

# CASE STUDY

Keith Yates Design Group

USA

Building Acoustics

Acoustic Optimisation of Home Theatres

2260 Investigator™, Software, Sound Intensity

*In a world bulging with multimedia novelties, and even more innovations waiting in the wings, it is true ingenuity, such as the acoustically optimised home theatres, private media rooms and intimate concert halls designed by Keith Yates Design Group, that helps set the standard in quality. KYDG's goal "...is not to simply place you in a movie theatre... it's to place you in the movie."*

*To achieve this, the company performs comprehensive acoustic tests using a Type 2260 Investigator™ Building Acoustic System before, during and after the construction of each of its uniquely designed home theatres.*

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Photos courtesy of Keith Yates Design Group and DJ Dowling General Contractor, Inc.

## Performance-Based Room Design<sup>SM</sup>

In the foothills of California's Sierra Nevada range, an audiophile's passion for superior sound experiences evolved into a booming business catering to the acoustical whims of the rich and famous. From a simple acoustics consultancy started in 1991, to a full-service design firm creating total immersion environments, Keith Yates Design Group launched the home theatre industry and continues to dominate the market with its emphasis on acoustically sound materials, thorough planning and individualised designs. Nothing is left to chance and circumstance. KYDG calls it, "...'Performance-Based Room Design' and it enables music and film lovers to improve, dramatically, the immersive power of the entertainment experience."

**Fig. 1**  
Keith Yates, founder  
and president of Keith  
Yates Design Group



KYDG employs 13 people internationally, including CAD experts, full-time interior designers, and low-noise mechanical and electrical engineers. In addition, the company can draw expertise from its affiliations and partnerships with acoustic, electroacoustic and engineering (video, vibration and optical) consultants. Its core market is based in the Western US, but current projects take the group far and wide; from Florida to France, and from New York to New Zealand. The group consistently maintains 30–35 projects going at any one time, and continually has a long list of upcoming projects on the back burner. Interest is spreading and the company’s headquarters in Auburn, California is, for the most part, becoming a bit too cramped. Thus, plans are in motion to expand both office space and international presence. Yes, one could say that business is doing extremely well for KYDG.

### **Solid Background**

Keith Yates also knows what it is like when the market is not so agreeable. Prior to trying his hand at consultancy, Keith was a successful retailer, selling high-end audio/video solutions and custom installations. From his 7000 sq. foot store with seven specialised sound rooms, one of which was a mini concert hall with room for 140 guests, and 19 full-time employees, Keith built up a reputation as being one of the nation’s premier sources of quality hi-fi equipment and industry know-how. After 10 profitable years, he was faced with the economic downfall brought on by the Gulf War and forced to close his business.

Today, with that experience richer, he can boast an impressive career spanning over 30 years, including: steadily increasing sales in his 14 years as founder and president of Keith Yates Design Group; continued recognition as an acoustics design specialist with titles such as author, teacher, consultant and featured panelist; and numerous certifications and affiliations within the acoustics and film industries.

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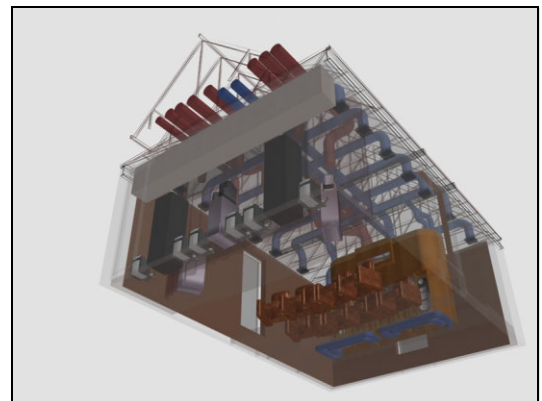
## **Teamwork**

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But Keith will be the first to admit that his current success is not a lone venture. He has amassed a group of extraordinary employees and partners around him who have the experience, knowledge and similar drive for perfection, which are crucial in running a successful business. He takes this cooperative spirit into every project, with KYDG acting as the “glue that keeps everyone on the same page.”

**Fig. 2**  
Worm’s eye view of  
theatre design  
highlighting the routing  
of HVAC ducts through  
the structure

When a theatre is planned in a new home or house refurbishment, KYDG gets involved at the very beginning and follows through to post-construction testing. Keith works with the project’s architects, builders, audio/video installers and especially the homeowner to ensure a good collaborative effort with common goals. Detailed colour CAD drawings are produced by his design team showing the acoustic design details, construction plans and finished project images. With these in hand together with Keith’s explicit specifications and periodic acoustic testing throughout the



building process, the project’s principals are clear on how the project should develop and what needs to be done to get there. The end result is a spectacular entertainment area stimulating enough for the family to congregate and worthy of public acclaim.

**Fig. 3**  
Dan Dowling, the building contractor on the celebrated Atherton home theatre project

And acclaim is what many of KYDG's projects receive. One of their latest projects, a dramatic home theatre set in a private home in Atherton, California, was recently featured in *Architectural Digest* (see the cover photo). The general contractor on the project, Dan Dowling of DJ Dowling General Contractor, Inc., worked closely with Keith, following his detailed plans and getting a hands-on lesson in building acoustics in the bargain. The resulting acoustically optimised room bears the fruit of Dan's exquisite craftsmanship as well as the successful integration between high quality equipment, well-placed acoustic material and inspired design.



**Fig. 4 Left:** Elliptical lath and plaster dome, under construction. The combination of the specialized (porous) acoustical plaster material, support structure and damped air cavity above makes for an effective, broadband absorber. The interior wall cavities (stud bays) are being fitted with varying densities of fibreglass absorbents to attenuate transverse waves **Right:** Side wall as acoustically transparent fabric is stretched into place. Yates employs a Brüel & Kjær Falcon™ Range 1/2-inch Microphone Type 4189 in a custom-built chamber to test the acoustic transparency of wall and ceiling fabrics under consideration



## Testing with Brüel & Kjær

Optimising a building's acoustics is not something you guess at, especially when the aim is to create a world-class venue. Consistent testing and quality checks performed with reliable equipment are essential to produce a theatre that envelops you in sensory bliss. Keith would like nothing more than to create a space where movie viewers can lose themselves. As he puts it, "A great theatrical experience elicits what the poet Coleridge termed 'the willing suspension of disbelief' – a moment where you forget where you are and placed in the fantastical world of make-believe, whether it be the cockpit of a Starfighter or a 17th century concert hall." However, great theatre experiences are often spoiled by:

- Impact and transient noise (doors slamming, footsteps above, etc.)
- Regular background noise (broadband noise) that infiltrates room from a noise source nearby, or from the HVAC system within the room
- Electrical buzzing from components, power spikes and surges, which may not be audible in normal rooms, but can interfere with the listener's ability to understand and appreciate details in the film's speech and sound

By coming in early in the construction and installation process, Keith and his group can measure the room's noise and acoustics levels using Type 2260 Building Acoustics System to see what and where the offenders are. Besides Modular Precision Sound Level Analyzer Type 2260 Investigator, the powerful measurement system comprises, Tapping Machine Type 3207,

Sound Intensity Probe Kit Type 3595, Building Acoustics Software BZ 7204, Sound Intensity Software BZ 7205 and Enhanced Sound Analysis Software BZ 7206. To measure vibration resonances, two Piezoelectric Cubic Charge Accelerometers Type 4501 are used and calibration is handled by Type 4231 Calibrator.

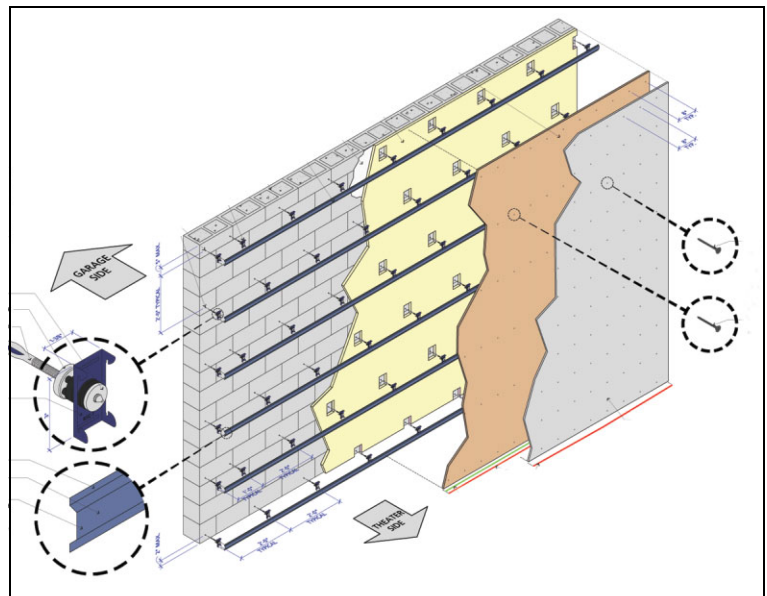
Keith says, “Since my noise specifications are roughly the equivalent of NC 5 to 10 (I actually specify level vs. frequency starting in the 16Hz octave band), ordinary instrumentation mics exhibit too much internal noise to be useful. I therefore rely on the world’s premier ultra low-noise microphone system – Condenser Microphone Type 4179 with Microphone Preamplifier Type 2660, WH3315 low-noise modification, WL1302 cable modification, and a 4-channel NEXUS™ Conditioning Amplifier feeding the Type 2260.”

He admits that he was originally put off by the system’s price tag. Now he calls it an ‘indispensable’ part of his tool kit.

**Fig. 5**

Keith calls it ‘immersioneering’ and notes that “nothing breaks the magic spell faster than sensory input (sonic, visual or vibrotactile) that is dissonant with the world created by the filmmaker!” Isometric wall assembly drawing – the goal is to create a wall effective at isolating the theatre interior from noise from the adjacent garage

Brüel & Kjær instruments are used to monitor sounds filtering into the room such as plumbing noise (toilets flushing, water running), footsteps and doors closing. As most home theatres are placed in the resident’s basement, the biggest culprit is the broadband noise generated by heating and ventilation systems, so special attention is placed on HVAC installations and/or devising solutions that will insulate the noise produced. Transmission loss



values of doors, windows and frames are checked, the reverberation time of the space is measured, and other typical building acoustic applications are performed.

### Project Development

Throughout the development of the project, measurements are made to quantify and compare the acoustic values of the room with and without insulation, sheathing, framing, and acoustic treatment (absorbers, diffusors, reflective material, etc.); determine the acoustic contributions of the room’s architectural features; define specific installations such as the acoustic fabric, dedicated electrical service, playback equipment, etc.; and target prime listening spots for the audience.

Once construction is finished, the acoustic devices installed, fabric stretched, equipment set up and the furnishings and fixings added, the acoustic levels are again verified and tweaked where needed. While the finished product should be a silent space, it should not leave you with a hollow, weird feeling. Fortunately, psychoacoustics has been Keith’s passion since his first course on the subject at Stanford a decade ago, so he is careful to “ensure a high correlation between the visual and auditory inputs”, making the room “the most inviting and sonically optimised room in the home.”

**Fig. 6**

*Sound is fed to subwoofers placed in various positions on the raised stage and the response sampled at each of the eight audience locations. The test results will be compared to the computer-predicted responses before final subwoofer locations and equalization settings are determined*

### Sound System Setup

A single project often carries a price tag somewhere in the million dollar range, with the sound equipment making up 15–40% of that figure. However, the hardware is rarely visible. According to Keith, “Occasionally the main speakers are shown, but the amplifiers, signal processors, power conditioners and so on are generally racked up in a dedicated ‘control room’ nearby. Our clients are usually company CEOs. While most home theatres can be seen as their ‘toys’, they are still prudent businessmen and want a sense of value. My intention is to create an environment that takes them out of the stress of their everyday lives. The equipment along with the acoustic treatment – a combination of devices designed to absorb, scatter or reflect sound – is typically concealed behind panels of acoustically transparent fabric, giving the room a nice tailored/upholstered look.”



**Fig. 7**

*The amplifiers, signal processors, power conditioners, etc., are usually installed in racks in the system’s control room*

Although Yates often specifies free-standing, audiophile type speakers for listening room projects, for home theatres he generally gravitates to large, pro-type control room monitors flush mounted in a purpose-built soffit or ‘baffle wall’. The flat response from the speakers is generally 28 Hz to 20 kHz on axis. In addition, he conducts speaker radiation pattern tests (off-axis measurements) in his large backyard ‘laboratory’ in order to better predict how the speaker will spread acoustic energy into the room. Sounds below 60 Hz are directed to the subwoofers.



Subwoofers may be placed immediately below the soffit wall, and often on the rear wall, side walls and/or ceiling as well, the precise number and positions depending on the results of his ‘modal landscape’ tests that show how low-frequency standing waves create high and low pressure areas at the various seating locations. Keith typically specifies six to ten surround speakers, and all speaker and sub woofer responses are optimised using studio-type digital signal processors (DSPs).

The screen material must be acoustically transparent, as it is positioned directly in front of the centre loudspeaker. The left and right speakers are generally positioned outside the outer edges of the screen, with care being exercised in their exact locations so as to avoid a perceptual disconnect between the visual and acoustic origins of actors, vehicles and other sound sources depicted on screen. (Keith points out that there is a small structure in the human midbrain that processes such spatial misalignments).

Once in place, a typical acoustics test of the equipment is carried out in several stages using Type 2260.

With the sound level analyzer set at ‘C’ frequency weighting and ‘Slow’ time weighting, and a low-noise microphone Type 4179 set up:

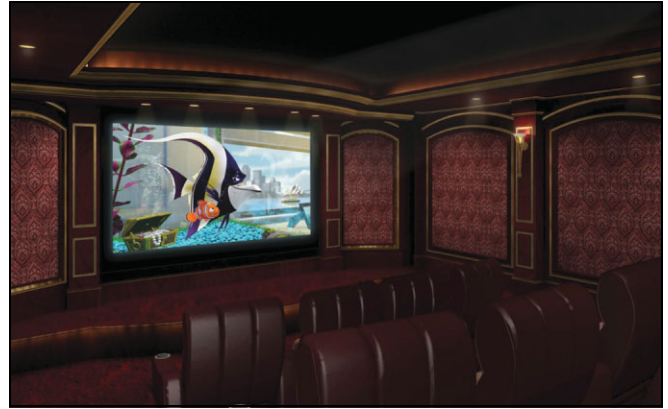
**Fig. 8**

Computer rendering of how the finished room will look from the right rear corner, with the stage drape closed. Yates often renders several different architectural themes and colour palettes for client review



**Fig. 9**

Rendering from the left rear corner with the drape open and the video projector operating from its concealed position in the ceiling soffit. The raised stage was included to give children a 'venue' to present skits



1. All equipment is switched off and noise levels are measured
2. Each speaker and subwoofer is switched on one at a time and its noise contribution measured at one meter
3. All speakers and subwoofers are switched on and the noise level measured throughout the audience area
4. Finally, the HVAC system is turned on and the noise measured at each terminal (supply or return air register), and then throughout the audience area

Noise levels are measured at each construction stage, then analysed and compared to see consistencies and changes in levels and note room reverberation times.

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## A Microphone with a College Education

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**Fig. 10**

Type 2260 at work after construction is complete at a home theatre



Keith first learned of Brüel & Kjær through our basic analyzers in the early 1970s. According to Keith, “Brüel & Kjær equipment is ‘the stuff’. There is nothing better.” He emphasises his enthusiasm with an anecdote, “If two competent consultants give evidence in a court case, it’s the one with a Brüel & Kjær instrument that will generally win the credibility battle. If both are highly competent and use Brüel & Kjær, the winner will be the one with the bigger instrument and the more recent calibration.”

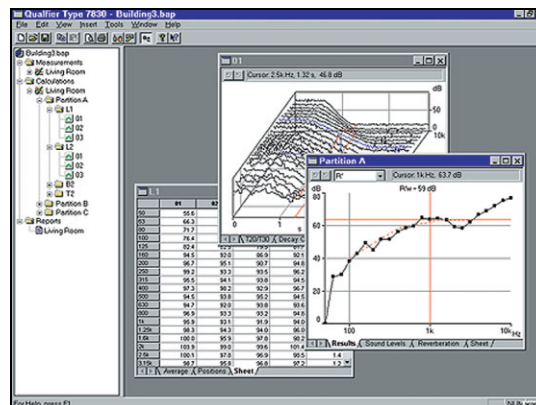
He acquired his first Type 2260 sound level analyzer about 3½ years ago, when a French engineer he hired insisted on using only Brüel & Kjær equipment. Since then Keith has stuck with Type 2260, adding modules and complementary Brüel & Kjær instruments to cover all his building acoustics measurement needs. “The 2260 is a microphone with a college education. It measures broadband, spectral and statistical parameters concurrently and with the accompanying building acoustics software installed on a remote PC, I can opt to calculate and modify reverberation times in the office or on-site.”

During a job with a new building contractor, Keith typically discusses the abilities of his Type 2260 system so that the contractor is aware of the system’s ability to test the quality of the construction and to show how the instrument measures building parameters.

“All construction work must conform to the UBC (Uniform Building Code) or local equivalent. But our requirements are stricter than what the UBC generally demands.”

**Fig. 11**  
BZ 7204 Building Acoustics software

“For example, we have detailed HVAC noise limitations and Indoor Air Quality standards, and we expect all of them to be fully realised in the field. It’s critical that the contractor grasp these requirements and the rationales behind them, and also that there will be ‘days of reckoning’ ahead, in which I’ll be relying on the world’s finest test equipment to determine whether our standards were met in the field. Consultant-type arm-waving has its place. But nothing succeeds like the prospect of verification using Brüel & Kjær’s hardware.”



## The Future

The future looks bright for Keith Yates Design Group. Trends in North America are trickling out to the rest of the world and orders for specialised home theatres extend from California, Europe and into Southeast Asia. And with each undertaking, Brüel & Kjær equipment will be right there with KYDG to ensure concise measurements, thorough analysis and flawless results. After seeing a recent demonstration, Keith has already made plans for his next Brüel & Kjær investment: “A great addition to our measurement system would be Binaural Microphone Type 4101 for recordings of sounds entering the ear from a true cranial position, both before and after calibration of the sound system. Playback of the WAV file recorded would give us a new and useful record of the ‘before and after’ conditions, and would also give us a way to compare what we achieved with what our modelling and auralization tools predicted we’d get at that location with those speakers in that acoustic environment.”

## Key Facts

- Keith Yates Design Group makes technical specifications and designs for acoustically optimised home theatres. The company makes intensive use of computer technology – even preliminary ‘look and feel’ sketches prepared for homeowner input are based on 3D AutoCAD models that have been photo-realistically rendered and then post-processed to impart more of an artist’s impression
- KYDG works collaboratively with the architects, builders, audio/video installers and homeowners involved in a project to achieve a world-class venue
- Impact and transient noise such as door slamming and footsteps; broadband noise such as that generated by a HVAC system; and low-noise such as electrical buzzing from components, all contribute to the degradation of the entertainment experience
- Taking into account the room’s structural design, architectural features, and HVAC and electrical installations, specifications are made regarding acoustic treatment (use of absorbers, diffusors, reflective material, etc.) and specific installations. The psychoacoustic properties of the finished theatre are also considered, as well as identifying the location of “money seats” for the listeners’ optimal enjoyment
- KYDG calls their specialised design “...Performance-Based Room Design<sup>SM</sup>” and it enables music and film lovers to improve, dramatically, the immersive power of the entertainment experience”
- The 2260 Investigator™ Building Acoustics System is used to detect and monitor noise levels, and determine reverberation times

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