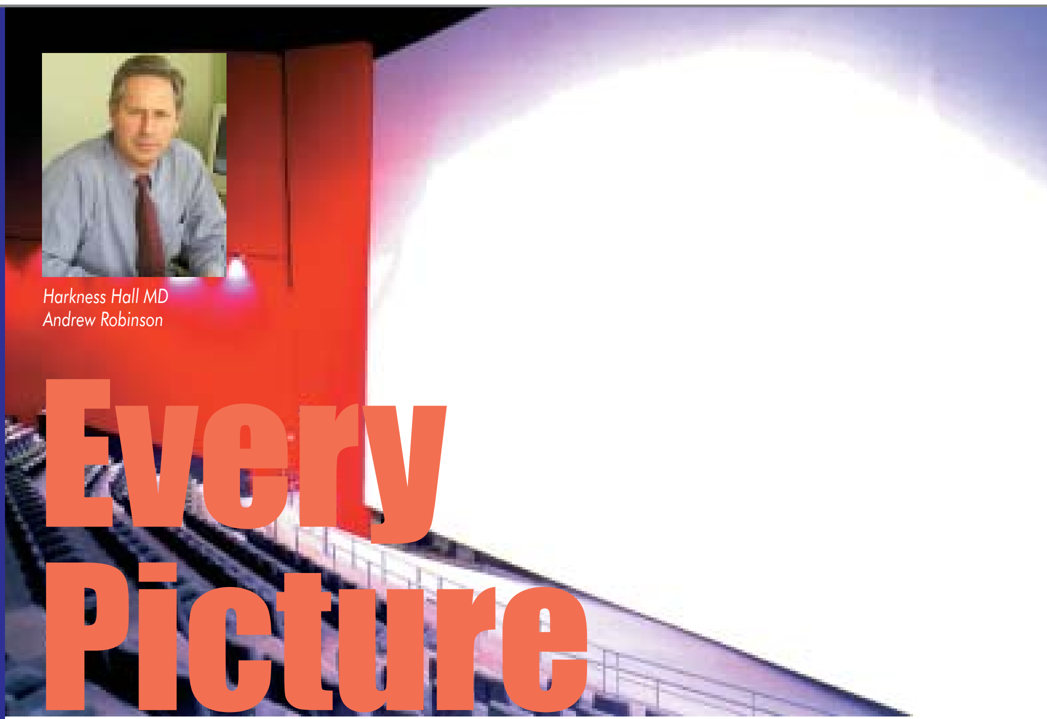


Harkness Hall MD
Andrew Robinson

Every Picture tells a story

By Andrew Robinson

Seven decades of projection screen development

On the surface there doesn't appear much to say about the 'big white thing' at the front of the auditorium.
It's not full of high tech bells and whistles, and it's not much to look at, but to the audience it's the summit of Everest, the diasaster of the Titanic, Rome's Coliseum and countless more experiences. It's entertainment!
For more than 75 years Harkness Hall have been making and developing a key element of cinema equipment - the only element all the audience looks at...but never sees.

With their screen surfaces and systems used in more than 50 countries worldwide Harkness quite rightly claim a pedigree second to none. Whether it's for giant screen, 70 or 35mm, 3D, special effects or digital the Harkness name has been synonymous with the development of projection screens for the entertainment industry.

In cinemas, theme parks, visitor attractions and multi-purpose venues, Harkness screens continue to thrill audiences wherever the projectionist's art is practised.

The right material

All Harkness screens are manufactured from unique PVC base materials. Different materials are used for matt white screens, gain screens and rear projection screens. The unique formulations are designed to give good colour rendition and contrast, as well as a bright picture. The PVC is formulated to be fire resistant and also to produce large screens with invisible seams with the Harkness Hall manufacturing process. Heat is applied to the back of the seam causing the material to join together forming a 'v'. Then pressure is applied to flatten the seam, rendering it virtually invisible under normal projection conditions.

The PVC material is quite thin (0.3mm) and is typically supplied in rolls 1.5m wide. These rolls are perforated in the first step of the process, if perforated screens are to be made. The second stage of the process is to weld cut lengths of the material together to form a complete screen using Harkness' exclusive 'Tearseal' method. In the third step, the screens are then finished to the final size and given the required edge treatment (usually web and eye). The final stage of the process is to coat the screen, if a gain or special effects screen is required. Uncoated screens can be made to virtually any size, but there is a limitation to the size of coated screens that can be produced in the factory (29 x 11m approx).

The world's largest fixed screen measuring 37.7 x 29.6metres (122 x 96ft) and featured in the Guinness Book of Records, was constructed at Harkness' Borehamwood UK headquarters, shipped to, and installed in the Panasonic Imax® Theatre, Darling Harbour, Sydney, Australia. The screen was coated on-site following installation.

Harkness Screens - A Brief History

In the Beginning

It started back in 1929, just a couple of years after Jolson famously sang his way through The Jazz Singer.

As the cinema world was going mad over sound (and what's changed since?), Andrew Smith Harkness - a man of vision (every pun intended) - was busy concentrating on what he saw was a 'great opportunity' to improve and standardise the visual experience.

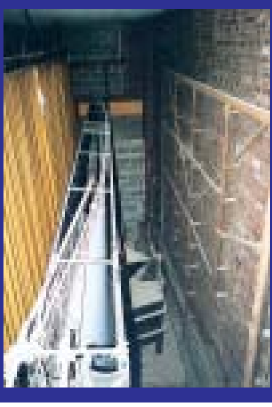
The First Screens

Harkness Screens started almost by accident. It's reported (vaguely remembered) that having 'something to do with textiles and sewing' Harkness was asked by a local cinema to make a replacement screen. In those days 'cloth' screens were fashioned from a cotton muslin type material which was webbed, eyeletted and stretched across wooden frames on the front wall of the auditorium. The ability to produce a reliably seamed screen large enough to do the job being the key factor.

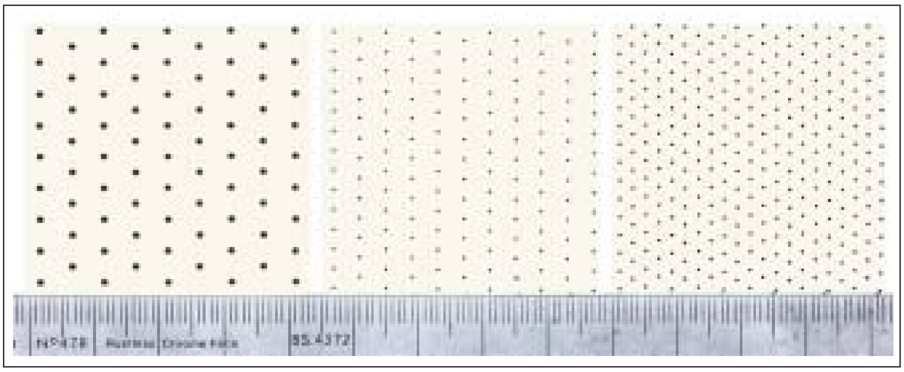
However, the problem with early cloth screens was that they 'yellowed' quickly. Smoking in the auditorium was the rule...not the exception...and ventilation left a lot to be desired. The very nature of the cloth screen material - it not only stretched but was absorbent - only hastened the yellowing effect. Projection lamps, with nowhere near today's output and efficiency, struggled to compete with the nicotine coating which increased at every show. So cinemas were left with little choice but to regularly renew their screens or risk 'losing their picture'.

Just six months into the new business tragedy struck. Andrew Smith Harkness died suddenly throwing his eighteen year old son Tom in at the deep end.

Determinedly Tom set about building the business and soon hit upon a unique concept which was to become known as 'one for the wall and one for the wash'. He formed a relationship with a laundry in Glasgow who were able to successfully wash these huge pieces of material. Then he sold a cinema the concept of a second screen. As soon as the 'on view' screen became soiled it was replaced with the spare and handed to Harkness for washing - creating a come again business. But that wasn't all. Constant washing eventually shrunk the screen leading to a replacement from the top market as the 'new' smaller screens were passed down. With more than 5,300 screens in the UK in 1930 business potential was enormous.



An original wooden wall mounted screen frame behind an updated curved replacement - at the Curzon Cinema, Clevedon, UK



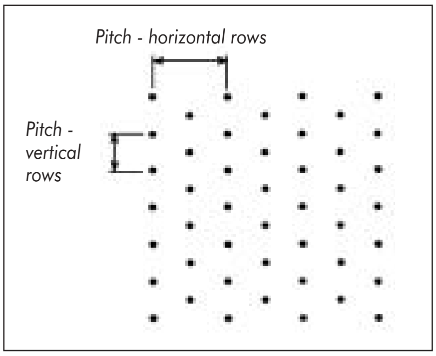
Harkness' three perforation forms: Regular, Mini-Perf and Mini-Perf Super. Scale for comparitive purposes only (mm).

Talking pictures - perforations

Where behind screen speakers are required optimum sound quality is provided through applying the correct perforation form. The material is perforated by an indexed press synchronised and co-ordinated to maintain a regular and even pattern of holes over the entire surface. Irregular patterns would become visibly obstrusive when the finished sheet is assembled. Perforation size and pattern are optimised to provide the best possible combination of audience satisfaction and acoustic transparency for particular viewing situations.

Perforations of 1mm to 1.2mm in diameter and with a 5% "open area" are usually considered optimum for cinemas. There is a trade-off with cost, as a better performance acoustically can be obtained by having smaller perforations, still retaining a 5% open area, but this is more expensive to manufacture. If the perforations are too large, they can be seen by the front rows of the audience.

Harkness screens feature three perforation forms. Regular perforations for standard cinema performance, Mini Perforations (MP) for smaller and preview cinemas where seating is closer to the screen than that recommended for regular perforations and Mini Perf Super (MPS) perforations for close viewing post production work and digital/electronic cinema.



	Perf Dia	Open area	Horiz Pitch	Vert Pitch	Min View Dist
Regular Perf	1.2mm	4.5%	10mm	5mm	5mtrs
MP	0.5mm	1.6%	8mm	3mm	1.5mtrs
MPS	0.5mm	4.9%	4mm	2mm	1.5mtrs

The photo and diagram above show the comparative size and density of the three forms.

For digital and electronic performances the increased open area afforded through Mini-Perf Super screens reduces any possible pixel/moiré effects which may occur using larger perforation patterns.

A sound investment

Acoustic performance - sound attenuation - is measured using BS 5382:1976.

Simply speaking, the less resistance offered by the screen the better the sound quality. Acoustic resistance varies with the size and

Below: 'Manufacturing' perforations

Plastic Arrives

Within a few years Harkness was looking to the USA and it was on one of his many trips during the early 40s that he 'discovered' plastic. A totally new material which seemed to possess all the properties required to produce the ideal screen - but it had to be joined. Not only joined with a reliable seam, but the resultant 'sheet' had to appear seamless. A revolutionary method of welding the plastic together was developed - the Tearseal method - and patented. Where other manufactures had failed to produce 'invisible' seams, the Harkness Tearseal method produced a flat seam. And this made all the difference! So the first plastic screens were introduced to a thriving industry - attendances in the UK had topped 1.6billion - and the brand new Harkness Screens were a huge success.

Talking Pictures

Into the late 40s and speaker systems were still placed alongside the screen. Simply because there appeared no method allowing production of a screen through which sound would pass. Early attempts to produce an 'acoustically favourable' screen - spraying a fine metal mesh material - were to fail because of the weight of the resulting screen. It wasn't until the early 50s that screen perforations were 'imported' from the USA and incorporated into Harkness screens, creating a whole new cinema experience.

Screen Coatings

Over the years various methods and substances were used to enhance screen performance. Mixtures of emulsions and polymers were painted or sprayed onto the screen surface with varying levels of success. The successful methods survived, and combined with the development of a mechanised spray tower, contributed to Harkness' steady growth. However, the greatest achievement was the emergence of Perlux™ - a screen coating solution that was to revolutionise gain screens and establish Harkness as the world's leading screenmakers.

Constant Development

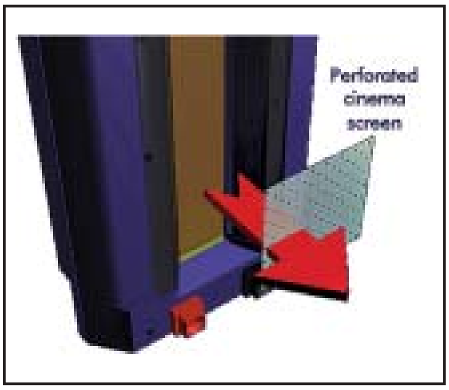
Since then we've seen new variations of perforation forms and, within the past year, the introduction of surfaces designed to compliment the 'new' digital age of cinema. So, 'big white thing it might be', but whatever projection method is used it's still the reason for going....to the pictures!

Finished screen sheets drying at Borehamwood

density of the screen perforations which effects high and low range frequencies differently. As cinemas invest regularly in improvements to their sound systems the use of the most effective screen perforation format becomes even more critical.

A test by speaker manufacturers Stage Accompany SA is reproduced below.

Stage Accompany Test



One of the biggest ‘handicaps’ to obtaining a superb response of a cinema sound system, is the screen in front of the speakers. SA has done extensive research in this field. The screen works as a "semi-permeable" filter, that starts effecting response as low as 4kHz. "Semi-permeable" because part of the acoustic energy comes through the perforated holes in the screen, another part bounces back from the screen. It is especially this latter energy that causes enormous phase problems.

With "traditional" systems with large horns, this "back-bounced" energy is collected again in the horn, creating standing waves, cancellation, etc. One of the reasons SA is not using deep horns in its cinema systems.

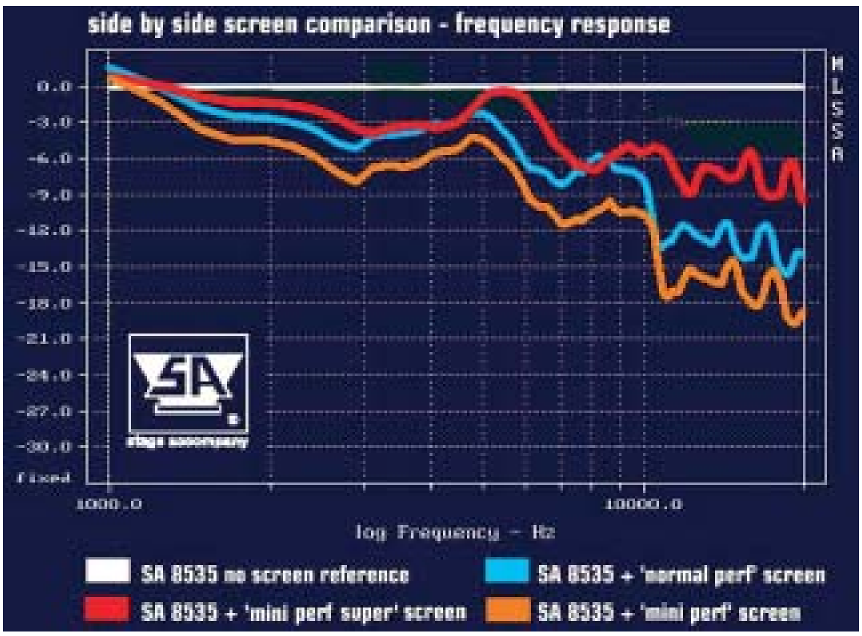
The distance between the speaker and screen is also very important! In order to minimize the energy-spill, the system should be as close to the screen as possible, not easy with large horn systems.

There are several different types of Harkness Hall projection screens for cinemas on the market; "Regular-perf", "Mini-Perf" and "Mini-Perf Super".

Philip de Haan of SA's R&D department conducted a comparison between these screens with the cooperation of Harkness Hall. The "side-by-side" screen comparison (fig.3 below) shows the MF/HF roll-off of the 3 screen types, with the "0" line being the reference SA 8535 Ribbon Compact Driver response without screen.

The Test Set-up:

- SA 8535 Ribbon Compact Driver mounted in a baffle, measuring 1.22m x 1.22m/4-ft x 4-ft.
- The unit placed at a distance of 5cm/1,9-in. from the screen.
- Bruel & Kjaer 4007 microphone placed "on-axis" at a distance of 2m./6.6-ft.
- MLSSA measurement program, on Stage Accompany AI 110 Audio Interface
- Temperature and humidity: average/NA
- All measurements smoothed with $^1/_3$ octave



Picture the difference

Installing the right type of screen will obviously make a big impact on the film viewing experience. It can also result in financial savings overall for the cinema operator.

The screen affects the film viewing experience in a number of ways - most importantly in terms of picture quality: the brightness, colour rendition, and contrast of the film image and also through potential distractions from imperfections in the screen.

The desirable level of picture brightness is best determined by reference to the SMPTE standards, which are internationally recognised. This specifies a level of illumination of 16 foot lamberts at the centre of the screen (55cd/m2) as viewed from the centre with a minimum of 12 foot lamberts at the corners.

The brightness of the screen as seen by the audience depends on a number of factors: the light emitted from the projector lamp; the light lost between the projector lamp and the screen as it passes from the mirror through the lenses and port glass; the light reflectance back from the screen.

Xenon lamps come in various power ratings; typically between 2.0 and 7.0 kVA lamps are used in most multiplexes, depending on screen size. The bigger the lamp the more the light output but also the higher the cost of lamps and the power consumption in operation.

The screen is a major factor in the amount of light reflected back to the audience. Matt white screens scatter light and much of this is reflected to the ceiling and side walls, and is therefore lost. So called "gain" screens direct more of the light back towards the audience. The gain level of a screen relates to the amount of light reflected back and is measured in relation to a reference standard (a magnesium carbonate tablet with a reference value of 1). Commercial matt white cinema screens vary in their reflectivity but usually have a light reflectance of from 0.8 to 1.0 by reference to the standard. "Gain" screens can have gains of 2 or more but for use in cinemas, screens with a gain of 1.4 or 1.8 are usually optimum, depending on the size of screen in the auditorium.

Over 11m (36ft) in width there is usually a benefit in using a gain screen, with a high gain (1.8) screen over 14m (46ft). Screens with a higher gain than 1.8 can cause "hot spotting" (i.e. the centre of the picture looks excessively bright).

Matt white screens are usually installed on flat frames. However, gain screens are best installed on curved frames to optimise the light return and viewing angles in different parts of

Measuring the performance of screen surfaces at Harkness Hall's USA plant

the auditorium. Because light is scattered by matt white screens, using a curved frame can result in loss of contrast and is not recommended.

The extent of curve for a gain screen depends on a number of factors but a guide is a 20:1 ratio for chord to rise-on-chord.

Perceived brightness of all screens varies with viewing angle, but gain screens give overall a much brighter image than matt white screens for a given lamp size.

Together with the ability to reflect light back to the audience, a good quality cinema screen will also have excellent colour rendition and contrast ratio and be free of any distracting imperfections.

As well as improving brightness, using the right screen installed in the correct way also makes economic sense. With big screens (in

British Standard for Gain Measurement
BS 5382 : 1976

The standard deals with cinema screens 'commonly' used for cinematograph purposes. It does not include the requirements for the optical characteristics of screen surfaces used for projection involving the use of polarised light.

The screen surface is invariably smooth and white and the reflectance characteristics follow the cosine law.

Definition

The gain measurement is defined by the ratio of luminance produced by a projected beam of white light falling normally upon a freshly cut surface of magnesium carbonate and the same projected beam falling normally upon the screen surface, the reflected light from these surfaces is measured at the horizontal angle of 5° from the normal to the screen surface.

Measuring reflectance gain ***(diagram below left)***

The sample of test surface material is set up on a frame facing the projector which is positioned so that the optical axis of the lens is normal, both in the horizontal and vertical planes, to the centre of the test sample and produces a circle of light approximately 500mm in diameter.

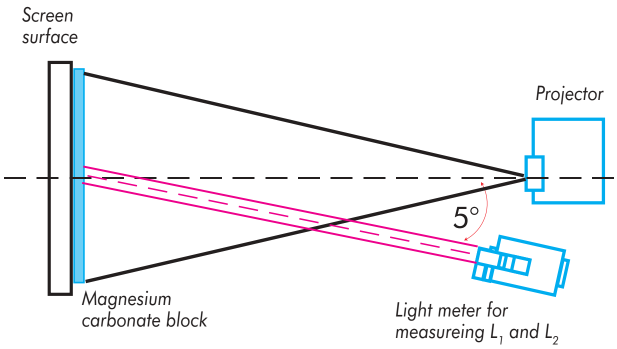
A freshly cut surface of magnesium carbonate is placed centrally and parallel to the surface of the test sample. With the room in darkness and the projector light switched on the luminance (L_1) at the centre of the magnesium carbonate block is measured from a position in the same horizontal plane as the centre of the sample but at a horizontal angle of 5° from the normal of the screen surface.

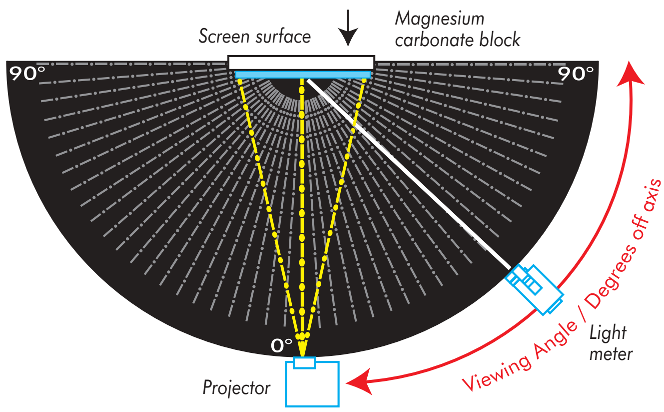
Removing the block of magnesium carbonate, a measurement of luminance (L_2) at the centre of the test sample is taken from the same position.

The reflectance gain is: $\frac{L_1}{L_2} \times 100\%$

Measuring the gain / viewing angle curve ***(diagram below right)***

The gain / viewing angle curve is achieved by taking measurements at a constant distance from the centre of the screen at intervals of 10° in the range 5° to 55° on either side of the normal to the screen. The procedure involves taking readings firstly off the magnesium carbonate block, and then the test material, at each increment.





excess of 15m wide) to get the brightness required using a matt white surface, at least a 5.0 kVA Xenon lamp is likely to be needed. Even with this, the screens may not meet the SMPTE (or THX) standards. With a gain screen, it is often possible to reduce lamp power (typically by a factor of 25% or more) with a resulting saving in initial cost, lamp replacement cost and electricity consumption (see diagram below).

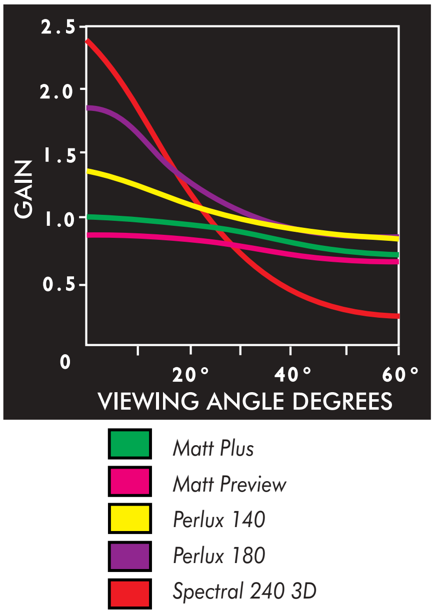
LAMP RATING vs SCREEN GAIN

Screen Width (m) (Cinemascope format)	9	12	15	18
Screen Gain Level		(Lamp kva)		
1.0 flat	2000	3500	5500	8000
1.4 curved		2500	4500	6000
1.8 curved		2000	3500	5000

The pay-back on the initially more expensive screen can often be as little as one year and therefore totally justifiable.

The Right Surface

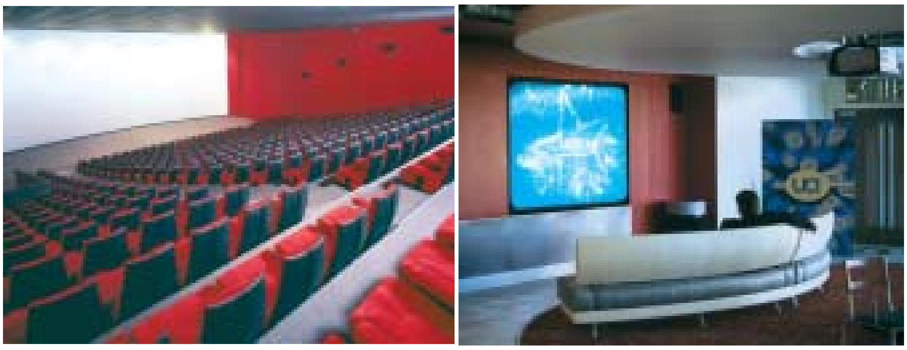
Typically Harkness' range of screen surfaces include the most widely used types to provide the most suitable combination of reflectance (gain) and viewing angle (summarised in the diagram below).



The following provides a brief description of each surface's performance and material characteristics.

Matt Plus: A unity gain surface recommended for flat screens up to approximately 11metres (36') wide. It provides a wide viewing angle with high contrast pictures and excellent colour temperature. With no practical limit to size. This surface can be folded for ease of transport.

Perlux™ 140: Introduced some three years ago, this is a mid-gain surface (gain 1.4) specially developed for smaller auditoria to enhance screen brightness without causing high reflectance. Sizes to 30 x 11metres (98 x 36')



Both ends of the scale - left, 70mm screen, Kinopolis Brussels and right foyer screen at UCI's Maidenhead cinema

are possibly, and crucially, may be folded for transport. A heavier material, Perlux 140+, is used for roller screens. However, 140+ cannot be folded.

Perlux™ 180: Probably the world's most widely used gain surface (gain 1.8). Ideal for the largest auditoria where screens up to 30 x 11metres (98 x 36') which can be folded for transit, may be installed. A heavier material, Perlux 180+ is recommended for roller screens.

Specialist Surfaces

Matt Preview: A specially coated below unity gain surface for preview and dubbing theatres with close viewing distances.

Spectral 240: A special effects and 3D surface used mainly in large format and events attractions venues. Silver coated to a higher gain level (gain 2.4).

High Contrast Grey: Recently introduced to meet the demands of electronic projection, increases picture contrast though deepening the black levels, enhancing shadow details and improving overall colour saturation. Available in three gain levels - 0.4, 0.6 and 0.8 which allows the progressive application of higher gain to larger screens.

Specialist screens and multi-purpose venues

With the development of alternative coatings and framing systems, and despite the increasing use of plasma type screens, the humble front projection screen retains its popularity. Venues under pressure to maximise useage, such as live performance theatres, are converting to cinema use for selected performances by installing roller screens as wide as 14m (48'). Frequently these, and other, alternative use venues fill the gap left by local cinema closures.

So the immediate and short term future for the 'big white thing' (or in many cases, the not so big white thing) looks secure.

Going to the pictures, however projected, will still rely on the screen to provide the magic demanded by increasingly discerning audiences ...otherwise it's just like listening to a very expensive radio.

Harkness Hall

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Screen coating plant at Harkness Hall's Fredericksburg USA facility. The spray tower is centre left.