A great deal of confusion exists in the term kVp. At present, there is no universally accepted definition of kVp. Differences exist between definitions by service engineers, physicists and manufacturers. The purpose of this note is to differentiate between the major definitions currently in use. A non-invasive meter may measure the “kVp” using any of the definitions given here. The first two definitions are generally used by invasive voltage dividers.

The definition of kVp involves interpretation. The factors to consider for an appropriate definition of kVp are: 1. Ability to define a reproducible physical method for kVp measurement, 2. Ease of measurement technique, 3. Clinical relevancy of the definition, i.e., relation to image density and contrast and 4. Relevancy to technical aspects of the x-ray machine and its performance. The University of Wisconsin Radiation Calibration Laboratory (UW RCL) is investigating a definition of kVp that combines all of the above factors.

The waveform of the x-ray generator is an important criterion to be considered. If a constant potential waveform is in use that has no variation from the constant voltage as set, then all of the following definitions yield the same results. Non-invasive meters use the x-ray beam as the quantity of measurement whereas the invasive dividers use the electrical system of the generator as the quantity to be measured.

There is no longer a national standard or a laboratory that will calibrate an invasive voltage divider at very high frequencies. Thus, the traceability of kVp is in question. The University of Wisconsin has a number of NIST traceable kVp calibrations obtained while NIST still calibrated kVp. It has been demonstrated that voltage dividers can change their calibration at higher frequencies. The highest frequency normally calibrated is roughly 8000Hz. Many generators, especially mammographic generators, operate at frequencies of 10,000Hz or more. In addition, national laboratories will not calibrate non-invasive meters. UW RCL has been calibrating non-invasive meters since 1981 and has a great deal of experience in the calibration of all types of non-invasive kVp meters.

The definitions of kVp generally fall into three main categories: kVp(max), kVp(ave) and kVp(eff). Any non-invasive kVp meter may measure one or more of these. It is important that the user be aware of what the meter is measuring and how it compares to the original calibration of the x-ray generator.

1. kVp(max): maximum peak potential. Maximum value of voltage any time during exposure.
2. kVp(ave): average peak potential. Average of all peak values during the exposure.
3. kV(ef f): effective potential. Effective voltage giving same image contrast as a constant potential x-ray system.
4. kVp(ef f): effective peak potential. Product of kV(ef f) and a factor (value >1) dependent on the x-ray generator waveform. The multiplicative factor is related to the voltage waveform and is dependent on the ripple of the x-ray generator: In the case of idealized ripple, kVp(ef f) = kVp(ave). If the ripple is less than idealized, then kVp(ef f) > kVp(ave) and finally if the ripple is greater than idealized ripple, then kVp(ef f) < kVp(ave).

The UW RCL is able to provide a calibration of any means of kVp for any type of non-invasive kVp meter. A full report is provided for each calibration as well as application information as requested by the customer.

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