CRITERIA FOR THE COMPARISON OF FIBER OPTIC LIGHTING SYSTEMS

There is no question that energy outside the visible spectrum damages artifacts. We have examined how ultraviolet, and especially infrared, drive both photochemical and photomechanical damage. Museum lighting must be both UV and IR free. Simple, practical, effective UV and IR free artifact lighting is available today. There is no reason to expose museum art or artifacts to the dangers, stresses and pollution consequences associated with high IR conventional lighting.

A zero UV, zero IR standard will simplify specifications for museum lighting, but there are still hundreds of lighting companies with a huge variety of lighting hardware marketed to museums. Words like “new,” “revolutionary,” and “high tech” have little technical meaning. How do you sort out the various products and their claims?

I have seen xenon lamps, the primary UV sources used for curing UV resins, advertised in museum publications as “low UV.” The ambiguities we examined earlier in the definitions of UV and the limited and scattered nature of true technical data on light sources give great leeway to spurious claims. This is why I have focused wherever possible on hard data, spectral power distributions, spectral transmission curves, absolute values and clear definitions.

The reality is that you will be presented with a great assortment of lighting products and performance claims. Few of these products were developed with museum needs in mind. Most are not even manufactured by the company presenting them. The separations between manufacturer, distributor, salesman and end user only add to the confusion in specifications and representations.

Today, the only practical lighting systems available that can eliminate all UV and IR are fiber optic systems. But “fiber optic” does not automatically mean “UV and IR free.” Nor does it mean “museum quality” lighting. On the contrary, most fiber optic lighting products were originally produced for other purposes, transmitting data with IR lasers, burning away tissue in surgery, or creating effects lighting in pools and signs. You must ask the right questions and insist on hard data as answers to be able to evaluate fiber optic (or any other) lighting systems.

The following questions will help you fairly evaluate and compare fiber optic systems. These are the basic questions that you should ask. Any proposed system that fails to adequately address each of these issues has significant problems and should be avoided. (You will find additional helpful information in following appendices.)

Safety - Is the system safety tested and listed for use as a museum lighting system? I've seen people promoting systems listed as electric sign accessories, swimming pool lights and theater or stage lights. Check the listing. All lighting, including fiber-optic systems, should be listed by UL or by ETL. ETL is the country's oldest test lab, actually founded by Thomas Edison. Lighting systems should be listed for use as portable lamps (UL Standard 153 and CSA Standard 22.2) or for use as recessed lighting fixtures (UL Standard 1598), and hopefully both.

Lamps - How long will they really last and what do they cost? Usually you get an average bench test life. Ask for field data and real life numbers. The three major factors that affect bulb life are voltage, vibration, and ventilation. A good system will be designed to address each of these factors.

Some manufacturers list their light levels at high power and their bulb life at low power. You can't have both! Balance life and replacement cost. Metal halide lamps may last a long time, but they can cost $200.00 each and their color goes long before the lamp does. A dichroic-reflector halogen projection lamp should cost around $12.00. In a properly designed fiber optic projector, actual service life should be 1500 hours on high power or 2000 hours on low power.

Maintenance - How hard is it to change a bulb or some other part? How much time will your maintenance department spend changing bulbs? One widely sold fiber optic projector requires 21 parts to be removed (with tools) before you can remove the lamp. Try that above a case of priceless ancient glass or standing on a 14-foot ladder! You should be able to change a lamp in less than 30 seconds.

Noise - Is it quiet? One curator said that his projectors sounded like B-52 bombers taking off. He wasn't joking. The unit of sound is the decibel (db). At the lower end of the scale the rustle of leaves in the breeze is about 10db. An average whisper (that you can hear) is about 20db. A quiet conversation is 40db. A well-designed projector runs at 7.5db, less than the rustle of leaves in a breeze. We have tested projectors that are 5 to 100 times louder. Ask for measured data, or compare candidate projectors side-by-side. The differences will not be subtle!

Performance – Projector wattage or intensity doesn't tell you *anything* worthwhile. The only important numbers are at the end of the fiber where you light objects. How much light do you get at what distances? Then, how well can you control that light? Can you aim? Can you focus? What does the beam look like? What color is the light? Will it stay that color? Will the system illuminate what you want, the way you want it illuminated?

A reputable manufacturer publishes real data in easy to read measured footcandles at measured distances. Beware of communications transmission data. Decibels per kilometer are hard to find on a light meter. It is also a sure sign that the fiber was designed for communications, not lighting. (All communications fiber will transmit IR. Communications technology is based on IR lasers centered at 1440 nanometers. Visible red ends at 770 nanometers!)

Always compare system costs for a given *light level* over a given area or a given number of artifacts. Compare total system costs that accomplish the job. A legitimate company will provide you with solid data about solid performance.

Color - What color is the light? The museum criterion is “pure-white, stone-cold light.” We have covered numbers to measure color. Don't settle for less than a CRI (Color Rendition Index) of 100. That means you can’t measure any better. Color balance must be very close to sunlight with no spectral peaks or valleys. All the colors have to be there, in balance. Look for CCI[1] of less than 15%.

Fiber - What kind of fiber is used, how good is it and what does it cost? There are four choices in optic fiber: glass, solid core, multi-strand acrylic and single-strand acrylic. (For more in depth comparisons, see the pdf file “Comparison of Fiber Optic Light Guide Materials”.)

Glass - Glass fiber isn’t totally glass. It is glass fiber imbedded in epoxy bonded ends. More than 40% of the cross section of glass fiber is epoxy and ineffective for light transmission. The epoxy is very susceptible to heat damage.[2]

Glass fiber has a transmission loss of 2% a foot and cannot be tightly focused. Glass fiber is also expensive. Because it must be cut and polished at the factory, design is difficult (and more expensive), delivery times are long and there is zero flexibility for changing exhibit design.

Solid core - Solid-core fibers don’t really have a solid core. Think of plastic jello in a flexible plastic tube. The jello allows it to bend. The problem is that the softeners used to make the jello are photosensitive. They turn yellow, sometimes in only a year. Transmission loss for new solid-core is around 3% per foot.

Solid core does not focus well. It can be cut in the field, but it cannot be polished because it is too soft. Solid core companies will tell you that fiber replacement is a routine part of maintenance! It should not be.

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[1] CCI, Correlated Color Imbalance also called Coefficient of Ugly is described in detail in Section 2-6. CCI combines color temperature and CRI and quantifies the difference between the spectral power distributions of sunlight and any source.

[2] As some glass fiber companies promise, the glass will last almost forever. The epoxy will not. You can figure out what use that a handful of separate, .002-inch glass threads will be after a few years.

Multi-strand Acrylic – Multi-strand acrylic can be easily cut in the field. It can even be polished, although most stranded fiber companies don't suggest this, or provide you the materials to do it. But, like glass fiber, stranded fiber cannot be focused. Trying to do so will project a number of spots of light onto your surfaces.

Multi-stranded acrylic has a slightly better bend radius than single-strand acrylic fiber, but a much, much smaller ability to carry light. To offset this inefficiency, multi-stranded acrylic is woven into bigger bundles. This further degrades the ability to focus, raises the cost of the fiber and lowers the number of fibers that can be illuminated by a single projector.

Single-strand Acrylic – High quality, aerospace grade pMMA (polymethyl methacrylate) "acrylic" fiber, is the same material used to make jet fighter aircraft canopies. It is strong, clear, and lasts a very long time when used properly. Acrylic fibers are the most efficient visible light transmitters available. Acrylic fibers are opaque to both UV and IR energy. They transmit visible light (380-770 nanometers) with a transmission loss of only 0.7% a foot. At $1.00/ft., acrylic fiber is inexpensive, a fraction of the cost of glass or solid core.

But, it is possible to melt acrylic fiber, as museums that have purchased inferior projectors have found out. Acrylic has a service temperature of roughly 70° - 80° C. The projector should run the fiber continuously at 40 - 50° C by taking out *all* of the heat before it gets to the fiber.

Warranty - Read the warranty closely! Does the company have one? Some don't. Some warranties won't cover moving exhibits. What are they saying about their products? One company voids its fiber warranty if the case is moved!

A reputable manufacturer should be able guarantee its fiber for ten years against yellowing or any loss of transmission. Beware of warranties that specifically exclude yellowing or loss of transmission or that pro-rate replacements when the fiber fails. They are planning for a failure. (If you use them, you should too!)

Some warranties are really clever in what they say. One very famous plasticware firm has a lifetime warranty not to "break, chip, crack or peel for the life of the product." "It will last until it breaks," is what they really say. Read warranties skeptically.

A museum-quality fiber-optic system, including fiber, should be warranted against defects in manufacturing of all structural, mechanical and optic elements for ten years. Even electrical and electronic components should be warranted for one year (other than lamp burnout). A quality product line should be provided with a meaningful warranty, and a telephone call should bring a replacement by overnight delivery.

Installation - How difficult is a system to install and adjust? Here's a typical example from NoUVIR's files. Seventeen new cases were installed in a new exhibit in a new gallery. That meant seventeen projectors and 320 luminaires. A conservation light level of 5-8 footcandles was mandated. Fibers were cut and polished by hand (although a buffing wheel is faster). Installing, aiming, focusing and dimming each luminaire took three people (an executive secretary, an exhibit designer and a salesman) four days to accomplish. And it looked beautiful!

Cost - What will the installed system cost? Base your comparisons on the cost of putting a *specified light level* in an exhibit or gallery. Some inexpensive projectors come with really expensive fiber. Some systems require a lot more hardware to provide comparable light levels. Some systems require expert installers (sometimes flown in from overseas) to install or adjust. Compare systems side-by-side.

Service - How will they treat you after the supplier has a P.O.? What are the delivery times? (Glass harnesses, being factory made and polished, usually have 8 - 12 week delivery.) Are delivery promises kept? Are they willing to help with free customer service in conceptual design for particular applications?

Who can you talk to if you have a question? Does an intelligent human being answer the phone? Or are you locked into a computer loop directory?

Sometimes an installation contractor buys the lighting systems, so the museum may not even know who the manufacturer is. Find out! The contractor may keep the installation and maintenance manual, so your personnel can't maintain you own lighting systems. Providing equipment sources and manuals ought to be part of any contract.

Sometimes contractors or "manufacturers" of fiber optic lighting mix projectors from one source with fiber from another with luminaires, "heads", crystals or other things from yet a third source. Often that means there is no warranty as it is only as good as the paper coming from the compiler of the hodge-podge of products. The real manufacturers will not service mixed systems of products made others and there is no control over quality. Do not let a vendor's profits get in the way of your ability to get good customer service or getting the performance you deserve.

Reputation - When you are selecting lighting, ask where you can see the candidate lighting systems installed and operating. Then go look. Talk to the museum personnel who are using them. Talk to those who installed the systems. Ask the hard questions above.

Patent Infringement - Many fiber-optic systems and components are patented. Check out the candidate manufacturers' catalogs for listings of issued patents, not "patents pending". Patent pending means "we don't have, and may never have an issued patent." It is a meaningless claim.

The technical leader who invented the technology will be the one who has the patents. They will be able to do what no one else can. The liability for infringement of one or more issued patents is not limited to those who make or sell patented items. It can extend to those who *use* them.

Additional Information

This pdf is in the NoUVIR Institute's website. Please see NoUVIR Lighting's .com site for descriptions of the NoUVIR® line of fiber optic lighting. The complete NoUVIR Catalog is over 130 pages. Roughly half of that information is instructional, describing the principles of exhibit lighting, the processes of controlling glare and reflection, the principles of reducing or eliminating photochemical damage, and fiber optic design and applications in detail. For questions, comments or more information contact:

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