Manufacturers of Engineering and Production Test Equipment
An ISO 9001:2000 registered company

AN102
APPLICATION NOTE

K-Factor Defined

In today's industrial workplace, the proliferation of solid state devices (lighting ballasts, motor drives and controls, communications equipment, and other DC-powered loads) has created a major problem for specifying engineers, contractors and building owners. The non-linear nature of their switched-mode power supplies generate harmonic currents that cause transformers and system neutrals to overheat and destroy themselves.

What is K-Factor?

K-factor is a weighting of the harmonic load currents according to their effects on transformer heating, as derived from ANSI/IEEE C57.110. A K-factor of 1.0 indicates a linear load (no harmonics). The higher the K-factor, the greater the harmonic heating effects.

When a non-linear load is supplied from a transformer, it is sometimes necessary to derate the transformer capacity to avoid overheating and subsequent insulation failure.

The reason for this is that the increased eddy currents caused by the harmonics increase transformer losses and thus generate additional heat. Also, the RMS load current could be much higher than the kVA rating of the load would indicate. Hence, a transformer rated for the expected load will have insufficient capacity.

The K-Factor is used by transformer manufacturers and their customers to adjust the load rating as a function of the harmonic currents caused by the load(s).

Generally, only substation transformer manufacturers specify K-factor load de-rating for their products. So, for K-factors higher than 1, the maximum transformer load is de-rated.

Some manufacturers, who produce both transformers and products like motors or ballasts, are sensitive to measuring K-factor since they know that poor K-factors of ballasts and motors will de-rate the maximum load their transformers can carry. From the customer's viewpoint, K-factor must be established in order to calculate the size of the transformer that is needed. In other words, if a company with many offices were to install poor quality electronic ballasts having a poor K-factor, a larger transformer would be needed than is apparent from the overall power consumption calculation.

K-Factor Calculation

The K-factor is a number derived from a numerical calculation based on the summation of harmonic currents generated by the non-linear load. The higher the K-factor, the more significant the harmonic current content

The algorithm used to compute K-factor is:

$$\frac{\sum_{1}^{34} (i_h * h)^2}{\sum_{1}^{34} i_h^{\,2}} \qquad \text{where h is the harmonic \#}$$

Details of the calculation method can be found in IEEE Standard 1100-1992.

So, the higher harmonics are heavily weighted. As an example, a current signal having a 10% 3rd, 5% 5th, and 3% 7th harmonic content, would have a K-factor of 1.18. From manufacturers specifications, one can read the load de-rating that has to be applied for this K-factor.

K-Factor Transformers

Underwriters laboratory (UL) recognized the potential safety hazards associated with using standard transformers with nonlinear loads and developed a rating system to indicate the capability of a transformer to handle harmonic loads. The ratings are described in UL1561 and are known as transformer K-factors.

K-factor transformers are designed to reduce the heating effects of harmonic currents created by loads like those in the table below. The K-factor rating is an index of the transformer's ability to withstand harmonic content while operating within the temperature limits of its insulating system.

Load	K-Factor
Electric discharge lighting	K-4
UPS with optional input filtering	K-4
Welders	K-4
Induction heating equipment	K-4
PLCs and solid state controls (other than variable speed drives)	K-4
Telecommunications equipment (e.g. PBX)	K-13
UPS without input filtering	K-13
Multiwire receptacle circuits in general care areas of health care facilities and classrooms of schools, etc.	K-13
Multiwire receptacle circuits supplying inspection or testing equipment on an assembly or production line	K-13
Mainframe computer loads	K-20
Solid state motor drives (variable speed drives)	K-20
Multiwire receptacle circuits in critical care areas and operating/recovery rooms of hospitals	K-20

Table 1. Typical Load K-Factors

To help get around the problem of successfully applying derating factors to conventional transformers, the K-factor is used by transformer designers to develop transformers made especially for non-linear loads and the extra heating caused by the harmonic currents. Transformers come in basic K-factors such as 4, 9,13, 20, 30, 40, and 50.

The strategy is to calculate the K-factor for your load and then specify a transformer with a K-factor of an equal or higher value. In this way, the transformer can be sized to the load without derating.
The advantage of using a K-factor transformer is that it is usually more economical than using a derated, oversized transformer.