CHAPTER 3

VOLTAGE SELECTION

3-1. General.

The design of electric supply and distribution systems can proceed only after a distribution voltage level has been determined. The electrical impact of the installation or facility as well as its location will influence the selection. A new service may be necessary or extension of an existing service may be acceptable. Before discussing selection of the system voltage, system voltage terminology and preferred voltage ratings need to be defined. Refer to the glossary for definitions of standard voltage terms.

3-2. System Voltage Classifications.

Voltage systems are classified either by the system use or the voltage range. More specific methods include using the voltage rating of equipment, the nominal voltage class, or the nominal system voltage.

a. System use. The requirement for electric power transfer will cause certain voltage levels to be more economical than others. A transmission system transfers energy in bulk between the source of supply (the utility) and the center for local distribution (the main electric supply station). A primary distribution system delivers energy from a main electric supply station to utilization transformers. A secondary distribution system delivers energy from a utilization transformer to points of utilization.

b. Voltage ranges. Voltage ranges are classified as low-voltage (1 kV or less); medium-voltage (above 1 kV to 99.9 kV); and high-voltage (above 99.9 kV).

c. Voltage rating of equipment. Voltage rating of equipment is based on nominal voltage classes which, in conjunction with the maximum voltage rating for that class, provides a simple method for rating equipment. Table 3-1 indicates the nominal voltage class designation (also known as the insulation class) used in this manual, along with the maximum voltage rating that may be handled by the equipment, and the normal basic insulation level (BIL) applying, and relates these characteristics to system use and voltage range.

d. Nominal system voltage. The nominal system voltage is the nominal value assigned to designate a system of a given voltage class. Nominal system voltages are classified by IEEE Std 141 as standard and nonstandard voltages. Table 3-2 lists standard and nonstandard nominal system voltages.

3-3. Selection of Primary Distribution Voltage for New Installations.

A preferred nominal system voltage such as 12 kV, 12.5 kV, 13.2 kV or 13.8 kV, will be selected for the primary distribution system. On sizable installations where distances to loads are considerable or loads are large, the use of 34.5 kV or 24.9

Table 3-1. System Use and Voltage Range Relationship to Equipment Rating,

System use	Voltage range	Equipment rating: Nominal voltage class kV	Equipment rating: Rated maximum voltage kV, rms	Equipment rating: BIL kV
Transmission	High	230	242	900
		161	169	750
		138	145	650
		115	121	550
		69	72.5	350
Primary distribution	Medium	46	48.3	250
		35	38.0	200
		25	25.8	150
		15	15.5	110
		7.5	8.25	95
		5	5.08	95

Standard Nominal System Voltages	Nonstandard Nominal System Voltages
Low-Voltages:	
120	110, 115, 125
120/240	110/220, 115/230, 125/250
208Y/120	216Y/125
240/120	
240	230, 250
480Y/277	460Y/265
480	440
600	550, 575
Medium-Voltages:	
2400	2200, 2300
4160Y/2400	
4160	4000
4800	4600
6900	6600, 7200
8320Y/480	11 000, 11 500
12 000Y/6930	
12 460Y/7200	
13 200Y/7620	
13 200	
13 800Y/7970	14 400
13 800	
20 780Y/12 000	
22 860Y/13 200	
23 000	
24 940Y/14 400	
34 500Y/19 920	
34 500	33 000
46 000	44 000
69 000	66 000
High-Voltages:	
115 000	110 000, 120 000
138 000	132 000
161 000	154 000
230 000	220 000
Ultra-High Voltages:	
345 000	
500 000	
765 000	
1 100 000	

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Table 3-2. Nominal System Voltages.

kV primary distribution systems may be more economical. Primary distribution voltages of the nominal 7.5 kV class and under will not be used, unless an off-site supply of a higher voltage is not available. Seldom is the lower voltage advantageous. For such cases, the size of the installation and the distances involved must make the use of voltages below 7.5 kV more economical in order to justify the selection.

3-4. Selection of Primary Distribution Voltage for Existing Installations.

When small facilities are added to an installation, the primary distribution system voltage within the addition will match the existing system. However, if the addition is substantial and large voltage drops or line losses can occur when existing voltages are retained, or if the main electric supply station is inadequate, then the economics of a higher voltage for the primary distribution system must be taken into account. The electrical master plan should have already provided for such deficiencies. When a master plan indicates a contemplated voltage increase, transformers for use in ongoing construction will be specified to have dual primary voltages, when economic and transformer delivery time considerations permit such a requirement. When a dual voltage, high-voltage transformer is specified, taps are not normally available for the lower voltage. For existing voltage drop problems, not having transformer taps available may create an untenable situation, requiring a facility boost transformer, or other means to serve the facility until the distribution system is upgraded. If the facility to be added is not included in the master plan, an engineering study will be necessary to determine the most feasible method of providing service. Acquisition or preparation of maps of transmission and distribution systems with distances between principle points and single line diagrams of the systems will be required. Then a determination of the extent to which the existing system voltage can satisfy installation requirements, or the economics of a higher voltage level and benefits of such a system will be evaluated.

3-5. Commercial Power for Air Force Installations.

Normally, the source of supply shall consist of a single tap into the nearest adequate utility company transmission line. Duplicate taps into the same source of generation or transmission shall be avoided. If duplicate taps are required for reliability, they shall have a single totalized metering point. Avoid multiple metering points for billing purposes. Metering of separate facilities or areas is encouraged for energy monitoring and control purposes. Engineering studies shall consider the entire cost of providing a reliable source of electric power. Arrange for the supply of commercial power during design. Resolve rates, terms, and conditions of service before making a commitment for construction charges, or minimum billings. AFI 32-1061 requires correlated action.

3-6. Selection of Primary Distribution Voltage for Air Force Installations.

The preferred primary CONUS distribution voltage is that found in the general area. Major expansions to existing systems utilizing 2,400-2,400/4,160-, or 4,800 volt primaries shall generally be converted to 12,470/7,200 volt primary system.