Brithinee innovation takes on inverter-fed voltage spikes

Since the early 1980s there has been a massive increase in the number of three-phase motors operated on electronic adjustable speed drives (ASDs). By the end of that decade, the use of very fast-acting power transistors were adopted, to reduce motor noise and smooth the operation of the motor, thus further increasing the uptake of motors and electronic drives for speed control.

Indeed, the largest opportunities for saving energy in industrial electric motor driven systems usually include adding speed control of pumps, fans, and compressors. So, there are plenty of reasons for expecting the further increase of ASD and motor combinations. But, the fast-switching transistors, in addition to other factors, created a more hostile electrical environment for the motors' windings and bearings. One effect, partial discharge, degrades the resins, varnishes and other organic electrical insulation used in a modern motor winding. This is similar to a static discharge. Its effect is to create ozone and oxides of nitrogen in the voids, and these erode the organic material used to insulate the conductors.

What is partial discharge?

The short voltage rise-time and high peak volt- ages at the motor terminals (due to a long cable run or a variety of other reasons), plus the simultaneous occurrence of an initiatory electron, are conditions necessary to produce partial discharge. These occur in the voids of the motor windings.

There is a threshold voltage, below which partial discharge does not occur if the peak voltages are below that threshold voltage. We call that the "partial discharge inception voltage." (Once partial discharge activity begins, there is still another value, the "extinction voltage", below which the partial discharge activity ceases. But, that's not our concern here.) Several devices can be used to determine the PDIV.

Xin (Crystal) Xue, Ph.D. measures partial discharge inception voltage at Brithinee Electric's Colton plant.

> Partial discharge is small electric sparks that occur within air pockets in the insulation or on the surface of coil insulation and degrade organic materials such as films, polyesters, and epoxies.
>
> **Greg C. Stone**

Partial discharge is a localized dielectric breakdown of the insulation system under high electrical stress. Partial discharge can occur at any point in the insulation system where the electric field strength exceeds the breakdown strength of that portion of the insulating material.

Measuring the partial discharge inception voltage (PDIV)

One method includes using a surge-generator, such as a Baker surge-comparison test device, plus Iris Power Engineering's PDAlert and an Agilent oscilloscope. By slowly increasing the magnitude of the surges from the Baker surge generator until partial discharge (PD) is observable on the oscilloscope, we determine the PDIV for each phase of the winding.

We will say that the lowest of the PDIV values obtained is the PDIV for the motor. If the peak voltages from an ASD installation exceed that value, then the motor windings will likely have an unacceptably short life.

Each ASD, motor, and cable installation system will have a somewhat unique electrical environment, but the NEMA Standard MG-1 Part 31 and International Electrotechnical Commission (IEC) technical specification 600034-18-41 recommended practices give some guidance for minimum acceptable PDIV.

Why do we measure PDIV?

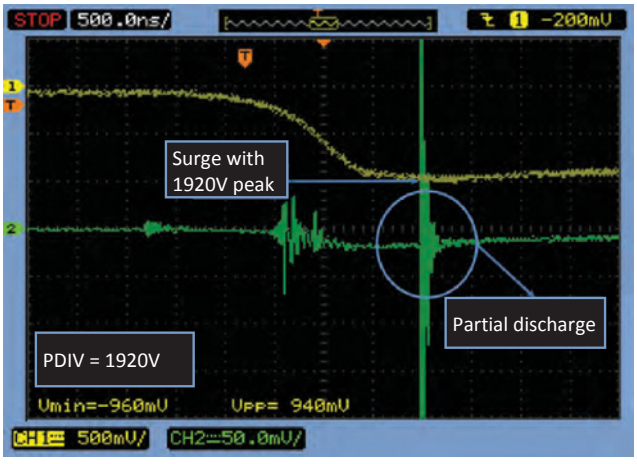
There have been no defined tests or set of tests for determining when a motor is "inverter-duty." Work still needs to be done in that area. However, we all know that premature failures are costly, and thus the measurement of PDIV, along with the IEC guidelines, help to avoid those costly failures.

By measuring the PDIV at various stages of the motor winding process, we can investigate the usefulness of the various winding materials and the processes involved in producing a finished winding in raising or meeting the desired PDIV values. So, for example, when DuPont[1] introduces new, innovative advanced fiber products, the PDIV values obtained will help in our material evaluation.

Further study of existing "old" windings will shed some light on the insulation aging process and on the introduction of contaminants into the windings.

[1] DuPont® and Nomex® are a trademarks or registered trademarks of E.I. Dupont de Nemours and Company and issued under license by Brithinee Electric.

Partial Discharge Inception Voltage (PDIV)	Lowest value of 3 phases
Brithinee winding (quad build wire, VP, 12-lead, 10 HP 6 pole)	2'920
Brand A	2'320
Brand B	1'840
Brand C	1'280
Brand D	1'840
Brand E	1'600
Brand F	480



Screen image from Agilent oscilloscope using Iris Power Engineering PDAlert instrument and Baker surge generator.

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