Fan Energy (*kW*h) = the sum of all fan energy, except for *ITE* internal fans, used to distribute and *exhaust air* for cooling, *ventilation*, humidification and dehumidification. For data center designs that provide cooling for *UPS* and *transformers*, that AHU fan energy must also be included in this term. *Fan brake ~~horse~~power* shall be used in the Fan *energy* calculation

AHU Fan Energy (*kW*h) = Σ[*Fan brake ~~horse~~power* x 0.746 / (fan motor *efficiency*)] x hours of annual operation

Data Center ITE Energy (*kWh*) = the sum of all energy used by the ITE in the *space*.

Informative Note: Brake ~~horse~~power may be used in the MLC calculation to account for energy use, and does not account for the sizing of the motor on the *system*. This eliminates issues with a design that is close to the motor nameplate being less efficient than a motor that is oversized compared to the nameplate.

6.2.1.2.2 Annual *Energy* calculations shall use the following requirements:

a. Weather data ~~may~~ shall be based on ~~follow~~ one of the following:

1. *Weather data shall* be divided into calculation bins with a maximum 2^0F (1^0C) increment. *System*s using evaporation process will use wet bulb with a mean coincident dry bulb temperature for creating the bins. *System*s with a non-evaporative process shall use dry bulb temperature with mean coincident wet bulb for creating the bins.
2. Typical Meteorological Year Version 3 (TMY3) ~~data (for the location in which the facility will be built) may be utilized~~ for ~~a more accurate~~ full hourly calculations~~,~~ with 8760 bins per year.

b. The *system*s' *energy* calculation may consider operation of economizer capacity in the design and available redundant *equipment* at the 100% *ITE* load condition and separately at the 50% *ITE* load condition, if calculated using partially loaded *equipment* efficiencies.

Informative Note: Mechanical *system*s can be calculated to operate at any temperature, with or without an *automatic* reset schedule, however the fluid and air temperatures used in the calculation must not exceed the conditions specified for *equipment* selection by the design (i.e. the scheduled coil entering and leaving temperatures, the fan capacities, the presence or absence of variable speed drives or compressor unloading features).

c. If the *data center* utilizes mechanical cooling, ~~T~~the calculated rack inlet temperature and *dew point* must be within Thermal Guidelines for Data Processing Environments ~~(3rd edition, 2012)~~ recommended thermal envelope for more than 8460 of the hours per year. If the *data center* does not use mechanical cooling this requirement does not apply.

Data Center Energy: The *data center energy* calculations shall be completed separately for 100% and for 50% of design IT *equipment capacity* in the calculations. The *system*'s *UPS* and transformer cooling loads must also be included in this term, evaluated at their corresponding part-load efficiencies.

Calculated Quantity of Operating Units (*N*): As shown in the example below, the number of HVAC units required to meet the load can vary based on ambient design conditions or a host of other factors determined by the design professional. ~~Nevertheless, any available redundant HVAC units may be assumed to operate at any given time~~ When redundant equipment is provided it shall be permitted to be used in ~~in~~ calculations to ~~show~~ demonstrate compliance only when the design will be~~, if calculated~~ using partially loaded *equipment* efficiencies.

Table 6.2.1.2.2 ***Building Energy Calculation Example; use of redundant equipment***

Example project's basis of design intent:	Example's *N*:(*equipment* installed to meet design load)	Example's R: (redundant *equipment* desired to improve reliability)	Total Units Installed:	Method of calculation to show compliance with *MLC*(Table 6.2.1.2):
If constant volume *equipment* is to be selected at less extreme conditions (e.g. ASHRAE 0.4% climate data)	8	2*	10	Calculation may be based on 8 operating units (redundant units might not be operating).

Same data center, except constant volume *equipment* is to be selected based on more extreme conditions (e.g. ASHRAE 20 year extreme max WB)	10**	2*	12	Calculation may be based on only 8 operating units (because only 4 units were determined to be required at ASHRAE 0.4% climate data, other units might not be operating).
If variable volume *equipment* is to be selected at less extreme conditions (e.g. ASHRAE 0.4% climate data)	8	8*	16	If variable speed (for example VFDs or ECM) are provided for fans or pumps, MLC may be calculated based on 16 operating units, using *manufacturer*'s partial load unit efficiencies.

* The *system*'s energy calculation may take credit for operating available redundant *equipment* if calculated using partially loaded *equipment* efficiencies.
**10 units because the more severe outdoor conditions require a de-rate of the selected units, thereby requiring more units to meet the *N* requirement.

6.3 Alternative Compliance Path

6.3.1 Data Center Systems. *HVAC systems* serving the heating, cooling, or ventilating needs of a *computer room* shall comply with Sections 6.1.

6.3.1.1 The data center *design* PUE_1 shall be less than or equal to the values listed in Table 6.3.1. Hourly simulation of the *proposed design*, for purposes of calculating *design* PUE_1, shall be based on the ASHRAE Standard 90.1 Appendix G simulation methodology.

Exceptions: This compliance path is not allowed for a proposed data center design utilizing a combined heat and power *system*.

6.3.1.2 The data center *design* PUE_0 is less than or equal to the values listed in Table 6.3.1, shall be the highest value determined at *outdoor* cooling design temperatures, and shall be limited to *systems* only utilizing electricity for an *energy* source. *Design* PUE_0 shall be calculated for two conditions: 100% design IT *equipment energy* and 50% design IT *equipment energy*.

Table 6.3.1 Power Usage Effectiveness (*Design PUE*) Maximum

Climate Zone	Design PUE[a]
1A	1.61
2A	1.49
3A	1.41
4A	1.36
5A	1.36

6A	1.34
1B	1.53
2B	1.45
3B	1.42
4B	1.38
5B	1.33
6B	1.33
3C	1.39
4C	1.38
5C	1.36
7	1.32
8	1.30

a. *Design PUE_0* and *Design PUE_1* shall not include *energy* for battery charging.

6.3.1.3.1 Documentation shall be provided, including a breakdown of *energy* consumption or demand by at least the following components: IT *equipment*, power distribution losses external to the IT *equipment*, *HVAC systems*, and lighting.

Table 6.8.1-11 Air Conditioners and Condensing Units Serving Computer Rooms

			Minimum Net Sensible COP Return Air Dry-Bulb Temperature/Dew-Point Temperature				
	-		Class 1	Class 2	Class 3	Class 4	
Equipment Type	**Net Sensible Cooling Capacity**	**Configuration**	**75F/52F**	**85F/52F**	**95F/52F**	**105F/52F**	**Test Procedure**
Air Cooled	<65,000 Btu/h	Raised Floor	2.20	2.30	2.40	2.55	AHRI 1360
		Ducted	2.10	2.10	2.20	2.35	
		Free Blow	2.30	2.35	2.45	2.60	
	>=65,000 and <240,000 Btu/h	Raised Floor	2.10	2.20	2.30	2.45	
		Ducted	2.00	2.05	2.10	2.25	
		Free Blow	2.15	2.25	2.35	2.50	
	>=240,000 Btu/h	Raised Floor	1.90	2.00	2.10	2.20	
		Ducted	1.80	1.85	1.95	2.05	
		Free Blow	1.95	2.05	2.15	2.25	
Water Cooled	<65,000 Btu/h	Raised Floor	2.40	2.50	2.65	2.80	AHRI 1360
		Ducted	2.25	2.30	2.45	2.60	
		Free Blow	2.45	2.55	2.70	2.85	

	~~>=65,000 and <240,000 Btu/h~~	~~Raised Floor~~	~~2.30~~	~~2.40~~	~~2.55~~	~~2.70~~	
		~~Ducted~~	~~2.15~~	~~2.20~~	~~2.35~~	~~2.50~~	
		~~Free Blow~~	~~2.40~~	~~2.45~~	~~2.60~~	~~2.75~~	
	~~>=240,000 Btu/h~~	~~Raised Floor~~	~~2.20~~	~~2.25~~	~~2.40~~	~~2.50~~	
		~~Ducted~~	~~2.05~~	~~2.10~~	~~2.20~~	~~2.35~~	
		~~Free Blow~~	~~2.25~~	~~2.30~~	~~2.45~~	~~2.55~~	
~~Water Cooled with Fluid Economizer~~	~~<65,000 Btu/h~~	~~Raised Floor~~	~~2.35~~	~~2.45~~	~~2.55~~	~~2.75~~	~~AHRI 1360~~
		~~Ducted~~	~~2.20~~	~~2.25~~	~~2.35~~	~~2.50~~	
		~~Free Blow~~	~~2.40~~	~~2.50~~	~~2.60~~	~~2.80~~	
	~~>=65,000 and <240,000 Btu/h~~	~~Raised Floor~~	~~2.25~~	~~2.35~~	~~2.50~~	~~2.60~~	
		~~Ducted~~	~~2.10~~	~~2.15~~	~~2.30~~	~~2.45~~	
		~~Free Blow~~	~~2.30~~	~~2.40~~	~~2.55~~	~~2.65~~	
	~~>=240,000 Btu/h~~	~~Raised Floor~~	~~2.15~~	~~2.20~~	~~2.35~~	~~2.45~~	
		~~Ducted~~	~~2.00~~	~~2.05~~	~~2.15~~	~~2.25~~	
		~~Free Blow~~	~~2.20~~	~~2.25~~	~~2.40~~	~~2.50~~	
~~Glycol Cooled~~	~~<65,000 Btu/h~~	~~Raised Floor~~	~~2.15~~	~~2.30~~	~~2.40~~	~~2.55~~	~~AHRI 1360~~
		~~Ducted~~	~~2.00~~	~~2.10~~	~~2.25~~	~~2.40~~	
		~~Free Blow~~	~~2.25~~	~~2.30~~	~~2.40~~	~~2.55~~	
	~~>=65,000 and <240,000 Btu/h~~	~~Raised Floor~~	~~1.95~~	~~2.05~~	~~2.15~~	~~2.30~~	
		~~Ducted~~	~~1.85~~	~~1.85~~	~~1.95~~	~~2.05~~	
		~~Free Blow~~	~~2.00~~	~~2.05~~	~~2.15~~	~~2.30~~	
	~~>=240,000 Btu/h~~	~~Raised Floor~~	~~1.85~~	~~1.95~~	~~2.10~~	~~2.20~~	
		~~Ducted~~	~~1.75~~	~~1.80~~	~~1.90~~	~~2.00~~	
		~~Free Blow~~	~~1.95~~	~~2.05~~	~~2.10~~	~~2.25~~	
~~Glycol Cooled with Fluid Economizer~~	~~<65,000 Btu/h~~	~~Raised Floor~~	~~2.10~~	~~2.25~~	~~2.35~~	~~2.45~~	~~AHRI 1360~~
		~~Ducted~~	~~2.00~~	~~2.10~~	~~2.15~~	~~2.25~~	
		~~Free Blow~~	~~2.20~~	~~2.30~~	~~2.35~~	~~2.50~~	
	~~>=65,000 and <240,000 Btu/h~~	~~Raised Floor~~	~~1.90~~	~~1.95~~	~~2.05~~	~~2.20~~	
		~~Ducted~~	~~1.75~~	~~1.80~~	~~1.90~~	~~2.00~~	
		~~Free Blow~~	~~1.95~~	~~2.00~~	~~2.10~~	~~2.20~~	
	~~>=240,000 Btu/h~~	~~Raised Floor~~	~~1.80~~	~~1.90~~	~~2.00~~	~~2.15~~	
		~~Ducted~~	~~1.70~~	~~1.80~~	~~1.85~~	~~1.95~~	
		~~Free Blow~~	~~1.55~~	~~2.00~~	~~2.10~~	~~2.20~~	

6.4 Submittals (Not Used)

6.5 Minimum *Efficiency* Tables (Not Used)

7. SERVICE WATER HEATING

7.1 General. Provisions of this section shall comply with provisions of Section 7.1 of ANSI/ASHRAE/IES Standard 90.1.

7.2 Definition of Compliance Paths. Provisions of this section shall comply with provisions of Section 7 of ANSI/ASHRAE/IES Standard 90.1 or demonstrate energy efficiency improvement compared to a data center designed to comply with Section 7 of ANSI/ASHRAE/IES Standard 90.1.

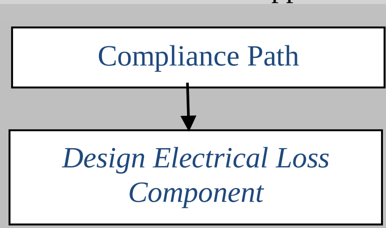
8. ELECTRICAL

8.1 General

8.1.1 Scope. This section applies to the building electrical *system*s delivering power to the *data center IT load*, and to *equipment* described below. ~~Refer to Figure 8.1.~~

8.2 ~~Definition of~~ Compliance Paths. Compliance with Section 8 shall be achieved by meeting all requirements in Section 8.1, ~~General;~~ and Section 8.2.1~~, Electrical *systems*~~.

Informative Note ~~for Reviewers~~: See informative appendix C for additional trade-offs



8.2.1 Electrical *systems*. Electrical *system*s shall comply with Section 8.2.1.1. *ITE power* is not assumed to be seasonably variable in this standard. Therefore *ITE energy* can be calculated by multiplying ITE power by 8,760, the number of hours in a normal year. The *data center design ITE power* must be specified on the construction documents.

8.2.1.1 Maximum *Design Electrical Loss Component* (*ELC*) for Designs Involving Electrical Systems Only. *Design ELC* shall be calculated in accordance with Section 8.3 and shall be less than or equal to the values shown in Table 8.2.1.1.

8.2.1.2 Maximum *Design Electrical Loss Component (ELC)* for designs involving both electrical and mechanical *systems*. Design ELC shall be calculated in accordance with Section 8.3 and shall be combined with the *Mechanical Loss Component (MLC)* in accordance with Section 11.

Informative Note: ELC numbers less than or equal to the values in Tables 8.2.1.1 or 8.2.1.2 combined with the MLC numbers less than or equal to the appropriate values in Chapter 6, will assure compliance with this standard.

8.2.1.1.1 *Design ELC* for New Designs or Total Renovations. Tradeoffs are allowed among the three segments to achieve the *ELC* values shown. (See Informative C.5 Examples - *Design ELC* Calculations)

8.2.1.1.2 *Design ELC* for Partial Renovations. For a facility being renovated where only one or two of the three *EEC* segments are being modified, compliance requirements apply only to the segment(s) being modified. Tradeoffs are allowed between segments being modified to meet the aggregate requirement of those segments.

Informative Note: See Appendix C.5 Examples = Design *ELC* Calculations for methods of combining *ELC* segment values.

Table 8.2.1.1 ~~Minimum~~ Maximum *Design Electrical Loss Component* (Less Than 100 kW ~~kVA~~ IT Design Load)

ASHRAE 90.4P – *Design Electrical Loss Component* (*ELC*) and *ELC* Segments Systems with IT Design Load Less Than 100 ~~*kVA*~~kW				
UPS Redundancy Configuration	Single Feed *UPS* (*N*, *N+1*, etc.) or No *UPS* See Informative Note A		Active Dual Feed *UPS* (*2N*, *2N+1*, etc.) See Informative Note B	
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 *Electrical Loss Component* and Overall *ELC*	Loss / *Efficiency*	Loss / *Efficiency*	Loss / *Efficiency*	Loss / *Efficiency*
Incoming Service Segment	15.0%/85.0%	11.0%/89.0%	11.0%/89.0%	10.0%/90.0%
UPS Segment	12.0%/88.0%	14.0%/86.0%	14.0%/86.0%	20.0%/80.0%
ITE Distribution Segment	6.0%/94.0%	4.0%/96.0%	4.0%/96.0%	3.0%/97.0%
Electrical *Loss* / *Efficiency* Total	~~11.6% / 88.4%~~ 29.7%/70.3%	~~12.6% / 87.4%~~ 26.5%/73.5%	~~12.6% / 87.4%~~ 26.5%/73.5%	~~13.5% / 86.5%~~ 30.2%/69.8%
Electrical Loss Component (*ELC*)	~~0.116~~ 0.297	~~0.126~~ 0.265	~~0.126~~ 0.265	~~0.135~~ 0.302

Table 8.2.1.2 ~~Minimum~~Maximum *Design Electrical Loss Component* (100 ~~*kVA*~~ kW or Greater IT Design Load)

ASHRAE 90.4P - *Electrical Loss Component (ELC) and ELC Segments* Systems with IT Design Load of 100 ~~*kVA*~~ kW or Greater				
UPS Redundancy Configuration	Single Feed *UPS* (*N*, *N+1*, etc.) or No *UPS* See Informative Note A		Active Dual Feed *UPS* (*2N*, *2N+1*, etc.) See Informative Note B	
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 *Electrical Loss Component* and Overall *ELC*	*Loss* / *Efficiency*	*Loss* / *Efficiency*	*Loss* / *Efficiency*	*Loss* / *Efficiency*
Incoming Service Segment	15.0%/85.0%	11.0%/89.0%	11.0%/89.0%	10.0%/90.0%
UPS Segment	9.0%/91.0%	10.0%/90.0%	10.0%/90.0%	15.0%/85.0%
ITE Distribution System	5.0%/95.0%	4.0%/96.0 %	4.0%/96.0%	3.0%/97.0%
Electrical *Loss* / *Efficiency* Total*	~~10.2% / 89.8%~~ 26.5%/73.5%	~~11.4% / 88.6%~~ 23.1%/76.9%	~~11.4% / 88.6%~~ 23/1%/76.9%	~~11.9% / 88.1%~~ 25.8%/74.2%
Electrical Loss Component (*ELC*)	~~0.102~~ 0.265	~~0.114~~ 0.231	~~0.114~~ 0.231	~~0.119~~ 0.258

*Example calculations shown in Informative Appendix C

Informative Note A: These columns in Tables 8.2.1.1 and 8.2.1.2 apply to electrical configurations resulting in a single output feed from the *UPS*, irrespective of the number of *UPS* modules that ~~are~~ may be paralleled prior to the output feed, or the number of branches or sub-feeders into which that output feeder may be divided.

Informative Note B: These columns in Tables 8.2.1.1and 8.2.1.2 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. Cross-ties and/or transfer switches downstream of the independent feeds shall not continually tie the two output sections together.

8.2.2 Electrical Distribution *System*s. Provisions of this section shall comply either with provisions of Section 8 of ANSI/ASHRAE/IES Standard 90.1 or with Section 8.3 below.

8.3 Compliance Path

8.3.1 Electrical Distribution *System*s for Mechanical Loads. The electrical distribution *system*s serving mechanical loads shall be designed with pathway losses not exceeding 2%; however, these losses shall not be incorporated into the *Design ELC* calculations set forth in this Section 8.0.

8.3.1.1 Where there are multiple paths for any segment of the electrical distribution *system*, the calculations shall use the paths with the highest losses and/or lowest efficiencies for each segment to demonstrate compliance.

8.3.1.2 The *Design ELC* calculations shall use the minimum operating efficiency or maximum operating loss of each component, unless a specific mode of operation (with higher efficiency or lower loss) is designated on the approved design documents.

8.3.1.3 It shall be permissible to apply corrections for losses and/or efficiencies of each component and/or segment for actual conditions to the extent those conditions can be demonstrated and such adjustments are in compliance with applicable codes and ordinances. (e.g., Conductor resistance correction as a function of actual operating temperature.)

8.3.1.4 *Incoming Service Segment***.** A segment loss value shall be calculated for the *incoming service segment* of the *design electrical loss component*. This value shall be based on all *equipment* efficiencies and resulting losses in this segment at the design load for all downstream *equipment* served.

Exception: Emergency or stand-by power *system*s are not considered a part of the *incoming 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*

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

a. For "*N*" ~~or~~ , "*N+1*" or *"N+n"* *UPS* configurations, losses shall be based on *manufacturer*'s stated efficiencies at 100% and 50% of the *UPS operational design load*
b. For "*2N*", "2N+1", 2(N+1) or other Dual Feed *UPS* configurations, the *system*s are each intended to normally operate at no more than half capacity. Therefore the *UPS* losses shall be based on *manufacturer*'s stated efficiencies at 50% and 25% of the *UPS operational design load*. Where *UPS system*s are identical, only one of the *system*s shall be used in the calculation. Where *UPS system*s are not identical, both *system*s shall be calculated and the *system* with the lowest *efficiency* shall be used to compute the *UPS segment* of the Electrical Loss Component.
c. Where *UPS*'s have 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 so-designated on the approved *construction documents*.

d. Where non-rated *UPS systems* are utilized the efficiencies and losses shall be as published or provided in writing by the manufacturer.

8.3.1.6 *ITE Distribution Segment Efficiency*. Where significant numbers of power paths exist between the *UPS* and the many *equipment cabinets*, the *ITE distribution segment efficiency* shall be that with the lowest path efficiency. This shall be the longest path with the largest numbers of loss producing components such as transformers, switchgear and/or panelboards. Calculations are required to determine the path with the greatest loss or lowest *efficiency*, which shall be used in developing the total *Electrical Loss Component*.

8.3.1.7 Combined *UPS* and Pathway Loss Calculations. The *design electrical loss component* (*ELC*) shall be calculated as the product of the calculated ~~*Pre-UPS*~~ *Incoming Service Segment loss*, the *UPS segment loss*, and the *ITE distribution segment loss*.

Informative Note: See Appendix C.5, Examples *Design ELC* Calculations, for methods of combining ELC Segment Values.

8.3.1.8 Alternate Designs. In the event 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. Where another device is used in place of the *UPS*, such as a rectifier, voltage regulator or harmonic neutralizing *transformer*, the *efficiency* and loss for that device shall be used in the *efficiency* calculation in the same manner as defined for a *UPS*.

8.3.1.9 Derivation of Electrical Component Efficiencies. Compliance shall be demonstrated by the following:

a. Rated *Equipment* –The efficiency values used in the calculations, or the *loss* numbers used in equivalent efficiency calculations, shall be the *manufacturer*'s numbers as derived from the standardized testing, and shall be based on the *design ITE load*.
b. Unrated *Equipment* – Where no testing and rating standards exist for an electrical component the efficiency values or loss shall be as published by, or as stated in writing by, the component manufacturer.
c. Wiring and cable – the efficiency or loss shall be calculated per the applicable electrical code.

8.3.2 Power Compliance Path. See informative reference C.5 for an illustrative diagram of the power compliance path.

8.4 Submittals

8.4.1 Drawings. Construction documents shall require that within ~~30 days~~ a time determined by the building owner and the contractor(s) after the date of *system* acceptance, record drawings of the actual installation shall be provided to the building owner, including

a. a *single-line diagram* of the building electrical *distribution system*,
b. floor plans indicating locations of and areas served by all distribution,
c. all conditions used for the basis of design and calculations such as *UPS n+1*, *UPS economy mode* operation, and
d. *Electrical Loss Component* calculations showing the actual numbers used and demonstrating compliance with the applicable Table 8.2.1.1 values.

8.4.2 Manuals. Construction documents shall require that an operating manual and maintenance manual be provided to the building owner. The manuals shall include, at a minimum, the following:

a. Submittal data stating *equipment* rating and selected options for each piece of *equipment* requiring maintenance.
b. Operation and maintenance manuals for each piece of *equipment* requiring maintenance. Required routine maintenance actions shall be clearly identified.
c. Names and addresses of at least one qualified service agency.
d. A complete narrative of how each *system* is intended to operate.

9. LIGHTING

9.1 General

9.1.1 Scope. This section shall apply to interior *equipment* spaces of *data center*s.

9.2 Definition of Compliance Paths

Lighting Systems. Lighting *system*s and *equipment* shall comply with Section 9 of ANSI/ASHRAE/IES Standard 90.1

10. OTHER *EQUIPMENT*

10.1 General. Provisions of this section shall comply with Section 10 of ANSI/ASHRAE/IES Standard 90.1.

> **Informative Note:** This standard is intended to provide a fair method of comparison between the estimated annual *energy* of the *proposed design* and a base design for purposes of compliance with the Standard. It is not intended to provide the most accurate prediction of actual *energy* consumption or other utilities and costs for the *building* as it is actually built or as it relates to other *building*s. Site *energy* and related metrics can be measured and verified, where the facility designers (and building owners or designees) have the most *control* and provides an incentive at the *building* level of preferred items. In addition to focusing on these site *energy* uses, this standard also does not evaluate overall use of related utilities such as water, including site harvested or source water provided from the local utility. Both can play a part in the overall *energy* use of the facility, in addition to the overall water use of the facility and its effect on the region. While these are important items to consider, including the efficient use of water, they are outside the scope and purpose of this document.

11. GUIDE TO ALTERNATIVE COMPLIANCE METHOD

11.1 General. Provisions of this Standard require the user to demonstrate compliance with provisions of Sections 5 through Section 9.

The complete submittal data requirements that the user must complete and provide to the AHJ as required for the specific project and outlined in section 4.
Informative Note: See the table in the Informative Appendix C for a sample submittal form.

11.1.1 Section 6 and 8 Trade-Off Method Scope. The Chapter 6 and 8 Trade-Off Method is an alternative to individually demonstrating compliance with Chapter 6 and Chapter 8 requirements. It shall be allowed for demonstrating compliance when evaluating the proposed designs when either the *Design MLC* or Design ELC is greater than the maximum allowed by the standard.

11.1.2 Section 6 and 8 Trade-Off Method Rationale. A design that has various physical or other types of constraints shall be allowed flexibility to demonstrate compliance with this standard. These constraints may impact the mechanical or electrical design. This trade-off method allows a less efficient electrical system to be off-set by a more efficient mechanical system of visa-versa in order to demonstrate compliance.

11.2 Chapter 6 and 8 Trade-off Method

11.2.1 Compliance. Compliance with Section 11 is demonstrated if

a. all requirements of Sections 5, 7, 9, and 10 are met;

b. The sum of the ~~The required~~ *Design MLC* value and the *Design ELC* value create a Design overall *systems* value. The calculated values of the proposed Design MLC and Design ELC values summed shall be equal to or less than the Max Overall systems value~~. in for the mechanical and electrical *system* may be summed to create an overall *systems* value. Compliance may be achieved if the calculated values of the proposed mechanical and electrical *systems* summed are equal to or less than the required summed values. (See Informative Appendix C.2 for an illustrative flow chart.)~~

Informative Note: See below for examples of demonstrating compliance with the Trade-Off Method.

For a particular design in Climate Zone 1A with a single feed *UPS* at 100% load, the Max MLC= .46 from Table 6.2.1.1 and the Max ELC .116 from Table 8.2.1.1. Adding the two values together provides a Max overall systems value of 0.576.

Max MLC Value	0.46
+Max ELC Value	+0.297
=Data Center Target Value	=0.757

If the electrical system design produces a Design ELC of .14 which exceeds the Max ELC value, a more efficient mechanical system can be used to off-set this. If the mechanical system had a Design MCL of 0.39, then the overall systems design value would be less than the Max overall systems value and would demonstrate compliance with the standard.

-

Design MLC Value	0.39
+Design ELC Value	+0.21

=Data Center Proposed Value =0.60

Informative note: See Informative Appendix C.2 for guidance on complying with the standard and for use of the trade-off method.

11.3 Use of Shared Systems. When existing or proposed mechanical and/or electrical systems are intended to be routinely support the data center and other spaces (spaces that may or may not meet the definition of a data center), the data center or data center addition may document its compliance using the annualized energy performance method (as described in Chapters 6.2.1.2 and 8.3). The shared systems' future total hourly loads must be determined for a typical year (using TMY3 weather data) to determine what fraction of the total shared systems' capacity (for each hour of the typical year) will be utilized by the data center addition. The total shared system input energy is multiplied by the data center addition's fraction of total system capacity, for each hour, to determine the data center addition's input energy used to show compliance. In the case where other spaces sharing systems with the data center are within the scope of ASHRAE Standard 90.1, the Energy Cost Budget Method described in Chapter 11 of Standard 90.1 may be followed to determine (for compliance's sake) the hour-by-hour fraction of the shared system's capacity that is utilized by the non-data center spaces.

Informative Note: Shared mechanical systems serving data centers and other spaces (within the scope of Standard 90.1) may or may not be required to provide economizer savings to the non-data center spaces. Standard 90.4 will not affect that requirement, nor require that economizer capacity be provided for the portion of a shared system serving a data center or data center addition that otherwise meets 90.4 annual energy performance targets when calculated as described above.

Informative Note: Recovered heat from a data center that routinely shares a mechanical system with non-data center spaces can reduce the energy use of non-data center spaces which are designed to accept the recovered heat. If the heat required by the non-data center spaces is significant, such a relationship can provide energy savings far beyond the savings which would be brought by applying an economizer to the data center addition.

12. NORMATIVE REFERENCES

Section numbers indicate where the reference occurs in this document.

Reference	Title
Air-Conditioning Heating and Refrigeration Institute (AHRI) **2111 Wilson Boulevard, Suite 500** **Arlington, VA 22201, United States**	
BTS-2000	Testing Standard Method to Determine Efficiency of Commercial Space Heating Boilers
AHRI 1160-2008	Performance Rating of Heat Pump Pool Heaters
AHRI 210/240-2008	Unitary Air Conditioning and Air-Source Heat Pump Equipment
AHRI 340/360-2007	Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
AHRI 310/380-2004	Package Terminal Air-Conditioners and Heat Pumps
AHRI 365-2009	Commercial and Industrial Unitary Air-Conditioning Condensing Units
AHRI 390-2003	Performance Rating of Single Packaged Vertical Air-Conditioners and Heat Pumps
AHRI 400-2001	Performance Rating of Liquid to Liquid Heat Exchangers
AHRI 460-2005	Remote Mechanical Draft Air Cooled Refrigerant Condensers
AHRI 550/590-2003	Performance Rating of Water-Chilling Packages Using the Vapor Compression Cycle
AHRI 560-2000	Absorption Water Chilling and Water Heating Packages
AHRI 1230-2010	Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air-Conditioning and Heat Pump Equipment
ANSI/AHRI 1360-2013	Performance Rating of Computer and Data Processing Room Air Conditioners
Air Movement and Control Association International **30 West University Drive** **Arlington Heights, IL 60004-1806, United States**	
AMCA 500-D-0712	Laboratory Method of Testing Dampers for Rating
American National Standards Institute (ANSI) **11 West 42nd Street**	

~~**New York, NY 10036, United States**~~

~~ANSI Z21.10.3-2004~~	~~Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h~~
~~ANSI Z21.47-2006~~	~~Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces)~~
~~ANSI 83.8-2009~~	~~Gas Unit Heaters and Duct Furnaces~~

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
1791 Tullie Circle NE
Atlanta, GA 30329, United States
1-404-636-8400; www.ashrae.org

~~ANSI/ASHRAE Standard 55-2010~~	~~Thermal Comfort Conditions for Human Occupancy~~
~~ANSI/ASHRAE Standard 62.1-2013~~	~~Ventilation for Acceptable Indoor Air Quality~~
ANSI/ASHRAE/IES Standard 90.1~~-2010~~2013	Energy Standard for Buildings Except Low-Rise Residential Buildings
~~ANSI/ASHRAE Standard 140-2004~~	~~Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs~~
~~ANSI/ASHRAE Standard 127-2012~~	~~Method of Testing for Rating Computer and data Processing Room Unitary Air – Conditioners~~
ANSI/ASHRAE Standard 169-2013	Climatic Data for Building Design Standards

Briggs, R.S., R.G. Lucas, and Z.T. Taylor. 2003. Climate classification for building energy codes and standards Part 1 –

Thermal Guidelines for Data Processing Environments (3rd edition, 2012)

~~**Association of Home Appliance Manufacturers**~~
~~**1111 19th St. NW, Suite 402**~~
~~**Washington DC 20036, United States**~~

~~ANSI/AHAM RAC-1-R2008~~	~~Room Air Conditioners~~

~~**American Society of Civil Engineers (ASCE)**~~
~~**1801 Alexander Bell Drive**~~
~~**Reston, VA 20191**~~

~~ASCE 7-10/IBC~~	~~Seismic Design Provisions of the Standard Minimum Design Loads for Buildings and Other Structures~~

~~**BSI Group**~~
~~**389 Chiswick High Road**~~
~~**London**~~
~~**W4 4AL**~~
~~**United Kingdom**~~

~~BS EN50082-1:1998~~	~~Electromagnetic compatibility. Generic immunity standard. Residential, commercial and light industry~~
~~BS EN 50091-1:~~1993	~~Specification~~ General and Safety Requirements ~~for uninterruptible power systems (UPS). EMC requirements~~
~~BS EN 50091-2:1996~~	~~Specification for uninterruptible power systems (UPS). EMC requirements~~
~~BS EN 50091-3:1999~~	~~Specification for uninterruptible power systems (UPS). EMC requirements~~
~~BS EN 61000-6-3:2007~~	~~Electromagnetic Compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments~~
~~BS EN 61000-6-2:2005~~	~~Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments~~
~~BS EN 60947-6-1:2005~~	~~Low-voltage switchgear and controlgear. Multiple function equipment. Transfer switching equipment~~

~~**Canadian Standards Association (CSA)**~~
~~**178 Rexdale Blvd.**~~
~~**Toronto, ON**~~
~~**Canada M9W 1R3**~~

~~C22.2 NO. 31-14~~	~~Switchgear Assemblies~~

~~**Cooling Technology Institute**~~
~~**2611 FM 1960 West, Suite A-101**~~
~~**Houston, TX 77068-3730, United States**~~

~~CTI ATC-105 (00)~~	~~Acceptance Test Code for Water Cooling Towers~~
~~CTI ATC-105S (96)~~	~~Acceptance Test Code for Closed-Circuit Cooling Towers~~
~~CTI STD-201 (09)~~	~~Standard for Thermal Performance Certification of Evaporative Heat Transfer Equipment~~

Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

CFR FCC Title 47 Part 15	Radio Frequency Devices
CTI ATC-105S (96)	Acceptance Test Code for Closed-Circuit Cooling Towers
CTI STD-201 (09)	Standard for Thermal Performance Certification of Evaporative Heat Transfer Equipment

International Electrotechnical Commission
3, rue de Varembé
P.O. Box 131
CH - 1211 Geneva 20 - Switzerland

IEC 60947-6-1 (2013)	Low-Voltage Switchgear and Control Gear - Part 6-1: Multiple function equipment - Transfer switching equipment (Ed. 2.1)
IEC 62310-3 Ed. 1.0 b:2008	Static transfer systems (STS) - Part 3: Method for specifying performance and test requirement

International of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08854-4141 USA

ANSI/IEEE C37.20.1-2002	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE C37.13-2008	IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.7 -2007/COR 1-2010	IEEE Guide for Testing Metal Enclosed Switchgear Rated up to 38kV for Internal Arcing Faults Corrigendum 1
ANSI/IEEE C37.51:2003 (R2010)	For switchgear - Metal-enclosed low-voltage ac power circuit breaker switchgear assemblies - Conformance test procedures
IEEE C57.12.01-	Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings
IEEE C57.12.70-2011	Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.91-2011	Standard Test Code for Dry-Type Distribution and Power Transformers

International Organization for Standardization
ISO Central Secretariat
1, ch. de la Voie-Creuse
Case postale 56
CH-1211 Geneve 20, Switzerland

ISO 9001 (2008)	Quality Management Systems
ISO 13256-1 (1998)	Water-Source Heat Pumps — Testing and Rating for Performance — Part 1: Water-to-Air and Brine-to-Air Heat Pumps
ISO 13256-2 (1998)	Water-Source Heat Pumps — Testing and Rating for Performance — Part 1: Water-to-Water and Brine-to-Air Heat Pumps

National Electrical Manufacturers Association
1300 N. 17th Street, Suite 1847
Rosslyn, VA 22209, Unites States

ANSI/NEMA MG 1-2006	Motors and Generators
ANSI/NEMA 37.50-2012	Low-Voltage AC Power Circuit Breakers Used in Enclosures — Test Procedures
NEMA 260-1996(2004)	Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA TP 2-2005	Test Method for Measuring the Energy Consumption of Distribution Transformers
NEMA TP 3-2000	Standard for the Labeling of Distribution Transformer Efficiency
NEMA TR 1-1993 (R2000)	Transformers, Regulators and Reactors
NEMA ICS 10-1993	Industrial Control and Systems: AC Transfer Switch Equipment
NEMA SG 4-2009	Alternating Current High-Voltage Circuit Breakers
NEMA ST 20 -1992 (R1997)	Dry Type Transformers for General Applications
NEMA 250-2008	Enclosures for Electrical Equipment (1000 V maximum)

National Fire Protection Association
1 Battery March Park, P.O. Box 9101
Quincy, MA 02269-9101, United States

NFPA 7 Article 645 NFPA 70 Article 708-2008	Critical Operations Power Systems (COPS)
NFPA 70-2014	National Electrical Code
~~NFPA 75-2013~~	~~Standard for the Fire Protection of Information Technology Equipment~~
~~NFPA 99-2012~~	~~Health Care Facilities Code~~
~~NFPA 110-2013~~	~~Standard for Emergency Standby Power Systems~~

Telecommunications Industry Association
2500 Wilson Boulevard
Arlington, VA 22201, Unites States

ANSI/TIA 942-2012 2014	Telecommunication Infrastructure for Data Centers

~~**Underwriters Laboratories, Inc.,**~~
~~**333 Pfingsten Rd.,**~~
~~**Northbrook, IL 60062, United States**~~

~~UL 181A-05~~	~~Closure Systems for Use with Rigid Air Ducts and Air Connectors~~
~~UL 181B-06~~	~~Closure Systems for Use with Flexible Air Ducts and Air Connectors~~
~~UL 508-05~~	~~Safety Standard for Industrial Control Equipment~~
~~UL 727-06~~	~~UL Standard for Safety – Oil Fired Central Furnaces~~
~~UL 1008-14~~	~~Standard for Transfer Switch Equipment~~
~~UL 1062-97~~	~~Standard for Unit Substations (Ed. 3)~~
~~UL 1066-13~~	~~Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures (Ed. 4)~~
~~UL 1558-99~~	~~Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Swithchgear~~
~~UL 1561-11~~	~~Standard for Dry-Type General Purpose and Power Transformers (Ed.4)~~
~~UL 1778-05~~	~~Uninterruptible Power Systems (Ed. 4)~~
~~UL 5085-06~~	~~Low Voltage Transformers (Ed. 1)~~
~~UL 60950-23~~	~~Standard for Information Technology Equipment~~

~~**U.S. Department of Energy**~~ ~~**1000 Independence Avenue, SW**~~ ~~**Washington, DC 20585, United States**~~	
~~42 USC 6831~~	~~Public Law 102-486 Energy Policy Act of 1992~~ ~~Public Law 109-58 - Energy Policy Act of 2005~~ ~~Public Law 110-140 Energy Independence and Security Act of 2007~~
~~**U.S. Security and Exchange Commission**~~ ~~**100 F Street, NE**~~ ~~**Washington, DC 20549, United States**~~	
~~The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System, April 7, 2003~~	

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INFORMATIVE APPENDIX A – INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of this standard and to acknowledge source documents when appropriate. Section numbers indicate where the reference occurs in this document.

Reference	Title	[illegible]
Air-Conditioning Heating and Refrigeration Institute (AHRI) 2111 Wilson Boulevard, Suite 500 Arlington, VA 22201, United States		
BTS 2000	Testing Standard Method to Determine Efficiency of Commercial Space Heating Boilers	
AHRI 1160-2008	Performance Rating of Heat Pump Pool Heaters	
AHRI 210/240-~~2008~~2014 with addenda	Unitary Air Conditioning and Air-Source Heat Pump Equipment	
AHRI 340/360-2007	Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment	
AHRI 310/380-~~2004~~2014	Package Terminal Air-Conditioners and Heat Pumps	
AHRI 365-2009	Commercial and Industrial Unitary Air-Conditioning Condensing Units	
AHRI 390-2003	Performance Rating of Single Packaged Vertical Air-Conditioners and Heat Pumps	

AHRI 400-~~2001~~2015	Performance Rating for Liquid to Liquid Heat Exchangers
AHRI 460-2005	Remote Mechanical Draft Air Cooled Refrigerant Condensers
AHRI 550/590-~~2003~~2015	Performance Rating of Water-Chilling Packages Using the Vapor Compression Cycle
AHRI 560-2000	Absorption Water Chilling and Water Heating Packages
AHRI 1230-2010	Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air-Conditioning and Heat Pump Equipment
ANSI/AHRI 1360-2013	Performance Rating of Computer and Data Processing Room Air Conditioners

Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1806, United States

AMCA 500-D-12 Laboratory Method of Testing Dampers for Rating

American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036, United States

ANSI Z21.10.3-2014	Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h
ANSI Z21.47-2012	Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces)
ANSI 83.8-2013	Gas Unit Heaters and Duct Furnaces

Association of Home Appliance Manufacturers
1111 19th St. NW, Suite 402
Washington DC 20036, United States

ANSI/AHAM RAC-1-R2015	Room Air Conditioners

ASHRAE
1791 Tullie Circle, N.E.
Atlanta, GA 30329, United States
404-636-8400; www.ASHRAE.org

ANSI/ASHRAE Standard 2013	Thermal Comfort Conditions for Human Occupancy
ANSI/ASHRAE Standard 62.1-2013	Ventilation for Acceptable Indoor Air Quality

ANSI/ASHRAE Standard 140-2004	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
ANSI/ASHRAE Standard 127-2012	Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners
TC 9.9 White Paper, 2013	Data Center Networking Equipment: Issues and Best Practices
Datacom Series, 3rd Edition, 2012	Thermal Guidelines for Data Processing Environments

ANSI/BICSI 002-2014
Data Center Design and Implementation Best Practices

8610 Hidden River Parkway, Tampa, FL 33637

www.bicsi.org

Tel: +1 813.979.1991

BSI Group
389 Chiswick High Road
London
W4 4AL
United Kingdom

BS EN50082-1:1998	Electromagnetic compatibility. Generic immunity standard. Residential, commercial and light industry
BS EN 50091-1:1997	~~Specification~~ General and Safety Requirements for uninterruptible power systems (UPS) in operation access areas. EMC requirements
BS EN 50091-2:1996	Specification for uninterruptible power systems (UPS). EMC requirements
BS EN 50091-3:2001	Specification for uninterruptible power systems (UPS). EMC requirements
BS EN 61000-6-3:2007	Electromagnetic Compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments
BS EN 61000-6-2:2005	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments
BS EN 60947-6-1:2005	Low-voltage switchgear and control gear. Multiple function equipment. Transfer switching equipment

Canadian Standards Association (CSA)
178 Rexdale Blvd.
Toronto, ON
Canada M9W 1R3

C22.2 NO. 31-14	Switchgear Assemblies

-

Consumer Electronics Association

CEA-310-E(2005)
Cabinets, Racks, Panels and Associated Equipment

Cooling Technology Institute
2611 FM 1960 West, Suite A-101
Houston, TX 77068-3730, United States

CTI ATC-105 (00)	Acceptance Test Code for Water Cooling Towers
CTI ATC-105S (96)	Acceptance Test Code for Closed-Circuit Cooling Towers
CTI STD-201 Feb 15	Standard for Thermal Performance Certification of Evaporative Heat Transfer Equipment

Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

CFR FCC Title 47 Part 15	Radio Frequency Devices

~~International~~ Institute of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08854-4141 USA

ANSI/IEEE C62.41-2002	IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
IEEE C37.16-2009	IEEE Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC (3200 V and below) Power Circuit Breakers
IEEE 446-1995	IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

ANSI/IEEE C37.20.1-2002	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE C37.13-2008	IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.7 - 2007/COR 1-2010	IEEE Guide for Testing Metal Enclosed Switchgear Rated up to 38kV for Internal Arcing Faults Corrigendum 1
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IEEE C57.12.01-2005	Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings
IEEE C57.12.70-2011	Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.91-2011	Standard Test Code for Dry-Type Distribution and Power Transformers

International Organization for Standardization
ISO Central Secretariat
1, ch. de la Voie-Creuse
Case postale 56
CH-1211 Geneve 20, Switzerland

ISO 9001 (2015)	Quality Management Systems
ISO 13256-1 (1998)	Water-Source Heat Pumps—Testing and Rating for Performance – Part 1: Water-to-Air and Brine-to-Air Heat Pumps
ISO 13256-2 (1998)	Water-Source Heat Pumps—Testing and Rating for Performance – Part 1: Water-to-Water and Brine-to-Air Heat Pumps

National Electrical Manufacturers Association
1300 N. 17th Street, Suite

1847
Rosslyn, VA 22209,
Unites States

NEMA TP 1-2002	Guide for Determining Energy Efficiency for Distribution Transformers
ANSI/NEMA MG 1-2014	Motors and Generators
ANSI/NEMA 37.50-2012	Low Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures
NEMA 260-1996(2004)	Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA TP 2-2005	Test Method for Measuring the Energy Consumption of Distribution Transformers
NEMA TP 3-2000	Standard for the Labeling of Distribution Transformer Efficiency
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NEMA ICS 10-2005	Industrial Control and Systems: AC Transfer Switch Equipment
NEMA SG 4-2009	Alternating Current High-Voltage Circuit Breakers
NEMA ST 20 -2014	Dry Type Transformers for General Applications
NEMA 250-2014	Enclosures for Electrical Equipment (1000 V maximum)

National Fire Protection Association
1 Battery March Park, P.O. Box 9101
Quincy, MA 02269-9101, United States

NFPA 75-2013	Standard for the Fire Protection of Information Technology Equipment
NFPA 99-2015	Health Care Facilities Code
NFPA 110-2013	Standard for Emergency Standby Power Systems

Telecommunications
Industry Association
1320 North Courthouse
Road, Suite 200
Arlington, VA 22201

ANSI/TIA-942-2014	Telecommunications Infrastructure Standard for Data Centers

Underwriters Laboratories, Inc.,
333 Pfingsten Rd.,
Northbrook, IL 60062, United States

UL 181A-13	Closure Systems for Use with Rigid Air Ducts and Air Connectors
UL 181B-13	Closure Systems for Use with Flexible Air Ducts and Air Connectors
UL 508-05	Safety Standard for Industrial Control Equipment
UL 727-06	UL Standard for Safety – Oil Fired Central Furnaces
UL 1008-14	Standard for Transfer Switch Equipment
UL 1062-97	Standard for Unit Substations (Ed. 3)
UL 1066-13	Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures (Ed. 4)
UL 1558-99	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Swithchgear
UL 1561-11	Standard for Dry-Type General Purpose and Power Transformers (Ed.4)
UL 1778-05	Uninterruptible Power Systems (Ed. 4)
UL 5085-06	Low Voltage Transformers (Ed. 1)
UL 60950-07	Standard for Information Technology Equipment

U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585, United States

42 USC 6831	Public Law 102-486 Energy Policy Act of 1992 Public Law 109-58 Energy Policy Act of 2005 Public Law 110-140 Energy Independence and Security Act of 2007

U.S. Security and Exchange Commission
100 F Street, NE
Washington, DC 20549, United States

The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System, April 7, 2003	

United States Environmental Protection Agency (EPA)
1200 Pennsylvania Avenue, NW
Washington, DC 20460, United States
1-919-541-0800;
www.epa.gov
ENERGY STARY® 1-88-782-7937

Version 1.0, April 9, 2010	ENERGY STAR Program Requirements for Data Center Storage
Version ~~2.0, February 1, 2011~~ 1.0, December 2, 2105	ENERGY STAR Program Requirements for LargeNetworking Equipment for Set-Top Boxes
Version 1.0, October 31, 2014	ENERGY STAR Program Requirements for Small Networking Equipment

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INFORMATIVE APPENDIX B – SAMPLE SUBMITTAL FORMS

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: ____________________________

Project Number: ____________________________

Client: ____________________________

Designer: ____________________________

SECTION 5 - *BUILDING ENVELOPE*

Section	Description	Pass/Fail	Code Value	Design Value
5.1	**General**			
5.1.2	Space-Conditioning Categories			
5.1.3	Envelope *Alteration*s			
5.1.4	Climate			
5.2	**Compliance Paths**			
	(a) Complies with 5.1 (General), and			
	(b) Complies with 5.4 (Mandatory Provisions), and			
	(c) Complies with 5.5 (Prescriptive Bldg. Envelope Option) or 5.6 (Bldg. Envelope Trade-Off Option)			
5.4	**Mandatory Provisions**			
5.4.1	Insulation			
	Insulation Materials installed in accordance with *manufacturer* and to achieve rated R-value			
	Exception: for metal *building* roofs or metal *building wall*s			

	Loose-fill insulation not used in attic roof spaces when slope of ceiling is more than three in twelve			
	Attic eave vents have baffling to deflect the incoming air above the surface of the insulation			
	Insulation installed in permanent manner in substantial contact with inside surface			
	Batt insulation installed in floor cavities supported in permanent manner by supports		<= 24 in. o.c.	
	Lighting fixtures, HVAC, and other *equipment* not recessed in ceilings to affect insulation thickness			
	Exception: recessed area is less than 1%			
	Exception: entire roof, *wall*, or floor covered with insulation to full depth required			
	Exception: effects of reduced insulation included in calculations using area weighted averages			
	Roof insulation not installed over suspended ceiling with removable ceiling panels			
	Exterior insulation covered with protective material to prevent damage			
	Insulation protected in attics and mechanical rooms where access needed			
	Foundation vents do not interfere with insulation			
	Insulation materials in ground contact water absorption rate limit		<= 0.3%	
5.4.2	Fenestration and Doors			
	U-Factor. U-factors for *skylight*s determined for slope of 20 degrees above horizontal		accordance with NFRC 100	
	Exception: Skylights U-factor		Table A8.1A	
	Exception: Other fenestration products U-factor		Table A8.2	
	Exception: Opaque doors U-factor		accordance with NFRC 100	
	Exception: Garage doors U-factor		accordance with DASMA 105	
	Solar Heat Gain Coefficient		accordance with NFRC 200	
	Exception: SHGC is determined by multiplying the shading coefficient (SC) by 0.86		accordance with NFRC 300	
	Exception: SHGC for the center of glass is used		accordance with NFRC 300	
	Exception: Skylights SGHC		Table A8.1B	
	Exception: Vertical fenestration SGHC		Table A8.2	
	Visible Light Transmittance		accordance with NFRC 200	
5.4.3	Air Leakage			
5.4.3.1	Continuous Air Barrier			
5.4.3.2	Fenestration and Doors			
	Exception: Field fabricated fenestration and doors			
	Exception: Metal coiling doors in semi-heated *space*s in climate zones 1 through 6			
5.4.3.3	Cargo doors and loading dock doors equipped with weatherseals in climates zones 4 through 8			
5.4.3.4	Entrance doors have vestibules			
	Exception: *Building* has revolving doors			
	Exception:Doors not intended as *building* entrance			
	Exception: Doors open from dwelling unit(s)			
	Exception: Climate zone 1 or 2			
	Exception: *Building* in climate zone 3 less than four stories and smaller than 10,000 ft²			
	Exception: *Building*s entrances in *building*s less than 1,000 ft² in climate zones 4, 5, 6, 7, and 8			
	Exception: Doors opening from *space*s smaller than 3,000 ft² separate from a *building* entrance			

5.5	**Prescriptive *Building Envelope* Option**			
5.5.3	Opaque Areas (insulation)		rated R-values of insulation	
	Opaque Areas (conductance factors)		max. U-factor, C-factor, F-factor	
	Opaque Areas (area-weighted averages [a-w avg.])		a-w avg. U-factor, C-factor, F-factor	
5.5.3.1	Roof Insulation		Table 5.5	
	Roof Insulation (*skylight* curbs)		>= R-5 or Table 5.5	
5.5.3.2	Above-Grade *Wall* Insulation		rated R-values of insulation	
5.5.3.3	Below-Grade *Wall* Insulaion		rated R-values of insulation	
5.5.3.4	Floor Insulation		rated R-values of insulation	
5.5.3.5	Slab-on-Grade Floor Insulation		rated R-values of insulation	
5.5.3.6	Opaque Doors		U-factor from Table 5.5	
5.5.4	Fenestration (solar heat gain coefficient [SHGC])		U-factor and SHGC	
5.5.4.2	Fenestration Area (gross *wall* area)		< 40%	
	Fenestration Area (gross roof area)		< 5%	
5.5.4.3	Fenestration U-Factor		Table 5.5	
5.5.4.4	Fenestration Solar Heat Gain Coefficient		Table 5.5	
5.5.4.5	Fenestration Orientation			
5.6	***Building Envelope* Trade-Off Option**			

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: ______________________________

Project Number: ______________________________

Client: ______________________________

Designer: ______________________________

SECTION 6 - HVAC

Section	Description	Pass/Fail	Code Value	Design Value
6.1	**General**			
6.2	Compliance Path(s)			
	(a) Complies with 6.1 (General), and either			
	(b) Complies with 6.2.1.1 (Design Mechanical *Efficiency* Component (*MLC*)), or			
	(c) Complies with 6.2.1.2 (Annualized Component (*MLC*))			
6.2.1	Mechanical Systems			
6.2.1.1	Design Mechanical *Efficiency* Component (*MLC*)		<= Table 6.2.1.1	
	Exceptions: exclude cooling tower basin heaters and *space* heaters power or *energy* from calculation			
6.2.1.2	Annualized Component (*MLC*)		<= Table 6.2.1.2A	
6.2.1.2.1	Annualized Mechanical Efficient Component (*MLC*)			
6.2.1.2.2	Calculations			

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: _____________________________

Project Number: _____________________________

Client: _____________________________

Designer: _____________________________

SECTION 7 - SERVICE WATER HEATING

Section	Description	Pass/Fail	Code Value	Design Value
7.1	**General**			
7.2	**Compliance Path(s)**			
	Complies with ANSI/ASHRAE/IES Standard 90.1, Section 7.2			
	(a) Complies with 7.4 (Mandatory Provisions) and 7.5 (Prescriptive Path), if applicable			
7.4	**Mandatory Provisions**			
	Complies with ANSI/ASHRAE/IES Standard 90.1, Section 7.4			
7.4.1	Load calculations provided for sizing of *system*s and *equipment*			
7.4.2	*Equipment Efficiency*		Table 7.8	
7.4.3	Service Hot-Water Piping Insulation			
	Piping meets insulation levels shown in Table 6.8.3A			
	(a) Recirculating *system* piping		Table 6.8.3A	
	(b) First 8 ft of outlet piping for constant temp. nonrecirculating storage *system*		Table 6.8.3A	
	(c) Inlet pipe between storage tank and heat trap in nonrecirculating storage *system*		Table 6.8.3A	
	(d) Externally heated pipes		Table 6.8.3A	
7.4.4	Service Water Heating System *Control*s			
7.4.4.1	Temperature *Control*s			
7.4.4.2	Temperature Maintenance *Control*s			
7.4.4.3	Outlet Temperature *Control*s		<= 110 degrees F	
7.4.4.4	Circulating Pump *Control*s			

7.4.6	Heat Traps			
7.5	**Prescriptive Path**			
	Complies with ANSI/ASHRAE/IES Standard 90.1, Section 7.5			
7.5.1	Space Heating and Water Heating			
	(a) Boiler or component of boiler *system* does not exceed calculated standby loss in Btu/h, or			
	(b) Use of single heat source consumes less *energy* than separate units, or			
	(c) *Energy* input of combined boiler and water heater *system*		< 150,000 Btu/h	
7.5.2	Service Water Heating *Equipment*			

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: ____________________________

Project Number: ____________________________

Client: ____________________________

Designer: ____________________________

SECTION 8 - ELECTRICAL

Section	Description	Pass/Fail	Code Value	Design Value
8.1	**General**			
8.2	**Compliance Path(s)**			
	(a) Complies with Section 8.1 (General), and			
	(b) Section 8.2.1 (Electrical Systems)			
8.2.1	Electrical Systems			
8.2.1.1	Minimum Design Electrical *Efficiency* Component (EEC)		>= Table 8.2.1.1	

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: ____________________________

Project Number: ____________________________

Client: ____________________________

Designer: ____________________________

SECTION 9 - LIGHTING

Section	**Description**	**Pass/Fail**	**Code Value**	**Design Value**
9.1	**General**			
9.2	**Compliance Path(s)**			
	(a) Complies with ANSI/ASHRAE/IES Standard 90.1, Section 9, or			
	(b) Section 9.5 (*Building* Area Method)			
9.4	**Mandatory Provisions**			
9.4.1	Lighting *Control*			
9.4.1.1	*Automatic* lighting shutoff *control*s provided based on scheduling device or occupant sensor			
9.4.1.2	Each *enclosed space* has its own *control* including bilevel or occupancy based where required			
9.4.1.3	*Control*s for parking garages, including bilevel, transition and perimeter *control* as required			
9.4.1.4	*Automatic* daylighting *control*s for primary sidelighted areas			
9.4.1.5	*Automatic* daylighting *control*s for toplighting			
9.4.1.6	Additional *control*s			
9.4.1.7	Exterior lighting *control*s including *automatic* shutoff and bilevel as required			
9.4.2	Exit signs limit	5W/face		
9.5	***Building* Area Method of Calculating Interior Lighting Power Allowance**			

ASHRAE 90.4P - *Energy* Prescriptive Compliance - Checklist

Project Name: ____________________________

Project Number: ____________________________

Client: ____________________________

Designer: ____________________________

SECTION 11.2 Data Center Target Value Trade Off Method

Section	Description		Pass/Fail	Code Value	Design Value
-	-	-	-	-	-
11.1	**General Presciptive compliance see Chapters 6 and 8**		-	-	-
-	-	-	-	-	-
11.2	Trade Off Method Compliance Path		-	-	-
-	-	Enter 6.2.1.1 (Design Mechanical *Efficiency* Component (*MLC*)), or	-	-	-
-	-	enter 6.2.1.2 (Annualized Component (*MLC*)) Value	-	-	-
		Enter Minimum Design Electrical *Efficiency* Component (EEC) Table 8.2.1.1	-	-	-
	Sum the MLC and ELC values above to create the Data Center Target Value		-	-	-
6.2.1.1	Enter Design Mechanical *Efficiency* Component (*MLC*) or 6.2.1.2		-	<= Table 6.2.1.1	-
-	-	Exceptions: exclude cooling tower basin heaters and *space* heaters power or *energy* from calculation	-	-	-
6.2.1.2	Enter Annualized Component (*MLC*)		-	<= Table 6.2.1.2 A	-
	-	Annualized Mechanical Efficient Component (*MLC*)	-	-	-
	-	Enter Design Electrical *Efficiency* Component (EEC)	-	-	-
-	-	Sum the Design MLC Value and the Design ELC Value	-	-	-
-	-	If the Design Sum is =< Data Center Target Value the Design Passes	-	-	-

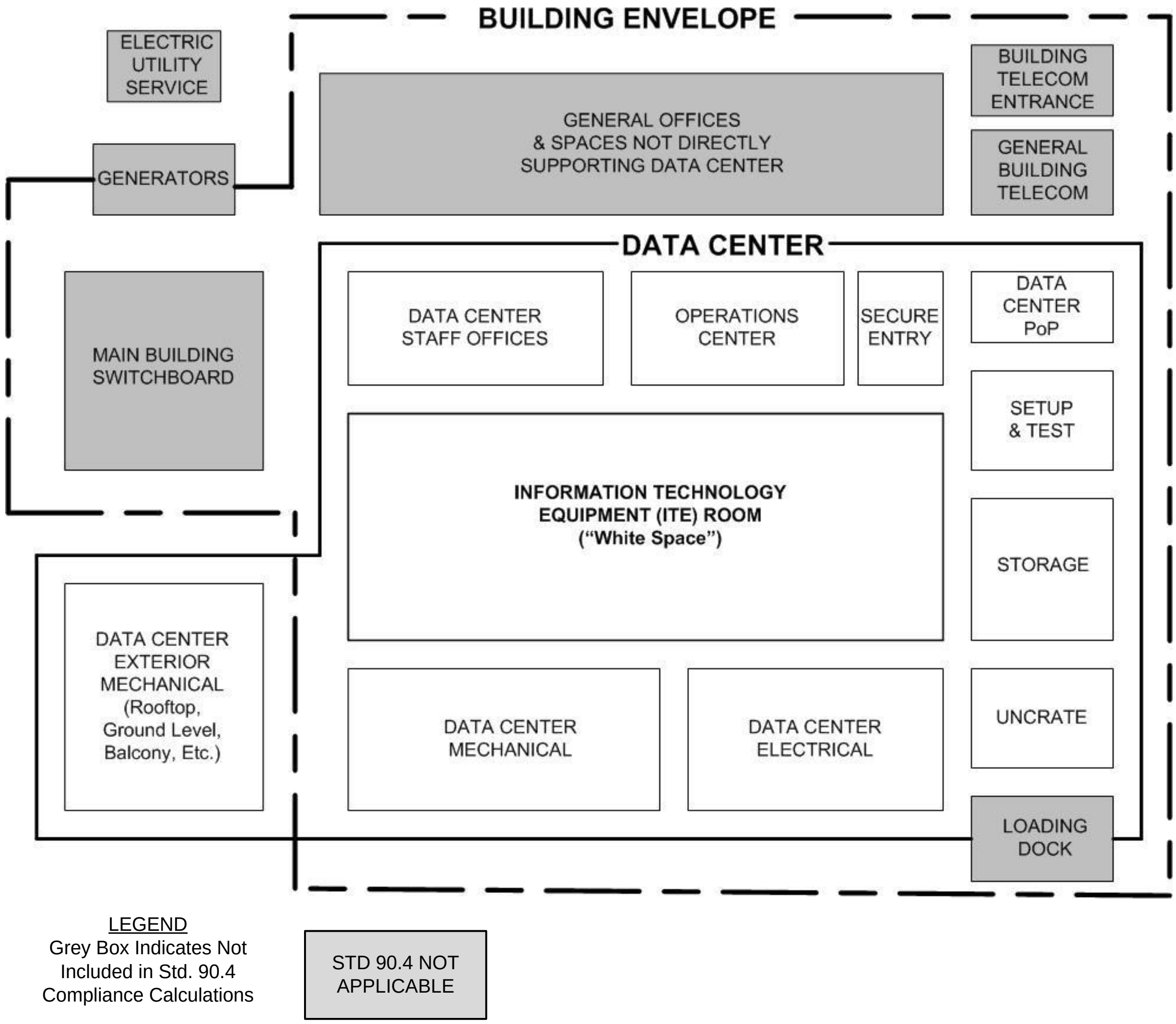
THIS APPENDIX IS NOT PART OF THIS STANDARD. IT IS MERELY INFORMATIVE AND DOES NOT CONTAIN REQUIREMENTS NECESSARY FOR CONFORMANCE TO THE STANDARD. IT HAS NOT BEEN PROCESSED ACCORDING TO THE ANSI REQUIREMENTS FOR A STANDARD AND MAY CONTAIN MATERIAL THAT HAS NOT BEEN SUBJECT TO PUBLIC REVIEW OR A CONSENSUS PROCESS. UNRESOLVED OBJECTORS ON INFORMATIVE MATERIAL ARE NOT OFFERED THE RIGHT TO APPEAL AT ASHRAE OR ANSI.)

INFORMATIVE APPENDIX C – DIAGRAMS FOR ILLUSTRATING COMPLAINCE

Informative Note: Figure C.1 illustrates the types of *space*s that constitute a *data center*, which includes *space*s that directly support the *ITE room*, consistent with ANSI/TIA Standard 942A and NFPA-70, Article 645. Not all of these support *space*s will be present in every *data center*, and may have different identifications. However, *space*s with similar functions shall be considered part of the *data center* and shall be included in the *design PUE* calculations as set forth in this Standard 90.4.

REVISED- Note to Reviewers Figure C.1 is Revised but not in underline format for readability.

Figure C.1 Demarcation of *Building* Areas Subject to the Provisions of Standard 90.4 and 90.1



Informative Note: Figures C.2, C.3 ad C.4 illustrate the applicability of Standard 90.4 to different types of *construction*, expansions, and existing facility modifications. The specifics of each project will be differ. These illustrations are provided only to exemplify how different versions of Standard 90.4 would apply to typical situations.

Figure C.2 Mechanical and Electrical Compliance Path

NOTE TO REVIEWERS: THIS REVISION IS NOT IN TRACK CHANGES FOR READABILITY.

Std. 90.4 Mechanical & Electrical Compliance Paths

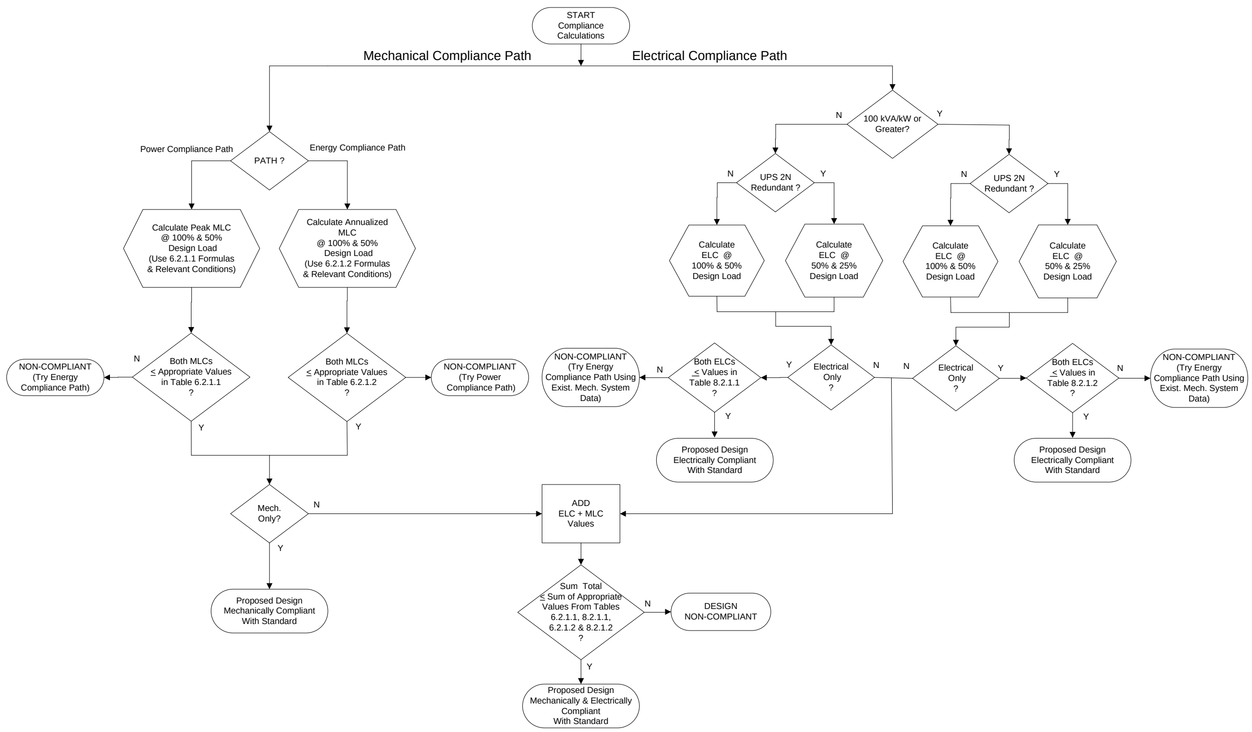
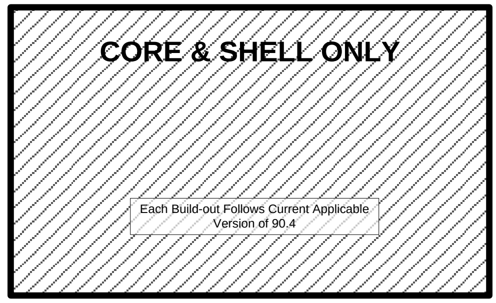


Figure C.3 Applicability for Datacom *Equipment* in New *Construction*

CORE & SHELL ONLY

Calculate Based On Expected Power Level

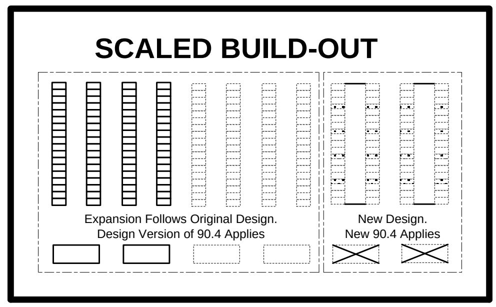
Current Applicable Version of 90.4 At Time of Each Build-out.
(Refer to Options Below for Type of Build-out)



SCALED BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

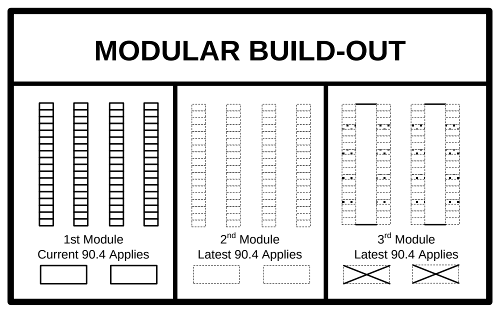
Current Applicable Version of 90.4 At Time of Design. Same Version Applies IF Build-out Follows Design.
(Deviations Revert to Current Version)



MODULAR BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

Current Applicable Version of 90.4 At Time of Build-out of Each Module



FULL BUILDOUT

Calculate Based On Expected Power Level

Current Applicable Version of 90.4 At Time of Design
(Continues to Apply Until Extent of Modification Requires Reverting to Newer Version)

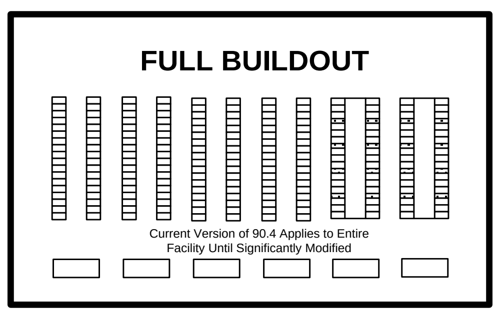
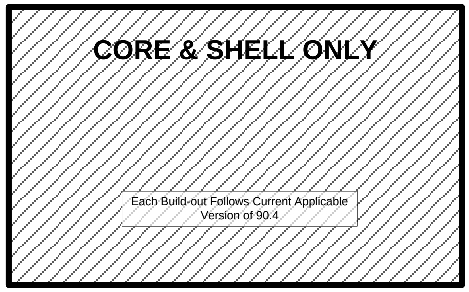


Figure C.4 Applicability for Mechanical *Equipment* in New *Construction*

CORE & SHELL ONLY

Calculate Based On Expected Power Level

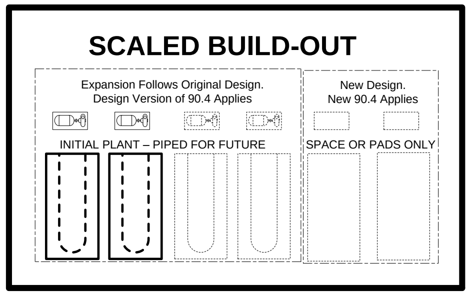
Current Applicable Version of 90.4 At Time of Each Build-out.
(Refer to Options Below for Type of Build-out)



SCALED BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

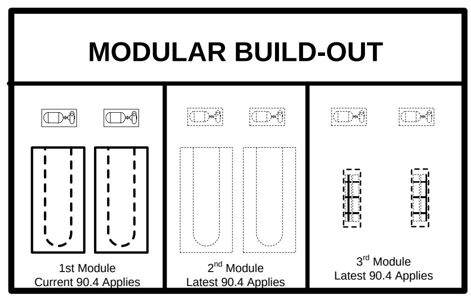
Current Applicable Version of 90.4 At Time of Design. Same Version Applies IF Build-out Follows Design.
(Deviations Revert to Current Version)



MODULAR BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

Current Applicable Version of 90.4 At Time of Build-out of Each Module



FULL BUILDOUT

Calculate Based On Expected Power Level

Current Applicable Version of 90.4 At Time of Design
(Continues to Apply Until Extent of Modification Requires Reverting to Newer Version)

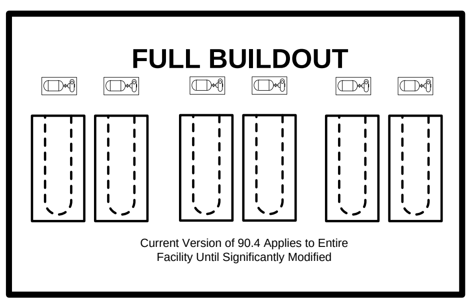
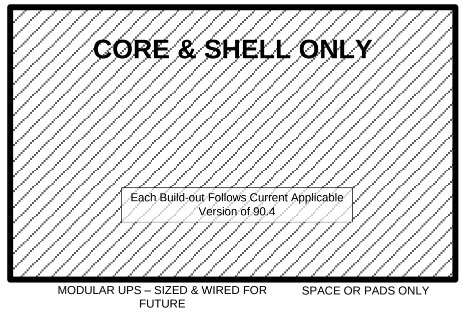


Figure C.5 Applicability for Electrical *Equipment* in New Construction

CORE & SHELL ONLY

Calculate Based On Expected Power Level

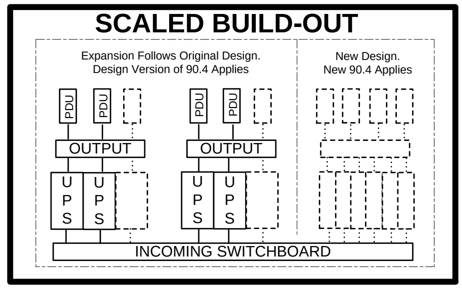
Current Applicable Version of 90.4 At Time of Each Build-out.
(Refer to Options Below for Type of Build-out)



SCALED BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

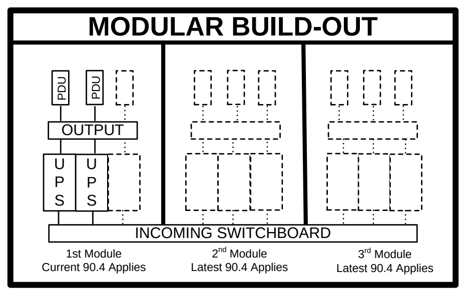
Current Applicable Version of 90.4 At Time of Design. Same Version Applies IF Build-out Follows Design.
(Deviations Revert to Current Version)



MODULAR BUILD-OUT

Calculate Based On Expected Power Level For Full Build-out

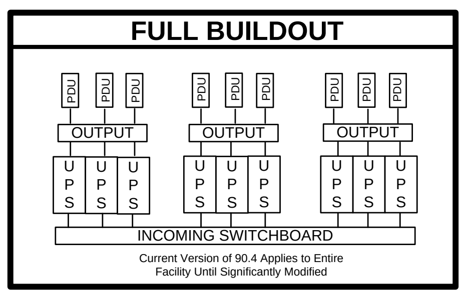
Current Applicable Version of 90.4 At Time of Build-out of Each Module



FULL BUILDOUT

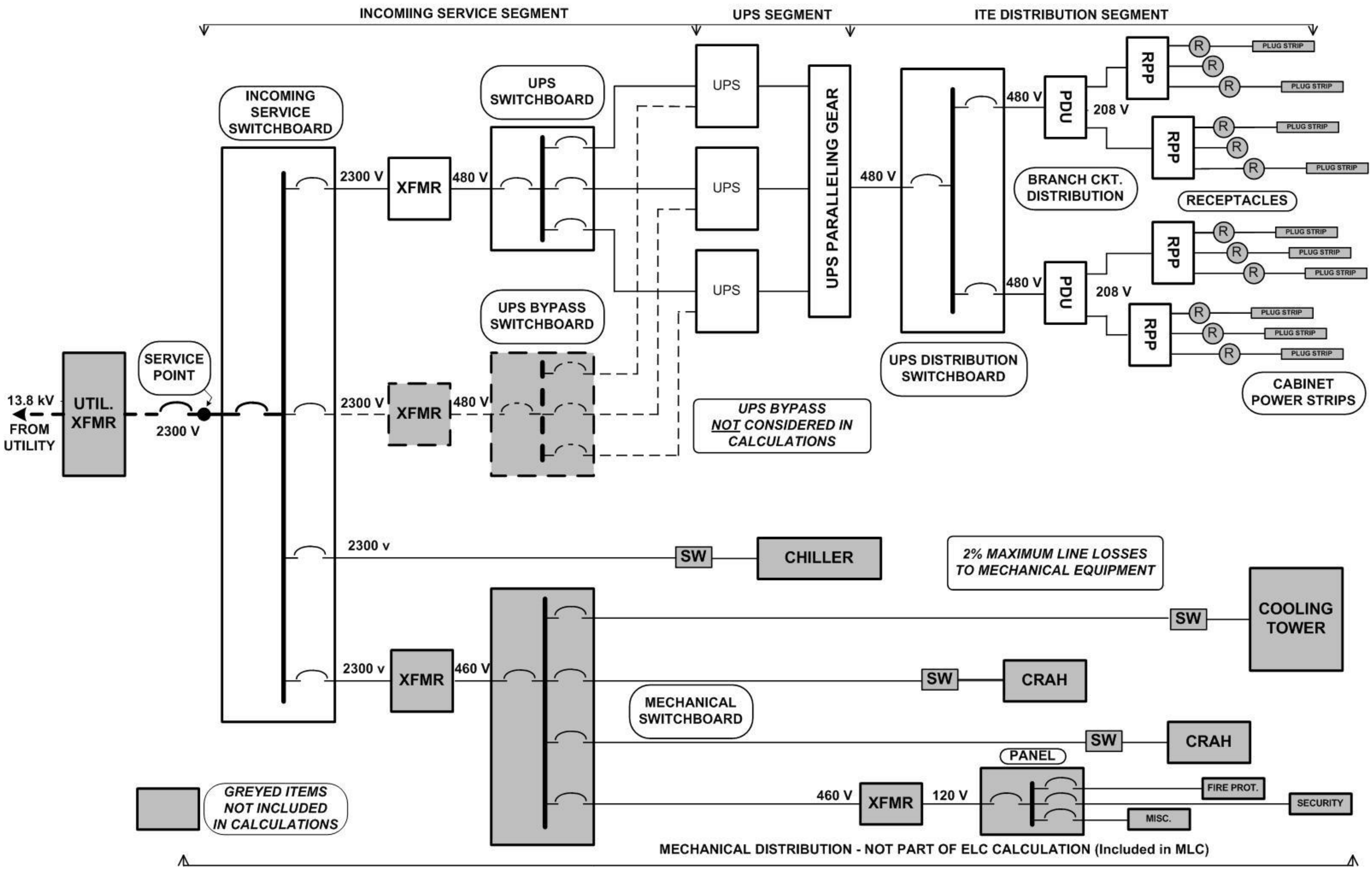
Calculate Based On Expected Power Level

Current Applicable Version of 90.4 At Time of Design
(Continues to Apply Until Extent of Modification Requires Reverting to Newer Version)



Informative Note: Figure C.5 illustrates the *Electrical Loss Component* (*ELC*) Compliance Path for the electrical power *system* serving the *ITE*. This diagram is not in any way intended to recommend or dictate any particular electrical design, and not all of the devices shown will be present in every data center, or connected in the same order or the same way. This diagram is provided only to illustrate the *Electrical Loss Component* Compliance Path using components of the *ITE* electrical *system* that typically appear in many designs.

Figure C.6 Electrical *Efficiency* Compliance Path **NOTE TO REVIEWERS: THIS REVISION IS NOT IN TRACK CHANGES FOR READABILITY**


INCOMIING SERVICE SEGMENT
UPS SEGMENT
ITE DISTRIBUTION SEGMENT
INCOMING SERVICE SWITCHBOARD
UPS SWITCHBOARD
UPS
UPS
UPS
UPS PARALLELING GEAR
480 V
UPS DISTRIBUTION SWITCHBOARD
480 V
PDU
208 V
RPP
R
PLUG STRIP
BRANCH CKT. DISTRIBUTION
RECEPTACLES
CABINET POWER STRIPS
2300 V
XFMR
480 V
UPS BYPASS SWITCHBOARD
SERVICE POINT
13.8 kV
FROM UTILITY
UTIL. XFMR
2300 V
UPS BYPASS NOT CONSIDERED IN CALCULATIONS
2300 v
SW
CHILLER
2% MAXIMUM LINE LOSSES TO MECHANICAL EQUIPMENT
COOLING TOWER
460 V
CRAH
MECHANICAL SWITCHBOARD
PANEL
FIRE PROT.
SECURITY
MISC.
120 V
GREYED ITEMS NOT INCLUDED IN CALCULATIONS
MECHANICAL DISTRIBUTION - NOT PART OF ELC CALCULATION (Included in MLC)

C.5 Examples - Design ELC Calculations.

Sample Calculation for an "*N*" (Non-Redundant) *UPS*:

CONDITIONS
Operational Design Load = 100 *kW*
Potential Maximum Load = 100 *kW*
[One (1) Module of 100 kW, Four (4) Modules of 25 kW, or Equivalent]
100% of Operational Design Load = 100 *kW*
Operational Load Percentage = 100 *kW* / 100 *kW* X 100% = 100%
50% of Operational Design Load = 50 *kW*
Operational Load Percentage = 50 *kW* / 100*kW* X 100% = 50%

CALCULATIONS
Efficiency at 100% Load for 100 *kW* Capacity = 9~~3~~2.0% (*Efficiency* Factor = 0.9~~3~~20)
Resulting Loss = (100 *kW* – (0.9~~3~~20 x 100 *kW*)) = (100 *kW* – 9~~3~~2 *kW*) = ~~7~~8.0 *kW*
Efficiency at 50% Load for 100 *kW* Capacity = 9~~2~~1.0% (*Efficiency* Factor = 0.9~~2~~10)
Resulting Loss = (50 *kW* – (9~~2~~1.0% x 50 *kW*)) = (50 *kW* – 4~~6~~5.5 *kW*) = 4.~~0~~5 *kW*

Sample Calculations for an "*N+1*" Redundant *UPS*:

CONDITIONS – ILLUSTRATION 1

Operational Design Load = 100 *kW*
Potential Maximum Load (With *Redundancy*) = 125 *kW*
[Five (5) Modules of 25 kW or Equivalent]
100% of Operational Design Load = 100 *kW*
Operational Load Percentage = 100 *kW* / 125 *kW* X 100% = 80%
50% of Operational Design Load = 50 *kW*
Operational Load Percentage = 50 *kW* / 125*kW* X 100% = 40%

CALCULATIONS
Efficiency at 80% Load for 125 *kW* Capacity = 91~~3~~.0% (*Efficiency* Factor = 0.91~~3~~0)
Resulting Loss = (100 *kW* – (0.91~~3~~ x 100 *kW*)) = (100 *kW* – 91~~3~~ *kW*) = ~~7~~9.0 *kW*
Efficiency at 40% Load for 125 *kW UPS* Capacity = 90.~~5~~0% (*Efficiency Factor = 0.900)*
Resulting Loss = (50 *kW* – (0.90~~5~~ x 50 *kW*)) = (50 *kW* – 45.0~~25~~ *kW*) = 4.5~~75~~ *kW*

CONDITIONS – ILLUSTRATION 2
Operational Design Load = 100 *kW*
Potential Maximum Load (With *Redundancy*) = 150 *kW*
[Three (3) Modules of 50 kW or Equivalent]
100% of Operational Design Load = 100 *kW*
Operational Load Percentage = 100 *kW* / 150 *kW* X 100% = 66.7%
50% of 100 *kW* Operational Design Load = 50 *kW*
Operational Load Percentage = 50 *kW* / 150*kW* X 100% = 33.3%

CALCULATIONS
Efficiency at 66.7% Load for 150 *kW* Capacity =90~~3~~.0% (*Efficiency* Factor = 0.9~~3~~00)
Resulting Loss = (100 *kW* – (0.9~~3~~00 x 100 *kW*)) = (100 *kW* – 9~~3~~0 *kW*) = ~~7~~10.0 *kW*
Efficiency at 33.3% Load for 150 *kW* Capacity = 89.~~5~~0% (*Efficiency* Factor = 0.89~~5~~0)
Resulting Loss = (50 *kW* – (0.89~~5~~0 x 50 *kW*)) = (50 *kW* – 44.5~~75~~ *kW*) = 5.~~25~~5 *kW*

Sample Calculation for a "*2N*" Redundant *UPS*:

CONDITIONS

Both UPS Systems are Identical, therefore Calculate for only One System:
Operational Design Load = 100 *kW*
Potential Maximum Load (One System) = 100 *kW*
[One (1) Module of 100 kW, Four (4) Modules of 25 kW, or Equivalent]
50% of Operational Design Load = 50 *kW*
Operational Load Percentage = 50 *kW* / 100 *kW* X 100% = 50.0%
25% of Operational Design Load = 25 *kW*
Operational Load Percentage = 25 *kW* / 100*kW* X 100% = 25.0%

CALCULATIONS
Efficiency at 50% Load for 100 *kW* Capacity = 9~~2~~1.0% (*Efficiency* Factor = 0.9~~2~~10)
Resulting Loss = (50 *kW* – (0.910~~20~~ x 50 *kW*)) = (50 *kW* – 45.5~~6~~ *kW*) = 4.5~~0~~ *kW*
Efficiency at 25% Load for 100 *kW* Capacity =86.0~~7.5~~% (*Efficiency* Factor = 0.860~~75~~)
Resulting Loss = (25 *kW* – (0.860~~75.5~~% x 25 *kW*)) = (25 *kW* – 21.5~~875~~ *kW*) = 3.5~~125~~ *kW*

Sample Calculations for a “2(N+1)” Redundant *UPS*:

Both UPS Systems are Identical, therefore Calculate for only One System:

CONDITIONS
Operational Design Load = 100 *kW*
Potential Maximum Load (one system with *redundancy*) = 125 *kW*
[Five (5) Modules of 25 kW or Equivalent]
50% of Operational Design Load = 50 *kW*
Operational Load Percentage = 50 *kW* / 125 *kW* X 100% = 40.0%
25% of Operational Design Load = 25 *kW*
Operational Load Percentage = 25 *kW* / 125*kW* X 100% = 20.0%

CALCULATIONS
Efficiency at 40% for 125 *kW* Capacity =89.0~~90.5~~% (*Efficiency* Factor = 0.890~~905~~)
Resulting Loss = (50 *kW* – (0.890~~905~~% x 50 *kW*)) = (50 *kW* – 44.5~~5.25~~ *kW*) = 5.54~~4.75~~ *kW*
Efficiency at 20% of 125 *kW UPS* Capacity = 84% (*Efficiency* Factor = 0.840)
Resulting Loss = (25 *kW* – (0.820~~40~~% x 25 *kW*)) = (25 *kW* – 20.5~~1~~ *kW*) =4.5_0 *kW*

SAMPLE CALCULATION OF ELC SEGMENTS & TOTALS
Note to reviewers this table is revised.

	Electrical Loss Component (ELC) Calculation Based on Losses Single Output *UPS* (N, N+1, etc.) or No *UPS*: *100 kW or Greater Operating at Design Load*							
EFFICIENCY SEGMENTS & LOSSES		IN kW	OUT kW	LOSS kW	EFFICIENCY (% OUT)	% LOSS	ELEC. LOSS COMP.	
1	*Incoming Service Segment*	646.41	549.45	96.960	85.00%	15.00%	0.150	a
2	*UPS Segment*	549.45	**500.00 ***	49.450	91.00%	9.00%	0.090	b
3	*ITE Distribution Segment*	500.00	475.00	25.000	95.00%	5.00%	0.050	c
T	*Electrical Efficiency Component*		475.00	171.412	73.48%	26.52%	**0.265**	
				x	y	z	ELC	

***Calculation begins with UPS Design Rating**
UPS is rated at 500 kW/~~kVA~~ output capacity.
UPS segment efficiency at Design Load is 9~~6~~1%
Therefore, UPS loss is 94% or ~~20.833 kVA~~ 90kW

~~Resulting~~Required Input to the UPS is 545.54 kW ~~is 520.83 kVA~~ to achieve full rated output.
4
Calculation of Losses & Efficiencies

Calculations must all be ~~in the same units (~~kW or ~~kVA)~~, which ~~may be~~ is set by the UPS Power Factor.
Total Loss (kW~~/kVA)~~ = Sum of Losses [x = a + b + c]
Minimum Efficiency (% Out) = Product of Segment Efficiencies [y = a * b * c]
Maximum % Loss = 100% – Min. Effic. % Out [z = 100% – y] OR
Maximum % Loss = Total Loss Divided by *incoming service segment* Input [z = x/a] OR
Maximum % Loss = Algebraically Combined Product of Loss Percentages
$[z = (((a+b) – (a*b))+c) – (c^2(a+b)) – (c^2*a*b)]$
Electrical Loss Component (ELC) is Decimal Value of Maximum % Loss [ELC = z/100]

CALCULATION OF ~~PRE-UPS FEEDER~~ INCOMING SERVICE SEGMENT
NOTE to reviewers this table will be deleted.

VOLTS IN	CURRENT AMPS	INPUT POWER (kVA)	LENGTH FT.	WIRE GUAGE	OHMS /1000 ' (75°C)	RESIST. OHMS	LOSS VOLTS	END VOLTS	VOLTAGE LOSS (%)	END POWER (kVA)	POWER LOSS (kVA)	POWER LOSS (%)
480	630	523	250	1750 MCM	0.00756	0.00378	2.4	477.6	0.50%	521	2.60	0.50%
480	637	529	250	1750 MCM	0.00756	0.00378	7.2	472.8	1.50%	521	7.93	1.50%

The Incoming Service Segment is computed from combined wire and equipment losses.
Calculation begins at the Service Entrance Point where the Public Utility hands-off power to the customer.

The Incoming Service Segment includes all wire, transformers, and switchgear between the Service Point and the Input to the UPS,
Therefore, all losses in that circuit path must be calculated and summed to obtain the ELC.
Total Losses = Primary Feeder Loss + Service Transformer Loss + Switchgear Loss + Secondary Feeder & Transformer Loss + Conductor Loss to UPS.
Segment ELC = Total Losses / Primary Feeder Voltage or Power (3-Place Decimal)

~~Input Current to UPS at 480V, 3-Phase, is 630A.~~
~~Required *incoming service segment* Feeder Size per NEC is 1750 MCM~~
~~Feeder to UPS is 250 feet in length.~~
~~Feeder Resistance at 75°C rating is 0.00756 Ohms/1000 feet~~
~~Feeder Loss is 2.4V or 0.5%, = 2.60 kVA (Well within the allowable 1.5% Segment Maximum)~~
~~(If Feeder Loss exceeded 1.5%, and/or if a Transformer was included in the Pre-UPS Feeder Segment, either Feeder Size would need to be increased, or other ELC Segments would require less than maximum allowable loss to compensate.)~~

~~At 1.5%, Power Loss in Feeder would be 7.2V or 7.93 kVA~~
~~Required Input to UPS Feeder would then be 529 kVA~~

CALCULATION OF ITE DISTRIBUTION SEGMENT
"Worst Case" Example ITE distribution segment includes:
100 foot Sub-Feeder from UPS to 250 kVA PDU (350 MCM Wire at 480 V, 3-Phase, 300A)
480/208V Transformer in PDU at 96.6% Efficiency (2.4% Loss)
30 Foot Branch Circuit to Farthest Cabinet
(#10 AWG Wire at 208V, Single Phase, 24A, for 30A Rated Circuit)
250 kW PDU at Full Load draws 300 A at 480 V.

Calculation of PDU Feeder Loss
Note to reviewers this chart will be deleted.

VOLTS IN	CURRENT AMPS	INPUT POWER (kVA)	LENGTH FT.	WIRE GUAGE	OHMS /1000 ' (75°C)	RESIST. OHMS	LOSS VOLTS	END VOLTS	VOLTAGE LOSS (%)	END POWER (kVA)	POWER LOSS (kVA)	POWER LOSS (%)
480	310	257	100	350 MCM	0.0382	0.00764	2.4	477.6	0.49%	256	1.27	0.49%

~~250 kVA PDU at Full Load draws 310 A at 480 V.~~
~~PDU Sub-Feeder Loss is 2.4V or 0.49% = 1.85 kVA (Within Allowable 1% Loss)~~

~~Calculation of ITE Distribution Segment~~
Note to reviewers this table will be deleted.

Segment Element	IN kW/kVA	OUT kW/kVA	LOSS kW/kVA	LOSS %	MIN. EFFIC. (% OUT)
Wire to PDU	260	257	2.6	1.00%	99.00%
Xfmr	257	250	8.0	3.10%	96.90%
Dist. Wire	250	248	2.5	1.00%	99.00%
Dist. Effic.		248	13.1	4.66%	95.34%

~~PDU Transformer Efficiency is 96.9% (Within DOE requirements)~~
~~PDU Transformer Loss is 8.0 kVA~~
Note to reviewers this chart will be deleted.

VOLTS IN	CURRENT AMPS	INPUT POWER (kVA)	LENGTH FT.	WIRE GUAGE	OHMS /1000 ' (75°C)	RESIST. OHMS	LOSS VOLTS	END VOLTS	VOLTAGE LOSS (%)	END POWER (kVA)	POWER LOSS (kVA)	POWER LOSS (%)
208	24	5	30	#10 AWG	1.26	0.0756	1.8	206.2	0.87%	4.9	0.04	0.87%

Calculation of ITE Distribution Segment
Circuit Rating is 30 A, 208V, Single Phase

Maximum Allowable Continuous Current is 24A (80% of Breaker Rating) per NEC.
~~Branch Circuit Loss is 1.8V or 0.87 (Within 1.0% allowable.)~~

***Calculation begins with PDU Design Rating**
PDU is rated at 250 kW output capacity.
PDU Transformer Efficiency is 96.9% (Within DOE requirements)
PDU Transformer Loss is 8.0 kW
ELC is Less Than Distribution Component Value of 0.04.

(THIS APPENDIX IS NOT PART OF THIS STANDARD. IT IS MERELY INFORMATIVE AND DOES NOT CONTAIN REQUIREMETNS FOR CONFORMANCE TO THE STANDARD. IT HAS NOT BEEN PROCESSED ACCORDING TO THE ANSI REQUIREMENTS FOR A STANDARD AND MAY CONTAIN MATERIAL THAT HAS NOT BEEN SUBJECT TO PUBLIC REVIEW OR A CONSENSUS PROCESS. UNRESOLVED OBJECTORS ON INFORMATIVE MATERIAL ARE NOT OFFERED THE RIGHT TO APPEAL AT ASHRAE OR ANSI.)

INFORMATIVE APPENDIX D – ADDITIONAL GUIDANCE ON TELEPHONE EXCHANGES

The Telephone Exchange definition is a specific reference to a facility that is owned, managed or operated by a company or organization that is either designated by or recognized by public service commissions or public utility commissions, or recognized as such under federal, state, or local law, as installing, operating, and maintaining telecommunication systems.

These are facilities that have historically been classified by Code Enforcement officials and the industry as sites where telecommunications services such as telephone (landline, wireless) transmission, data transmission, internet transmission, voice-over internet protocol (VoIP) transmission, and video transmission are rendered. As such, the facilities typically include signal-processing equipment areas, cable entrance facility areas, power areas, main distribution frame areas, standby engine areas, and technical support areas. However, these space allocations and equipment profiles are also characteristics of a data center *not* delivering telecommunications services to the public, therefore the definition is properly applied where the facility being occupied by a telecommunications provider is the distinguishing factor.