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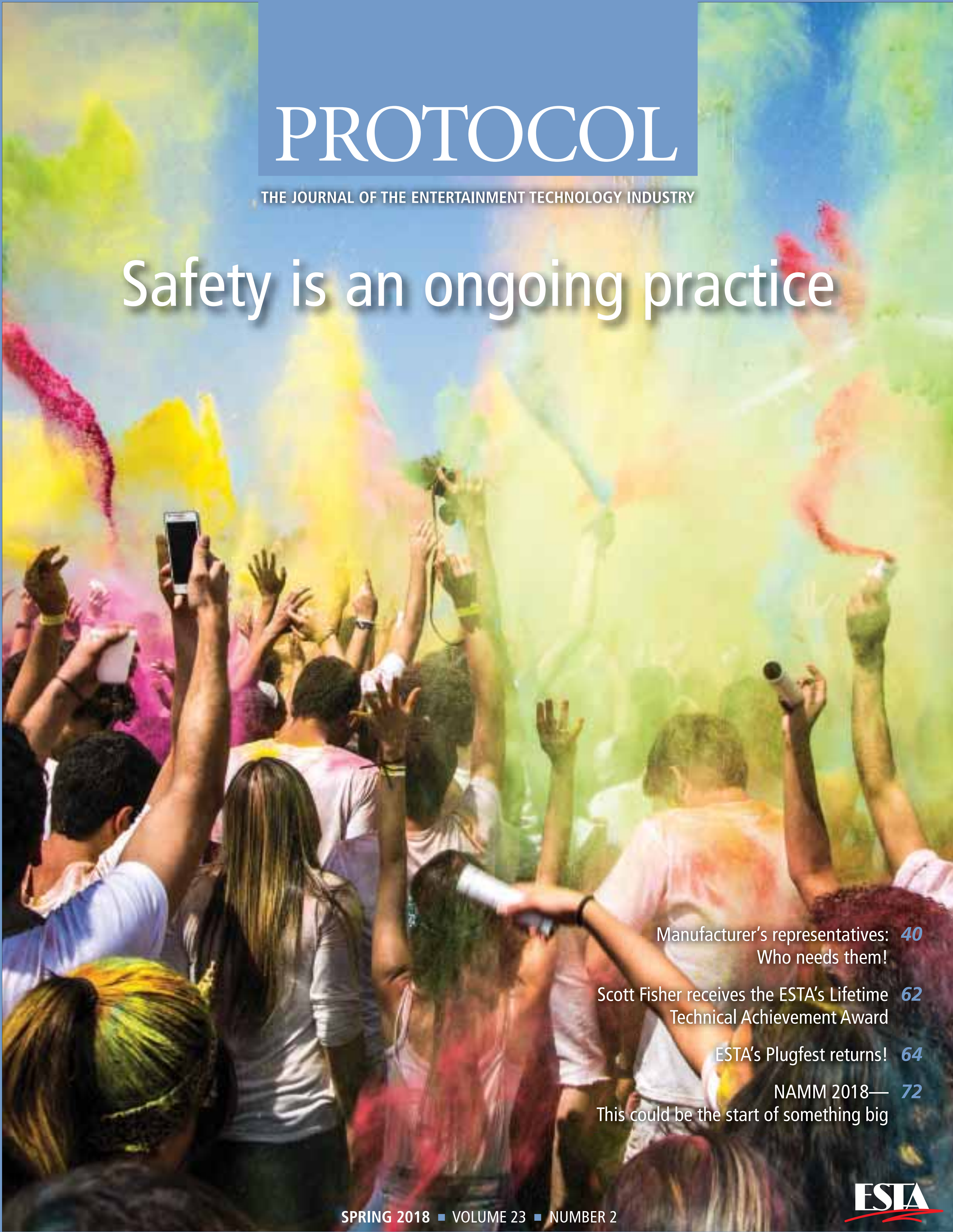
THE JOURNAL OF THE ENTERTAINMENT TECHNOLOGY INDUSTRY



Safety is an ongoing practice

SPRING 2018 ■ VOLUME 23 ■ NUMBER 2

ESTA

As darkness fights the light, we need a dimming protocol

BY PETE BORCHETTA

ALMOST A YEAR AGO this author wrote an article for the 2017 Spring *Protocol* issue entitled "Mains dimming for LEDs—Why?" This article dives deep into the use of LEDs in theatre and their operability on theatrical grade dimming systems. The article went on to explain how it is done, what is needed, how LEDs and purpose-built drivers react to phase cut dimmers. Before you read any further—if you haven't had the opportunity—please take a look at http://www.esta.org/Protocol/protocol.html.

Now that you are all caught up . . . Following the publishing of the article, a number of focused questions were asked specifically about the dimming performance metrics in the article itself. These questions pointed directly to a problem with dimming LEDs today.

The problem with dimming LED luminaires today, whether they are controlled directly via DMX512 or driven by dimmers, is that there is no metric to measure and quantify dimming performance. Up until this point, what we know about dimming is from our experiences with lamps dimming in an incandescent world. In the past, our dimming curves and reaction times of filaments depended on a number of physical factors, from the dimming system performance and type, as well as the size of the lamp's envelope, and the size and shape of the lamp's filament.

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Dimming was simple . . . in a way. As we change the voltage or wave form applied to a tungsten lamp we raise or lower its intensity. This is where we have used the term "fade" for many years, whether it is a fade to black or a cross-fade. The lamp follows a very specific curve depending upon the input to the dimmer itself. What this means is that, either the interface to the lighting controller or the lighting controller itself controls the input signal to the dimmer in such a way that various dimming curves can be obtained. Dimming up might be slow at first, allowing the filament to heat, then quickly in the middle, and then again slowly at the top end. Common dimming curves range from linear, to square law, to custom configurations.

Many dimming system manufacturers offer a multitude of dimming curves in their dimming racks, which will allow designers to select which is best for the lamps that they are using. Many times a small preheat or modified linear curve might be used on larger lamps to allow for the lamps to react faster and better match some of the smaller filament luminaries that they are dimming with. **Figure 1**, below, represents a few different types of dimming curves graphically and what each one represents.

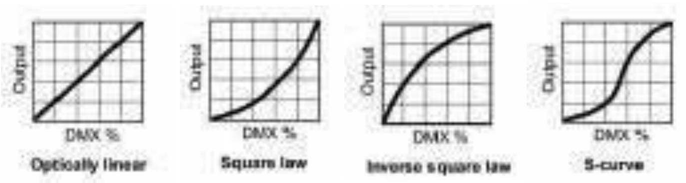

Figure 1

- **Linear**—The increase in light intensity appears to be linear as the DMX value is increased.
- **Square Law**—The lighting intensity control is finer at the low levels and coarser at the higher levels.
- **Inverse Square Law**—The light intensity control is coarser at the low levels and finer at the higher levels.
- **S-Curve**—The light intensity control is finer at the low levels and high levels yet coarser at the medium levels.

So after all of this, the reaction time of the filament in conjunction with the dimming curve is what sets and denotes the physical reaction of the tungsten lamp. At this point the heating and cooling of the lamp—depending upon a number of variables, such as its wattage, envelope size, power feed, and lamp life—will then follow a similar path each time it is dimmed.

When we perform a DBO (Dead Black Out) with an incandescent fixture, even when the console reaches zero, there is still illumination on stage as the lamps are cooling and going to black, which was something that would have to be accounted for on the design side of DBO timing. Many designers when performing a DBO with incandescent lamps employ a number of simple tricks to fool the eye achieving an "instant" black out even though the lamps are still cooling and producing light. These can be anything from raising light levels or changing the look's color right before the DBO occurs. Due to the changing light levels or color, our eye is in the midst of adjusting just as we add another change.

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Adding another layer to this issue is perception vs. output. As illustrated in **Figure 2**, on a linear power-light level perception chart the perception of the perceived, not measured, light does not follow the same line as the power. It is also because of this that so many manufacturers manipulate LEDs in different ways to achieve and replicate the perception of the incandescent dimming curve.

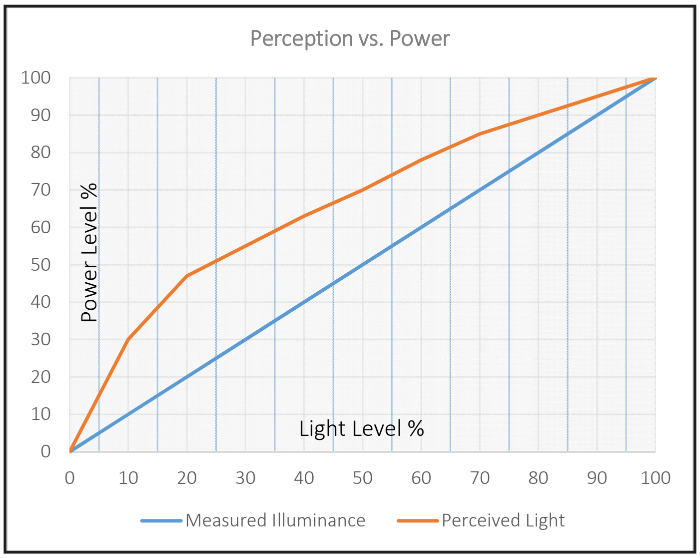

Figure 2

Now back to the problem: We are not able to point directly to a scale or a norm of what is considered "good" dimming, when we cite the dimming performance of an LED-based luminaire. Does it dim like the incandescent luminaire as prescribed above? If so, how was this performance measured? Add to this, what was its "perceived output" at different levels?

Today, when we dim an LED luminaire we expect its dimming to perform like that of its incandescent counterpart, and it must also be able to perform a DBO and reach zero at the same time that the console does.

Let's move away from mains dimmable LED luminaires and take a deep dive into digitally controlled luminaires using 8-bit to 16-bit control scenarios. When DMX is applied to a luminaire and directly controlled how does it dim? Do you see steps in the dimming curve in 8-bit or 16-bit modes? Do you see this performance when shining the luminaire on the wall or is it visible when looking back at the luminaire's source? Is there flutter, flicker, swelling?

With these questions we rely heavily on the eye or camera as our reference scale. Some might see a flicker or flutter or a stepped dim curve. Adding complexity is that every LED luminaire manufacturer has its own "digital recipe" for LED control fades. Some LED units employ smoothing techniques or "incandescent curves" to elongate the dimming curve and replicate the cooling of an incandescent lamp.

More and more manufacturers are stating that they have "theatrical grade dimming," but what does this actually mean? Does it mean it dims like an incandescent? If so, which one? Does it behave like a 500 W leko or 2,000 W fresnel? What does the dimming curve look like?

I am a lighting designer who, for the majority of my career, has designed around the incandescent lamp. Its smooth cooling to dim has always led to specific cue timing as well as fade out and lamp cooling anticipatory cue timing. Today, LED units employ a number of dimming curves, trying to replicate similar curves that the previous dimmers were able to produce, depending upon the load attached to them.

A common protocol is markedly needed for describing and specifying LED luminaire dimming performance.

At the end of the day in a pulse-width-modulation world, we are sending a linear signal to the LED drive and array, and then trying to replicate the look and feel of a smooth analog curve from 100% – 0% and 0% – 100%. Many of my specs have the following language, taken from a list of approximately 150 bullet points that describe the dimming of an LED luminaire.

Theatrical Dimming Curve:

- *Dimming must be smooth from 0% – 100% at any and all fade rates—no steps, flutter, or phasing—must dim as smooth as an incandescent lamp*
- *Smooth from 100% – 0% at any and all fade rates—no steps, flutter, or phasing—must dim as smooth as an incandescent lamp*
- *All levels of output must match whether moving up or down on a fade. i.e.: If a fixture moving down on a fade stops at 20% and a fixture moving up on a fade stops at 20% their output must match, at all operating temperatures and mounting positons.*

In the entertainment and architectural worlds of LED luminaire dimming, we need a metric to compare the dimming of fixtures. Statements like "theatrical grade dimming" do not work for the entertainment and architectural worlds since such terms or statements do not clarify the specific needs or requirements.

On the color side of LEDs quite a bit of research and time has gone into a number of different color metrics from CRI to CQS and now into TM-30-15, all of which give us a scale to reference and evaluate different luminaires' performance. Film and TV has added metrics, such as TLCI to rate and equate LED luminaires via a grading system. This system is a bit broad, but it still gives a reference scale and a scorecard for the performance of a luminaire.

As more and more LED luminaires are introduced to the market daily we need a metric to measure the dimming performance and compatibility of luminaire to luminaire. Writing custom control profiles for every manufacturer's dimming performance is no longer a viable option.

A common protocol is markedly needed for describing and specifying LED luminaire dimming performance. Without a common protocol we can only expect dimming performance to remain as it is and without this change the theatrical and architectural lighting industries will remain moving forward without a metric to design products to. We need a common protocol. ■

Pete Borchetta's passion for lighting over the past three decades has led him to positions as a theatrical and architectural lighting designer, theatrical lighting professor, theatrical lighting consultant, and product innovation manager. Pete has worked for some of the industry's most critical designers and manufacturers, including Altman Lighting where he now serves as the Product Innovation Manager. Pete's origins stem in theatre lighting where his passion for lighting continues to grow daily.