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A cinema industry breakthrough: Sony's HPM lamp array

Cutting costs, improving reliability and protecting revenues with Sony's first 4K digital cinema projector to feature an innovative High Pressure Mercury(HPM) multi-lamp array.

Sony's HPM lamp array: a new era in quality, reliability and cost-efficiency

Introduced in 2012, the SRX-R515P is Sony's fifth-generation 4K digital projection system. Delivering four times the image resolution of 2K projection systems, it also offers an average contrast ratio of 8,000:1 – currently the highest in the cinema industry and far in excess of DCI specifications (2,000:1).

Bringing the benefits of 4K picture quality to smaller and medium-sized theatres, the projector's ground breaking design enables significantly reduced ownership costs for cinema exhibitors.

The SRX-R515 is the world's first fully DCI compliant true 4K digital cinema projector to use an array of six High Pressure Mercury (HPM) lamps that together deliver a total rated light output of 15,000 lumens. Trusted for many years in other projection applications because of their compact size, lower cost and high light output, these lamps are new to the digital cinema market.

This paper discusses how this advanced HPM lamp array is deployed within Sony's acclaimed SRX-R515P digital projection system to achieve stunning 4K images while meeting full DCI compliance.

Benefits at a glance

The innovative optical engine and High Pressure Mercury (HPM) lamp array in Sony's SRX-R515P projector

Bright: The array of six HPM lamps in the Sony SRX-R515P 4K projector offers ample light levels to meet the exhibition needs of small-to medium-sized cinemas.

Consistently accurate: Excellent colour accuracy is maintained over the lamp's operating life.

Safe: There's no risk of injury from safely-contained HPM lamps, unlike Xenon sources that present a significant danger from shattered glass in the event of a lamp explosion.

Resilient: The HPM multi-lamp array keeps the whole screen evenly illuminated even in the event of one (or more) individual lamp failures.

Protected revenues: Resilience of the lamp array prevents show-stopping failures. Additional reassurance is also provided for cinemas with free lamp replacement within terms of a standard warranty.

Simple: No special training or protective clothing is needed to change lamps. All six cartridge-based lamps in the SRX-R515P can be replaced in just 5 minutes.

A question of illumination:
the challenge of D-cinema projection

The primary purpose of all digital projection systems used in movie theatres is to place a bright image onto a large viewing surface. To do this, a projector combines light with an image. Between the light source and the screen are a number of critical components in the 'optical pathway' – including light integrator, colour separation filter, the SXRD panel, prism and lens as well as other elements.

Together, these components reduce the total amount of light that ultimately reaches the screen. For this reason most current Digital Cinema projection systems use sources of illumination that are many times brighter than standard domestic lighting.

The volume of light passing through a projection system is only one of the factors that determine how the final image looks on the screen. Digital projectors are thus designed to meet industry standards measuring the quality of light delivered (referred to as its 'chromaticity'), as well as the volume of light ('luminance') that's delivered on screen. These standards are contained within the current Digital Cinema Initiatives (DCI) (http://www.dcimovies.com/specification/index.html) specifications.

Sony digital cinema projectors:
the right lamp for the job

Sony uses both Xenon and HPM illumination systems for its family of 4K digital cinema projectors. The choice of light source – and the design of the projector itself – is optimised in each case to meet the technical requirements of each projector and its intended application.

Ideal for medium - and larger - cinema operators, the SRX-R320 uses a single Xenon lamp that's available in varying outputs up to 4.2kW. Designed to meet the needs of exhibitors with smaller screens, the SRX-R515P uses HPM lamps with 330W and 450W outputs in a multi-lamp array with six separate lamp sources. Both systems meet and exceed the standards required by the Digital Cinema Initiative (DCI) for use in D-cinema applications.

The traditional choice:
Xenon lamps

First introduced commercially in 1951, Xenon lamps remain the most widely used illumination source in cinema projection. They generate light by the ionisation of highly-pressurised xenon gas within the lamp by an electric current.

The temperature of the light-generating plasma at the electrodes can reach 6000°C, while the lamps are pressurised to around 30 atmospheres (440 PSI) when hot. Of the radiation produced by Xenon lamps around a third is visible light, with the remainder in ultraviolet and infrared parts of the spectrum. UV light emitted by these lamps is intense, making exposure potentially hazardous. Thermal emissions are also high, with temperatures of around 1050°C when operating.

Failure of a running lamp can result in an explosion that propels shards of hot glass around the inside of the lamp house, causing expensive damage to the reflector. Even a cold lamp is pressurised to around 10 atmospheres, so careful handling and protective clothing is recommended when changing lamps. Normally, failures occur towards the end of a lamp's nominal operating life: most lamps are changed before any catastrophic failure.

Smaller size, longer life:
High Pressure Mercury lamps

First developed by Phillips in 1995, High Pressure Mercury (HPM) arc lamps are used today in millions of commercial displays, projection systems and home theatre systems worldwide. Unlike traditional metal-halide lamps they use only vaporised mercury. HPM lamps are popular because they deliver high luminance levels relative to their power consumption, as well as longer operating life and compact size. Changing lamps is a simple operation and does not require specialist protective clothing that's essential with Xenon lamps.

The lamps comply with relevant European RoHS directives, and exemptions relating to hazardous substances which are recommended by the European Lamp Companies Federation (ELC).

Seeing the light: differences between Xenon and HPM

For decades, Xenon lamps have been used as the default choice in commercial cinema projectors. As well as a difference in colour spectrum between Xenon and HPM sources, the maximum achievable lamp power using HPM is lower than that of Xenon.

In designing the SRX-R515P projection system, however, Sony developed a wholly new optical design featuring an HPM lamp with a spectrum output that's comparable with Xenon. In addition, the other traditional drawback of HPM sources – their relative lack of power – is addressed by the adoption of a brand-new multi-lamp array. This alone has yielded dramatic improvements in convenience and handling safety that have always caused significant challenges to theatre operators using Xenon lamps.

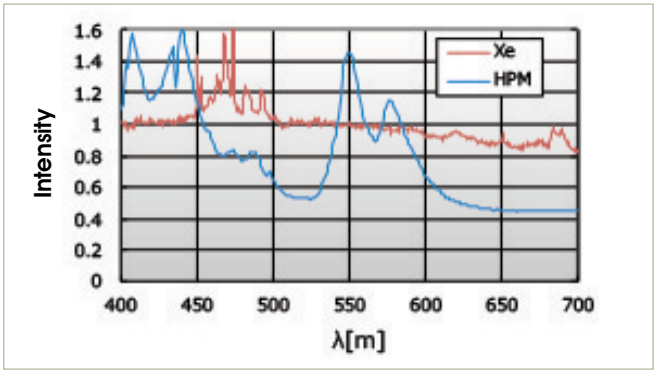
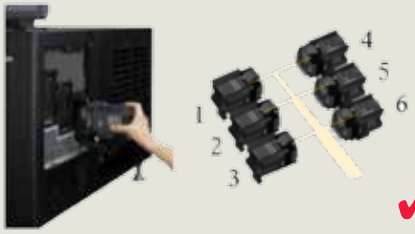
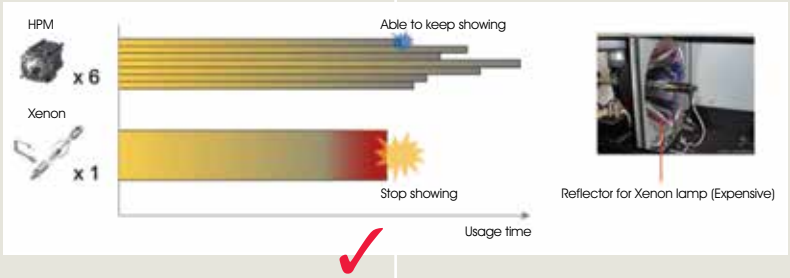


Fig: Typical Xenon vs HPM light spectrum

Representing an industry step-change, the six-lamp HPM system featured in the SRX-R515P offers several significant benefits to cinema operators that are summarised here:

Issue	HPM lamp	Xenon lamp
Lamp replacement time and handling requirements	Under 5 minutes for 6 lamps. The lamp cartridge is easy to insert and does not require adjustment of the igniter position. No need to take special handling precautions, since the lamp is not pressured and there is no risk of explosions causing injury when not in use.  ✓	More than 30 minutes. Special tools are needed to replace the lamp, and the igniter position must also be adjusted. Special protection gear must be worn and extra care exercised to guard against risk of highly pressurised lamp exploding.  ✗
Show stop	Multi lamp system never causes a show stop even if some lamps go down.  ✓	Single lamp may cause a show stop if the lamp goes down. ✗
Flicker	Individual lamp's flicker on multi-lamp system has very little influence on image quality. ✓	Lamp flicker on single lamp system has significant detrimental effect influence on image quality. ✗
Lamp power (brightness)	In general, HPM lamp power is lower than Xenon. HPM lamp is commonly used in smaller projectors, or configured as multi-lamp array. ✗	Xenon lamp power is higher and good for illuminating very large screens. ✓
Management of lamp lifespan	Better to keep lamp on during the day.	Better to turn off lamp between shows.
Lamp power consumption	Theatres with small screens can use fewer lamps, reducing power consumption.	Can turn off lamp between shows, contributing to lower overall power consumption.

Beautiful images by design: a complete optical system

The optical system of the Sony SRX-R515P combines light from multiple HPM lamps. The projector's innovative optical design achieves a similar light output to that of the SRX-R320 projector equipped with a single Xenon lamp.

The projector's SXRD imaging panel is specifically designed to optimise the light spectrum of HPM lamps and achieve DCI specifications. Also, the architecture of the light path is combined with additional colour filtering that broadens the range of red spectrum as shown below. These factors compensate for relatively low levels of red light in the HPM lamp's natural spectrum, boosting levels to match those of naturally-occurring green and blue.

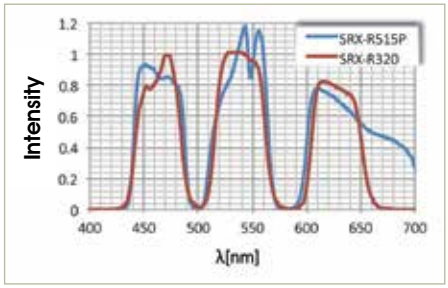


Fig: Comparative profile of actual light output (SRX-R320 uses a single Xenon lamp, SRX-R515P uses 6x HPM lamps)

The result is light with an even spectral balance and high light intensity which conforms to the DCI colour gamut. The following diagram shows the colour of both the SRX-R320 (using a Xenon lamp) and the SRX-R515P (using HPM lamps). The colour gamut achieved by the SRX-R515P extends beyond DCI specifications, and is almost equal to that of SRX-R320.

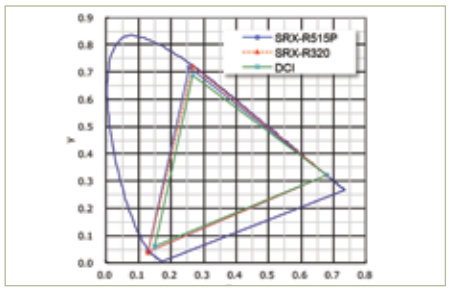


Fig: SRX-R515P & SRX-R320 conformity to DCI color space

True colours: achieving a stable, consistent colour spectrum

The colour spectrum of Xenon, HPM and all other lamp types changes gradually throughout their operational life. This is typically due to the high electrical voltage and temperature inside the lamp that causes 'sputtering' of arc materials inside the bulb, and a variation in chemical composition of the silica glass bulb itself. These materials absorb particular wavelengths of light, changing the lamp's spectrum output with prolonged use.

The optical design of the SRX-R515P is optimised to use the most stable parts of the available colour spectrum. By avoiding parts of the spectrum with the highest levels of change, the system minimizes colour shift over the life of the lamps.

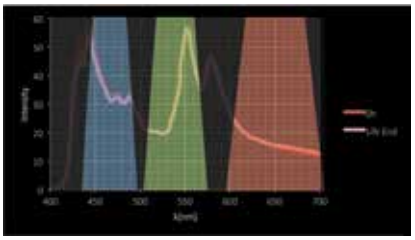


Fig: Change in HPM lamp spectrum over time

Power of six: the world's first HPM multi-lamp array lets the show go on

The Sony SRX-R515P is the world's first DCI-approved digital cinema projector to use a specially-designed array of six separate HPM lamps. The lamps used in this system have been designed specifically for use in mission-critical cinema applications where business continuity is paramount.

A projection system using an array of lamps is intrinsically more reliable than a system using one lamp. Failure of a single lamp system during a performance would bring the show to an abrupt end. This severely impacts on business continuity for cinema owners – both in terms of money lost in refunds on the night and also potentially discouraging customers from returning.

A similar failure on a multi-lamp system would not result in the show stopping. The HPM array in the SRX-R515P allows the show to continue, even in the event of a number of lamps or lamp power supplies failing. In exceptional circumstances, the projector could run with as few as two lamps lit.

For even greater peace of mind, the HPM lamps used in the SRX-R515P are protected by a manufacturer's warranty. If an individual lamp fails, a free replacement will be supplied by Sony Professional Solutions Europe within the warranty conditions. Future system updates will allow cinema operators to extract lamp operating data directly from the projector, and email this information directly to Sony in support of warranty claims.

Greater operational flexibility for cinema owners

The intrinsic versatility of this multi-lamp array gives other operating advantages. If desired, cinema owners can opt at any time to run the projector with fewer than six lamps lit. As well as extending operating life, this reduces electrical power consumption with consequent savings in running costs.

This flexibility can be particularly attractive for small cinemas that do not require the HPM array's maximum rated light output to achieve optimum image brightness. Here, the SRX-R515P can operate with as few as two lamps lit, without unduly compromising picture quality or contrast.

This ability to control illumination levels also helps cinemas cater for the differing needs of 2D and 3D presentation. For 2D screenings, the SRX-R515P can be run with fewer lamps lit – as few as two, depending on screen size. For 3D programmes, the projectionist may elect to operate the projector with all six lamps lit. This delivers maximum brightness that's desirable for 3D presentation because of inevitable light losses in the optical system.

This contrasts favourably with projectors using xenon lamps, where brightness cannot be controlled at will to suit 2D or 3D presentation. Typically, xenon lamps (and often their respective power supplies) need to be exchanged for 2D/3D screenings – a laborious and potentially risky process.

With the SRX-R515P and its unique HPM multi-lamp array, cinema operators are offered unprecedented flexibility in balancing their day-to-day operational requirements with other factors including power consumption, energy costs and lamp life.

Fewer lamp strikes, longer lifespan

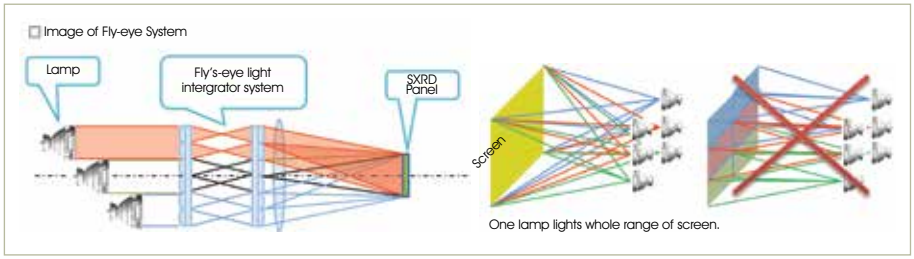
The HPM lamp array in the SRX-R515P is designed to offer a long, reliable operating life. To fully realise this, however, lamp management differs from the xenon lamps in conventional cinema projectors.

With xenon lamps, real-world operating life is directly related to total hours lit. With HPM lamps, in contrast, actual working life is also governed by the number of 'strikes' (or power on/off cycles) sustained by each lamp. In reality, this means maximising operational life by reducing strikes and minimising thermo/electrical stresses on each lamp.

It is recommended that cinema owners reduce non-vital projector switch on/off cycles that may reduce the HPM lamp array's life. For example, the lamp array can be safely left switched on continuously for longer periods during the working day, including short breaks between screenings.

Multi-lamp redundancy for greater reliability

Multi-lamp systems are specifically designed to create a smooth, even light distribution from non-uniform sources, such as an HPM lamp array. This is achieved using a pair of devices called Fly-eye integrators. These use a large number of refractive 'cells' that blend and transform light from individual lamp sources into a uniform, evenly-distributed light that illuminates the whole of the SXRD panel.



Adding a new lamp to the array has the effect of making the light across the whole projection screen brighter. If one lamp is switched off (or fails for any reason) light levels across the whole screen area are reduced uniformly, rather than audiences seeing any undesirable 'dark spots'.

Summary

Appealing to small- and medium-sized exhibitors, the SRX-R515P 4K projector represents the next exciting step in the evolution of perfect cinema picture quality. To meet the goals of reliability, operational flexibility and affordable running costs, Sony has developed an innovative array of six High Pressure Mercury (HPM) lamps.

This innovative approach delivers several benefits to cinema operators who have traditionally depended on projection systems using Xenon lamps. The multi-lamp HPM array in the SRX-R515P offers unprecedented reliability, protecting cinemas from the risk of lost revenues in the event of catastrophic single-lamp failure during a performance.

The intrinsic flexibility of this multi-lamp array gives other operational advantages. If desired, cinema owners can opt to run the projector with fewer than six lamps – reducing power consumption and extending operating life. HPM lamps are easy to handle and replace, with no special training or protective equipment required for busy projection staff. Sony also offers a standard warranty scheme, giving cinemas the extra reassurance of free replacements in the event of lamp failure within standard operating conditions.

Fully compliant with DCI specifications, the SRX-R515P delivers superlative 4K picture quality with industry-leading contrast ratio – making every screening a more immersive, exciting experience for cinema audiences.

Discover more about the 4K advantage with Sony

For further information on Sony 4K Digital Cinema and the SRX-R515P projector visit: **www.sony.co.uk/pro/products/dcinemalink**

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