Standard Voltage Ranges and Ratings

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Standard equipment voltage ratings and the associated tolerance limits are established by ANSI Standard C83.1 for electrical systems from 100 volts through 230 kilovolts. The question is often asked, "How do established equipment ratings relate to utilization voltage?" This Powell Technical Brief explains equipment voltage ratings, where they come from, and how they are related to the utilization voltage.

The voltage variation of a distribution system as a function of the actual load and the impedance between the source point and the point of voltage measurement is well understood. C94.1 identifies several of definitions necessary to understand the equipment's voltage ratings and the system's operating ranges.

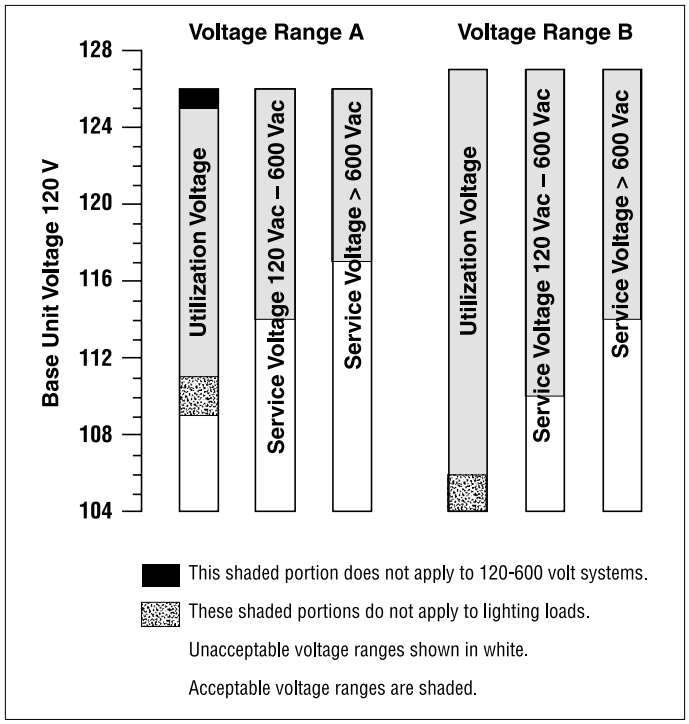
These definitions include:

- *System voltage* — the voltage bounded by the step-up and step-down transformer voltage, e.g., 240 volts, 480 volts, and 600 volts
- *Maximum system voltage* — the highest voltage at which the system will operate under normal conditions; the greatest voltage for which the equipment is designed to operate continuously without derating of other values such as short circuit rating
- *Utilization voltage* — the voltage at the terminals of the equipment, e.g., 230 volts, 460 volts, and 575 volts
- *Service voltage* — the voltage at the utility, or source supply, boundary.

The attached chart identifies the allowable voltage ranges in *per unit* values with a base voltage of 120 volts per unit. The chart shows two different ranges of voltage. The Range A portion of the chart illustrates the range over which voltage systems are designed to operate under normal conditions. The Range B portion of the chart is the allowable level of overshoot and droop that will happen while trying to regulate the system to the Range A values. It is the intent of ANSI C84.1 that operator intervention will compensate for extended operation at voltages outside Range A boundaries.

Range B also defines the range of voltage variation within which equipment must be designed to operate satisfactorily. The equipment nameplates vary in which voltage is used as *rated voltage*. For low-voltage power circuit breakers and the metal-clad switchgear, the voltage rating is the maximum system voltage as required by ANSI C37.12 and C37.20.2. For insulated case circuit breakers and molded case circuit breakers, NEMA ICS-1 allows either the utilization voltage or the nominal system voltage to appear on the nameplate.

For example, a motor control center will carry a nameplate listing the nominal system voltage, while the close-connected switchgear carries a nameplate listing maximum system voltage, and the motor is rated based on the utilization voltage as required in NEMA Standard MG1.



Why the differences? The differences in the standards are set to match up to the way the equipment fits into a system design. Switchgear is often operated at close to maximum voltage, since transformers are tapped to maintain the utilization voltage high in order to increase motor torque in the field. The motor control center can be close-coupled to the switchgear or remotely located, so the same design may have a utilization voltage approaching either the maximum service voltage or the system voltage.

An example of how the chart works:

For a 480-volt system the *maximum voltage* will be proportional to the new system's nominal system voltage by the ratio of the maximum per unit voltage (127 per unit) to the nominal voltage (120 per unit).

Maximum voltage rating for 480 volts is 508 volts. Therefore, "508V" will appear on the nameplate of the low-voltage power circuit breaker as the maximum voltage. The motor control center will list the system voltage of 480 volts. The motors connected to the motor control center will list the utilization voltage of 460 volts.

The difference between minimum service and minimum utilization voltages is the intended voltage drop within the wiring system. This difference is greater for services greater than that of 600 volts ac, which allows for a transformer voltage drop between service voltage and utilization equipment.

The Range B utilization voltage limits for 6900 volts ac and 13800 volts ac are 90 percent and 110 percent of the voltage rating of the standard motor and, thus, vary slightly from the chart.

I hope this helps to clarify the different voltage ratings. Please do not hesitate to contact me if I can be of further help.

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