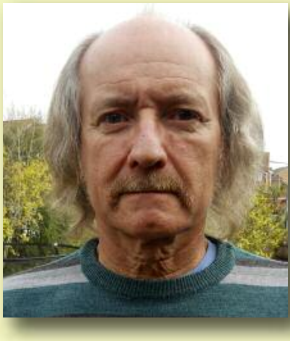
# Cinema calibration and the X-curve

## Facts and myths

Philip Newell



Philip Newell is an independent acoustics and electroacoustics consultant. He is a fellow of the Institute of Acoustics, member of the Audio Engineering Society, and member of SMPTE. He was formerly the technical director of the recording division of Virgin Records. He has also been responsible for many pioneering designs, including the Manor Mobile, in 1973, which was the world's first, purpose-designed, 24-track mobile recording studio.

Within both the SMPTE and the AES, committees are currently studying the question of the drafting of new standards for the calibration of dubbing theaters and cinemas. The current process has evolved with the changing technology since the introduction of the X-curve in the 1970s, often in an empirical way, but solid, documented explanation of the changes has been lacking. Indeed, even the premises upon which the initial concepts were based have since been called into question. As a result, myths have often been mixed with facts and incorrectly propagated as truths.

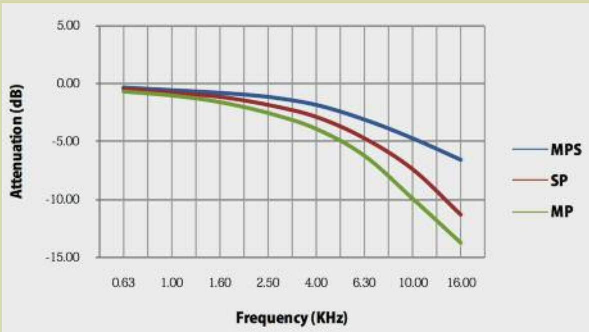



Fig. 1. Typical transmission losses through Matt Plus series of perforated cinema screens. SP = standard perforated, MP = mini-perforated, and MPS = mini-perforated super. (Courtesy Harkness Screens.)

Essentially, when a loudspeaker system is placed behind a perforated cinema screen, there will be a roll off in the mid and high frequencies as shown in Fig. 1.

Cinema calibration is carried out in a way that can compensate for the different screen loss characteristics, in order to ensure a reasonably uniform spectral response in the theaters when measured mid way into the seating areas. The one-third-octave, steady-state "target response" standard to which most cinemas and dubbing theaters are now calibrated is shown in Fig. 2. This is known as the X-curve, which the literature variously describes as meaning either eXperimental, as it surely was at its inception, or eXtended, as it did extend the overall response as compared to its predecessor, the Academy curve. The former meaning was probably, slowly superseded by the latter. In many cases, the typical cinema loudspeaker systems still do not have sufficient output capability to allow for the compensation of the screen losses at high frequencies, so if correction were attempted, to arrive at a flat response, excessive distortion or driver failure would be likely to result.

De facto, and irrespective of what else may have been written, this curve is used as a target curve by the vast majority of installation engineers and maintenance technicians when calibrating theaters. The usual method for calibrating screen and surround loudspeakers is to inject pink noise into each loudspeaker channel in turn, and take measurements with a real-time analyser, using from one to eight microphones in the prime listening areas of the theaters. Each loudspeaker system is then equalized until the steady-state response corresponds as closely as possible to the X-curve.

The multiple loudspeakers mounted on the theater walls for the "surround" channel(s) were often, in the early days, fitted with a switch so that for cinema

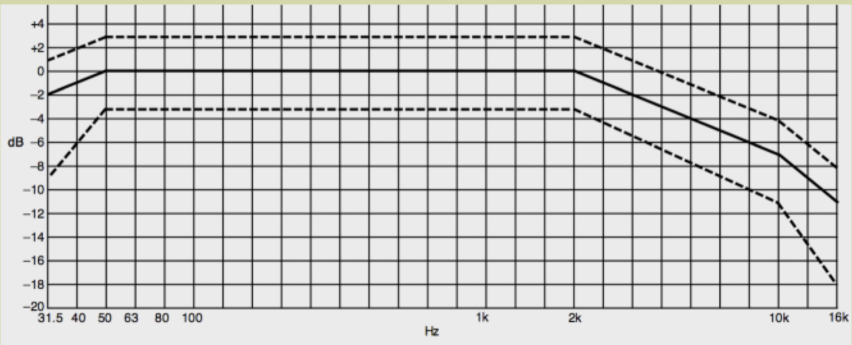



Fig. 2. The X-curve (showing upper and lower limits dotted), after SMPTE ST202 (2010)

use the HF could be rolled off in a similar manner to the X-curve so that timbral matching could be achieved with the screen channels. The JBL 8330 surround loudspeaker publicity stated "Switchable crossover network allows SMPTE/ISO2969 Curve X high frequency de-emphasis for cinema surround installations or flat response for foreground applications." This clearly indicates how a major manufacturer viewed the situation.

Despite some claims in the past, the direct response from the screen loudspeakers, measured in the close field beyond the screen, has the same X-curve shape as the steady-state frequency response measured at two-thirds distance into the audience area. The principle difference is air-absorption loss as a function of distance. The suggestion that cinema loudspeaker systems emit a flat-tish direct sound beyond the screens is a myth. The need to apply the same response curve to the surround loudspeakers, which passed through no screen and are close to the audience or re-recording (soundtrack) mixers, is testament to this fact.

Fig. 3 shows the responses of nine cinemas and eleven dubbing theaters that had been calibrated to the X-curve. It can clearly be seen that the HF responses at two meters are only slightly higher than the corresponding responses deeper into the rooms: a difference that in all cases can be explained by air-absorption losses with distance. Whatever the historical reasoning behind other explanations for the X-curve, the current situation that applies is the one described here.

As film soundtracks are both mixed and exhibited with the electroacoustic responses in the theaters conforming to the X-curve, as shown in Fig. 3, any compensation for this loss of high frequencies is entirely in the hands of the re-recording engineers when the soundtracks are mixed. They may choose to apply HF boost to individual channels, via the mixing consoles, but no global HF loss-correction is applied to the soundtracks. Indeed, given the limitations of the HF driver output capabilities, as mentioned earlier, global compensation to raise the HF response back to flat would be likely with some existing sound systems to lead to excessive distortion or driver failure, or at least to unpleasant harshness in some marginally-equipped theaters. However, work is currently underway to assess the capacity of the most-recent cinema systems to accommodate such equalization. How this may affect the majority of current, in-situ, systems will need to be addressed.

Although the harshness sometimes noticed in cinemas is often attributed to the comb-filtering given rise to by the multiple reflections between the screens and the loudspeaker faces, recent research isolating just the comb-filtering component of a loudspeaker/screen response indicates that comb-filtering, per se, is not significantly audible.

Relatively recently, some dubbing theaters and smaller cinemas have begun to use woven screens, which exhibit much lower levels of HF loss. When such screens are used, the HF responses are usually attenuated by means of equalization, often of a one-third-octave-band nature, to meet the standard X-curve. These screens tend to allow a greater degree of sonic transparency as the reduced requirement for the HF drive to the loudspeakers often results in lower nonlinear distortion, and thus a cleaner sound.

The current SMPTE and AES work in the areas of cinema sound system calibration and performance standards is on course to specify some much-needed new standards which will bring cinema sound and system performance into line with the rest of the audio industry. The recent release of the SMPTE TC-25CSS report on "B-Chain Frequency and Temporal Response of Theatres and Dubbing Stages" (see https://www.smpte.org/standards/reports), in conjunction with the upcoming "Digital Pink Noise Standard" and "Digital Cinema Sound System Setup and Calibration Recommended Practice," provides a strong basis from which to move forward.

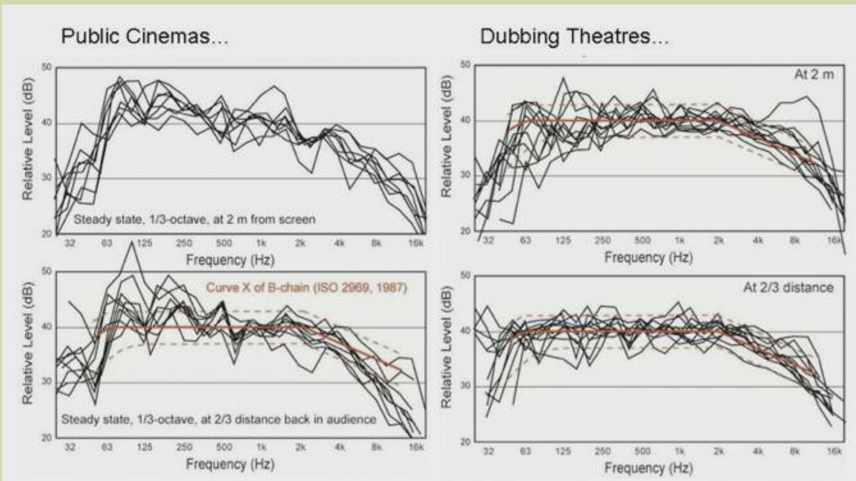



Fig. 3. One-third octave responses measured in 9 cinemas and 11 dubbing theaters using a pink noise source, in conventional cinema sound approach. The lower plots show the responses at positions approximately two-thirds of the distance into the rooms, while the upper plots show the responses measured at approximately two meters from the screens. (Originally published at IOA Reproduced Sound, 2010, and in AES convention paper 8383, 2011.)