Electrical installations in theatres and performance venues

Bord Gais Theatre, Dublin ©Ros Kavanagh

In this, the first in a series of articles looking at electrotechnical job roles in the entertainment industry, the Association of British Theatre Technicians (ABTT) talks to Richard Bunn about the role of contractors and engineers in designing and installing the permanent electrical systems in theatres and performance venues.

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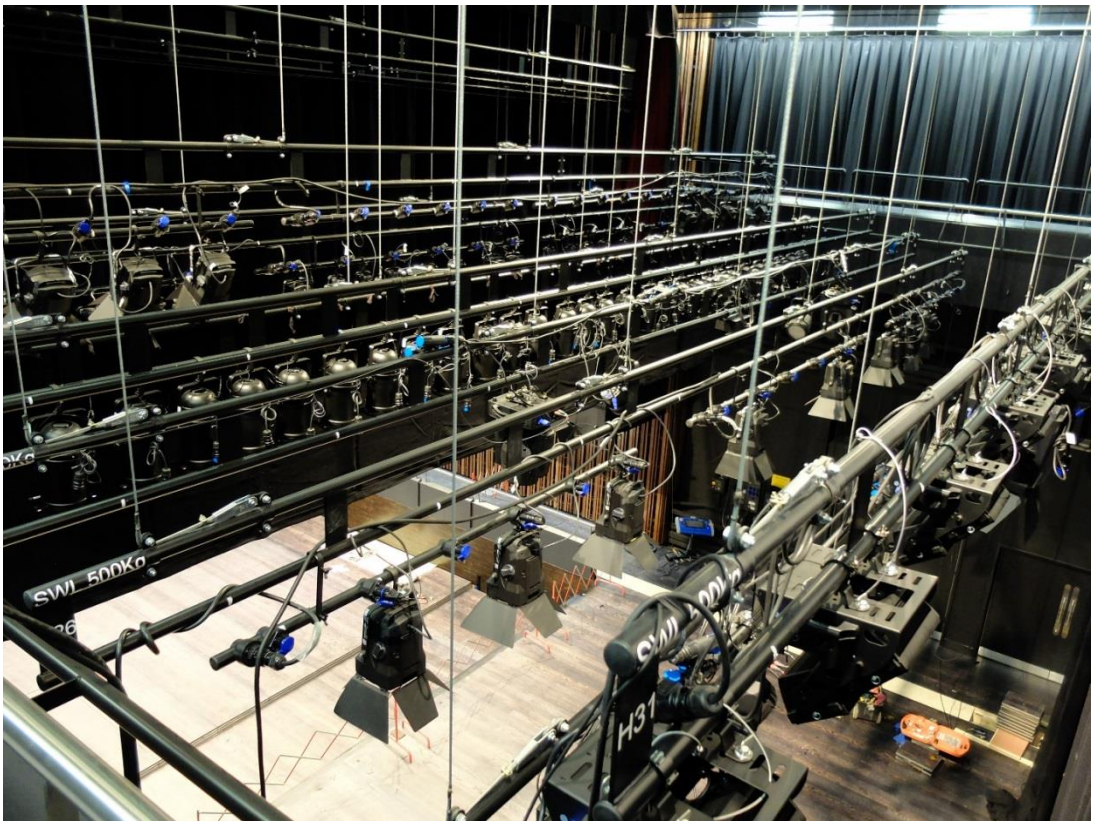
Richard is also Vice-Chairman of the Association of British Theatre Technicians (ABTT), a charity that campaigns on behalf of the theatre industry to ensure that legislation is appropriate to the industry's needs and that regulations are appropriately drafted and enforced.

What makes theatres and similar performance venues different from other buildings?

Theatres are some of the most heavily serviced of all buildings. The systems and complexity are sometimes compared to those found in a hospital. This comparison highlights the requirement for significant specialist electrical systems in supporting a performance. These include systems for production lighting, sound, video, broadcast, stage machinery and special effects. These systems are safety critical in an environment with heavy moving scenery, variable lighting, loud audio and large numbers of performers and audience members.



A view from above stage at the Bryn Terfel Theatre, Bangor, ©Arup

At its heart, the use of a performance venue is driven by creative directors, designers and performers. The same stage may have a large-cast musical one night and a single stand-up comedian the next. Consequently, necessity demands that the electrical and associated systems must enable flexible use and do not constrain the artistic vision. Careful planning is needed to provide just the right amount of services and equipment in all the required locations; too much could get in the way or not earn its keep.

Although they are focused on performance spaces, these systems permeate throughout the building to provide audio and video for show relay and communications in backstage spaces and for performance presentations in foyer spaces.

What standards should be considered for performance building installations?

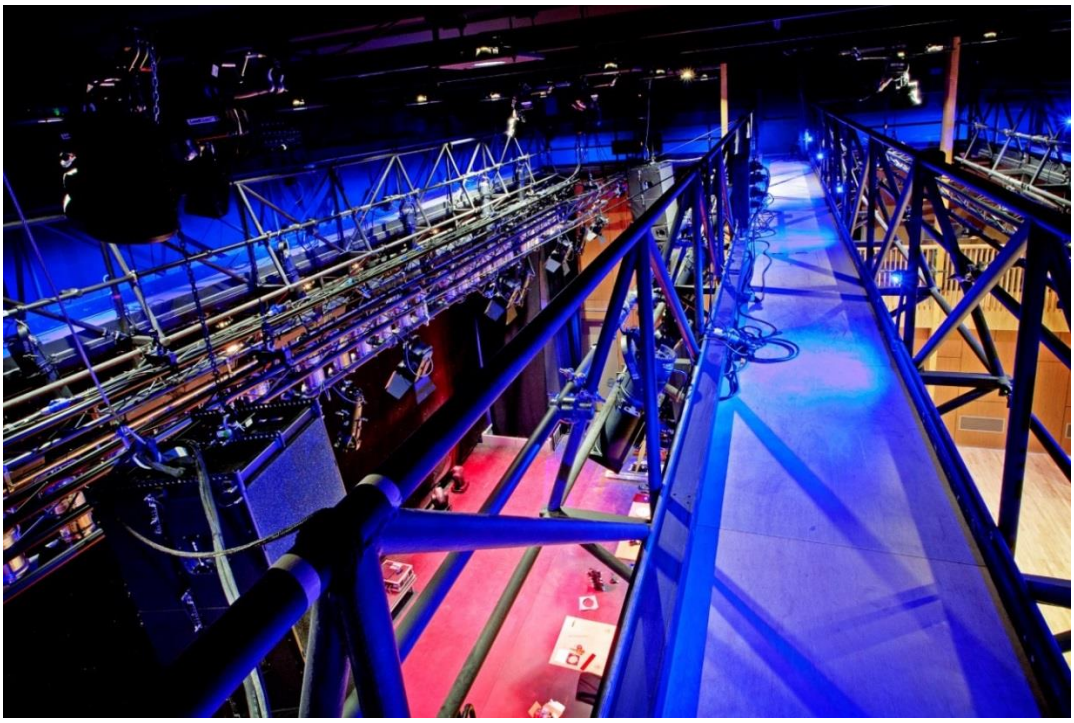
BS 7671 remains the primary reference document for the UK and sets the foundation for safe electrical installations. The *Technical Standards for Places of Entertainment* co-published by, and available from, the ABTT (www.abtt.org.uk) is essential reading to understand theatre operation and how regulations should be applied, particularly to assist in compliance with licensing requirements. As well as providing commentary and recommendations on core electrical installations, this guidance also includes recommendations for the planning of general and emergency lighting systems and fire detection systems.

What are the particular challenges and considerations for the electrical installation?

Although performance buildings are large, space is at a premium. The spaces close to the stage are needed for performers' dressing rooms and technicians' workshops meaning that spaces for electrical distribution are rarely in ideal locations.

Areas that look empty on plans are critical to the flexibility required to produce spectacular performances. As an example, an over-stage grid may look similar to a plant space, but the use is very different. It is a working area for technicians to suspend scenery and create effects, so a misplaced piece of containment may easily compromise the artistic possibilities for the space.

Several systems of containment are required, and these need to be rigorously separated to prevent noisy power associated with dimmers and machinery from introducing noise to sensitive millivolt-level microphone signals. In key areas such as balcony fronts and control rooms, this wiring will have to fight for space and be coordinated with structure and other services. Handling of low noise air demands big ducts that also consume large amounts of space, thereby making early containment planning important. Entertainment technology is constantly evolving and low-fill factors are needed to allow space in containment for future cabling.



Lighting bridges above the auditorium at Mareel Arts Center, Lerwick ©Phatsheep

Associated with this is the way that an auditorium and stage carves a void in the building requiring cables to be routed around a wide, long volume several stories high. All this means that cable runs end up longer than may originally be anticipated, which impacts on cable size to meet volt drop and loop impedance requirements. Care is also needed to ensure data cable run length limits are not exceeded.

What is the role of specialist contractors and how does this interface with the work of the electrical contractor?

A specialist contractor will usually be employed to supply, install and commission specialist lighting and sound equipment. These systems depend on electrical supplies, wiring and containment provided by an electrical contractor. There will also be interfaces between the specialist systems and other electrical systems, for example, between fittings and controls for architectural lighting and the fire and building management systems.

Close coordination between the specialist and electrical contractors is important to achieve a successful and well integrated project. At the outset, responsibilities should be agreed between both contractors to ensure that everything is included and interfaces are well understood. This relationship is usually mirrored in the design team, with a theatre consultant defining the specialist packages to interface with the systems specified by the electrical engineer.

Side stage gallery, Swansea University Great Hall ©Arup

How much power is required for a theatre building and how is it distributed?

Because a theatre building needs to offer flexible use in order to support a wide range of performances, the brief for the building must be analysed. Central to this is whether the building is designed as a 'producing house', with workshops and rehearsal rooms for creating shows, or as a 'receiving house' designed to accommodate touring shows.

Stage lighting remains the largest electrical load and supplies need to be sized to illuminate the stage to give the impression of the brightest summer days. In the next instance this could be replaced by a single spot on a solo performer. So, although big supplies are required to meet maximum demand, average electrical use is much lower. Stage machinery is similar with large supplies required for lifts and motorised bars during scene changes, but minimum power use in between.

Dimmer rooms, audio rack rooms and motor rooms are usually provided as hubs for the electrical and control infrastructure. These are similar to other plant areas, but dedicated to the specialist systems and with access controlled by theatre technicians.

Dimmer racks at Theatre Royal, Bury St Edmunds / Motor room at Victoria Halls, Singapore ©Arup

In addition, large supplies are required adjacent to the stage and in other locations to support extensive temporary power distribution as part of a touring show or for powering outside broadcast vehicles. The size of these supplies varies with venue size, and may be up to 800 A TPN.

Resilience of supplies is essential. There is an expectation that 'the show must go on', and loss of a show due to power failure is financially and reputationally damaging. Providing some UPS to protect critical systems is advisable, but full back-up generation for all the theatre systems can rarely be justified against the cost and space required for worst case loads. Sub-metering and monitoring is increasingly used to alert users early to any risk of overloading during technical rehearsals prior to a performance.

How are new and emerging technologies changing the planning of electrical installations?

There have been some recent significant changes in technology that affect the design of electrical installations for performance spaces.

Widespread adoption of LED lighting for the stage has lagged behind other sectors. It has taken time for the technology and products to develop to meet the industry's exacting requirements – smooth dimming, excellent colour rendering, full spectrum colour mixing, high output, compact size, low acoustic noise and affordability. However, LED sources are now here to stay and require cabinets of relays with switched power.

This is a change from the previous generation of thyristor dimmer racks developed for controlling power to tungsten lighting. To allow for the migration to new technologies, hybrid dimmer racks have been developed, which include dimmers and relays compatible with both future and historic luminaries. The new lighting fixtures eliminate some of the old challenges of managing the noisy low frequency triple-n harmonics associated with the chopped waveforms. However, they introduce new issues associated with having large quantities of switch mode power supply LED drivers with high inrush currents, high frequency switching noise and high leakage currents to earth, which need to be managed.

There have also been significant changes in the audio and video world. To minimise noise associated with analogue audio systems, separate low impedance earth networks (often referred to as 'technical supplies') have historically been used to eliminate noise from other equipment and manage circulating currents. For this reason, great care should be taken when works are undertaken to maintain or provide additional circuits in existing buildings.

The digitisation of professional sound and video systems over the past 10 years, coupled with a greater understanding of electrical magnetic compatibility (EMC), means that separate earth networks are no longer preferred for managing the high frequency noise present in audio and video networks. Use of a common bonding network (CBN) or mesh earthing arrangement following the guidelines of BS EN 50310 (and the related advice in Part 444 of BS 7671) is now more appropriate for most installations in order to manage the potential impact of both high and low frequency noise.

The widespread adoption of Building Information Modelling (BIM) is changing how buildings are designed and refurbished, particularly for publicly procured projects. Any change in working practices is challenging, but BIM is providing great opportunities for co-ordinating space requirements early in design and capturing the details of the electrical installation to allow future maintenance and expansion.

Why do you choose to work on theatres and performance venues?

There is no doubt that these projects can be long and challenging, but they also provide the opportunity to work with great architects, engineers and contractors. The project stakeholders almost always have great passion and vision for their new venue, and share this expectation with their cities and communities. There is a special reward when the first show opens, and satisfaction in seeing these spaces and systems that allow the audience to connect with a performer and with each other.

Performance at Stormen, Bodo, Norway ©Arup