INFRARED LIGHT (Radiation)

> ***"Deterioration needs energy – either light or heat. Light is much more potent than heat in the museum."***
>
> ***– Garry Thomson*** [1]

Light is itself an environmental factor. It causes damage. It is a major component in all the other risks to art and artifacts.

For the present purposes you need only to understand that light and radiation are synonymous terms. All light is comprised of photons. A photon is made up of two particles, an electron and a positron, spinning around each other.

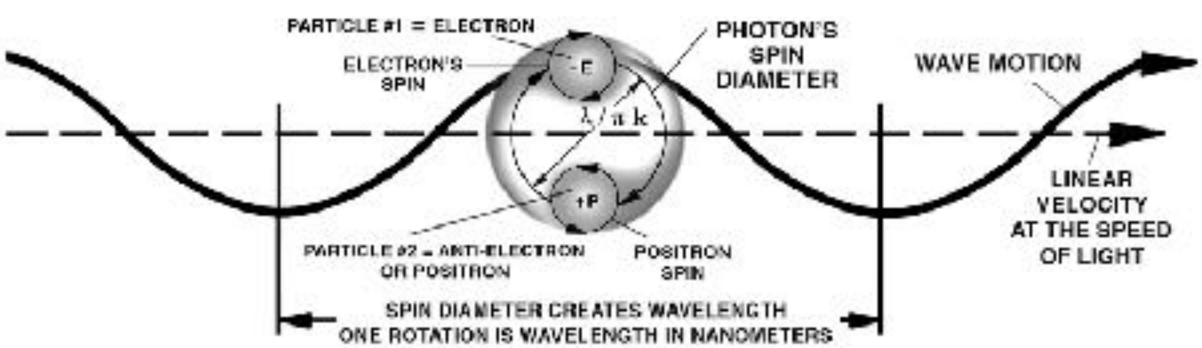


Figure 2-1. The structure of a photon as described by quantum electrodynamics.

Light is made up of physical particles with mass that impact the atomic structure of any object they strike. Infrared light is made up of photons with a bigger diameter compared to visible light and ultraviolet. The particles, the movement, the speed forward, the mass…everything is identical except the distance between the two spinning particles.

[1] Garry Thomson, p. 4.

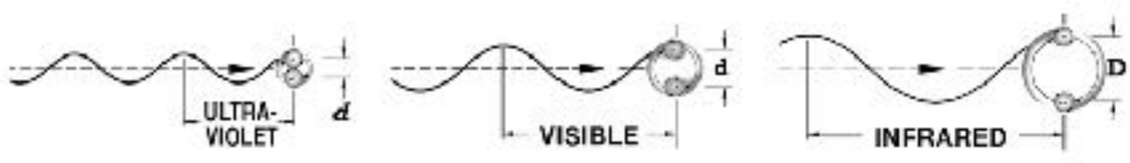
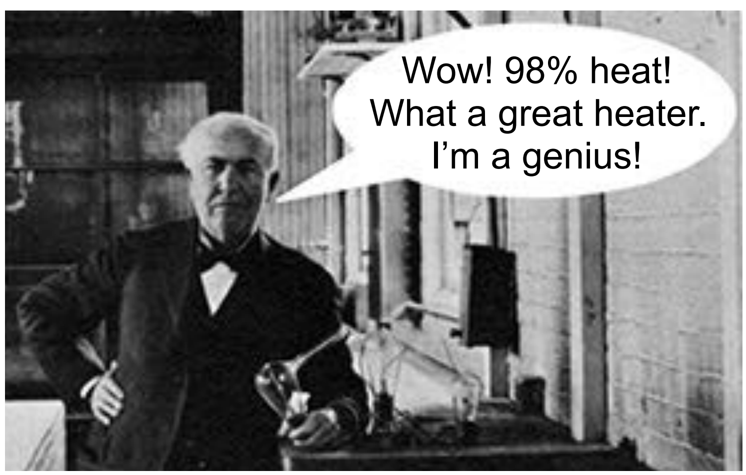


Figure 2-2.
The structures of ultraviolet, visible and infrared light.

The wave of light is created by the movement of the two particles as they spin around each other. Infrared has a longer wave. There are fewer rotations over the same distance. The photon takes more space to rotate, so it seems bigger. But IR is identical except for the distance to all other light.

In the lighting industry there can be confusion over infrared and heat. Marketing and sales people try to make a distinction to delineate between light sources and heaters. But quantum physics is very clear. Infrared and heat are the same thing. It is a photon with a spin frequency (diameter) greater than 770 nanometers.

We cannot see infrared. The eyes interpret as data light from 380 nanometers to 770 nanometers. But we can feel the infrared.



In 1882 Thomas Edison invented the first practical light bulb that glowed without combusting. Using carbonized bamboo, the density of the material was tight enough to force electrons to convert in positrons and generate photons. Edison has no idea he was creating particles or how those photons came into being from electricity.

But he did know that his glowing bulb was better than gas lights, oil and kerosene flames. The incandescent light bulb was born. It was 2% visible light and 98% heat.

Incandescent lamps ruled for decades. Fluorescent lamps as an invention followed just a few year later as did neon lamps, but were not practical until the late 1930's. However, fluorescent lamps, technically low intensity gas discharge lamps, were and are still mostly infrared at 72%. The reason is that the most photons are created off of the outer rings of the atoms. The orbits of those rings are what determine the wavelength of the photons. Outer orbits make larger spin diameters.

This means that visible light is accompanied by infrared light. It is how the quantum electrodynamics work and is built into the physics of how light is generated from a flow of electrons (electricity). Even the “new” LEDs are 72% infrared. Infrared can be filtered out of a beam, but infrared photons are always present and have to go somewhere.

That means heat. Infrared and heat are the same photons. None of these infrared photons create sight. But basic chemistry tells us that a 10° rise in temperature will double a chemical reaction. Put another way, increase the temperature of an artifact by 10°C and cut the artifact’s exhibit life in half. Infrared greatly impacts a collection.

Infrared Light (Radiation)

Our corporate understanding of infrared radiation (IR) is following the same learning curve we followed with UV light and damage, but about ten years later. Infrared (IR) radiation was long considered benign. In 1984, Garry Thomson, who might well be considered the father of modern conservation, wrote the following:

> “One can confidently assume that in the museum red light never causes any photochemical damage (damage due to chemical change by radiation).”[2]

Early in the 1990’s NoUVIR Lighting began teaching that any light outside the visible spectrum was unnecessary for vision and a cause of damage. By 2000, the Illuminating Engineering Society (IES) agreed:

> “Visible light contributes to both vision and damage; infrared (IR) and ultraviolet (UV) energy, which are not visible, contribute only to damage. Unless all artifacts in a display area are totally insensitive to exposure, UV and IR should be controlled…”[3]

Toby Raphael at the National Park Service Division of Conservation states, “Research attributes up to 40% of color loss in dyes to IR radiation.”[4] Current science therefore attributes almost half of the damage to the silk dress in our earlier picture to IR rather than UV radiation. This represents a radical change in thought and conservation policy in a relatively few years.

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[2] Garry Thomson, The Museum Environment, 2nd ed. (London and Boston: Butterworths, 1986), p. 15. Note: We can confidently assume that the only light that causes no photochemical damage is reflected light. Any light energy that is absorbed by a surface will cause damage, even if that damage is limited to a simple rise in surface temperature. These ideas are covered in more detail later in this paper.

[3] The IESNA Lighting Handbook: Reference and Application, p. 14-4.

[4] Toby Raphael, B:1: p. 2.

IR radiation forms the major portion of conventional museum lighting. Incandescent sources (tracklights and downlights) are 90% or more IR.

> "Most of the electricity which passes through an ordinary tungsten lamp is converted into heat (94 per cent for a 100 watt lamp) not light."[5]

These numbers have a significant impact on museum conservation. More than 90% of the output of incandescent light sources is invisible, usually undetected, unmeasured and dangerous to artifacts! Fluorescent sources are slightly better in IR (70+%), but significantly worse (2 to 5 times) in UV. HID sources share fluorescent problems, but with greater intensity and far worse color rendition.

LED lamps can be a mixed bag depending upon what LED. Some LEDS have UV and IR as intense and even more destructive than fluorescents, because of the visible blue intensity that is harmful. Some select LEDs filter the UV and use heat sinks to remove part of the IR. LEDs have to be carefully sorted. And as they age, they change their characteristics.

The tragedy is that today a great number of conservation references limit their discussions of radiation to UV and to visible light. They totally ignore the effects of the IR radiation that makes up most of the output of our most common museum light sources.

The 94% IR for incandescent tungsten lamps cited above is total energy. It is a radiometric and not a photometric term. The 75 µw/l maximum for UV we discussed earlier calculated out to energy equivalent to roughly 5% of the CIE[6] corrected visible energy present. The IR energy here is 20 times the CIE corrected visible energy, 2000%. Expressing it in the same terms commonly used for UV, this IR energy is 30,000 µw/l.

Clearly, an individual UV photon may be more destructive than an IR photon as it penetrates deeper into objects. But the huge amounts of IR present in conventional lighting make IR a photochemical danger equal to UV. IR, however, has been almost universally ignored.

There is one more idea necessary to understanding the photochemical dangers of IR. Current conservation techniques often depend on dimming lighting to conservation levels with rheostats. As the dotted line on the graph on the next page demonstrates, dimming a halogen source sufficiently to cut the visible light by 50% shifts the peak of the curve further into the IR spectrum where the light meter cannot see it. The total energy reduction (and the real conservation value) is only about 10%. Dimming is not an effective conservation tool. The light meter indicates 50% less radiation when it is only a 10% reduction.

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[5] Garry Thomson, p. 7.

[6] CIE stands for Commission International de l"Enclairage. It represents the visible spectrum adjusted for the sensitivity of the human eye (about 1/2 the energy actually present).

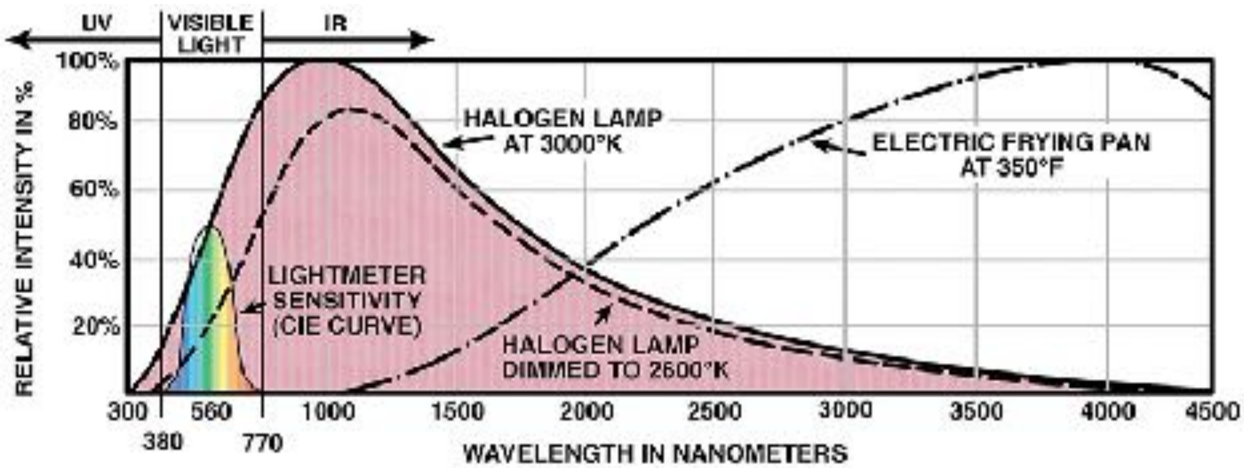

Figure 2-3. Typical output of a halogen lamp verse dimmed.

The huge IR content of conventional lighting is responsible for much more than just Toby Raphael's 40% of fading and photochemical damage. As we look at temperature, humidity and pollution in subsequent pdf files, you will find that the IR in conventional lighting is the major energy source driving cycles which endanger collections.

Setting "Safe" Light (Radiation) Levels

Light meters read visible light only. In fact, as we have discussed, the sensors in a light meter are filtered to match the CIE curve, the sensitivity curve of the human eye. A light meter does not measure energy directly, but only as the eye sees it. A light meter gives you photometric data about what you see. IT does not give radiometric data about the total amount of energy present. A light meter only provides a part of the data you need.

The CIE curve is shown above in Figure 2-3 as "Lightmeter Sensitivity." You can see by the shape of the bell curve within the visible portion of the spectrum that light meters are weighted toward green light by about four times that of blue and red light. As a matter of fact, if you took the filter out of your light meter, you would see that it is very dark green.

You can also see by comparing the areas under the curves that the CIE bell curve only represents about 50% of the energy present in the visible output of the halogen lamp. That is half the visible light. And it only represents about 5% of the total energy present.

The CIE curve demonstrates that because of this filter, light meters are blind to both UV and IR. The meter sees no light energy below 380 nanometers and no light energy above 770 nanometers. The light meter sees only about half of the visible radiation present between those wavelengths.

Light meters are the conservator's primary tool for protecting against photochemical damage. It is quite a shock to realize that the light meter fails to register up to 95% of the total energy and roughly half of the of the visible energy of a conventional light source. This is why wise people focused on protecting their collections use a light meter, but lean on spectral output curves provided for the light source they are using.

Until fairly recently this huge misrepresentation of energy had little practical impact. All light sources had very large IR components. The fact that a light meter showed only 4% or 5% of the actual energy impacting an artifact meant little. Everyone was in the same boat and everyone's numbers were off by the same factor. Everyone used the same recommended footcandle guidelines and limits for artifacts established by the museum community over decades of research. (See Recommended Footcandle Intensities, the first pdf in the list.)

This is no longer the case. Museum professionals today are faced with a bewildering array of light sources; incandescent, quartz halogen incandescent, several types of fluorescent, HID, a variety of LEDs, OLED sources and different fiber optic lighting, again in several types.

Each will have a different UV and IR component that is not measured by your light meter. The amounts can be from the 95% UV and IR of a quartz halogen incandescent light to the absolutely zero UV and IR in NoUVIR® fiber optic lighting. The point to be made here is that without specifying the source and composition of the light, conservation footcandle recommendations can be misleading almost to the point of being meaningless.

Here we repeat the practical example we used for UV. Several years ago we had the opportunity to supply the lighting for a temporary exhibit showing among other things the original check that the United States used to purchase

Figure 2-4.
The original United Sates Treasury Warrant (check) for the purchase of the Alaskan Territory.

the Alaskan Territories (Figure 2-4). The National Archives specified a maximum light level of fewer than 3 footcandles for that particular artifact. They also specified no fluorescent light, due to the high UV content. Finally they limited the exhibit display to 30 days (roughly 700 footcandle hours) under normal halogen lighting.

A light meter reading of 3 footcandles of quartz-halogen track lighting (94% IR, 1% UV) would have exposed this fragile artifact to roughly 60 footcandles of total light energy. More energy-efficient fluorescent lighting at the same 3 footcandle light meter reading would still have a total energy level almost 5 times the recommended light level even had it been UV filtered. Because the NoUVIR fiber optic lighting used had absolutely no IR and no UV the artifact was lit with 2.7 footcandles of visible light and exposed to only 2.7 footcandles of total energy. Because of the quality of the lighting and the huge reduction in total energy, the National Archives extended the exhibit time to 120 days.

This is a major shift in the numbers caused by a change in light source reducing the radiation. The exhibit was limited to 30 days. The exhibit was extended to 120 days. That is 4x the exhibit life.

The point is that a light meter alone cannot give you enough information to safeguard your collection. You have to identify (and eliminate) any energy outside the visible spectrum. To do that you must know the exact spectral output of your light sources.

Even then, following the IES guidelines of no ultraviolet and no infrared may not be enough. The spectral output of the visible light is important. Your light meter only measures a portion of the energy in the red and blue parts of the spectrum. Light color is important not just for presentation but as a conservation factor.

Reflected Energy Matching

Knowing that light energy is comprised of photons that impact an artifact surface, we can assume (and testing proves) that the only safe light is light that will be reflected.[7] Any energy absorbed by a surface results in change. Photochemical damage then is a function of absorbed energy. Lighting a blue object with red light will greatly increase the absorbed energy and the damage. Measured data shows mismatching the color of light to the color of an object can increase damage 30 to 70 times.[8]

Note the results in comparing light sources using ISO blue wool samples. Dimmed incandescent halogen light was more damaging to blue wool than

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[7] The mechanics of photon reflection and refraction are described in Light and Matter: The Dangerous Romance.

[8] Jack Miller, Evaluating Fading Characteristics of Light Sources (Seaford, DE: NoUVIR Research, 1993).

I.S.O. BLUE WOOL FADING SAMPLE TESTS

250,000 Footcandle Hours @ 10,000 Fc

TEST LIGHT SOURCE:	I.S.O. #1	I.S.O. #2	I.S.O. #3	I.S.O. #4	% SOLAR FADING	REM FACTOR
A. SUNLIGHT					100%	1.0
B. COOL-WHITE FLUORESCENT					89%	1.1
C. DIMMED INCANDESCENT					79%	1.3
CC. WHITE L.E.D.					67%	1.5
D. UV FILTERED FLUORESCENT					55%	1.8
E. MR-16 HALOGEN					53%	1.9
F. IR FILTERED HALOGEN					47%	2.1
G. NoUVIR® FIBER OPTIC LIGHTING					16%	6.3
H. RED FILTERED ACRYLIC FIBER					14%	7.1
I. REM FILTERED ACRYLIC FIBER					1%	100.0
J. UNEXPOSED (CONTROL)					0%	∞

Testing of light sources except LEDs done in 1992. Data and REM Theory peer reviewed 1992 through 1994. White LED light source tested using blue wool from same 1992 lot tested 2010.

© NoUVIR Lighting 1992 and 2010

Figure 2-5.
Comparison of Light Sources Tests Including Results from Reflected Energy Matching Samples

undimmed halogen light. Red filtered fiber optic lighting was 14x more damaging than blue filtered fiber optic lighting. The sample of the REM filtered source that matched the reflected blue of the wool looked identical to the the blue wool samples lit with a white unfiltered light that in turn matched sunlight. The fiber optic lighting is an extremely close match to the visible output of sunlight. The sample looked the same and looked blue.

But for the red filtered sample, the blue wool looked black. The red light was absorbed. No blue light was reflected as data. Almost all the damage was from mismatched light.

So to extend exhibit life, a basic rule emerges. First remove all the UV possible. Second remove all the infrared possible. Use balanced visible light, because a peak in a single visible color can mismatch and cause harm. The exception to the rule is if the object has a single color, a dominant color or a particular color that is very fragile. Then the last piece of Reflected Energy Matching Theory can be applied to preserve that color from fading.

To return to the practical example of the Alaskan check used earlier, and to give credit to the National Archives, their current specifications for rare documents (like The Declaration of Independence, The Constitution and The Bill of Rights) require an absolute energy cut off at 500 nanometers. This not only eliminates all of the UV (380 nanometers and below), but also the very blue and violet visible light that would be totally absorbed by a sepia colored parchment. Unfortunately, National Archive's current specifications ignore the other end of the spectrum and the IR radiation of conventional light sources.[9]

Matching the color of lighting to the color of the object to decrease absorbed energy and photochemical damage is called Reflected Energy Matching. Over the years it has been used in a number of museums. The first part of the theory is to remove all invisible light. It is radiation that is not needed. All it can do is cause harm.

The second part of the theory may or may not come into play. But filtering out a specific color that mismatches like blue lighting a yellow, brown document further extends life. Reflected Energy Matching has demonstrated its effectiveness as a conservation tool over and over again. It is described in detail with actual fading test data in NoUVIR Lighting Publications.[10] See the pdf list for a large file of two combined papers titled *Reflected Energy Matching as a Conservation Tool*.

Because photochemical damage is a function of absorbed energy, we commonly think of it as being directly related to light intensity. This is true. Reflected Energy Matching is not so commonly understood, but is just as true. And, while Reflected Energy Matching helps explain the necessity of removing UV and IR from museum lighting, it goes much further than that.

Reflected Energy Matching also demonstrates that within the visible spectrum, photochemical damage is directly related to color. In particular, photochemical damage is related to the difference between the color of an object

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[9] As Figure 2-6 demonstrates, NoUVIR fiber optic lighting corrects this oversight by eliminating all energy above 770 nanometers (all IR). An accessory notch filter at the projector removes all the energy between 380 and 500 nanometers to absolutely meet National Archive standards.

[10] Ruth Ellen Miller, Jack V. Miller, Fading of Fugitive Colors By Museum Light Sources (Seaford, DE: NoUVIR Research, 1993).

and the color of the light illuminating it. That difference determines the percentage of total energy of visible light absorbed by an object. In some cases this difference is more important to a conservator than the actual intensity of the light.

For example this famous Marilyn Monroe red dress is an excellent candidate for further filtering. The dress has turned to a tomato red from the vivid

Figure 2-6. Famous Marilyn Monroe dress.

color it originally had. It is posed in one of the well-known shots taken by the photographer. But the pose also allows the dress to be partially supported by the floor of the case. The blue visible light in an LED would mismatch the fabric. The heat in a halogen would warm the material causing not just photochemical damage, but driving other problems. The dress would look dull under warm-white fluorescent lighting, ghastly under cool-white fluorescent, and again have mismatched color problems.

Under fiber optic lighting the dress is lit with all the UV and all the IR removed. The dress is evenly lit. The shoulders are not too bright nor is the bust line. The skirt is lit. Therefore, the museum recommended footcandle level guideline is not only followed; but meets the specification over the whole costume.

The lighting extended the exhibit life by a factor of 5 times compared to good-quality LED lighting. With a perfectly matched tomato red filter the life would be extended yet again to 65 times what it would have been under good-quality LED lighting. LEDs would not have had the control to evenly light the dress.

Plus with LED lights installed in the case to control the case's viewing windows from imaging the room as a reflection, LEDs would have added heat into the case. That in turn would not just have subjected the dress to infrared to drive photochemical and photomechanical damage.

But it would have made the case exchange air with the gallery and increase pollution. As it is, this case was sealed with an AIR-SAFE micro-climate control system that passively (no electricity) cleaned the air and treated it to a specific humidity level. The AIR-SAFE system needed such a simple seal to operate that the case's normal construction including a well-fitted, but screwed down door, provided all the sealing required. The AIR-SAFE system was installed in the ceiling where the fiber optic projector was also located. Two tubes and the fiber reached down columns to luminaires installed in the case. This means the dress was in a very clean environment.

Figure 2-7. Fiber optic projector on the left with AIR-SAFE system on the right above in the ceiling attached to the Marilyn Monroe dress case in the room below.

Knowing light sources and their spectral output lets you do impossible exhibits. Being aware of the technology available and the products designed just for museums provides the tools. You can protect valuable and fragile objects ***while still letting the public completely enjoy them on exhibit.*** Applied science unlocks preservation.

Again, this famous dress' exhibit life was extended by a factor of 65 **times**. Exhibit recommendation would have been 6 to 9 months for display. Then the dress would have been placed into archives for a decade before rotating back out for view. Applying Reflected Energy Matching Theory using fiber optic lighting a 6 month exhibit window is now the equivalent of 32-1/2 years.

Even partially filtering a light source to match the color of an artifact can extend its exhibit life 50 times or more. Interestingly, such filtering does not change the appearance of the object illuminated. This is because only the light that will be absorbed by an object is removed.

There is no change in reflected light and therefore no change in what the eye sees. In demonstrations to conservation and museum professionals, as well as surveys done with the public in different museums' gallery spaces, people have been unable to guess which objects were lit with reflected energy matching filters and which were not.

It is possible to determine the photochemical danger of any light source to any particular object. You do this by comparing the spectral power distribution of the light source to the reflection spectrum of the object.[11] The difference between the two curves identifies the percentage of light energy that will be absorbed by an object. We have identified this value as the coefficient of damage.

Observable Warning Signs of Infrared Light Damage

Can you observe the photochemical damage caused by infrared light? Because the IR photon has a large diameter spin, the photochemical changes in the object are usually at the surface. Photomechanical damage can be harder to detect. But there are warning signs.

However, the easiest first step is to measure temperatures. Today small digital thermometers are as inexpensive as digital watches and calculators. Put one in the case in the light. Placing it in the corner in a shadow will not tell you what the artifacts are being exposed to as the artifacts are lit and not in shadow. Put one in the gallery space. Is there a temperature difference?

For every rise of 10°C in temperature, a chemical reaction doubles in speed. Or put another way, you cut the artifact exhibit life in half. The infrared is heat. The heat in the lighting drives the photoCHEMICAL damage. This is basic high school chemistry.

A way to test objects not in a case is to use an infrared Temperature Gun. These laser sighting instruments are also cheap. But they are accurate enough to get a good idea of what the lighting is generating as infrared exposure for the objects. Sight and read the center of a painting, sculpture, piece of furniture, antique carousel horse, costume figure, painted teepee…then take a reading of the shadowed wall or floor next to the object. Is there a temperature difference? Again, knowing is always better than ignorance.

The first signs of infrared damage is usually in a varnish, coating or at the surface. The surface can slightly yellow. It can darken with a film of pollution. It can be tacky or sticky to touch.

Dirt build up that does not easily dust off is a warning sign. Of course, just as in UV, fading, color change or bleaching is observable photochemical damage. UV damage tends to be a fading behind the color almost like an under

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[11] Spectral power distribution curves should be available from any reputable lighting manufacturer. Spectral curves for the most common light sources can be found in the Illuminating Engineering Society North America Lighting Handbook, Mark Rea Editor. Reflectance curves can be found in sources like Artists' Pigments, A Handbook of their History and Characteristics edited by Robert L. Feller. Both of these books are listed in the bibliography.

powder or lightening back color. IR tends to be more at the surface. But such determination usually happens unobserved. You only detect the fading.

Surface cracks and splits, shrinking, gaps inside a fossil, surface etching, thinning (for example, extinct egg shells), spalling, warping…damage often attributed to drying by exposure to too low of a humidity level is actually the results of infrared in the lighting.

Dust is an important detail to pay attention to when it is around an object. Who would think that light could damage a rock? But mineral specimens will shed small pieces and crystals will sheer apart.

Alway handle and inspect any object with care and conservation gloves. Do not use rubber gloves unless they cover the hands with a fie cotton glove between hands and the object. Latex and nitrate gloves will transfer skin oils and other contact pollutants even if they do not leave finger prints. A head mounted light is also a good way to examine for artifact details.

All photochemical damage for collections has a hidden cost. Because the object escalates in value, often the financial losses are never realized. As an example, let's pick an artifact with numerous auction activity to establish value.

A Superman #1 comic book is worth over $3M dollars in excellent condition. The comic is rare. But a fair to marginal Superman #1 comics with condition issues drops to under $100,000.

A Charles Russel illustrated letter in watercolor with the same subject, size and detail will have a division in value of over $80,000 depending upon condition. The collector will look at an increase in value. The artwork sold for far more than its purchase price. But if the color had turned slightly pastel and the paper slightly embrittled, the work did not bring at auction nearly the value of one that is bright, colorful and the paper in good shape.

A Hollywood costume from a very famous movie can have a spread of over $150,000 just based on condition and if there is light damage. Errors made in protecting these types of textile assets can be extremely costly. Not only do costumes that are faded command 30% to 60% less in a auction, but the auction house usually demands a higher percentage or fee to compensate making the sale more difficult.

This Superman costume of Christopher Reeves was lit by fiber optic lighting in a sealed case using an AIR-SAFE system. The reason was more than superior presentation. The real concern was protecting the owner's investment.

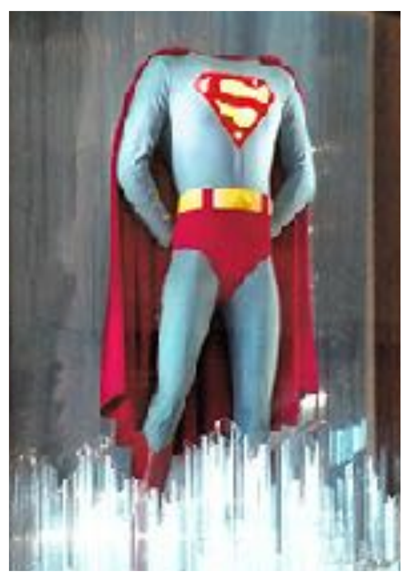

Figure 2-8.
Superman movie costume.

Some costumes shift from being valuable and museum pieces to being semi-collectable and selling to fans instead of being added into a serious memorabilia collection. The same is true for fashion examples. A historic uniform or a superior example of a woman's dress can become too damaged to invest the costs of restoration. The tier of collectors drops. Some costumes sell for a tiny fraction of what their value would have been if they had been cared for and protected from damage.

What are the costs of a careful conservation job requiring full restoration?

A well-known institution raised over $300,000 to conserve their brown red pair of Ruby Red Slippers form the *Wizard of Oz*. Restoration would require the removal of every sequins, indexing the sequin, dying red again and adding the finish, sewing each sequin into the original location using the same holes and even faking the original dance wear on the shoes.

Conservation treatment will get the Ruby Red Slippers back to shiny red. But if the lighting had been without UV and without IR, the funding could have been raised for another project. The best for the shoes would have been for them to never change color, loose their gloss and not chipped. What could the museum have done with the $300,000?

The examination of paintings is more difficult as so many things impact the work depending upon materials and technique. Sometimes the IR damage is absorbed into the protective varnish or over glaze. The conservation treatment has to be done carefully. But the yellowing once clear glaze and the dirt accumulated on the surface can be removed. The work is finished with a new protective coating.

This type of work can greatly increase the value of the work.And it can be painstaking. One museum stated that any conservation treatment started at $10,000 for a painting.

This type of damage can also surprise the art world. Probably the most public example was the restoration of the Sistine Chapel ceiling, painted by Michelangelo. Though some of the changes were from removing previous corrections, restorations and glues by restorers; a great deal of the mute colors, pastel shadings and darkness of the images was decades if not centuries of infrared damage. The restoration and cleaning revealed a bright colored and dramatic work with a great deal of use of primary colors and colored shading.

Painting in a museum can have the same revealing. Look closely. A painting may not be warm toned and dark. Brighter colors may be below the infrared damage.

For signs of problems, look for a slight wave as the canvas fails to be stretched. Pay attention to a wood panel where it was joined creating a line in the work. Look for the start of more serious problems like migration of color, bloom, cracks at the surface that pull away from the ground, yellowing and darkening.

The damage will look surface deep. Unless the painting is warmed and cooled at its the surface every day. This infrared not only heats the work, but changes the work's humidity levels. Over time pieces of the painting can literally crumble off the painting. Lighting can cause a host of problems. Fortunately most painting are fairly durable.

The point is that light damage seriously degrades resell value. What should have escalated into a large return as an investment was capped and depressed. You got less money by failure to control the lighting and conditions the object was displayed under.

The piece might have brought in more money in than it's original purchased price. But it took in pennies on the dollar compared to its potential as an object in good condition. The light damage cheated the owner of the gain.

Defenses Against Photochemical Damage

The first priority in protecting your collection from photochemical damage is to limit overall intensity. Safe lighting automatically implies museum light levels. See the first pdf for a chart of Recommended Footcandle Intensities.

Where it is possible, use UV-free lighting. Remember that UV can be filtered. For objects that are organics that are yellow and brown like rare documents, filter out the visible blue light.

The next step is to remove the infrared. Correctly designed cases always protect and preserve artifacts better than no cases. Preference is to use light with zero infrared content. But even if you have to use conventional lighting instead of fiber optic lighting, the cases should not trap heat. They should not ingest pollution. It is too easy to seal a case and use a AIR-SAFE system even if the lighting has IR.

Care should also be used in evaluating lighting. The greatest mistake is to let some contractor pick for you. The choice in light fixtures determines what problems the collection will have in the future; and will, not just can, impact what the collection's conservation costs will be as well as the valuation of the collection. Harming an artifact costs more than taking the time to specify your lighting.

Ultraviolet light and infrared light never help you see. All the radiation can do is cause damage. Different lights have different damage rates. Pick what is best for your collection. You will save a lot of grief and a lot of money over time.

Be warned that the lighting industry is against you specifying your lights. The industry's goal is not to save your collection from light damage. Instead the salesman or woman wants to sell you lights with the highest profit margin for the manufacturer or the best, deepest discount and highest mark-up for the contractor. It is not uncommon for a lighting company to have 20 or more different prices for the same products (not NoUVIR.) If you do not choose for your collections' safety, someone else will choose for you for entirely different reasons.

An important, Final Word

Finally light is how you communicate. Light is the voice of the collection. Its beauty, details and color show up as presentation, because the lighting is "good". Or the collection is dull and boring, because the lighting is "poor".

If the public or even friends for a private collector are not impressed and don't want to show up for visit, it may not be any problem with the objects. It probably is marginal lighting. How-hum lights make the most spectacular artifacts how-hum.

Find the best lighting you can afford. Pay attention to presentation. That is the life blood of any collection. To enjoy, people have to see and see well.

Do not ignore preservation.

Pick the best lighting you can for protecting your investment. Do not let something as simple as investing in good lighting ***steal pleasure and value*** over the years.

And watch your budget!

Especially if you are doing a project or exhibit. When costs are overrun, the fastest thing a contractor will reach for is to change your lighting. The contractor's profit on lighting is well hidden. There are lots of choices in dropping performance and substituting something harder to maintain. There is lots of incentive to pick retail lighting instead of museum lighting. And it is hard for the end user to figure out it is junk lighting until a few years later when valuable things start to fade (even furniture, carpeting and wallpaper) and the lighting starts to break.

So guard your future. Hold to your lighting specification. Fight for your budget. Do not let someone plunder your funding for safe lighting ***as poor lighting plunders your collection's value for decades.*** Lighting is too important.

You need good lighting. Mediocre lighting robs you of the joy of your collection! And it chains you to long term costs that add up over and over and over again over the years.