Cutler-Hammer

IT. Operation with Unbalanced Voltages

Application Note

Electromechanical Overloads and Starters

General

A motor operated with unbalanced three-phase voltages will be subject to higher heating than a motor operated from a balanced supply. This results from unbalanced current flow which is caused by the unbalanced voltages. The motor uses some of the current to generate the required load torque, the remainder only contributes to motor heating.

A 1% voltage unbalance can lead to as much as 6 – 10% current unbalance. NEMA recommends that a motor be operated on a three-phase line with a voltage unbalance of less than 5%, with an appropriate load reduction. NEMA defines voltage unbalance as:

Percent Voltage Unbalance = 100 x (Maximum Voltage Deviation from Average Voltage / Average Voltage).

For example, if the line voltages are 460, 467 and 450, the average voltage is 459 [(460 + 467 + 450)/3]. The maximum deviation from the average is 9 [459 – 450]. This results in:

Percent Voltage Unbalance = [(100 x 9) / 459] = 1.96.

The motor load must be reduced to counteract the additional heating that this unbalance causes. NEMA publishes a curve with the recommended derating factor in NEMA Standard MG 1-14.35.

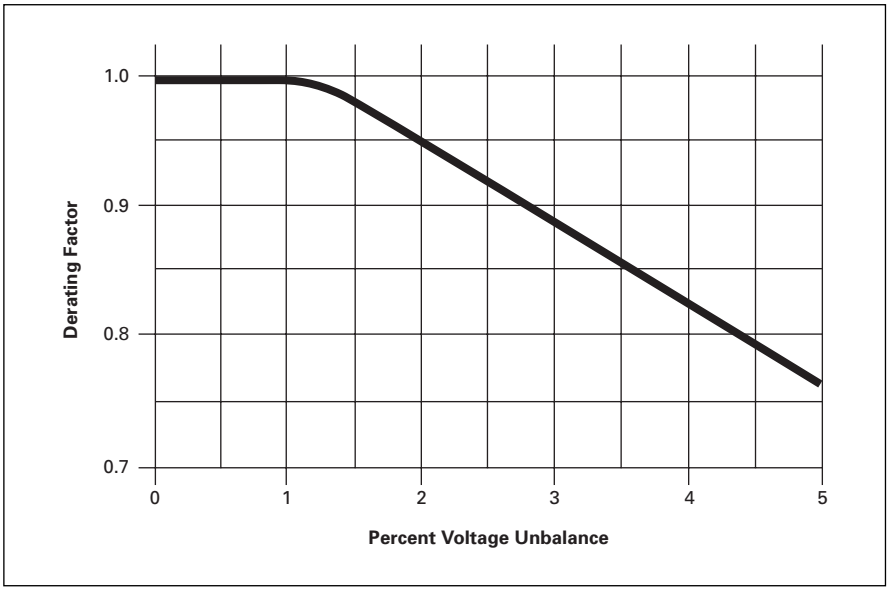

Figure 1. Derating Factor vs. Percent Voltage Unbalance

From this curve, the derating factor for a 1.96% voltage unbalance would be 0.95, which equates to a required motor load reduction of 5% to keep the motor's temperature within rated limits.

IEC unbalanced voltage information is contained in IEC 610034:

Three-phase AC motors shall be suitable for operation on a three-phase voltage system having a negative-sequence component not exceeding 1% of the positive-sequence component over a long period, or 1.5% for a short period not exceeding a few minutes, and a zero-sequence component not exceeding 1% of the positive-sequence component.

IT. Overload or Starter Response to Unbalanced Current

The response to an unbalanced current depends upon the magnitude of the unbalance. If the phase current unbalance is such that the magnitude of one or two of the line currents is 50% or less of the remaining line(s) for longer than 10 seconds, a phase current unbalance trip will occur.

If the magnitude of the current unbalance is less, but one or two of the line currents exceed the overload full load ampere setting, the thermal memory is increased leading to an overload trip when the level becomes high enough.

Setup — *IT.* Overload or Starter

Because of the additional motor heating, the desired temperature of part of the motor windings will be exceeded at lighter loads than would be typical for a balanced supply. This must be taken into account when setting up the motor full load ampere setting on the ***IT.*** Overload or Starter.

After the appropriate derating factor has been calculated, the FLA setting for the ***IT.*** Overload or Starter must be reduced by this factor. For example: if the motor FLA rating is 52 amperes, and the line voltage unbalance is 1.96%, the correct setting is 0.95 x 52 = 49.4 amperes.

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