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## NEMA Response to Comments on NEMA Standard Publication 77-2017 in Docket 17-BSTD-02

*Additional submitted attachment is included below.*

Setting Standards for Excellence

**KYLE PITSOR**
Vice President, Government Relations

February 22, 2018

Online via: https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=17-BSTD-02

Mr. Payam Bozorgchami
California Energy Commission
Dockets Office, MS-4
Re: Docket No. 17-BSTD-01
1516 Ninth Street
Sacramento, CA 95814-5512

**NEMA Response to Comments on NEMA Standard Publication 77-2017 in Docket 17-BSTD-02**

Dear Mr. Bozorgchami,

As the leading trade association representing the manufacturers of electrical and medical imaging equipment, the National Electrical Manufacturers Association (NEMA) provides the attached comments in response to docketed criticism of NEMA Standard Publication 77-2017 with respect to its usefulness in the evaluation of Flicker for California's Title 24 Building Energy Efficiency Regulations Joint Appendices 8 & 10 and the legality of allowing it as a substitution with respect to anti-backsliding laws in California. These comments are submitted on behalf of NEMA Lighting Systems Division Member companies.

The National Electrical Manufacturers Association (NEMA) represents nearly 350 electrical equipment and medical imaging manufacturers that make safe, reliable, and efficient products and systems. Our combined industries account for 360,000 American jobs in more than 7,000 facilities covering every state. Our industry produces $106 billion shipments of electrical equipment and medical imaging technologies per year with $36 billion exports.

Our Member companies count on your careful consideration and we look forward to an outcome that meets their expectations. If you have any questions on these comments, please contact Alex Boesenberg of NEMA at 703-841-3268 or alex.boesenberg@nema.org.

Sincerely,

Kyle Pitsor

Kyle Pitsor
Vice President, Government Relations

**NEMA Response to Comments on NEMA Standard Publication 77 in Docket 17-BSTD-02**

General Comment:
We request that NEMA Standard Publication 77-2017 "Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria" be reinstated as it appeared in pre-rulemaking language[1] as a method for qualifying products to Title 24. The NEMA 77 standard measures for Temporal Lighting Artifacts (TLA), Short-Term Flicker Index (Pst) and Stroboscopic effect Visibility Measure (SVM), are based on direct measurements of human sensitivity to flicker and stroboscopic effect, and have a firm scientific basis. NEMA 77 is much stricter than Title 24's present requirements in the frequency range where humans are most sensitive to TLA (below about 50 Hz). It is less strict than Title 24's present requirements at higher frequencies, where humans are less sensitive to TLA and health risks are low.

Some parties have implied that acceptance of NEMA 77 as an alternative flicker test method and performance requirement would constitute backsliding of CEC efficiency regulations. NEMA disagrees. NEMA does not concur in that view and comments on that issue at the end of this document.

Aside from the aforementioned legal consideration, several docket submissions have suggested that NEMA 77 be disallowed in Title 24. We disagree with those arguments and provide detailed responses to them below.

1. TN221851_20171122T123607_Dave_Bannister_ Response to California Energy Commission consultation on 2019 Building Energy Efficiency Standards Pre-Rulemaking[2]:
    a. We note that Mr. Bannister has a driver IC company in the United Kingdom that claims to produce a specialized driver for low-ripple driving current for LEDs.
    b. We dispute Mr. Bannister's statement that IEEE 1789-2015, is "now widely accepted". It is not, and it is not suitable for general lighting regulations. IEEE 1789-2015 is merely widely discussed. Its limits are intended to rule out any possibility of any biological effect (including visibility), whether that effect is to a person's health *or not*. From that perspective it is overly strict and not suitable for general lighting regulation. At the time IEEE 1789 was written in 2014-2015 there was little or no information for many of the effects of TLA on humans. Because IEEE 1789 is a literature study and IEEE did not conduct original research, the limits selected in IEEE 1789 are quite conservative, and informed only by the literature that was available at the point in time when the standard was developed. The limits are so conservative in fact, that a regulation which implemented the IEEE 1789 'Low-Risk' limit would not allow the majority of historic incandescent lamps (see Figure below). Incandescent lamps used in the United States straddle the low risk line. No incandescent lamps used in Europe

[1] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221269_20170920T160742_Draft_2019_Standards_Joint_Appendix_8.pdf See clause 8.3.7

[2] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221851_20171122T123607_Dave_Bannister_Comments_Response_to_California_Energy_Commissio.pdf

meet the low-risk limit. No incandescent lamps anywhere meet the even stricter 'No-Effect' limit. The CEC would be contradicting its long-standing position that replacement lamps should mimic incandescent lamp visual performance as closely as possible (most typically in the case of Color Rendering Index) and miss this important fact. The suitability of visual appearance of incandescent lighting has been well-established for over 100 years. *It follows that while IEEE 1789's recommendations may be reasonable to use in special applications where it is absolutely essential to avoid TLA, they are not suitable for general illumination applications.*

c. This following table summarizes the IEEE 1789 effects for various biological effects. It originates from International Energy Agency (IEA) (graphics are taken from a presentation[3] by Mr. Stephen Coyne):

## Cause and Effects

| Biological Effect | Frequency range reported | Other conditions reported | Suggested low risk level requirements |
|---|---|---|---|
| **Visible flicker** | • 0.5 – 35 Hz (8.8 Hz peak sensitivity) | • Low threshold for % modulation | • Short-term flicker metric, $P_{st}$ LM < 1 (IEC 61000-4-15) |
| **Photosensitive seizures** | • 3 – 65 Hz (15-25 Hz peak sensitivity) | • Visual field ≥ 0.006 sr<br>• Luminance change ≥ 20 cd.m$^{-2}$ | • ≤ 5% Light modulation (frequency independent)<br>or<br>• ≤ 20 cd.m$^{-2}$ variation for 3 – 65 Hz |
| **Stroboscopic effect** | • 50 – 2000 Hz | • High % modulation<br>• Low duty cycles for | • More research required |

[3] https://ssl.iea-4e.org/news/sydney-conference

## Cause and Effects

| Biological Effect | Frequency range reported | Other conditions reported | Suggested low risk level requirements |
|---|---|---|---|
| **Migraine** | • Unknown (But flicker confirmed as trigger) | • None | • More research required |
| **Autistic behaviour** | • Unknown (But indication of flicker as trigger) | • None | • More research required |
| **Task performance and eyestrain** | • < 1250 Hz | • % modulation<br>• Duty cycle for Pulse Width Modulated | • ≤ 1% Light modulation (frequency independent)<br>or |

Migraines are frequently listed as a reason to use IEEE 1789 specifications for stroboscopic effect. However, quoting directly from IEEE 1789 itself:

> "A single case report [emphasis added] was located (Kowacs et al. [B68]) involving a 25-year-old male who suffered migraines consistently when viewing a 60 Hz computer screen but encountered no ill effects from the same screen when the refresh rate was set to 75 Hz."
>
> and
>
> "7.4.3.2 Conclusions
>
> Data and Expert Opinion exist that flicker can trigger migraines. Very Limited Data and Expert Opinion exist on the nature or range of influential parameters. Solid Data exist on the epidemiology of migraines. Limited Data exist on the fraction of migraine sufferers for whom flicker acts as a trigger.
>
> 7.4.3.3 Low-Risk Level
>
> No information available."

Conclusion: The above quoted content from IEEE 1789 and the IEA 4E SSL Annex[4] are obviously not sufficient data on which to base a regulation for frequencies above 60 Hz. The only data showing an effect of TLA on migraines is for frequencies below 75 Hz, which is in the region where flicker plays a dominant role, not stroboscopic effect. While IEEE 1789 was the leading reference available when JA-10 was written, better references are now available and should be made alternatives, if not replacements, to the existing Annex.

d. We note the proposed limits of NEMA 77 are much closer to the IEEE 1789 specification than CA Title 24 Joint Appendix JA-10 are. (See Figure below.)

e. Mr. Bannister suggests in his comments that NEMA 77 is inappropriate because it was developed in highly controlled laboratory conditions. Highly controlled lab conditions make TLA visibility clearer, not less clear. Subjects are exposed to only one light source, told what to look for and asked to report visibility. In the real world, stroboscopic effect is less likely to be observed, because there is usually more than one light source in a space. Phantom array is visible in high-contrast situations – like brake lights on cars outdoors at night. Indoors, for luminaires using Pulse Width Modulation (PWM) at certain frequencies, phantom array may be visible when one scans one's eyes across the luminaire. In general, phantom array is a smaller issue than stroboscopic effect. Additional research is still needed to quantify phantom array.

f. At a visual interference level of 50% (SVM = 1.0) the visual phenomenon of flicker is just barely perceptible if you have been asked to pay attention in highly controlled lab conditions. That is why SVM=1.0 is the appropriate threshold for *observation*. In contrast, Title 24's present specification allows TLA that is visible to nearly 100% of the population, with or without motion (30% modulation depth below about 50 Hz – see figure below).

g. There is no available substantiated evidence that non-direct visible effects cause problems. A normal individual may notice TLA and not know how to describe it or see it (by waving a pencil for example) and therefor conclude that it is 'invisible'. *If flicker is barely perceptible, it follows that sensors in the eye are not reacting reliably to the phenomenon.* It also follows that there is reduced or negligible opportunity to cause additional biological interference if the perception is low to non-existent. Highly common, and widely accepted, devices such as cell phones, monitors and televisions all have high modulation depth at a few hundred hertz or less, but there is no credible evidence that these devices are causing visual health problems.

h. Mr. Bannister's argument that non-harmonically related components are somehow adding differently and do not create a problem is not substantiated. He argues NEMA 77 causes "Unfair penalization of a lighting source which uses multiple modulations". We rebut, that if the modulations are all below the single

[4] https://www.iea-4e.org/

component threshold, and yet are visible to the eye when combined, as shown by Perz et al[5], NEMA 77 is not an 'unfair' penalization.

i. Mr. Bannister goes on to state: "However, it is unclear from either NEMA 77, or the proposed amended JA8, how a lighting system would be tested against SVM, if there is more than one modulating tone present and where the modulating tones are not harmonically-related (for a real-world example, modulation at twice mains frequency and at a PWM dimming frequency, which is not a multiple of twice mains frequency). It is therefore entirely unclear how a lighting system in which non-harmonically related modulation tones are present can be represented, in terms of the stroboscopic effect, by way of a single SVM value, as proposed in the amended JA8."
This argument again presupposes that non-harmonically-related components do not add up in the way that SVM adds them.

j. There is no scientific reason that NEMA 77 cannot be applied at other conditions than 100% light output. With that said, the human eye is less sensitive to TLA at lower light levels, so the limits should be different at dimmed conditions. Application research is still needed to determine suitable levels. NEMA does not recommend the establishment of flicker requirements or limits in the dimmed state at the present time due to lack of scientific study.

k. Item 6 states that NEMA 77 should not be accepted until reviewed and accepted my non-manufacturers. If this is true, then the converse holds true for JA10 as well – it should not be used until reviewed *and accepted* by others, including manufacturers. (NEMA's comments opposing the adoption of the current JA10 are on file.)[6] SVM has been published in peer-reviewed journals. SVM is being examined by the Illuminating Engineering Society (IES), International Electro-Technical Commission (IEC), and the International Commission for Illumination (CIE) for use in their documents. Furthermore, the U.S. Environmental Protection Agency (EPA) has recognized NEMA 77 for use in the ENERGY STAR Lamps program and is considering it for the ENERGY STAR Luminaires program.

2. TN221872_20171130T094945_ Sierra Club Comments on the Draft 2019 Building Energy Efficiency Standards[7]

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[5] Need citation

[6] http://www.nema.org/Policy/Documents/14BSTD01%20NEMA%20comments%20on%20Title%2024%202016%20Building%20Standards%20Update%2031Oct2014%20v8_1.pdf

[7] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221872_20171130T094945_Edward_Moreno_Comments_Re_17BSTD01_Sierra_Club_Comments_on_the.pdf

a. These comments state: “In 2016, the Commission adopted a conservatively high (lax) flicker standard in Joint Appendix JA8 of Title 24 due to there being little information on the flicker characteristics of products on the market. However the 2016 Title 24 standard required that products installed into new homes be tested for flicker and the data posted in a public (JA8) database which could be directly compared against the IEEE PAR 1789 Standard, “Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.” It should be noted that the IEEE standard recommends half the flicker value than the current Title 24 criteria. Close to 10,000 products complying JA8 have posted their data. We recommend this data be analyzed and the results considered on whether the current Title 24 required flicker value should be dropped to a more protective value. We concur with the Utility Codes and Standards Team that the JA10 data should continue to be published in Joint Appendix JA8 under the revised 2019 standard and not be replaced with the NEMA 77 Pst and SVM metrics which cannot be directly compared to the low risk recommendations in the IEEE standard.”

NEMA Comment:

- The Title 24 TLA specifications are based on IEEE 1789, so it follows there is no need to compare data gathered from CEC database submissions to IEEE 1789. There could be some use in comparing that data to NEMA 77 submissions to the same database, which is why the CEC should allow NEMA 77 as an alternative.
- As noted above in item 1b, IEEE 1789’s low risk recommendation excludes many of the incandescent lamps in the US and *all* of the incandescent lamps in parts of the world with 230V 50Hz grids. It is therefore unsuitable for use in setting requirements for general illumination, since it excludes a light source that has been used for over 100 years without problems from TLA.
- It is incorrect to say that IEEE 1789/JA10 2015 data cannot be compared to NEMA 77. Any of the parameters common to these references (SVM, $P_{st}$, modulation depth, ASSIST’s Mp, PPF, etc) may be calculated and compared at will, by those who have the data.
- The statement that IEEE 1789 recommends half the flicker value of Title 24 is incorrect. The relationship between the two depends strongly on frequency -- it is a “sliding scale” as clearly shown by the figure below. At some frequencies, IEEE 1789 is more than two orders of magnitude stricter than Title 24. NEMA 77 also recommends levels stricter than roughly half the Title 24 limits over much of the frequency range.
- NEMA 77 allows about 40% modulation depth at 120 Hz, with SVM=1.6, if the modulated light is a pure sine wave. However, the allowed modulation depth is lower if the waveform is more complicated. Changes in the frequency and in the waveform are accounted for in the NEMA method because it is based on human sensitivity. Title 24’s specification is not based on human perception – in some cases it allows light modulation 6 times greater than the recommended limit (in attempt to address photo-epileptic sensitivity).

3. Two items from Mr. Luke Price:

a. TN221892_20171204T090812_Luke Price Comments 17-BSTD-01 Draft 2019 Building Energy Efficiency[8]
b. TN221894_20171204T132217_Presentation - Physiological Percent Flicker (PPF) Calculations by Luke Price[9]

NEMA Comment: This docket item is a statement advocating yet another measure for TLA, PPF. PPF is related to IEEE 1789. Interestingly, the commenter notes that Professor Wilkins, a primary contributor IEEE 1789, has stated that IEEE 1789 may not be stringent enough! As already noted, IEEE 1789 is *too strict* for general illumination. It is designed to eliminate any possibility of any physiological effect, whether health related or not. This includes even the slightest chance of visibility. Again, IEEE 1789 even excludes historically-accepted incandescent lamps.

4. TN221679_20171103T170734_ Statewide Utility Codes and Standards Team Comments on Lighting Topics[10]

The document states: ""Flicker occurring at frequencies in the range of 120-200 Hz can have serious negative impacts on specific segments of the population (such as migraines, headaches, and reduced visual performance) despite being less perceptible."

NEMA Comment: This statement is incorrect. As stated in #1 above, migraines have not been proven to originate from frequencies above 60 Hz.

The availability of IEEE 1789-formatted lamp performance data is limited today because IEEE 1789 is not a widely used reference; however it would be an oversight if CEC were to only seek data in the IEEE 1789 format alone. The IEEE format does not include the effects of the presence of multiple frequencies (although the text discusses them). By implementing (adding) the NEMA 77 reporting format as an alternative requirement, California would gain data on SVM and Pst – which is more relevant to the concerns at issue, because it is based on human sensitivity.

There is no justification given for claims that 'market benefits' are provided by JA10 data that would not also be provided by Pst/SVM data. Such claims must be dismissed unless they can be substantiated.

[8] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221892_20171204T090812_Luke_Price_Comments_17BSTD01_Draft_2019_Building_Energy_Efficie.pdf

[9] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221894_20171204T132217_Presentation__Physiological_Percent_Flicker_PPF_Calculations_by.pptx

[10] http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221679_20171103T170734_Statewide_Utility_Codes_and_Standards_Team_Comments_Statewide_U.pdf

If the CEC believes that additional IEEE 1789 data is truly needed, NEMA suggests that the Commission pursue this matter a CASE study or by working with the California Lighting Technology Center, which CEC funds through the recently reaffirmed public-private partnership.

The goal of any healthy regulatory requirement is to set an acceptable *minimum* performance for an application through the least strict means, and then allow product differentiation within the remaining space. A regulation should not set a minimum performance for the application requiring the strictest conditions, which forces unnecessary over-design and higher cost in application.

For reference the figure of IEEE 1789 at issue cited in previous NEMA comments is repeated below with an additional shaded area to visually demonstrate the performance area required by NEMA 77. We note the conditions given in the figure for non-LED light sources (in red) are based on measurements done at Pacific Northwest National Labs (PNNL), except for the line for 50 Hz incandescent lamps, which came from Shackle and Erwin.

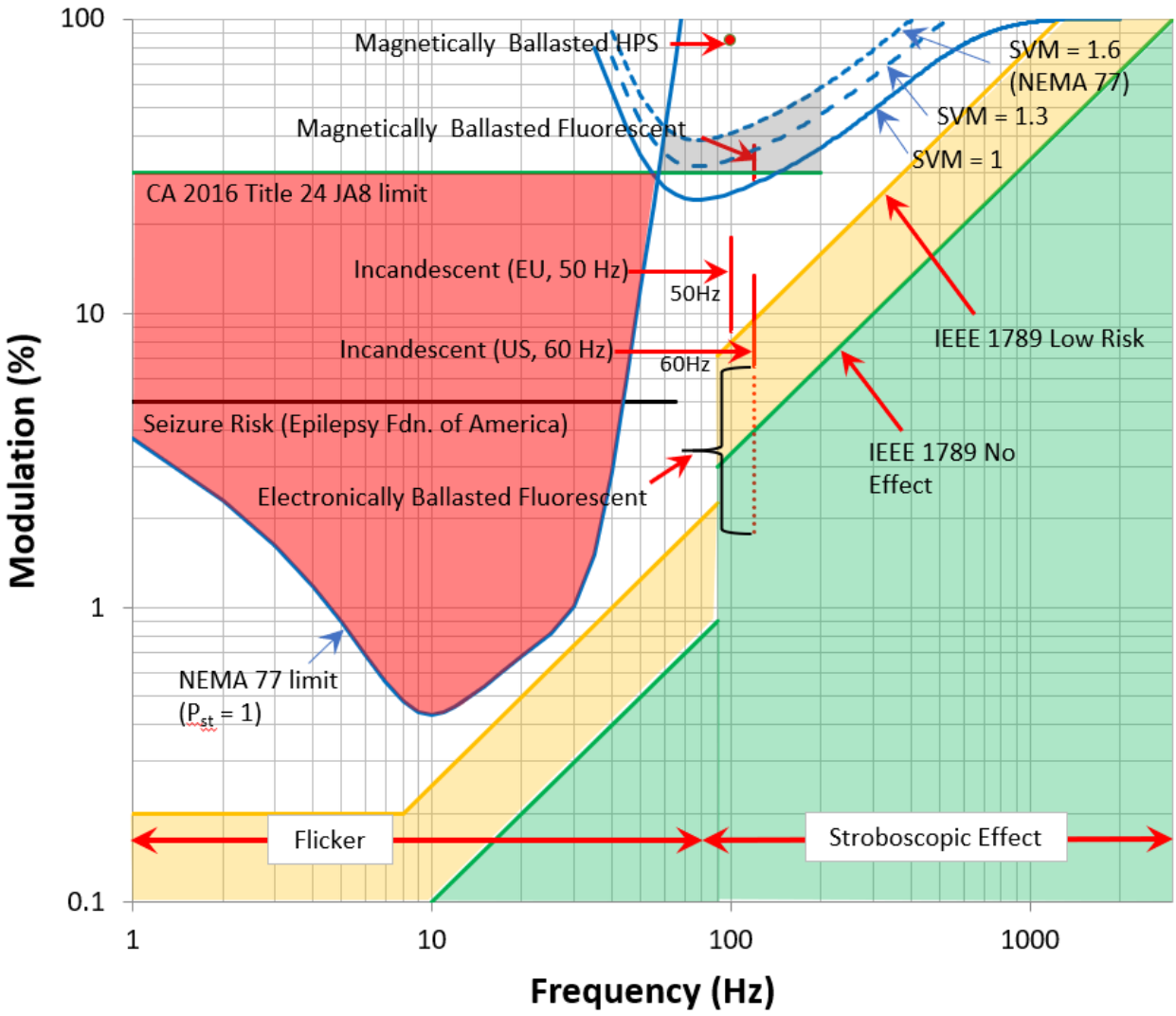


*Figure 1: Comparison of TLA measures and conventional light sources. Pst and SVM are plotted for pure sine wave modulation. The red region shows where NEMA 77 is stricter than Title 24. The smaller gray region shows where Title 24 is stricter than NEMA 77. For non-sinusoidal waveforms the SVM and Pst curves will move downward, decreasing the size of the gray region, and increasing the size of the red region.*

**NEMA Comments on Legality of Accepting NEMA 77 as an Alternative Flicker Requirement**

In response to concerns about "backsliding" expressed by Commission staff during the February 5-6 public hearings for the Title 24 45-day Express Terms, NEMA offers the following examination:

The Warren-Alquist Act grants authority to the Commission to prescribe lighting and other building design and construction standards that increase the efficiency in the use of energy for new residential and new non-residential buildings. Implicitly, the Commission would not have authority to decrease the efficiency in the use of energy:

> "**§ 25402. Reduction of wasteful, uneconomic, inefficient or unnecessary consumption of energy**
>
> The commission shall, after one or more public hearings, do all of the following, in order to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy, including the energy associated with the use of water:
>
> (a)(1) Prescribe, by regulation, lighting, insulation climate control system, and other building design and construction *standards that increase the efficiency in the use of energy* [emphasis added] and water for new residential and new nonresidential buildings. The commission shall periodically update the standards and adopt any revision that, in its judgment, it deems necessary. Six months after the commission certifies an energy conservation manual pursuant to subdivision (c) of Section 25402.1, no city, county, city and county, or state agency shall issue a permit for any building unless the building satisfies the standards prescribed by the commission pursuant to this subdivision or subdivision (b) that are in effect on the date an application for a building permit is filed. Water efficiency standards adopted pursuant to this subdivision shall be demonstrated by the commission to be necessary to save energy."

The Warren-Alquist Act does not define "energy efficiency," but the CEC's Title 20 Appliance regulation does inform us of the legal meaning of the term at Section 1602 in a variety of contexts:

> "Energy efficiency standard" means a performance standard expressed in numerical form, such as energy factor, EER, or thermal efficiency.

The Title 20 regulation also defines energy efficiency ratio (EER) and "energy factor" as follows:

> "Energy efficiency ratio (EER)" means the ratio of the produced cooling effect of an air conditioner or heat pump to its network input, expressed in Btu/watt-hour, as determined using the applicable test method in Section 1604(b) or 1604(c).
>
> "Energy factor for dehumidifiers" means a measure of energy efficiency of a dehumidifier calculated by dividing the water removed from the air by the energy consumed, measured in liters per kWh (l/kWh).
>
> "Energy factor" of a dishwasher means cycles per kWh, as determined using the applicable test method in Section 1604(o).
>
> "Energy factor" of a clothes washer means ft3 per kWh per cycle, as determined using the applicable test method in Section 1604(p).

> "Modified energy factor (MEF)" of a clothes washer means the quotient of the ft3 capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load, as determined using the applicable test method in Section 1604(p).
>
> "Integrated modified energy factor" of a clothes washer means the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of: (1) the machine electrical energy consumption; (2) the hot water energy consumption; (3) the energy required for removal of the remaining moisture in the wash load; and (4) the combined low-power mode energy consumption.

What each of these terms has in common is a performance standard expressed in numerical form that includes a measure of energy consumption. In lighting, the CEC regulations' performance metrics are expressed in terms of "efficacy" such as "ballast efficacy" or "lamp efficacy", which likewise include a numerical form that includes a measure of energy consumption.

Lamp "flicker" neither increases or decreases energy use. It is a visual test. Furthermore, there is no measure of lamp flicker that relates to or includes a measure of energy consumption. Consequently, a performance measure for flicker is <u>not</u> a "standard that increases [or decreases] the efficiency in the use of energy." With respect to any statutory constraints the CEC believes it must practice with respect to enacting or amending energy efficiency or energy use standards, these constraints would not apply to non-energy measures such as flicker.

<u>NEMA concludes that the Commission is not bound by anti-backsliding principles when it comes to flicker, and the Commission may allow our proposal to accept NEMA Standard 77-2017 as an alternative test method and requirements for JA8/JA10 compliance regarding flicker.</u>