The Electrical Power Engineers

Qual-Tech Engineers, Inc.
201 Johnson Road – Building #1 · Suite 203
Houston, PA 15342-1300

Phone 724-873-9275 – Fax 724-873-8910
www.QualTechEng.com

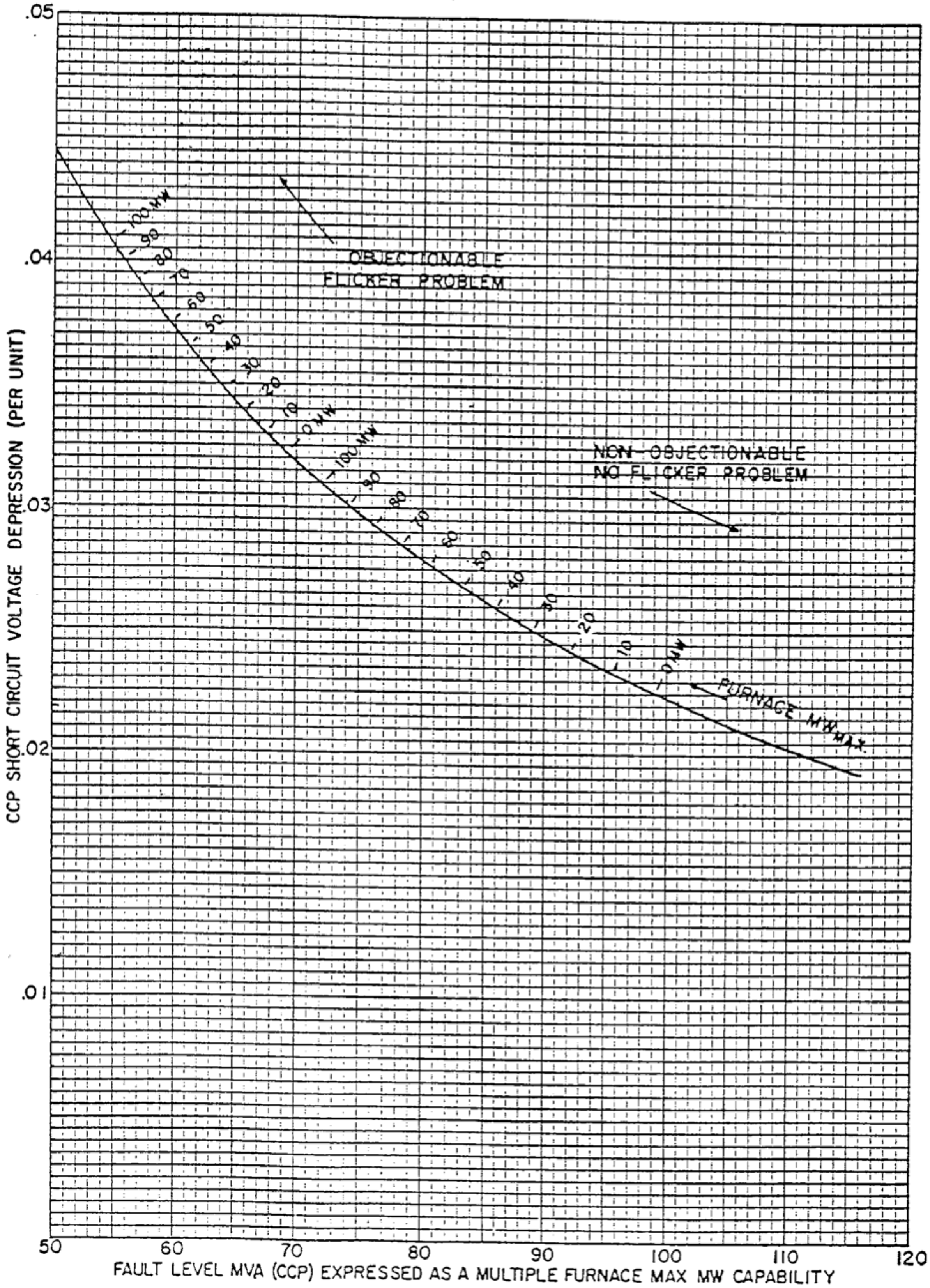
THE HISTORY OF FLICKER LIMITS

Flicker generally refers to lighting variations that are detectable by the human eye. It is caused by voltage fluctuations on the utility system most commonly due to large industrial arc furnaces. Much has been written with regard to limiting flicker as far back as the 1920's. The most recent standard with regard to flicker limits is IEEE Standard 1453-2015, "IEEE Recommended Practice for the Analysis of Fluctuating Installations on Power Systems". This standard is based on IEC-61000-4-15-2010, which gives details for flicker calculations and measurements. A brief summary of the recent history of how these new standards were developed is given here.

1. A paper written by General Electric Company in 1975 gives guidelines for applying large arc furnaces based on the most recent data at that time concerning flicker. Based on the MW rating of the furnace, the user can determine the MVA short circuit that is required such that flicker will not be objectionable. Figure 1 gives the key guideline graph developed in the paper. For example, if a plant was installing a 100 MW arc furnace, the MVA short circuit at the point of common coupling would need to be greater than 7200 MVA for flicker to be non-objectionable based on Figure 1. If the MVA short circuit was less than 5500 MVA, the flicker would be objectionable. If the MVA short circuit was between 5500 and 7200 MVA, flicker would be borderline. The short circuit voltage depression at the point of common coupling can be read from the scale along the x-axis. The voltage depression was based on typical arc furnace impedance quantities.

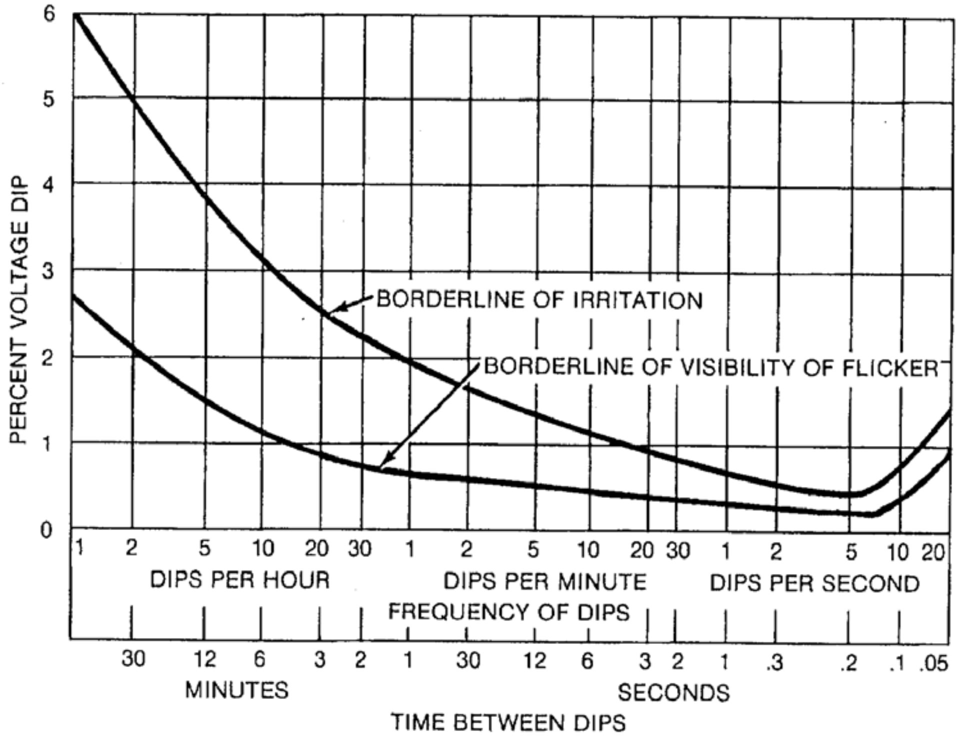
2. Section 3.9 of the Red Book (Standard 141-1993) gives a guideline graph for flicker used by many utilities and is based on both the magnitude and frequency of changes to the supply voltage. This guideline graph is shown in Figure 2.

3. The most recent guidelines for flicker are given in IEEE Standard 1453-2015. Section 4 of this standard gives a brief history of the development of voltage flicker limits in the United States. The most recent guidelines are designed to include loads that produce modulation of the voltage magnitude that is more complex than what was expected by the original flicker curves. Figure 3 is taken from IEEE Standard 1453-2015. It gives the weighting curves for 230V lamp applications, which are common in much of the world, and 120V lamp applications, which are more common in North America. These have been referred to as the Pst = 1 curves.

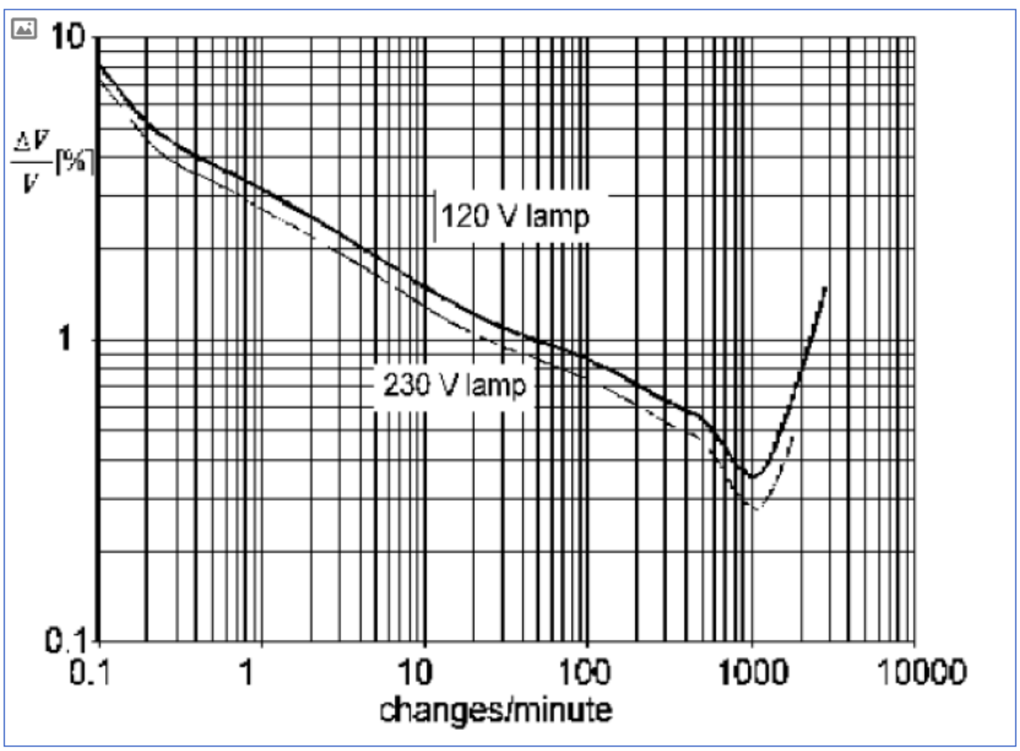


Fault Level MW_{MAX} Ratios and Accompanying Short Circuit Voltage Depression

Figure 1



Range of Observable and Objectionable Voltage Flicker versus Time
Figure 2



Note – Two consecutive voltage changes (one positive and one negative) constitute one "cycle", i.e. two voltage changes per second mean a 1 Hz fluctuation.

Pst = 1 Curve for Regular Rectangular Voltage Changes
Figure 3

4. It can be seen that the Pst = 1 curves in Figure 3 are similar to the borderline of irritation curve given in Figure 2. When comparing graphs, care must be taken to be sure that the x-axis of the graphs being compared are in the same units. One must know that 1 dip per second equates to 2 changes per second and the term dips per second is used interchangeably with the term frequency. This is discussed and illustrated in Annex B of IEC-61000-4-15.

5. The development of the Pst probability concept gives a means for numerically evaluating the severity of the flicker based on both the magnitude and rate of fluctuation of the supply voltage. The 95% and 99% Pst values are recommended for use in the evaluation. The details of this concept are given in IEEE Standard 1453-2015. It is the basis of the methodology used in modern flicker meters.

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