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Re submission by NEMA and Philips concerning JA10

Additional submitted attachment is included below.

Comments on NEMA77, SVM and Philips request

1. The NEMA77 document perpetuates the idea that there is something called a static observer. No observer is ever static. The eye is in continuous motion and in consequence of the occasional great rapidity of this motion very high frequency flicker is rendered as a pattern on the retina.
2. The pattern is called the *phantom array*. Humans make 2-3 saccades per second and some are large. When large, saccades are fast, up to about 700 degrees per second for saccades with amplitude of more than 10 degrees. In consequence, patterns can sometimes be seen at frequencies in excess of 3kHz. They can be seen when the target is a stationary light fixture, giving multiple images of the fixture with each saccade.
3. NEMA 77 refers to temporal light artefact (TLA) but considers only the *stroboscopic effect* – the visibility of ghosting when tracking a moving target that is intermittently illuminated. The NEMA77 document makes no mention of the phantom array, even though this temporal light artefact is far more prevalent than the stroboscopic effect, having the potential to occur with every saccade independently of the motion of objects in the scene. This selective consideration of TLAs renders any 'standard' partial, and in this instance, overly permissive.
4. The measurements made by Philips are exclusively of the stroboscopic effect that occurs when observing a rotating wheel 15 degrees in diameter on which is a white spot. The saccades involved in such measurements are small and mixed with movements of smooth pursuit. The measurements are not a surrogate for measurements of other TLAs, including the phantom array.
5. The effects of wave shape and duty cycle are, contrary to frequently promulgated misconceptions, well described in terms of the Fourier transform of the waveform, and the Fourier components can then be described in terms of their amplitude, as spelled out in IEEE1789. Such an approach is represented in practical terms by JA10.
6. The criteria set out in IEEE1789 are not "overly strict for many applications" and the applications for which they may be unnecessarily strict are not identified in NEMA77 (an interesting omission in itself). Does one wish to specify the range of applications for which a given lighting product may be used, and then police those instances where it is incorrectly used?
7. Attempts to estimate the additional cost of adhering to IEEE1789 would seem to indicate that the marginal cost is cents, not dollars.
8. IEEE1789 is based partly on preliminary data concerning the phantom array and for simplicity it assumed a monotonic function. Although it has been criticised as too conservative, there are now recent data to suggest that it is actually insufficiently so, at least for the purposes of eliminating perception of the phantom array. This is because:
    a. The phantom array is a pattern and patterns are most visible at a spatial frequency of 3 cycles/degree, at least in normal view. As the frequency of flicker increases from 100Hz to 300Hz so the spatial frequency of the phantom array should increase from about

1 cycle per degree to about 4 cycles per degree with a 10-degree saccade. We have data to show that the phantom array in response to 300Hz flicker is MORE visible than that in response to 100Hz flicker, i.e. the visibility is a *non-monotonic* function of frequency.

b. The visibility of the phantom array is determined by the size of the retinal image of the target. With large targets the image from one flash is partially superimposed on the image from the next flash, reducing the contrast, and with it, the visibility of the pattern. In recent work we have observed that with small targets subtending less than 6 minutes of arc, thereby avoiding superposition from one flash to the next, the phantom array can reliably be seen by some observers at frequencies as high as 6kHz.

9. Many incandescent lamps fall within the low-risk region of IEEE1789. Their output is sinusoidal, with no frequency components above the frequency of the ac supply. As mentioned above, the phantom array is more visible at 300Hz than at 100Hz probably because the pattern is closer to the peak of the contrast sensitivity function. This means that in principle incandescent lamps are less likely to induce a phantom array than, for example, a gas discharge lamp, the output of which has harmonics at frequencies higher than that of the supply.
10. At 120Hz the phantom array is not visible at contrasts less than about 10% (the modulation depth typical of incandescent lighting) but becomes visible at contrasts in excess of 30% (the variation typical of magnetically ballasted fluorescent lamps). Fluorescent lamps have been associated with complaints whereas incandescent lamps have not. The phantom array may be a proxy for discomfort. If so, it is important to consider those frequencies and modulation depths at which it becomes visible.
11. SVM is derived substantially from Philips' own measurements of the stroboscopic effect. It does not apply to the phantom array. With its suggested 'acceptability' threshold of 1.0 (with some proposing even higher values) the shortcomings can be summarised as follows:
    a. SVM captures a restricted subset of flicker/TLA sources and phenomena
    b. This restricted subset relates to the (relatively) less serious manifestations of TLA – includes the stroboscopic effect, but excludes phantom arrays, etc
    c. The proposed SVM=1.0 threshold corresponds to a detection-rate amongst a sampled population, of 50%!
    d. The latest 'lobbied for' limit of 1.3 corresponds to a significantly higher detection-rate, thereby allowing TLA levels that are detected by a *majority* of the healthy population. . There is no consideration of the visibility of flicker by the minority of light-sensitive people. Lighting should be satisfactory to all sectors of the community.

    Therefore, in summary, SVM limits exposure to the relatively less-serious forms of TLA, to an extent that would be deemed acceptable by half the population, or less, whilst neglecting more serious forms. To place it, therefore, on a level-footing with IEEE 1789 would be, in

our view, both a categorical error and an inappropriate use of a restricted dataset.