LAMP SPECIFICATION ABBREVIATIONS

RATINGS

W	Watts
V	Volts
kV	Kilovolts
A	Amps
h	Hours
K	Kelvin
lm	Lumens
lm/W	Lumens per Watt
lx	Center Screen Illuminance
cd	Candela
cp	Candle Power
CRI	Color Rendering Index
m/sec	Meters per Second

DIMENSIONS

LL	Light Length (filament length)
LCL	Light Center Length
C-to-C	Contact to Contact
MOL	Maximum Overall Length
Dia	Diameter
Max	Maximum

All dimensions are approximate measurements in millimeters (mm)

BURN POSITION (BURN POS)

BD	Base Down
BD/45	Within 45° of vertical base down
BD/Hor	Base Down to Horizontal
BU	Base Up
Horiz	Horizontal
H±10	Within ±10° of horizontal position
H±15	Within ±15° of horizontal position
H+10/-45	+10°;-45° of horizontal position
H+15/-45	+15°;-45° of horizontal position
H+60	Within +60° of horizontal position
V±15	Within ±15° of vertical position
V±30	Within ±30° of vertical position
Univ	Universal Burn Position

SAFETY AND HANDLING

TUNGSTEN HALOGEN AND INCANDESCENT LAMPS

- Always wear eye protection when installing Halogen lamps. Some Halogen lamps have internal pressures of several atmospheres.
- Halogen lamps operate at extremely high temperatures that can cause serious physical injuries and property damage.
- Only use Halogen lamps in Halogen-approved fixtures. Fixtures should fully contain any parts of the halogen lamp upon the event of a lamp burst.
- Do not use Halogen lamps in close proximity of paper, cloth or other combustible materials that can cause a fire hazard.
- Lamps are very fragile, do not drop, crush, bend or shake them.
- Do not touch the Halogen bulb surface or inside reflectors with your bare hands. Oils from skin can lead to breakage or shorten the life of the lamp. Use clean gloves or lint free cloth for installation and removal.
- Clean any dirt, oil, or lint away from the lamp with alcohol and a lint free cloth or tissue. Any foreign particles or materials on the bulb surface can cause hot spots on the bulb and result in lamp failure.
- Never touch the lamp when it is on, or soon after it has been turned off, as it is hot and will cause serious burns.
- Do not look directly at the operating lamp for any period of time; this may cause serious eye injury.
- Always turn off the electrical power before inserting, removing, or cleaning the lamp.
- Affix the lamp securely in the socket. Improper installations will cause electrical arcing, overheating and short life to lamp and socket. Replace lampholders and sockets when necessary.
- Keep the temperature of the Halogen lamp seal below 350° C.
- Keep the temperature of the Halogen bulb wall above 250° C.
- Keep the temperature of the Halogen lamp bulb wall below 800° C.
- Make sure lamps of specified wattage and voltage are only used in appropriately rated fixtures. Unspecified use will lead to short lamp life, breakage and overheating of fixture.
- Lamps should not be operated beyond the total rated voltage. Avoid the use of dimmers that may drive your lamp over its rated voltage.
- Operate the lamp only in the indicated burn position. Failure to do so will lead to overheating and short life of the lamp.
- Use an external fuse when required.
- Do not allow one lamp to directly expose another. This may lead to overheating and shortened lamp life.

FLUORESCENT LAMPS

- Fluorescent lamps operate at high surface temperatures that can cause serious physical injuries. Turn power off and allow adequate time (approximately 10 minutes) for the lamp to cool before attempting replacement.
- In order to avoid the risk of electrical shock, make sure the power to the fixture is turned off when replacing a lamp. Hold compact fluorescent lamps by the lamp base.
- Lamps are very fragile. Do not drop, crush, bend or shake them. Fluorescent tubes may shatter with considerable force when broken.

FLUORESCENT LAMPS (Continue)

- To ensure that the lamps remain in the sockets for the duration of the operation, make sure that the fixture's sockets are not worn prior to installation of the lamps. If the lamps are installed in worn sockets, the lamps could fall out of the fixture during operation.
- Never operate a lamp above or below its rated current voltage.
- Electrical connections should be clean and in good condition. Replace lamp holders and sockets when needed. Affix the lamp securely in the socket. Improper installations will cause electrical arcing, overheating and short life to the lamp and socket.
- Do not look directly at the operating lamp for any period of time; this may cause serious eye injury.
- Fluorescent lamp use is not recommended in extreme weather conditions. Excessive cold/warm temperatures dramatically affect starting, lamp life and lumen maintenance.
- There is a NEMA recognized industry issue where T2, T4 and T5 fluorescent and compact fluorescent lamps when operated on high frequency electronic ballasts may experience abnormal end-of-life phenomenon. This end-of-life failure can result in the bulb wall cracking near the base of the lamp, or the lamp overheating in the base location and possibly melting the base and/or the socket. NEMA recommends that if high frequency electronic ballasts are used that the ballast has an internal end-of-life protection circuit that will safely and reliably shut down the system in the rare event of a end-of-life failure as described above. For additional information please refer to NEMA papers on their website www.nema.org.

METAL HALIDE DISCHARGE LAMPS

- Always wear eye protection when installing Metal Halide discharge lamps. Some Metal Halide discharge lamps have high internal pressure even while cold.
- Metal Halide discharge lamps emit ultraviolet radiation which is harmful to eyes and skin!
- Metal Halide discharge lamps should only be used in enclosed fixtures with ultraviolet absorbing filter glass. Failure to do so may cause serious skin burn and eye damage. Do not use these lamps in fixtures where any unfiltered light is emitted from the fixture. Do not operate these lamps if the ultraviolet absorbing filter glass is broken or not installed.
- Metal Halide discharge lamps should only be operated in an enclosed fixture that safely contains all lamp parts in the event of a lamp burst or rupture. These lamps operate at a high internal pressure and at high temperatures. A lamp burst can occur causing physical injury and property damage.
- Lamps should never be operated beyond their rated useful life. The risk of a lamp burst increases with lamp age, temperature, improper operation and improper handling.
- Never bump, drop, apply excessive stress, or scratch the lamp. This could cause the lamp to burst! Do not operate any lamps with any traces of scratches, cracks, or physical damage.
- Never operate a lamp above or below its rated current or voltage. This may cause the lamp to leak or burst.
- Always turn off the electrical power before inserting, removing, or cleaning the lamp.
- Clean any dirt, oil, or lint away from the lamp with alcohol and a lint free cloth or tissue.
- Electrical connections should be clean and in good condition. Replace lamp holders and sockets when needed. Affix the lamp securely in the socket. Improper installations will cause electrical arcing, overheating and short life to lamp and socket.
- Never touch the lamp when it is on, or soon after it has been turned off, as it is hot and will cause serious burns. Lamps should be allowed to cool for a minimum of ten (10) minutes after the lamp is turned off.
- Do not use lamp in close proximity of paper, cloth or other combustible material that can cause a fire hazard.
- Do not look directly at the operating lamp for any period of time; this may cause serious eye injury.
- Metal Halide discharge lamps contain mercury. USHIO strives to preserve the environment and make efficient use of resources. Please refer to your local environmental laws regarding disposal and recycling of mercury containing lamps. For more information, please go to www.lamprecycle.org.

Hg contains mercury
contient du mercure
Manage in Accord with Disposal Laws
www.lamprecycle.org 1-800-895-8842

Metal Halide, Fluorescent and High Pressure Sodium discharge lamps contain Mercury. USHIO realizes the importance of lamp recycling and we encourage all lamps to be properly disposed of in order to help preserve the environment and our Earth's precious natural resources. Please refer to your local environmental laws regarding disposal and recycling of Mercury containing lamps. To learn more about lamp recycling requirements in your area, you can contact your state environmental authorities or visit www.lamprecycle.org.

R - NON SELF-EXTINGUISHING LAMP

WARNING: This lamp can cause serious skin burn and eye inflammation from shortwave ultraviolet radiation if outer envelope of the lamp is broken or punctured. Do not use where people will remain for more than a few minutes unless adequate shielding or other safety precautions are used. Lamps that will automatically extinguish when the outer envelope is broken or punctured are commercially available. Complies with the USA Federal Standard 21 CFR 1040.30 and Canada Standard SOR/80-381.

HIGH PRESSURE XENON ARC LAMPS

WARNING!

- Xenon arc lamps could burst when not in operation causing serious injuries! It is critical to follow safety instructions when handling Xenon arc lamps!
- Xenon arc lamps have a high internal pressure. Depending upon the lamp, the internal pressure can exceed 10 ATM or 147 PSI, even when not in operation.
- Always wear eye/face and body protection when handling Xenon arc lamps!
- Never bump, drop, apply excessive stress, or scratch the lamp. This could cause the lamp to burst!
- Always transport the lamp in the provided protective case or cover until installation!
- Save the protective case or cover and packaging materials (box) for lamps that have been used to their rated service life. Use the protective case when disposing of the lamps.
- Never touch the lamp when it is on, or soon after it has been turned off, as it is hot and will cause serious burns. Lamps should be allowed to cool for a minimum of ten (10) minutes after the lamp is turned off.
- Always operate the lamp in closed, protective housings.
- Do not look directly at the operating lamp for any length of time; this may cause serious eye injury.
- Do not use lamp in close proximity of paper, cloth or other combustible material that can cause a fire hazard.
- Some Xenon arc lamps produce Ozone that is considered toxic at relatively high concentration levels. Use ozone-producing lamps in lamp housings equipped with exhaust systems.
- Never operate a lamp above or below its rated current or voltage. This may cause the lamp to leak or burst.
- Affix the lamp in the correct polarity according to the lamp and fixture design.
- Affix lamps by hand tightening only. Do not use any tools to tighten nuts or the lamp itself. Any excessive stress to the lamp will cause a burst.
- Electrical connections should be clean and in good condition. Replace lamp holders and sockets when needed. Fix the lamp and its lead wire firmly to the terminals.
- Clean any dirt, oil, or lint away from the lamp with alcohol and a lint free cloth or tissue.
- Xenon arc lamps should not be used beyond their rated service life. Operation beyond the rated service life will cause the lamp to burst.
- The lamp must be operated under the specified conditions such as lamp amperage, voltage, and cooling conditions.
- Do not overcool the lamp. Air should never be directly forced on the bulb because uneven cooling will result.
- Recommended cooling methods are: air flow, N_2 gas flow, heat sink and an exhaust duct.
- The lamp base temperature must be kept below 200^o C.

XENON ARC LAMP DISPOSAL

- Xenon arc lamps must be disposed of in a careful and proper manner in order to prevent injury.
    1. Wear a protective mask, leather gloves and protective clothing when handling a spent lamp.
    2. Place the used lamp in its original protective case and original cardboard packaging (box) that was provided when the lamp was new.
    3. Firmly attach tape around the original cardboard box to seal the lamp securely.
    4. From approximately three (3) feet in height, drop the cardboard box, with the lamp and protective case inside, onto a hard floor to break the lamp.
    5. Shake the cardboard box to determine if the lamp is broken.

XENON SHORT ARC LAMPS

PART 1
SAFETY AND HANDLING OF XENON SHORT ARC LAMPS

INTRODUCTION
Short arc lamps have many applications in today's world of technology and applied sciences. As with many other devices used in production fabs or field applications, potential hazards exist. Caution along with a general understanding of any device or chemical significantly reduces the possibility of injury.

In order to better understand the precautions associated with the various short arc lamps, we must first examine the products within the lamp and the products produced by the lamp.

All discharge lamps contain metals, gas, or a combination of the two (some non-standard arc lamps, e.g. HMI, sodium vapor, etc., contain inorganic compounds).

SAFETY PRECAUTIONS
Xenon arc lamps typically have a high internal pressure. Depending upon the lamp, the internal pressure can exceed 10 ATM or 147 PSI, even when it is not in operation. For this reason, it is wise to handle the xenon lamp with great care. Use the following precautions when handling xenon lamps:

1. Never bump or drop the lamp.
2. Always wear eye protection.
3. When transporting the lamp, make sure it is in a protective case or cover.
4. Always operate the lamp in protective housings.

Mercury and mercury/xenon lamps are generally at high pressures during operation only. Lamps of this nature should always be operated in closed housings that provide some form of chamber exhaust. In the event of a catastrophic failure (explosion), the closed chamber will prevent injury from flying debris and exhaust stack will provide an escape for mercury or mercury vapor. Some systems may be equipped with condensers, which are designed to protect the equipment and the immediate environment. Since the operating temperature of these lamps will critically affect their performance, exhaust flow rates will vary between the size of the lamp and the size of the chamber. It is best to set exhaust flow rates based upon the desired performance of the lamp. Experimentation of individual systems and system location is highly recommended.

WHAT TO DO IN CASE OF A CATASTROPHIC FAILURE
With most mercury type short arc lamps, the mercury will condense and assume its natural phase very rapidly after explosion. Therefore, small beads of mercury will be present in the lamp housing. Since continued exposure to mercury through the skin, eyes, or respiratory system can be hazardous, it is important to take the following steps when cleaning up mercury:

1. Wear surgical gloves, proper face masks, and goggles.
2. The best way to remove mercury from the system is by aspiration. The suction of a syringe or vacuum device is very effective (do not use lungs). After the noticeable amounts of mercury are removed, gently wipe the optics with lint free paper that is slightly dampened by a residue free liquid.
3. It is important to note that small particles of glass may be present, therefore operators or technicians should take caution to avoid cuts or scratches. The aftermath of a xenon lamp explosion will leave glass particles. No potentially hazardous chemicals will be present, but again, be cautious! Glass particles can cause injury.
4. Any used or spent lamps should be discarded by proper disposal organizations.

Mercury snoop devices are available to measure the presence of mercury in a chamber. These devices may be used where concern about damage to the optics by free mercury is present.

BY-PRODUCTS OF SHORT ARC LAMPS
Ultra-Violet
The primary function of the gas discharge lamp is to produce light for illumination and/or to utilize the various wavelengths for specific photochemical reactions. All discharge lamps will produce ultraviolet light.

All lamps should be operated in a closed chamber. Any time UV leakage is present (through cracks or optics), protective UV glasses should be worn. These glasses are available at any lab supply outlets. Never look at a short arc lamp with the naked eye while it is operating. In fact, it is not advisable to examine a free standing short arc lamp unless you have good reason to do so. In this case, protection for the skin and dark welding type glasses should be worn.

Infrared
Short arc lamps will also produce infrared light. As a result, chambers, direct optics and the lamp will reach relatively high temperatures. Take caution not to touch or expose these areas to temperature sensitive materials.

Ozone
Ozone is the combination of diatomic oxygen (oxygen and monatomic oxygen). Ozone is a strong oxidizer and it will decompose organic compounds. Ozone has a bittersweet smell that is unique to itself. It is considered toxic and relatively high concentrations can be hazardous.

It takes energy to create ozone. Energy will also break it down (UV, 253.7nm). Any lamp which produces wavelengths below 225nm is capable of producing ozone. The amount of ozone produced by a lamp will vary according to the type of lamp and the amount of oxygen in the immediate atmosphere around the lamp.

Most short arc lamps are very inefficient below 225nm. Because the percentage of oxygen in the atmosphere is approximately 20% (this will vary with humidity), ozone production is rarely a problem. However, depending upon the sensitivity of the process and the equipment being used, ozone control may be necessary.

Exhaust systems from the chamber or doping the quartz are two ways to control ozone. Exhausting the lamp chamber will effectively remove ozone. The exhaust flow will depend upon the lamp type and the size of the chamber. The lamp performance will be affected if the exhaust flow is too high. Ozone detectors may be placed within the chamber and the levels can be monitored to establish comfortable levels. Since ozone is a gas and not a vapor, it is not necessary to exhaust at high flow rates.

XENON SHORT ARC LAMPS

Ozone levels can also be controlled by the absorption of the lines emitted by the lamp below 225nm. Titanium or cerium doping is possible however, users should make careful evaluations and be certain that ozone is in fact a problem. Since the lamp is absorbing UV and this phenomena occurs at reduced values of average power densities, the lamp life will suffer. Lamps made of doped quartz tend to be expensive and where relatively short wavelengths are necessary or process, doping is not recommended.

Summary

1. Short arc lamps are invaluable sources for many of today's technical needs.
2. Products within the lamp and produced by the lamp are only harmful when misunderstood or mishandled.
3. Be careful in choosing a vendor for the short arc lamp. Quality products are a key element in avoiding unpleasant surprises.
4. Handle lamps with care. Do not take any unnecessary risks.
5. Make careful evaluations before assuming a problem exist. In this way, future issues may be avoided.

PART 2
SHORT ARC LAMPS AND OZONE PRODUCTION

SHORT ARC LAMPS AND OZONE PRODUCTION

A considerable amount of interest has been generated lately concerning the harmful affects of items produced by short arc lamps. With the newly enacted U.S. Clean Air Act, more and more questions have been raised in particular.

1. How much ozone is produced by a short arc lamp?
2. How can this ozone production be stopped or controlled?

First of all, all non-filtered xenon, xenon/mercury and mercury lamps will produce ozone. How much is difficult, if not impossible to say. To understand why, you have to look at some basic facts.

Ozone is a natural compound of oxygen, occurring in the outer atmosphere. It is a tri-atomic (O-three) phase of oxygen at molecular weight 47.9982 g/g-mol as opposed to 31.9988 g/g-mol for the stable O-two (bi-atomic) oxygen.

In order to produce ozone it takes energy, in this case light. Without light, in specific wavelengths below 225nm, ozone will not be produced. In the outer atmosphere, ozone is produced by sunlight. The excitation of an otherwise very stable O-two molecule, causes it to either split or be joined to a free oxygen radical, creating this tri-atomic phase. This layer acts as the filter protecting the Earth's surface from UV C and B, and to a certain extent, UV A radiation.

Let's consider what it might take to produce ozone here on Earth. Basic components needed:

1. Lamp
2. Chamber
3. Oxygen

Lamp

As stated above, any non-filtered short arc discharge lamp will produce ozone. However, these lamps also produce a wavelength at 257.3nm, and this wavelength will break ozone back down.

When the gas in the lamp is not purely xenon, most of the ozone is produced when the lamp has just been started, before the thermionic arc is fully achieved (mature steady state operation). This is usually during the first 5 minutes or so, of operation when the lamp is operating at a pressure consistent with the production of ozone. During the steady state operation of most discharge lamps, the area under the points on the wavelengths under 225nm is less than 0.5% of the total spectrum of the lamp; in special cases, perhaps as high as 5 or 6%. In other cases there is no line production at all.

Chamber

Most lamps operate in a lamp house. The amount of potential ozone created will depend on how large that lamp house is, how much air is moving through that lamp house (rate and volume), and what the relative humidity is in the lamp house.

Oxygen

Certainly, no one cools the lamp with pure oxygen! This is not safe nor advisable. Therefore, the oxygen must come from free air. The basic percentage of oxygen in the atmosphere is twenty percent, and this with forced flow is dynamic at best.

In order to determine exactly how much ozone is produced by a lamp, a device for ozone measurement must be placed directly onto a specific chamber. The flow rate must be consistent and so should the humidity. It is not possible to ascertain precise data any other way.

Filtering

How do you control the production of ozone? Short of operating the lamp in a vacuum, the only way to avoid ozone production from a lamp is to filter it. Titanium and cerium doped quartz does this very nicely, often cutting off the spectrum at 380-410nm. However, for applications needing energy densities below the cutoff point, doping the lamp is not possible.

Why is ozone considered a problem?

Ozone is a strong oxidizer. In heavy molecular concentrations it will break down organic tissue. There are applications using specific lamps for decomposing bacteria. In some equipment where ozone would be a problem, rubber parts are not used in the exposed environment and nitrogen will be used for cooling.

In the course of technology the well being of the people involved is always a concern. The question is not if we should be concerned. We should be. But what are the limits of reasonable concern? At what point does the reductions of potential harm in one area, increase the real harm to people in another, such as cost? These are issues the user needs to investigate. As a lamp manufacturer, we are asked to produce products for highly specific applications. Danger revolving around the use of lighting products need never be an issue if the risk is managed and clearly understood. It is strongly recommended that users contact their system suppliers for specifics.

THORIUM USE IN DISCHARGE LAMPS

HISTORY
Thorium, first discovered by the Swedish Chemist Jons Berzelius in 1828, was named after the Scandinavian god of war, Thor. The atomic weight of thorium is 232.0381, atomic number 90. The melting point is 1750°C, with a boiling point of 3800°C (approximate).

Thorium is relatively abundant mineral with large deposits found in New England. It occurs in thorite and in thorianite. Thorium is commercially extracted from the mineral monazite.

The method of extraction involves reducing thorium oxide with calcium by the electrolysis of anhydrous thorium chloride in a fused mixture of sodium and potassium chlorides. Other, more complex methods are also used.

Thorium is the second member of the actinide series of elements. A silvery-white metal, it is air stable and retains luster for many months. Only a few elements or compounds, such as tungsten and tantalum carbide, have higher melting temperatures.

The principle use for thorium has been in the Welsbach mantle used in gas camping lanterns. It is also used to impart high strength and creep resistance in magnesium products.

Since thorium has a low work function and a high electron emission (and the oxide is excellent for controlling grain size) it is used to coat or impregnate lamp filaments and arc discharge electrodes.

Thorium oxide is also used in glass where a high refractive index and low dispersion is desired.

ATW 232 thorium occurs naturally and has a half life of 1.41×10^{10} years. As an alpha emitter, it goes through six alpha and four beta decay steps before becoming the stable isotope ATW 208 Pb (lead).

THORIUM USE IN LAMPS
Since Edison's day, thorium oxide has played a major role in lamp production. As previously stated, thorium's value in lamp manufacturing is well established and no known material can replaced it with the same practical integrity.

Lamp stability, lamp life, and consistent production replication is extremely important in lamp manufacturing, especially where micron and submicron lithography work is desired.

In short, without complex electrode materials and production systems, lamp based photolithography would not be possible.

Electrode/thorium mixtures are 2% to 4% thorium by weight. It is also important to note that in a DC short arc lamp only cathode (emitter) is thorium impregnated. The anode (the larger electrode) is the target, and as such requires no thorium. AC long arc xenon lamps are typically manufactured with both electrodes impregnated with thorium, typically 2% each.

THORIUM AND SAFEFY
Since the application of thorium in a lamp product in the hands of an end user is not known, nor regarded as hazardous, this paper does not deal with it as hazardous compound. Obviously, effort should be extended in order to justify this position.

Many individuals simply hear the term "radioactive" and they cringe. Historical events come to mind: Three Mile Island, Chernobyl, and of course, Diane Silkwood, not to mention those very unfortunate individuals exposed to massive amounts of radiation during bouts with cancer.

Radiation is subject to many physical phenomenons. Since radiation is simply a term designated for any source that emits some form of wave or particle from a center hub out to an outer wave from rim; such as radio waves, light waves and atomic decay. Most of these resources are not harmful, and may be controlled to the point of being in a nonhazardous condition.

The key to safety regarding all aspects of radiation is education and a nonemotional evaluation of the source. Sensationalism is fine for playwrights and paperback novels, but contributes little to science.

WHAT OF THORIUM?
Thorium is a radioactive compound. The important distinction is that thorium is a primary alpha emitter. What is an alpha? Very importantly, alpha is a non-penetrating particle.

The British physicist, Ernest Rutherford, was the first to identify the different kinds of radiation. Alpha, beta and gamma rays were distinguished by the way they responded in magnetic fields, and he discovered, by their differences in penetrability.

Basically, it was found that gamma rays displayed x-ray like penetrability, beta rays were much less penetrable, and alpha rays (thorium primary) were scarcely penetrating at all.

Rutherford further examined the alpha ray and in measuring the e/m ratio found it equivalent to that of a helium atom. It is important to note that unlike the relatively hazardous uranium atom, thorium is not fissionable.

However, since thorium is radioactive, and as such is experiencing decay, what is the danger from the daughter products, in this case the four beta decay steps before becoming lead?

Bear in mind the time consideration. One half life is over millions of years. By the nature of ATW 232 thorium, actual production of beta particles (still far less penetrating than gamma rays) is very ray. In fact, statistically, it does not exist relative to the background radiation that we are all exposed to day to day.

So far we have examined the properties of thorium through the documented work and particle history of the product.

No aspect is complete within the scientific method without including actual quantitative data. As such, a series of simple test were conducted on five items, all containing thorium oxide.

THORIUM USE IN DISCHARGE LAMPS

LAMP – THORIUM VALUE TESTING
Items utilized

1. Lamp cathode from a 5000 watt xenon/mercury lamp. Total weight of cathode was 1.7 grams at 2% thorium oxide or 0.03401 gram.
2. Coleman camping mantle silk-lite 21A.
3. 1000 watt short arc discharge lamp for semiconductor lithography.
4. 5000 watt lamp short arc lamp for PC lithography.
5. 6.5KW xenon long arc AC lamp.
6. Two 0.050 inch thick metal sheets.
7. G-M counter Ludlum model #18 analyzer.
8. Thin window G-M sensor model #44-9.
9. Sodium iodide crystal gamma probe #44-3.

THORIUM VALUE TESTING

Note: Background was 50 CPM with Detector A 500 CPM, with Detector B translating to about .02 millirem.

Please note the radiation source and shield diagram and the assessment chart.

	Detector A		Detector B			
	Source	S-1	S-2	Source	S-1	S-2
1000 Watt Lamp	60 CPM	50	50	- -	-	-
5000 Watt Lamp	75 CPM	50	50	- -	-	-
6.5KW	110 CPM	50	50	- -	-	-
Cathode	75 CPM	50	50	500	-	-
Mantle	10,000 CPM	50	-	- -	-	-

The concept here was to measure the emission from the standpoint of an individual placing a lamp into a system, and from the standpoint of an individual operating a machine using the lamp.

Please note the diagram S-1 and S-2 represent two metal shields. S-1 would be an inner housing and S-2 would represent the outer housing or door of the machine.

If you use water to cool the lamp within a quartz jacket this too would act as a shield. Distances were kept minimal and far smaller than most large systems.

By observing the chart it is plain to see that the statistical value of radiation from each product with the exception of the camping mantle was not above background radiation.

In fact, the camping mantle at 10,000 CPM was 90 times more active than the 6.5KW lamp 110 CPM. Remember we must subtract 50 CPM from these figures to account for background noise leaving the 6.5KW lamp at 60 CPM and the mantle at 9,950 CPM (camping mantles of older vintage are relatively high in alpha production, newer ones are far less active, if at all).

Again, in this case the background was 50 counts per minute or approximately 0.2 millirem. In fact, one of our customers in an independent test with a 2.4KW lamp observed the same readings.

Given the overall statistical value, the arc discharge lamp at the stated level of thorium content is not any higher than background radiation. As such, its presence does not put anyone at any more risk than one could expect by simply sitting in a room and reading this paper.

Furthermore, according to the Radiology Health Handbook 1970 page #104, one gram of ATW 232 is equal to 1.9 X 10-7 Curie.

Given the fact that the largest cathode we make for short arc photolithography lamps has only 0.03401 of a gram of thorium, there is little concern. Even the AC 6.5KW lamp at 0.04701(approximate) of a gram of thorium, the total with both electrodes impregnated is of no concern, falling very well below the roentgen equivalent physical (REP) for soft tissue absorption and extremely well below the soft tissue extent of 93 ergs/g.

On a comparative risk assessment value the common smoke detector or vintage camping mantle produces thousands of times more potential saturation than any of today's thorium impregnated arc discharged lamps.

With all that has been noted on thorium and alpha radiation by various health organizations at worst in small or large amounts, inhalation is the "do-not-do" condition. Certainly a lamp or bare electrode should never fall into this realm of concern.

For further information it may be noted that according to the state of California Radiation Control regulations, California Administrative Code Title 17 Health, page 15, article 3 (exemptions), item B, number nine: "Any finished product or part fabricated of, or containing tungsten-thoriated or magnesium-thorium alloys; providing that the thorium content is not over 4% by weight is exempt from any radiation health regulations."

Given the test performed for this paper it is obvious why the 2-4% thoriated tungsten electrode is not a health risk. Found in high performance automobile rims, bicycle frames, camping mantles, optics, and lamps, thorium has established itself as a critical, as well as safe, useful products. Understanding its properties and metallurgy contributions will no doubt keep it with us for some time.

References:
California Radiation Control Regulations Handbook, State of California Department of Health Services; Handbook of Chemistry and Physics, 69th edition; History of Physics, Isaac Asimov, 1966; Radiology Health Handbook, 1970.

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