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CRAFTING PHILIPS XENONS

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Bright sparks and craftsmanship from Philips

Jim Slater visited the Philips xenon factory in Los Angeles and saw how some of the highest technology products are the result of the application of hands-on craftsmanship.

L-R: Ana Simonian, Dave Beaulé, Tom Hardenburger, Linda Roesch - H.R. Manager, Curt Glover, Michelle Wei - Logistics Manager and Alan Luttio

In the beginning …

With such a biblical sub-heading preceding an article about xenon lamps my journalistic instincts cried out for the words 'let there be light' to follow, but my more careful engineering head knew that the actual creation of light wouldn't be appropriate until much later on!

The beginnings we are talking about concern the factory that began life as LTI (Lighting Technologies International) in 1999, when a group of just seven people, all of whom had varied backgrounds in different areas of lamp manufacture, and had worked with well known optical companies including ORC (Optical Radiation Corporation) and Perkin-Elmer, decided that there would be a good market for high quality xenon lamps made in North America for the expanding cinema business. Up until that time most cinema xenons used in the US had been imported, and there were good reasons for being able to provide locally sourced lamps in the US.

LTI grew and expanded, exporting its lamps worldwide, and I noted from the Cinema Technology magazine index that Australian BKSTS Member Daryl Binning had written a CT article about the LTI factory in March 2006, describing it as "a modern, progressive specialist lamp production facility equipped with the latest research and manufacturing equipment, and staffed by some of the most experienced people in the Xenon lamp business."

So successful was the plant that in 2007 the Philips company showed an interest and decided to purchase the company outright. It is now part of the Entertainment segment of Philips Special Lighting. Many of the original founders of the company remain today, and I was privileged to meet the current management team. Tom Hardenburger, Global Product Manager, Alan Luttio, Engineering Manager, Curt Glover, Plant Director, Ana Simonian, who is in charge of global sales, and Dave Beaulé, Quality Manager. Between them, and with the help of other colleagues they explained the history of the company, and we had some interesting discussions about the past, present, and what they are convinced is the very positive future of the xenon lamp in the cinema business.

Number 1, Number 3 …

With typical US panache I was told that Philips is number one company in the world in lighting, involved in everything from entertainment, through education, to street lighting and even providing the searchlights that reach high into the sky at the Ground Zero memorial in New York. In Paris the giant searchlight on the top of the Eiffel tower was specially designed as a 'one off' lamp that has become almost as famous as the monument on which it stands. Although the Baldwin Park factory, on the outskirts of Los Angeles, has a history of building many types of lamp (below) from metal halide to ceramic to mercury arc lamps, in recent times it has concentrated entirely on cinema xenons. In this very specialised area of lighting, Philips admits to currently being number three in the world, behind Osram and Ushio, although it soon became clear that they are not remaining content with this position, and are working hard to improve their position, primarily aiming to do this by focusing unreservedly on quality and customer service. Philips are currently number two in the North American cinema lamp market. Xenon lamps are manufactured with powers of from 700 to 10,000 watts, but most of the production typically ranges from 2000 to 6000 watts.

The factory, dedicated completely to cinema xenons, currently employs an ethnically diverse workforce of some 300 people, reflecting the population of greater LA, and

Just part of the massive manufacturing and production area. Notice the multiple workstations with extensive fume extraction equipment and ducting, used to remove the heat from the glassworking operations, always ensuring that the atmosphere is clean, safe, and comfortable for the operators to work in.

it serves the global market. The feisty Ana Simonian told me proudly that a Philips customer anywhere in the world can expect a speedy response to a sales or service query 24 hours a day, challenging me to be able to say the same of her competitors!

Tom Hardenburger was keen to tell me that Philips really takes its '100%' lamp warranties seriously – if a lamp fails after 99% of its rated hours it will be replaced with a new one, provided that there hasn't been any damage caused by the customer, and Tom said that this another USP for the Philips brand. I was interested to learn that the output of the factory really does reflect the fact that the transition to digital cinema is reaching completion – Tom told me that some 85% of the output is lamps for digital cinema, with Philips lamps being officially certified for use in Barco, NEC and Sony projectors, with a majority of the Sony projectors worldwide using their lamps, primarily, I guess because of the huge market represented by AMC and Regal cinemas. I remarked on the one projector manufacturer missing from that list – it seems that Christie have their own reasons (Ushio?!) for not wanting to certify other manufacturers' xenons! Nevertheless. the Philips sales material says that they have cinema xenons designed for use in Christie digital cinema projectors.

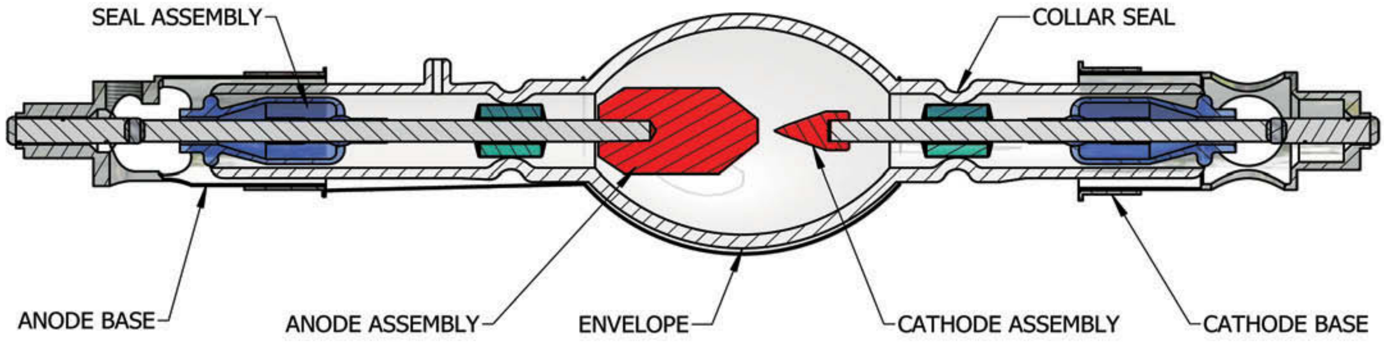
The digital questions …

I was told that Philips makes four ranges of cinema xenons, each designed to provide the ultimate total cost of ownership for different market sectors. In addition to its Standard range it offers Helios® lamps that provide greater brightness and efficiency at a higher price, along with growing quantities of the Digital range, lamps which have been specially designed to provide optimum performance from today's digital projection equipment. There is also a range of Digital Helios® lamps, based on film lamp technology but adapted for digital applications; these are intended for smaller digital screens and offer a lower total cost of ownership.

Since one of the few disadvantages of going digital for the cinema operator is that the lamp prices are generally higher and the lifetimes lower than for the original 'film' lamps, I really did try to find out on behalf of our readers just why this should be. But I am afraid that even after watching how the lamps are constructed I wasn't initially convinced that the sometimes significant cost differences are justified, which led to some interesting discussions with Curt and the team - they obviously felt passionately that I should be able to understand that digital lamps really do require something extra in the manufacturing process, and that this is what requires such lamps to be more expensive.

The accepted technical explanation, which I am quite happy with, is that the TI DLP™ based projectors require a very small aperture for the light to illuminate the micromirror devices, which means that lamps have to have shorter arcs, providing a smaller, denser light source. Whilst being able to accept that these more compact lamps will have to deal with more concentrated heat in a smaller volume, and therefore it might be reasonable to expect a shorter lifetime, my factory tour hadn't highlighted any great differences between the manufacture of the different types of lamp, and I hadn't at that point really seen any convincing evidence that it is more complex to manufacture the requisite short arc digital lamps.

It is always good to talk, of course, and in subsequent discussions with Curt he told me that because of the concentrated heat generated in a smaller volume, special electrode processing is needed to achieve the required lifetime, and this extra processing adds to the cost of making the digital lamps. Philips uses special proprietary manufacturing processes on its digital lamps to achieve this, but Curt admitted that they deliberately hadn't shown me this part of the process during my tour, since it was regarded as too business-sensitive to reveal all their technical secrets to competing lamp manufacturers - you can be sure that these



What it is all about - schematic diagram of a typical cinema xenon lamp showing the essential parts and assemblies described in the article

will soon be busy dissecting this piece!

We had, though, during the tour, discussed how the 'dark arts' of electrode shaping and various special coatings are the features that distinguish one manufacturer's product from another, so I have no problem in accepting that the extra electrode processing required by digital lamps will lead to their necessarily being more expensive - it seems that you really aren't being 'ripped-off'!

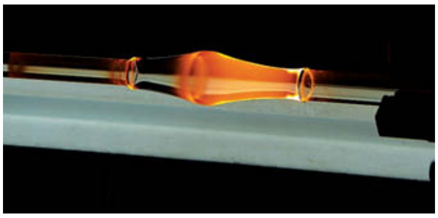
As explained in the 'training' section, later in this article, new staff are trained to work on smaller 35mm lamps and only progress to the digital models as they become more experienced, and their pay increases as they develop their skills to work on the more expensive lamps. When discussing the increased costs of digital lamps Curt said that only the best operators are qualified to produce digital lamps with the required short arc gap specifications. Even these highly trained operators need more time to build these lamps, which adds additional labour costs relative to film lamps.

One thing that was made clear, however, as I pressed the team for information about whether we might expect better, more efficient and perhaps even cheaper lamps in the future, was that, in spite of decades of development, the design and manufacture of xenon lamps is far from mature - the research engineers are constantly coming up with new ideas to improve light output and efficiency, with reducing the total cost of ownership being a constantly moving target for the Philips engineers

The factory tour ...

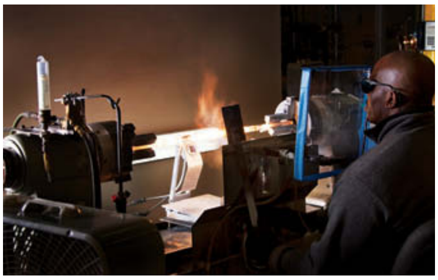
Plant Director Curt Glover spent several hours taking me on a conducted tour of the factory. He had been involved since its inception, and was therefore responsible for much of its design, both originally and as it has moved forward and been updated to provide the best possible environment for the manufacture of the latest generations of xenon lamps.

Everywhere I looked there was evidence that existing equipment was being replaced with new and being updated with new functions and capabilities. Many of the precise measuring techniques that had been traditionally been carried out using mechanical calipers (and it was interesting to see this still happening) are being replaced or supplemented by carefully calibrated 'vision systems' which allow the operator to see a much magnified video image of the electrodes or glass seals being worked on, making it easier to achieve consistent accuracy every time. These can be seen in some of the photographs of the manufacturing process.



Above: The lamp building process begins by taking pre-cut lengths of high-quality quartz tubing, mounting them in the lathes, and gently heating with various gas flames until the material begins to soften. The burners use pure hydrogen and oxygen to reach the temperatures required to melt quartz glass.

Below: Envelope forming. In this process, quartz glass tubing is joined together and an envelope is "blown" in the center. The shape of the envelope is controlled through the use of a graphite template. It takes months of training under close supervision to be able to make large envelopes for high wattage xenon lamps.



I spoke with Dave Beaulé, Quality Manager, and it was interesting to learn that he is constantly making checks on all aspects of the production, and has the right to stop production at any time if he is not happy with any aspect of the work – fortunately, he wasn't able to remember the last time that this had actually proved necessary, since it is usually possible to spot potentially harmful problems before they actually affect lamp production in any significant way.

Curt took me through all the individual steps in the production of a xenon lamp, from the inspection of the original quartz tubing (bought in various lengths and diameters from a specialist company, with some of that company's stocks being stored on site), through each of the production processes, right through testing, packaging and dispatch. The photographs and their captions explain the procedures in detail.

Craftsmanship in glass ...

I have to say that I was totally surprised by much of what I came across in the Philips factory. I had, quite wrongly, expected to find that complete glass bulb assemblies would be bought in from outside ready to be fitted automatically with the various electrode assemblies by complex automated machinery which would align and adjust everything to suit. Imagine, then, my surprise, to come across dozens of individual work stations fitted with complex glass-working machinery – as you can see from the pictures each work station is effectively a rotating lathe fitted with a series of moveable gas jets and mechanical tools made from carbon, which are used to shape the glass. My only previous experience of glass-making, apart from making pipettes in chemistry lessons using a Bunsen burner, came from a visit to the Pilkington's

Lamp sealing process. The electrode assemblies are inserted into the lamp envelope and the quartz material is fused together to provide a strong, gas-tight seal.

Building lamp seal assembly. Multiple layers of glass with different expansion coefficients are built up under vision system guidance, to allow the seal to compensate for the difference in expansion rates between quartz and tungsten.

Operator sealing a xenon lamp. Most lamp manufacturing operations are performed on specialized glassworking lathes.

In another part of the factory Electrode assemblies being spot welded. These assemblies are put together by hand to exact specification.

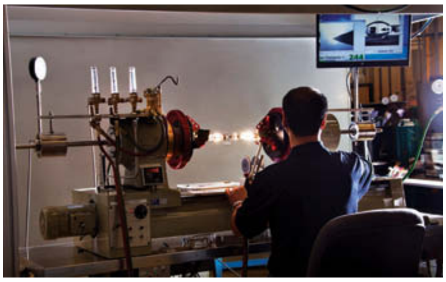
glass factory in St. Helens in the UK and from watching artists create fantastic glass sculptures in a studio, so it was surprising and amazing for me to watch these Philips craftsmen at work.

Beginning from tubes of highest quality quartz the operators carefully apply heat from various types of gas burners and then gently blow the molten tubing to form a bulb in the centre of the tube, all the time carefully shaping the bulb and the ends of the tubes using carbon tools, whilst constantly checking that the measurements of each part of the bulb and its associated tubing are within carefully defined parameters, with no bubbles and no air pockets. Not surprisingly, each bulb is slightly different from any other, and I was fascinated to learn that although each bulb looks the same to an untrained eye, and is, of course, within the tightly specified tolerances, an operator can tell you which bulbs he or she has made. Inspections are made at each stage of the process, and it was interesting to see that each different glass bulb could be traced back to its particular producer, allowing any possible problems such as air bubbles to be spotted early on and for corrective measures to be taken.

And some careful metalwork...

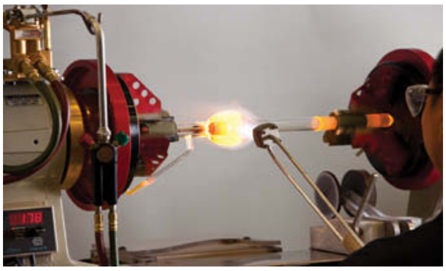
After the envelope (bulb) is complete and has been scrupulously inspected, including measuring wall thickness at various points, the electrode shafts are coated with different layers of special glasses designed to cope with the very different coefficients of expansion of the metals and the quartz, and it was fascinating to see the care with which the lathe operator was adding the different layers, and how the visual inspection equipment enabled constant checking.

The electrodes require high-purity tungsten, which can be extremely difficult to machine and require diamond tools to work them. The seal is created by wrapping different types of glass around the electrodes to form a graded seal that can compensate for differences in thermal expansion between the quartz and the metal shafts of the electrodes. As the electrode assemblies are inserted into the ends of the envelope, again by hand, and again with extreme care, with various different gas flames playing over the different parts of the graded seals, the final positioning of the electrodes and the gap, which has to be accurate to within one tenth of a millimetre, is carried out using the vision inspection system, and the seals are then made and the complete glass assembly is annealed to remove any potential stresses before being allowed to cool.

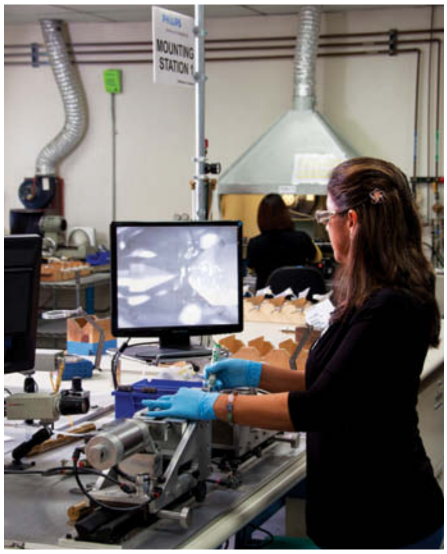


Overview of lamp sealing operation, showing vision systems which provide real time feedback to the operator of arc gap and electrode concentricity.

The thickness of the electrode glass seal assemblies are 100% inspected using a high accuracy digital microscope, to ensure all assemblies are built within specification.



Lamp sealling process. The quartz glass is heated red hot during an annealing step to remove stress.



Installation of metal fittings on the end of the lamp. The metal fittings are unique to each model of digital and film projector and are held in place by compression rings. The dimension from the cathode end base and cathode tip is carefully controlled to ensure the cathode tip is in the focal point of the reflectors inside the projector.

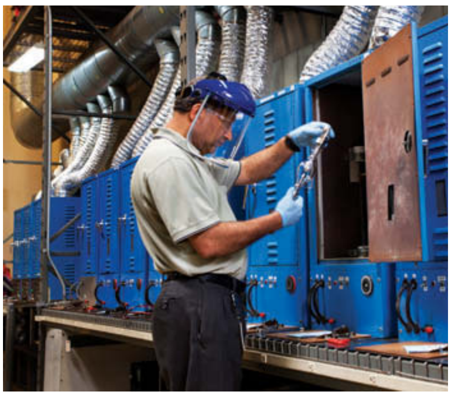
Close up of lamp xenon gas filling process.

The metal fittings are then installed on each end of the lamp, being held in place by compression rings. The fittings are unique to each model of digital and film projector and the dimension from the cathode end base and cathode tip is carefully controlled to ensure the cathode tip is at the focal point of the reflectors inside the projector.

As the lamp is being assembled, with the various electrodes and connections and the clever sealing technologies incorporated, ten to twelve people will have been involved in the manufacture of a typical lamp, and each of the individual contributions is logged and recorded and each lamp is given a distinct serial number.

Filling with xenon …

The process of filling the assembled lamp with gas is complex, dramatic, with liquid nitrogen vapour splashing about, and very interesting. All the existing gas is extracted from the bulb under high vacuum in order to remove all traces of contaminants, and then pure xenon gas is backfilled to a precisely controlled pressure. The lamps are then cooled with liquid nitrogen to freeze and compress the xenon, (you could actually see a xenon ice cube in the bulb at this stage), allowing the operator to seal the lamp without the xenon gas escaping.



Xenon lamps are 100% tested

Testing every one…

After the final inspection each lamp is individually tested in a series of special lamp houses - blue in the photograph below left - to check that it ignites properly and that its electrical characteristics meet the specifications. I guess that now is the time to use the phrase I wanted right from the beginning of this piece - 'and there was light!'

Packing carefully

Almost immediately afterwards the lamps are packed ready for despatch. This is a process that is, not surprisingly, carried out with extreme care, using specially designed double-walled cardboard boxes within which the lamps are suspended in their own individual boxes.

Curt told me that they hardly ever receive reports of lamps that are damaged when they arrive at the customer. The factory despatches lamps in small quantities to individual cinemas as well as in quantities of hundreds to installation companies, and they pride themselves on being able to manufacture and supply special orders rapidly. The factory currently works a three shift system over 24 hours, but closes from Friday evening to Sunday evening, giving most staff every weekend off.

Planning ahead

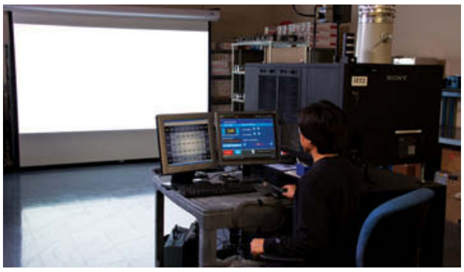
The business takes great care to make forecasts of anticipated requirements over a period six months ahead, and, based on these forecasts a materials requirement plan is drawn up and discussed with their key suppliers. It isn't a 'just in time' delivery system, but modest stocks of the various component parts are kept in racks around the factory, and 'pulled' from the holding stocks as required.

I gathered that it typically takes a couple of days for a lamp to be manufactured from the 'raw' quartz tubing before it is ready to be despatched, but because the factory prides itself on being flexible, if a customer has a really urgent need for a particular lamp they can often turn it around within the working day. Curt said that this type of service really is one of the Unique Selling Points of the Philips xenon operation, something that their customers really do appreciate. The lathes and the optical test equipment are all US made, so that spare parts and any necessary servicing requirements are readily available, eliminating fears of production downtime due to equipment problems.

Training – the Quartz University

I asked how on earth these people can be trained to produce such consistently high-quality products, and Curt was delighted to tell me how new recruits, often taken from craft and technical colleges but sometimes brought in on the recommendations of existing staff, are taken through a six-month apprenticeship which provides them with a complete knowledge of the various properties of quartz and how to deal with it – after the first six months the operators are considered proficient, and they then start on the longer term tasks of continuously improving their skills, starting on 35mm lamps and eventually graduating to the digital ones as their skills improve. I was interested to see that each bulb is individually identified and coded, so that any problems can be traced back to the operator concerned, not just to point the finger of blame, but to identify where further training might be beneficial. Training continues throughout the operator's career, and they move up in pay grade as their skills develop. I was interested to learn that staff turnover is very low, with most of the people having been with the company for many years. I gather that the pay and the conditions of service that a big company like Philips can offer are attractive compared to the limited number of other opportunities in manufacturing in the region, which obviously helps with staff retention, and there is also a certain pride in being able to tell your neighbours that you work for Philips. I was interested to learn that specialists in glass manufacturing and engineering from other parts of the Philips empire often contribute their expertise to the training programme.

Ongoing training isn't restricted to the manufacturing staff – one of the afternoons when I was on site I noticed most of the top management were attending an interactive management training seminar aimed at improving their 'people' skills over a wide range of areas. I jokingly suggested that this might just be a



'big company' way of scoring brownie points for their training policies, but two of those who had taken part in the course assured me that it had been useful and had genuinely made them think of new ways of going about the business.

Engineering and R&D

From my extensive discussions with the management team it became apparent that the business takes future developments very seriously, and I was taken upstairs to the extensive engineering development and research areas. It was stressed that although I would be seeing some of the R&D work being carried on at the factory, this isn't done on a completely stand-alone basis, and that one of the major benefits of being part of a larger enterprise is that the factory is always able to take advantage of the global R&D resources within the Philips organisation.

I was greeted by a collection of projectors from the major manufacturers (above left), all of which were ready for immediate use in testing, and saw a Sony digital projector set up in the specialist test area where projector brightness and uniformity can be tested with different lamps and lamp conditions (above right).

I was surprised to see dozens of 'Strong' projector lamp houses mounted in racks (right), and was shown how these are used for long-term testing of lamps under all sorts of realistic usage conditions, as well as for trying out new designs.

I was interested to discuss future developments with the team - how could I resist suggesting that it might not be too long before laser light units eliminate the need for their core product?! Unsurprisingly they were fully up to the minute with all that is happening in that field - Tom was even off to a laser discussion at NAB in Las Vegas the following weekend - and we had some useful discussions about the progress that different manufacturers are making, but didn't do any better than any of the other pundits as to knowing whether laser light sources for cinemas are two or five years away.

Looking to the future

The whole team was, however, totally confident that there is a market for their specialist xenon lamps for cinemas for many years ahead, and they said that all their research indicates that the development of xenon lamps hasn't yet reached maturity. There are still many areas in which xenons are capable of being improved to provide better efficiencies, lifetimes and TCO. When I asked how, and why they were so confident, there was the natural reluctance of R&D people to divulge the secrets on which their future prosperity might depend, but I gathered that there is still much work to be done on the careful shaping of electrodes (look at some of the 'dimpled' electrodes that are currently available), and that significant improvements in performance can be expected from more exotic material being used to coat the electrodes. It will be interesting to see how these developments turn out in the years to come.

It is always interesting to visit factories, and I particularly enjoyed my visit to Philips as I found so much skilled craftsmanship in use, rather than the extensive mass-production that I would have expected. I had often wondered why a single xenon bulb for a cinema projector can cost £1000 - surely the most expensive lamps in the world? Now that I have seen everything that goes into the making of a lamp, I will perhaps find it easier to explain to colleagues in the projection room just why such prices may be justified! I did ask the Philips guys whether mass-production techniques might take over in the near future, and we discussed some areas of manufacture where new techniques are already coming into use (vision systems for accurate measuring, for example). I also asked whether they felt that a competing Japanese manufacturer, for example, might be able to invest in mass-production technology that could seriously reduce prices, but Tom, Curt and their colleagues genuinely believe that to produce a high-quality product there is no substitute for the craftsmanship that goes into every Philips xenon lamp.

Jim Slater

Behind every Philips Cinema lamp is a world of expertise and support designed to deliver you more than just high quality. Our global network of cinema lighting specialists offers you personal support whenever you need it. From TCO checks and online comparisons to training and installation advice. Approved for Barco, NEC and Sony digital cinema projectors. Just like many leading cinema chains worldwide, find out what's behind every lamp at:

www.philips.com/cinemalamps

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