CHAPTER 3
EQUIPMENT DERATING

3-1. Derating under 50 Hz conditions.

Derating factors for 50 Hz operation are developed differently for different types of equipment. Derating factors for HVAC, electrical distribution and protection, safety and security equipment, communication equipment, lighting, and other electrical equipment are discussed below.

3-2. Heating, ventilating, and air conditioning (HVAC) for derating.

The frequency of the supply voltage affects two types of components in HVAC systems: motors and controls. From the discussion in paragraph 2-2, for the same mechanical load and voltage level, a 60 Hz motor will draw 20 percent more current when supplied from a 50 Hz voltage source. This assumes the iron core of the motor does not saturate. Therefore, a 60 Hz motor would have to be capable of handling the increase in current level. However, as was also mentioned in the previous chapter, saturation can be a serious problem when running a 60 Hz motor off a supply frequency of 50 Hz. Developing a derating factor to account for saturation is not possible, since the motor designs vary from vendor to vendor, and hence, the degree of saturation that would occur, if any, would be impossible to predict. Consequently, it is recommended that no horsepower derating be performed, and a 50 Hz motor be purchased.

a. However, if the vendor can guarantee the user that a given 60 Hz motor would not saturate at 50 Hz, then the motor would need only to be derated to handle the 20 percent increase in current level. The amount of horsepower derating required would depend on the motor's mechanical load, service factor, and thermal limit. The service factor is a measure of how much the motor can be overloaded continuously without exceeding safe temperature limits. The thermal limit is the minimum speed at which an AC motor can be operated with rated amperes, without exceeding safe temperature rise. The thermal limit is important because the motor's ability to cool itself will be reduced at lower speeds unless, of course, some sort of auxiliary cooling is used. In most cases, however, the minimum shaft speed necessary to exceed the thermal limit is much lower than 1500 revolutions per minute (RPM, for example, for a 4-pole motor), so 50 Hz operation should not be a problem, although the vendor should be contacted for verification. A 60 Hz motor with a 1.20 service factor can be operated safely while overloaded continuously by 20 percent. The same motor can be operated safely with a rated mechanical load and a 50 Hz power supply with no horsepower derating, assuming saturation is not an issue, the thermal limit of the motor is not exceeded, and the same voltage amplitude is applied. However, a 60 Hz motor, with a 1.0 service factor, driving a rated mechanical load would have to be derated for horse power by 20 percent, since it is not capable of handling greater than the rated current. In summary, the user should find out the service factor and thermal limit of the motor to determine the amount of horsepower derating required, and to ensure that the 20 percent increase in current level in the motor does not exceed the motor's rating (again, assuming saturation is not a concern].

b. Another issue to be considered when purchasing HVAC equipment for a 50 Hz environment is that the motor's shaft will spin 5/6 as fast as it would with a 60 Hz supply. For a 4-pole motor, the shaft will rotate at roughly 1500 RPM when run off a 50 Hz supply, where as with a 60 Hz voltage source it will rotate at about 18OO RPM. Consequently, equipment that is directly coupled to the shaft of the motor will rotate at 5/6 the speed it would in a 60 Hz environment. Hence, direct-drive equipment must be derated to account for the change in speed. In cases where the equipment is indirectly coupled to the motor shaft, through the use of adiustable pulleys for example, the reduction in shaft speed is not as much of a problem since the required speed of rotation can be obtained through the proper adjustment or selection of the pulleys.

c. Additionally, electronic HVAC controls that contain their own power supply may be 50 Hz sensitive. Most of the vendors contacted stated that this typically is not a problem because most controls are frequency-sensitive. If the control are 50 Hz sensitive, they must be purchased in a 50 Hz configuration. The HVAC vendor must be consulted on a case-bycase basis to determine if the controls can be used in 50 Hz environments.

3-3. Electrical distribution and protection.

In general, a 60 Hz transformer should not be used with a 50 Hz voltage source because of the potential saturation problem. As with motors, a derating factor cannot be developed to account for saturation because of the many different transformer designs on the market. It is recommended that a 50 Hz transformer be purchased for use with a 50 Hz voltage source. However, if a 60 Hz transformer vendor can ensure that a transformer will not saturate when operated at 50 Hz, the transformer should be fully capable of safely supplying its nameplate rated load (that is, no horsepower derating is required). In terms of the transformer's equivalent impedance, sometimes used for power system studies (for example, short-circuit and load-flow analysis), the 60 Hz value should be derated by 5/6 to account for the reduction in system frequency.

a. Power factor capacitors rated at 60 Hz must also be derated to 50 Hz. Capacitors do not consume any real power, but they do consume reactive power. The rating given to power factor capacitors is given in units of kilovolt-amperes reactive (KVAR), which indicates the amount of reactive power the capacitor will consume at the rated frequency. As mentioned in chapter 2, the capacitor's impedance, X_c, is inversely related to frequency. If the frequency drops from 60 to 50 Hz, the impedance will increase to 6/5 of its 50 Hz value. Since the KVAR rating equals V^2/X_c, if X_c at 50 Hz increases to 6/5 of its 60 Hz rating, the KVAR rating will decrease to 5/6 of its 60 Hz rating when the capacitor is used in a 50 Hz environment. Therefore, a 60 Hz-rated capacitor must have the KVAR rating multiplied by 5/6 to yield its 50 Hz KVAR rating.

b. Other electrical protection and distribution equipment either cannot or should not be derated. Electrical protection devices are generally able to be used at either 50 Hz or 60 Hz, but a different trip curve needs to be used by the power system designer for 50 Hz. These 50 Hz trip curves are readily available from vendors of this equipment, so no derating is necessary. The only exception is that some circuit breakers are designed differently at 50 Hz and 60 Hz.

c. Voltage, current, and power meters can be derated, but this practice is not recommended. A meter should display the true value it is supposed to measure to ensure that the readings are interpreted correctly and that no dangerous situations result. Meters, therefore, should not be derated. Automatic transfer switches use power supplies that may or may not be frequency-sensitive. Vendors must be contacted regarding 50 Hz configuration of these devices. Electrical generators must be purchased already configured to provide a 50 Hz voltage source.

3-4. Safety and security equipment for derating.

Safety and security equipment operate on a low-voltage AC or DC source that is generated by a power supply. Some power supplies are sensitive to frequency; others are not. In either case, derating is not necessary since power supplies sensitive to frequency cannot be derated, and power supplies insensitive to frequency do not need to be derated. In cases where the power supplies are sensitive to 50 Hz, vendors are able to ship the equipment with a 50 Hz-compatible power supply.

3-5. Communication equipment for derating.

Communication equipment operates on a low-voltage DC supply and does not need to be derated for frequency. Vendors will either ship the units with frequency-insensitive power supplies, or they will configure the units for 50 Hz operation before shipping.

3-6. Lighting for derating.

Incandescent lighting is not frequency-sensitive since this type of lighting consists of a resistive element (the filament), which is not frequency-sensitive. Fluorescent and high intensity discharge (HID) lighting, on the other hand, use a ballast to generate the proper lamp voltage and to limit the current flowing through the lamp. These ballasts are sensitive to frequency. Because of the numerous ballast designs and styles on the market, and the potential saturation problem, a simple derating factor cannot be developed and it is recommended that a vendor supplying 50 Hz-rated ballasts be located.

3-7. Other electrical equipment for derating.

Other electrical equipment consists of motors, motor starters, computer power supplies, and clocks. Motor derating was mentioned earlier in the HVAC section of this chapter. Motor starters are sensitive to frequency as well, but indirectly so. Since a 60 Hz motor will draw 20 percent more current when operated off a 50 Hz voltage source, assuming the same voltage amplitude is applied and there is no saturation problem, the motor starter current rating must be derated by 20 percent to account for the increase in current. Clocks and computer supply equipment are sensitive to frequency and cannot be derated. Clocks rely on the frequency of the supply to keep correct time, so a 60 Hz clock will not keep correct time at 50 Hz. Although derating factors could be developed for clocks, they would be meaningless. Computer power supply equipment cannot be derated due to the way the equipment is constructed.

3-8. Derating under alternate voltage conditions.

As appendix B shows, standard one-phase voltages around the world are either in the range of 100-127 VAC or 220-240 VAC. Voltage variations within about 10 percent of an equipment's rated voltage are acceptable, so derating for voltage will only be necessary when a piece of equipment rated for U.S. voltage (approximately 120 VAC) needs to be operated in an environment using 220-240 VAC. This would be a doubling of rated voltage. None of the equipment sensitive to voltage level is capable of surviving this increase without rapid failure. Thus, no derating factors for voltage level are offered. Instead, it is recommended that transformers be used to step the higher voltage level down to a voltage level in the range of 100-127 VAC, which U.S. equipment can tolerate. It has been found, however, that most vendors of voltage-sensitive equipment are able to configure the equipment for 220-240 VAC and corresponding threephase voltage levels.

3-9. Recommendations.

Derating factors were discussed and developed for the six generic types of equipment. Appendix C, which summarizes the discussion of derating factors presented in this chapter, is useful in identifying derating factors quickly and easily. Although this chapter presents derating factors for equipment, it is recommended that, whenever a piece of equipment is to be derated, the vendor be contacted to discuss the derating. It is always preferable to locate a vendor that will supply the equipment with the desired ratings before derating is attempted. The majority of vendors contacted are able to supply equipment rated at 50 Hz and a variety of voltage levels, so derating should be necessary in only a few cases.

3-10. Summary.

Appendix B can be used to rapidly identify the standard frequency and voltage levels in other countries. In cases where cities within a country differ in their electrical standards, the cities are listed separately. For countries in which all cities have the same electrical standards, typically only the capital city is listed. In these cases, assume that all cities in the country have the same electrical standards.