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Tolerancing and its Role in Illumination and Nonsequential Optical Design

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Introduction

Tolerancing is a subject that is often overlooked, or not fully addressed, in the design of illumination and nonsequential optical systems. Tolerancing methods are well developed and understood in the lens design and imaging system design fields, but tolerancing of illumination and nonsequential optics is a much less well-developed field. Optical design and optimization software tools can allow the designer to make new and exciting designs, but it is possible that the design may not be economical to manufacture due to the sensitivity of the design to variations in the manufacturing process. New tolerance analysis tools in optical design and analysis software allows designers and engineers to evaluate the effect of manufacturing variations and how it will affect the overall performance of the system. This makes it possible to see if a design is truly practical and economical. We will look at the tolerancing methodology as well as some tolerancing examples in this article.

One definition of tolerance in the Merriam-Webster online dictionary is: the allowable deviation from a standard; especially: the range of variation permitted in maintaining a specified dimension in machining a piece. In optical and illumination design this is used to define how much a manufactured design can deviate from the optimized or "perfect" design and still deliver an acceptable level of performance. An optical designer will realize that the part that is produced based on their design may not fully match the original design. A tolerant design is one that will still perform within a give range despite these inevitable differences due to manufacturing.

Many computer based optical design and analysis programs feature powerful optimization tools that optical engineers and designers can use to design complex and high performance components and systems for lighting and illumination applications. In some cases, these designs may not translate well to a production environment. **Figure 1** shows an optimized luminaire reflector that would be difficult to produce accurately and consistently. Fortunately, some of these same software tools can also allow the capability to check the tolerance of a design to see if changes to the base design need to be made.

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