WiringMatters #48

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YOUR**LETTERS**

Send your letters to The Editor, Wiring Matters, Michael Faraday House, Six Hills Way, Stevenage, Herts SG1 2AY, UK, or to wiringmatters.editor@theiet.org. We reserve the right to edit letters and use submissions in any other format.



MORE SOCKET PERILS

Although I appreciate, from the editor's note in issue 47, that the subject of socket protectors is now closed, it's important to recognise that these are not the only items on the market that can compromise plug/socket safety.

A few weeks ago a Kleeneze catalogue popped through our door and a new item caught my eye, which at first glance seemed quite innocuous until I realised that it compromises the whole design concept of the BS1363 plug/ socket system.

As is clear from the image below, the product in question is nothing more than a rather thick piece of plastic intended to be used between the plug and socket. The obvious danger is that it prevents the plug from being fully inserted into the socket; thus potentially impairing full and proper contact and posing a serious risk of overheating.

It even appears to impair the socket being switched off and also I have no idea what type of plastic the item is made from but it is likely that it's not flame retardant either.

Buyer beware indeed.

James C Hughes



Socket danger from Blue Cuckoo Land?

SUPPLY VOLTAGE

In his article (*Wiring Matters* Summer 2013 p29) James Hunt says "Electricity supply companies in the UK provide an average incoming voltage to users of 242V." Those with long memories will know that the UK rationalised its supply voltage on 240V (\pm 6 %), but negotiations in the EU sought to agree a common voltage across Europe and after a long struggle ended up with 230V \pm 10%. As a good deal of the continent had a supply voltage of 220V the wider tolerance enabled both this and 240V to be acceptable with no need to change.

The companies supplying 220V could see that revenue would be generated by increasing to 230V, but they had to move carefully as an increase in voltage might produce safety issues. I believe that at least in some countries the voltage was increased by 1V per year till the agreed 230V was achieved.

In the UK there was no incentive to change, and it has not happened, as can be seen from Mr Hunt's statement. They



just took advantage of the greater leeway when long supply cables ended up with low voltages at the extremities.

Manufacturers of equipment are expected to supply products which work on $230V\pm10\%$, but many are limited by the physics of the energy conversion process. In the UK filament light bulbs continued to be supplied rated for 240V since customers would not tolerate a life reduction of 45 per cent which would result from a 230V rated bulb being run at 240V. Often all manufacturers can do is ensure their product are not unsafe at 253V and, hopefully, still work at 207V

It's time the EU position on standardised supply voltage was revisited and the tolerance reduced to $\pm 6\%$, as was achieved before.

Our government is concerned about the capacity of the grid in the near future with so many power stations being shut down. A useful increase in safety margin would easily be made available by demanding that the supply companies really do supply power at the harmonised voltage, not 242V. **Ray Burgin**

A CALL TO AUTHORS

Wiring Matters welcomes contributions from anyone involved in electrical installation and safety. If you have something to say that you think could be of value and interest to your fellow professionals, then why not turn it into an article?

If you're new to article writing, it can be a daunting process, but we can offer lots of help and advice to would-be authors. This can cover advising on the suitability of topics, suggesting how an idea can be structured into a suitable article, and, if appropriate, detailed editing of copy to ensure a clear and readable end result. Articles are typically in the range 1,500 to 2,500 words.

Along with articles we'd welcome opinion pieces – our 'guest editorial' – of around 700 words. Alternatively, you might just like to send a letter to the editor.

If you've any ideas you'd like to discuss, please contact the editor at wiringmatters.editor@theiet.org

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Boosting electricians' career aspirations



A LACK of recognised standards for industry competence is hindering electricians' ability and desire to progress their career, according to recently published research. *Electrician Technician Registration in the UK* studied electricians' perceptions of their professionalism and found confusion around what constitutes 'competence' and which of the many industry bodies could be called upon for careers guidance.

Participants also believed that the wide array of electrical certifications and qualifications creates considerable difficulty in deciding which routes of study to undertake to lead to professional recognition. It was felt by the majority interviewed that without a visible benefit to pursuing additional professional qualifications, there is virtually no reason for an electrician to aspire towards professional registration awards and recognition such as Engineering Technician.

The research was commissioned by the Technical Advisory Panel and Steering Group (TAPS) – a collaboration of industry bodies comprising the Institution of Engineering and Technology (IET), the Engineering Council, the Electrical Contractors' Association, the Joint Industry Board (JIB), Unite the Union and SummitSkills. The Gatsby Charitable Foundation sponsored the project.

To address this disconnect and help electricians raise and recognise their professionalism, the TAPS partnership is now acting on key recommendations arising from the research, including: developing career pathways to enable professional recognition for electricians to progress to Engineering Technician;

adopting a 'one body' consistent approach to the provision of advice nationally with an electrician technician membership package;

mapping the Engineering Technician professional standards to the established industry competence card schemes, NVQs and apprenticeship frameworks;

promoting the benefits of gaining Engineering Technician recognition to support career progression.

Working jointly as the TAPS group will allow the project partners to generate a stronger collective impact for the good of the industry: "With so many different industry organisations aligned, this project offers a major opportunity to promote professional standards and to achieve clear recognition for all professional electricians," said Michelle Richmond, director, membership & professional development at the IET.

The findings of the research align with existing industry feedback, with both the Engineering Council and SummitSkills aware of issues or interest in technician status. Welcoming the publication of the report, Jon Prichard, chief executive of the Engineering Council, said that it "highlights the need for clarity to be brought to the sector, both for the benefit of electricians themselves as well as the clients and consumers who seek simple, recognisable competence assurance".

Keith Marshall, chief executive of SummitSkills, added: "This research report comes at just the right time, when there is increased interest in technicians, and confirms what we have been hearing from electricians for some time. The issues identified in the report are important to the future success of our electrotechnical industry and its ability to tap into the talent and potential of those working within it."

To download the full report visit http://www.theiet.org/factfiles/ taps.cfm

FACT BOX ONLINE ACCESS FOR IET TECHNICAL PUBLICATIONS

A SURVEY conducted by the IET, has found that over 80 per cent of respondents now source technical information relating to their job online, suggesting that many electrical contractors are moving away from traditional print versions of technical publications and opting to use digital content instead. More than 87 per cent of the 1,333 respondents to the survey, run by Wiring Matters, stated that they access technical information via their PC, with a further 27 per cent accessing information via smartphones and 19 per cent via tablet devices.

The research provides a strong endorsement of the recent launch by the IET of *The IET Wiring Regulations Digital: Online*, a suite of browserbased versions of its publications in e-book format. IET publications available digitally include: the *IET Wiring Regulations 17th Edition; BS* 7671:2008 incorporating Amendment No.1, 2011; and the IET On Site Guide, as well as a range of the IET's expert guidance and new titles which are added as they publish.

The suite of publications has a number of features which can help support electrical engineers and FE college lecturers in accessing and sharing information more easily. All of the publications contained in the platform are automatically updated to the latest edition - giving users peace of mind that they are accessing the most up-to-date information when they need it. Wiring Regulations Digital: Online also allows organisations and lecturers to share regulations and guidance across a far greater number of employees and students by offering them a multi-user licence. To save time, the digital publications are also equipped with an intuitive search function, which allows users to guickly find answers to their questions. For more information on the Wiring **Regulations Digital Online, or to** request your free trial, visit www.theiet.org/wrdo-pr



FACT BOX E-CAR TRIAL TO TEST IMPACT ON NETWORK

A FIRST-OF-ITS-KIND trial will examine the potential impact of local clusters of electric vehicles on the electricity distribution network when they are all drawing their charging current from the same substation, and will test a way of managing that impact without costly network reinforcement.

The My Electric Avenue (MEA) project is led by EA Technology and hosted by Scottish and Southern Energy Power Distribution (SSEPD), with other industry and technical partners. It aims to recruit ten groups of ten neighbours who are willing to drive a plug-in car for 18 months (paying a subsidised monthly rent) and provide feedback on their experience.

Participants will pay a subsidised monthly rent for a five-door Nissan Leaf, plus estimated electricity costs of $\pounds 2$ -3 for a range of 80-100 miles, with no road tax. They will be provided with a home charging point and a 'black box' control device that is part of the trial technology.

Electricity suppliers are already observing the effect of 'neighbour influence' on the uptake of solar panels and expect to see similar clustering effects with electric vehicles. The prospect of drivers all getting home from work and plugging in their cars during the 6-8pm period of peak domestic demand is giving rise to fears of voltage drops or melting wires.

The traditional solution – digging up roads to reinforce local feeders – is expensive, disruptive and slow. My Electric Avenue aims to address these concerns through a demandmanagement system developed by EA Technology that can control when vehicles are charged.

Dave Roberts, future networks director, EA Technology Europe, said the Esprit technology consists of a monitor and controller installed at the substation and slave devices at each charging point. If the feeder cable shows signs of being overloaded, a signal will be sent by power line communications to one or more slaves to switch off the vehicle charger for a time.

Speaking at the launch of MEA, held at the IET's London Head Office, Savoy Place, Roberts explained that the trialling of a number of different algorithms would be a key element of the project. "The first generation will



Nissan Leaf at the MEA launch at Savoy Place, London

randomly select which car to switch off, but we want to find the optimum solution. Should we feed the 'hungry child' first, or all equally? We are looking at three things: will it work in different types of network (such as urban or rural), and with different patterns of customer usage, and how do we do it in a way that's sympathetic to the battery?"

Stuart Hogarth, director of distribution for SSEPD, added: "This project opens the doors for a lot of learning. We need to understand how innovation affects our network, and that means getting involved. This will be the first time that a UK network has been tested for the impact of groups of vehicles. It will help us make changes in how we operate the network, to save us from having to do expensive reinforcement."

The £9m project is part of Ofgem's Low Carbon Networks Fund programme, and the first not led by a distribution network operator. It will create a blueprint for how DNOs and third parties can work together in the future.

Other partners are Nissan, Fleetdrive Electric (rental programme management), Zero Carbon Futures (charging point network developer) and Northern Powergrid (participating DNO). The University of Manchester and De Montfort University will offer technical and socio-economic modelling, and Ricardo will provide independent technical verification.

Five potential cluster sites are currently under active development, four residential: Watlington and South Gosforth, Chiswick and Marlow, while Kidlington-based Drayson Racing Technologies are strong contenders for becoming the first workplace charging cluster. It's expected that three of these clusters will be 'fully signed-up' by the end of September, with delivery of the first Nissan Leaf cars due before the end of the year.

Learn how to take part at www.myelectricavenue.info

WiringFeature #48



THE WIRING Regulations (BS 7671) are based on international standards. Work is ongoing at present at international level to integrate requirements for energy efficiency into IEC 60364. This is a completely new section. The worldwide need to reduce the consumption of energy means we have to consider how electrical installations can provide the required level of service and safety for the lowest electrical consumption.

The draft proposals enable a client to specify the level of energy efficiency measures applied to an electrical installation. Energy efficiency ratings are included for a wide variety of equipment types and installations, including motors, lighting, HVAC, transformers, wiring systems, power factor correction, semiconductors, measurement, and renewable energy.

Ratings for lighting are shown in Table 1. The table gives ratings EM0 to EM4. The first column EM0 indicates where no consideration for energy efficiency measures has been made, which is the lowest level. The last column EM4 (which is the highest level) indicates where the greatest energy efficiency measures have been applied. In this particular table, which deals with lighting, the last column EM4 indicates that the installation includes lighting controls to take account of natural lighting, occupancy, and lamp type. The table gives ratings for residential buildings (dwellings), commercial, industrial and infrastructure.

Points are allocated for each equipment rating (see Table 2). For example, a lighting installation rated EM3 is allocated three points. Power factor correction rated EM2 is allocated two points, and so on. The total number of points for all the types of equipment in an installation are added together to make a points total for efficiency measures as shown in Table 2.

Installations can also be awarded points for energy efficiency performance levels, for example, for transformer efficiency. These points can be added together with points for efficiency measures to give an electrical installation efficiency class. Electrical installation efficiency classes range from EIECO to EIEC4 depending on the number of points awarded.



It is important to point out that this rating system is given as an example of a method to assess the energy efficiency (not a requirement) which is included in an informative annex in the draft proposals.

Electric motors

Electric motors represent a large proportion of the industrial electricity consumption in the UK. Electric motors are used in a wide variety of applications in commercial and industrial installations. These include motors driving fans for ventilation and air-conditioning

Requirement	EM0	EM1	EM2	EM3	EM4
Residential buildings (Dwellings)	No consideration	To consider lamp type and position	To consider lamp type and position with natural lighting	Control according to natural lighting source or building use or lamp type	Control according to natural lighting source and building use and to consider lamp type
Commercial	No consideration	To consider lamp type and position	To consider lamp type and position with natural lighting	Control according to natural lighting source or building use or lamp type	Control according to natural lighting source and building use and to consider lamp type
Industry	No consideration	To consider lamp type and position	To consider lamp type and position with natural lighting	Control according to natural lighting source or building use or lamp type	Control according to natural lighting source and building use and to consider lamp type
Infrastructure	No consideration	To consider lamp type and position	To consider lamp type and position with natural lighting	Control according to natural lighting source or building use or lamp type	Control according to natural lighting source and building use and to consider lamp type

Table 1: Example of optimisation analysis for lighting

systems, motors driving pumps for refrigeration and chilling applications and air compressors. Motors are also used in lifts, hoists, and cranes. In manufacturing and warehouses motors are used to drive conveyors for packaging, and process conveying. Motors are also used to drive a variety of machines such as paper making machinery, textiles, woodworking machines etc.

The induction motor is probably the most widely used a.c. machine in power applications today, and is usually single speed, but multiple speed motors are available. This type of motor is robust in construction and provides a useful torque characteristic making it suitable for a wide range of applications.

Pumps and fans probably represent one of the largest

applications for motor-driven power. From an energyefficiency point of view it is understood that centrifugal pumps and fans have the greatest potential for energy savings as these are variable torque loads. This means, for example, that a 20 per cent speed reduction can result in a 50 per cent energy reduction.

In the UK, BEAMA has shown that most pump and fan applications are driven by very simple control systems where the motor runs at constant speed and the required flow variation is obtained by using a valve or damper to restrict the flow. This means that the energy consumption falls very little when the flow decreases. At 80 per cent of the nominal flow the energy consumption remains virtually unchanged. A more efficient option is

to use a variable-speed drive (VSD) to adjust the speed of the motor or fan to deliver the required flow. For fans, savings can be in the region of 50 per cent and for pumps about 30 per cent savings are seen.

The type of load to be driven has a direct bearing on the selection of the drive type and the amount of energy that can be saved. For example, reciprocating air compressors are constanttorque loads with power directly proportional to speed - so that a 20 per cent speed reduction will result in a 20 per cent energy reduction. However, in the case of motors used to drive machine tools torque varies with speed and power is constant, and in this instance a 20 per cent speed reduction will result in no energy savings. It is **>**

Table	Requirement	EM0	EM1	EM2	E 3	EM4	Points
A.1.1	Motors						3
A.1.2	Lighting						4
A.1.3	HVAC						2
A.1.4	Transformers						1
A.1.5	Wiring system						1
A.1.6	Power factor correction						2
A.1.7	Electrical distribution equipment with semiconductors						3
A.1.8	Energy and power measurement						3
A.1.9	Voltage measurement						0
A.1.10	Power factor measurement						2
A.1.11	Harmonics and inter-harmonics measurement						2
A.1.12	Renewable energy						4
Total							26

stage. Although this will increase the initial cost of the switchboards, it will prove more economical than having to add metering at a later date.

How metering information will be used needs careful consideration. The system may be required to measure power quality, voltage levels and loads. It may also produce alarms, control loads or change tariffs if pre-set limits are exceeded.

Consideration should be given to the environment where the meter is installed, which should be in accordance with the manufacturer's instructions. Metering needs to be installed in an area that is accessible for the meter reader and where the display can easily be read. Areas where the instrument is likely to be subjected to excessive heat, moisture, and vibration should be avoided. Meters are available that provide pulse generation. These can be linked to building management systems to provide an electrical pulse proportional to a unit of measurement.

Current transformers

Essential to the operation of the meter is the current transformer (CT). Its function is to transform the high current levels to match the input requirements of the meter. In most cases the input value of the meter is 5A. For example the rating plate of a CT may show 400/5. The high value represents the maximum current of the circuit, and is referred to as the primary value; the low value is referred to as the secondary value. The accuracy is expressed as a percentage, i.e. class 1 is 1 per cent, class .5 is 0.5 per cent.

Cable losses

The procedure generally used for the selection of a cable size leads to the minimum admissible cross-sectional area, which

Table 2 Example of energy efficiency measures. The shaded cells indicate the efficiency	y
levels applicable to the different items of equipment	

necessary for the user to be aware of the speed and torque characteristics demanded by the driven load in addition to the actual power requirements for the application for which the drive is to be selected. For the best results the drive system should be matched to the load requirements as closely as possible. It is recommended that users should seek advice from the manufacturer when considering a variable-speed drive.

Lighting

Lighting can represent a substantial proportion of the energy consumption in an electrical installation, depending upon the types of lamps and luminaires used, and their applications. Lighting control is one of the easiest ways to improve energy efficiency. These systems should be flexible and designed for the comfort of the users. The solutions can range from very small and local controls, such as occupancy sensors, up to sophisticated customised and centralised solutions that are part of complete building automation systems.

Lighting controls

Lighting controls for residential buildings are easy-to-install devices that are able to detect the presence of people and only switch on lights when required. Lighting controls eliminate wasted energy and save energy simply by switching lights off when not required. Lighting controls for commercial, public and industrial buildings are again easy-to-install devices that are able to automatically switch off lights when no occupants are detected or there are suitable levels of natural light.

When considering the design and installation of lighting controls there are a number of points to consider. First, it is important to take into account the type of space, how it is used and the amount of daylight available. The type and use of space will determine the type of sensor and therefore the control used.

Safety is also an important consideration. The operation of lighting controls should not endanger the occupants of the building. This may happen if a sensor switches off all the lighting in a space without daylight. It is therefore important that lighting controls are designed correctly to ensure the safety of occupants and save energy.

Commissioning should be included as an essential part of the installation of lighting controls. Commissioning could include calibrating photoelectric controls, checking that occupancy sensors are working, and setting a suitable delay time for occupancy sensors.

Metering

It is understood that there is no obligation on an electricity supplier to provide any other metering than that required to obtain the basic data to enable tariff charges to be applied. While this may be adequate for the smaller installation, it does not give sufficient information to allow a larger consumer to allocate costs to various facilities or to control consumption. To enable larger consumers to measure the amount of electrical energy consumed and monitor and control energy effectively metering equipment needs to be allowed for at the planning



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minimises the initial

investment cost of the cable. It does not take into account the cost of the losses that will occur during the life of the cable. This issue is being considered as part of the process of integrating energy efficiency into IEC 60364

Transformer losses

There are basically two types of losses in transformers: iron losses and copper losses. Iron losses occur in the magnetic core of the transformer, causing it to heat up. They can be divided into two components: hysteresis losses, and eddy current losses. In general, it is understood that iron losses in a transformer remain constant regardless of load conditions, i.e. the iron loss on no load will be the same as the iron loss on full load. Copper losses (load losses) result from the heating effect of the primary and secondary currents passing through their respective windings.

No-load and load losses in a transformer result in a loss of efficiency, and represent the major running cost of a transformer. They result in heat which is normally dissipated to the atmosphere.

Load losses depends on the load factor (LF). It is understood that in the UK the average industrial load factor on a transformer is probably between 50 and 60 per cent, but where security of supply is of supreme importance the use of two transformers reduces this value to below 50 per cent. Even lower load factors can apply where both load growth and supply security have to be taken into account. A key requirement when considering energy efficiency is to decide on the load factor of the transformer at the planning stage, thereby ensuring that it is run at its most efficient.

Power-factor correction Low power-factors are caused by the reactive power demand of inductive loads, such as induction motors and fluorescent lights. There are a number of reasons why they are undesirable. A poor power-factor reduces the effective capacity of the electrical supply as the more reactive power that is carried the less transmission capacity is available for the transmission of useful power. It also results in losses at transformers, can cause excessive voltage drops in the supply network and may reduce the life expectancy of electrical equipment.

Understandably, electricity tariffs encourage the user to maintain a high power-factor (nearly unity) in their electrical installation by penalising a low powerfactor. On commercial and industrial installations powerfactor correction technology is used to achieve a power factor as close to unity as is economically viable. There are a number of ways in which power-factor correction can be provided. The most common is to install powerfactor correction capacitors. These can be installed in bulk at the supply position or at the point of usage on motors. Anyone involved in this type of work should seek advice from specialists on the most economic system for an installation.



Kilowatt hour meter

Harmonics

Harmonics are a steady-state disturbance, in contrast to, for example, short-term transient over-voltages. Harmonics are generally caused by non-linear loads such as computer switchedmode power supplies and discharge lighting.

In electrical installations there is a particular problem in three phase circuits. The third and other triple harmonics combine in the neutral to give a neutral current that has a magnitude equal to the sum of the third harmonic content of each phase. The heating effect of this neutral current could raise the temperature of the cable above its rated value and damage the cable. Regulations 523.6.1 and 523.6.3 of the 17th edition

recognise the effect of triple harmonic currents in the neutral conductor and the need to take account of it.

Other harmonics can cause problems with electric motors, for example, increasing the frame temperature and reducing the life expectancy and efficiency. With the increased use of switched-mode power supplies harmonic distortion is now a major concern. It is therefore important to be able to measure the power quality and where harmonic distortion is found, provide a solution to ensure that it is reduced to an acceptable level. 🕸

Please note this article is only intended as an overview of issues being considered at a very early stage; as such, they may not lead to new international standards.

For further information: England and Wales -The Department of Communities and Local Government www. communities.gov.uk

Scotland - The Scottish Building Standards Agency http://www.scotland. gov.uk/Topics/Built-Environment/Building/ Building-standards









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THE TRANSMISSION and distribution network is creaking, struggling under the onerous challenges of distributed generation, renewable energy and increasing demand. These are all challenges for which the grid was not designed: its strengths lie in bulk transmission of power from huge, decentralised power stations through 400kV lines stepping down through 132kV, 11kV until it reaches the domestic consumer at 400V. That scenario is now a model that is well past its sell-by date.

Renewable energy enters the grid at a variety of stages: at the distribution level local generation enters the system and at consumer-level combined heat and power (CHP). Add domestic photovoltaic (PV) and electric vehicle (EV) charging to the the mix, and you increase the complexity and damage power quality. So how are these

challenges to be addressed? One proposal is the Smart Grid, an often elusive concept despite periodic rebranding over the years, being variously labelled as the 'intelligent grid', the 'self-healing grid', and so on. Whatever the label,

the essence is always the

same: it is really a grid that permits network operators to maximise their assets with real-time information, which allows them to react to changing demand and fluctuating generation patterns, as well as power disruption caused by failures in part of the system. It is a transmission and distribution system that employs fledgling technologies such as real-time monitoring,



A vision for the future – a network of integrated microgrids that can monitor and heal itself

autonomous control, two-way communications, smart meters and energy storage.

Regulatory framework

At the heart of grid development in the UK is the regulatory and financial framework supplied by Ofgem. The regulator's Project Discovery identified that £200bn needs to be found over the next ten years to guarantee energy



supplies. Its Electricity Market Reforms programme will be addressing the shortage of generation, but that still leaves a £32bn gap required for network investment – a huge amount when you consider that the industry is currently worth only £43bn in total. Ofgem's answer is 'RIIO', heralded as "a new way to regulate energy networks".

"Our interest in smart grids is driven by the benefits they bring rather than the technology: we are technology neutral," Gareth Evans, head of professional engineering, Ofgem, says.

"We are all aware of the challenges that the industry faces in terms of decarbonisation, security of supply, trying to keep costs down and dealing with ageing assets. There are a whole bunch of technologies that can be deployed, but the networks are the unsung heroes of the process who join the whole thing together."

The nucleus of RIIO is outputs: ensuring that the money that companies spend delivers outputs. "In order to deliver those outputs we are encouraging the companies by the core price mechanism itself; but on top of that an incentive is built into that price mechanism, and of course this stresses innovation," Evans continues. "At the heart of the RIIO process is the well-justified business plan. This must convince us that the money that they are spending is going to deliver those outputs in an effective and efficient way and those outputs must be clearly specified."

There is a real stress on innovation in the framework. First of all the core price control incentives encourage companies to perform more efficiently because that transfers straight to their bottom line. But more importantly there is the Innovation Stimulus package which is an important part of the RIIO framework.

This has three components. First, the Network Innovation Competition (NIC), which is effectively a development of the Low Carbon Networks Fund (LCNF). Whereas the LCNF only applies to electricity distribution companies, the NIC applies to all four sectors in the network industry. "We are proposing £240m for electrical transmission over the eight-year price control and there will be an additional amount, which is yet to be agreed, for distribution that will top that fund up," Evans says.

Together with this is the Network Innovation Allowance (NIA) which permits companies to invest money unilaterally, subject to a set of rules and governance: they will be allowed to spend between 0.5 and 1 per cent of their allowed revenue in this way. The third component is IRM, which is a mechanism to allow the roll-out of projects that would otherwise have to wait until the next price control.

Network hierarchy

One major barrier to innovation in the grid is the aversion to risk traditionally maintained by the transmission and distribution companies. Tried-and-tested products **>**



are still preferred to innovative technologies that may only have tasted action in small-scale pilot schemes. This creates another problem, that of technology lock-in as most transmission and distribution (T&D) projects have an operational life of up to 40 years.

"We have clearly got a power network that has been optimised over many years and, as with any organisation, that creates inertia," says John Scott, director at Chiltern Power, a consultancy serving the electric power sector. "But it makes good sense to deploy new solutions, not just have them as demonstrations. If we roll them out it will bring a benefit to customers and companies and deliver a return on the investment."

In a sector that has got long lead-times, long asset-times and a demanding regulatory framework, there is a need for a strategy to ensure that the innovative technologies become part of the planner's tool set. "Innovation always has uncertainty and this may equate to business risk for the company; do you want to be the project manager to try and deliver this if there is still some uncertainty around?" Scott adds.

His belief is that we need a change in the hierarchical

thinking of the network to make effective changes. "Today's network model is a hierarchy; this has been very effective and has traditionally met the market's needs," he says. "We are adapting it today to various technologies such as active network management, electric vehicles and so on, but still staying inside the established framework.

"But is this suited for the future? If we take this hierarchy we will be adding technologies such as smartmeter data, distributed storage, EV charging, home automation and storage. At the moment we tend to plug them into the existing architecture. But these weren't conceived for such a volume of multiple real-time data. The complexity and consumer interaction is all going to start to appear. We will have requirements appearing for concurrent processing – close to real time."

He argues that this power system based on a centralised architecture, centred on Distribution Network Operator (DNO) and Transmission System Operator (TSO) control centres needs a rethink and both operational and asset management data needs to be considered. His idea is to create a coherence engine, an intelligent framework that allows a coherent approach to the systems and data. According to a report published last year by ENA/Telent, DNOs have 54,000 sites connected. The prediction is that by 2030 there will be 700,000 connected sites – and therein lies the dilemma.

"How about thinking of a stable core grid system, which we are familiar with today, along with its architecture working with devolved, semi-autonomous sub systems?" he says. "You would start to devolve the intelligence and control. This allows it to be more scalable and flexible, but of course they still need to be secure. maintainable and fail-safe. But I believe this will be a key enabler for continuous change."

Grid optimisation

Grid optimisation, the ability to utilise the grid to its full potential, is a crucial weapon in the smart-grid armoury. Armed with real-time data the transmission system can often carry more than its stated capacity, by fully understanding its loading and utilising often generous safety margins. "There is a certain amount of installed grid capacity which has the ability to deliver a certain amount of power," Dr Bob Currie, technical director and co-founder of Smarter Grid Solutions says. "What usually happens is that some of that capacity is reserved for the worst-case outage – so there is spare capacity to supply the demand.

"What we are talking about with this new approach to allocating capacity for connections and managing the grid is trying to use as much of that as possible during times when the system is intact. Still focusing on the reliability and security of supply for demand, but recognising that there is more capacity available in real time."

In London, Smarter Grid Solutions is conducting a project on distributed generation trials with UK Power Networks called Low Carbon London. The aim is to overcome barriers to connecting more generation to urban networks and look at deploying a system that can autonomously manage clustered areas of technology adoption to keep things within limits while providing enough energy throughput access to those new devices.

"There is CHP, solar and diesel back-up in London," Currie adds. "It is about constraining them on to the network when we are trying to reduce the amount of power being fed into a particular area, but it's also integrating with aggregators.

"What we are doing is seeing if we can control aggregator resources using an autonomous system for network benefit. If we detect an overload on a substation we would normally just interface directly with the generator and ask it to do something, increase or reduce power output. Now we're going to see if we just send an automatic message to the aggregator saying that we need 2MW at this substation in the next minute or seconds."

Western Link

A lot of the focus in smartgrid research focuses on maximising the use and productivity of the existing network but that is not the sole emphasis. New infrastructure is often required to mould the grid to the future energygeneration trends.

In the UK transmission system power tends to flow from north to south, from Scotland to England along some of the most congested power trunk routes that have been creaking at the seams for years. Various grid optimisation projects have augmented their capacity but with the growing offshore wind and potential marine energy coming on line there has been a pressing requirement for additional capacity.

The latest project added some series compensation to enhance the existing connection but there was no



escaping the need for extra capacity. The option selected was the Western Link – or bootstrap – between Scotland and England that would accommodate an extra 2GW

of transmission capacity to bring the total up to 6GW. Having assessed the

technologies available high

voltage direct current (HVDC) was selected as the preferred solution.

"The reason we did not go down the AC route was cost and the fact that for an overhead line we would have to deal with local authorities for rights of passage," Vandad Hamidi, system performance manager – >





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The upper reservoir of the Dinorwig pumped storage system holds eight million cubic metres of water

network strategy at Transmission Network Services (TNS) explains. "The Western link is 2.2GW with another 200MW overloading capability based on the proven technology of LCC (Line Commutated Converter) using LTT (Light Triggered Thyristors). It offers a short-term rating and has low losses and does not require a black start capability. This is the first project in the world that is using a 600kV DC cable."

This project complements the aims of smart grids in renewable energy by providing an HVDC link to transmit 2GW – designed to connect Hunterston in the north to Connah's Quay in North Wales, running offshore through the Irish Sea.

In principle, AC transmission can be used for undersea cables, but two factors contribute to making DC the preferred technical option. First, in an AC system heavy currents are required to charge and discharge the cable capacitance each cycle - the longer the cable the higher the capacitance. In extreme cases these reactive currents can seriously reduce the active power transmission capacity of the cable. With a DC cable, the corresponding charging current is only required when the cable is initially energised.

The second factor favouring DC transmission is the absence of the socalled skin effect – the tendency of an AC current to become concentrated near the surface of a conductor. DC's immunity to the skin effect means that thinner conductors can be used, contributing to lower costs.

The plan is for the southern terminus to use an old power-station site at Kelsterton, although at present some planning issues need to be resolved. The facility would include a filter yard, switching yard, reactive compensation as well as some fire and ancillary services.

Inside the converter halls will be huge, ceilingmounted thyristor stacks that are capable of switching 4,000A and blocking 8,000V. The stacks convert AC to DC at the sending station and DC to AC at the receiving station, with the thyristors triggered (switched on to pass current) by pulses of light. "All this chopping action creates a lot of harmonics on the system which is why we require so much filtering to tune out specific frequencies before passing back into the system," Talbot adds.

Searching for storage

Storage is a vital component of any smart-grid system all along the T&D value chain. All energy-storage systems need some medium to store energy. Energy is stored in the medium when demand is low and electricity is cheap and then returned to the system when demand is high and electricity is expensive. In a pumped hydro system, for example, the energy store is represented by the potential energy of a large volume of water that has been pumped 'uphill' by reversible turbine generators. Europe's largest pumped hydro system at Dinorwig in North Wales holds a massive eight million cubic meters of water at a head of 500m - enough to supply 1,728MW for more than five hours.

Pumped hydro is an established mature technology, but many new technologies are now challenging for a place in this vital market including fuel cells and a variety of batteries from Lithium to Metal-Air and Sodium Sulphate to Nickel. One company with a particularly promising approach is Highview Power Storage. The company's Cryo Energy System uses liquefied air as the storage medium. Lowcost electricity is used to drive an air liquefier (effectively the charging system) and the resultant



liquid air is stored in an insulated tank at atmospheric pressure. When the stored energy is required, the liquid air is released from the storage tank, pumped in its liquid form to high pressure, vapourised and heated to ambient temperature (using either ambient heat or waste heat); the resultant highpressure gaseous air is used to drive an expansion turbine which powers a generator.

As with a traditional steam engine, a cryogenic engine harnesses stored energy via a liquid-to-gas phase change and expansion within a confined space – a cylinder in the case of a steam engine and a turbine in the Cryo Energy System.

"We are pursuing this particular technology because we think it has some aspects that differentiate it from deeply embedded storage technologies," Gareth Brett, CEO Highview Power Storage, says. "We are looking for a replacement for a pumped hydro-storage technology or carbon-based compressed-air technology, the problems of which are that they are geographically constrained. We are looking for large scale - tens to several hundred megawatts that can be delivered where you need it without any physical constraints."

Cryogenic liquids are widely used in a variety of industrial applications, but their use as an energy vector is only just emerging and the prospects are encouraging. The cryogenic industry is very mature, well regulated and supported by an extensive infrastructure. In addition the energy density of liquid air compares favourably with other low-carbon competitors such as compressed air.

"All of the kit needed to do this is already in the market and benefits from mature supply chains," Brett explains. "We have a pilot plant at Slough. It's basically a thermo mechanical storage system. It is a mechanical system so it doesn't respond within a cycle like a battery would, but it does respond quickly. You can wind it up in a couple of minutes; carry out big load changes in less than ten seconds. The reason it's responsive is that we're heating the air to ambient temperature so there aren't any changes going on in the turbine so you can change load very quickly.

"Even in our little pilot plant you can convert 47 per cent of the heat you add to it to electricity." The Centre for Low Carbon Futures in its report 'Pathways for Energy Storage in the UK' concluded that liquid air energy storage (LAES) is competitive in terms of cost, discharge duration, capacity and lifetime when compared with other technologies. The centre also estimates that the capital cost for LAES per kilowatt can be more than one-third cheaper than Sodium Sulphur (NAS) batteries which are currently commercially deployed.

The move towards an effective smart grid will be an evolution. Incremental changes as assets need replacing coupled with focused development of new transmission and distribution circuits, such as the Western Link, will continue to shape the network, but as always the investment is crucial.





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AMENDMENT 2 OF THE 17TH EDITION (BS 7671:2008) PUBLISH

Requirements for supplies to electric vehicles are detailed in the new Section 722 of BS 7671:2008 Requirements for Electrical Installations. By Geoff Cronshaw

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AMENDMENT 2:2013 to BS 7671:2008 Requirements for Electrical Installations was issued on 1 August 2013. Installations designed after 31 July 2013 are to comply with BS 7671:2008 Amendment 2:2013.

This amendment introduces a new section, Section 722 (electric vehicle charging installations), which specifies requirements for the supplies to electric vehicles. Section 722 includes requirements for the type and current rating of socket outlets, RCD protection, measures of protection against electric shock, IP rating of equipment, impact protection against mechanical damage, isolation and switching and fixing arrangements, etc.

The protective measures of obstacles, placing out of reach, non-conducting location and protection by earth-free local equipotential bonding are not be permitted. These measures are contained in Sections 417 and 418 of BS 7671:2008 and are not for general application. The protective measures of section 417 provide basic protection only and are for application in installations controlled or supervised by skilled or instructed persons. The fault protective provisions of Section 418 are special and, subject to control and effective supervision by skilled or instructed persons.

The protective measure of electrical separation is permitted, but must be limited to the supply of one electric vehicle and the circuit must be supplied through a fixed isolating transformer complying with BS EN 61558-2-4.

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended) permit the distributor to combine neutral and protective functions in a single conductor provided that, in addition to the neutral to earth connection at the supply transformer, there are one or more other connections with Earth. The supply neutral may then be used to connect circuit protective conductors of the customer's installation with Earth if the customer's installation meets the requirements of BS 7671. This protective multiple earthing (PME) has been almost universally adopted by distributors in the UK as an effective and reliable method of providing their customers with an earth connection.

Such a supply system is described in BS 7671 as TN-C-S. Whilst a protective multiple earthing terminal provides an effective and reliable facility for the majority of installations, under certain supply system fault conditions (external to the installation) a potential can develop between the conductive parts connected to the PME earth terminal and the general mass of Earth.

The potential difference between true Earth and the PME earth terminal is important when body contact resistance is low and/or there is relatively good contact with true Earth. Contact with Earth is always possible outside a building and, if exposed-conductive parts and/or extraneous conductiveparts connected to the PME earth terminal are accessible outside the building, people may be subjected to a voltage difference appearing between these parts and Earth.

Regulation 722.411.4.1 does not allow PME as a means of earthing for an electric vehicle charging point where the charging point or the vehicle is located outdoors except where 722.411.4.1(i) or 722.411.4.1(ii) or 722.411.4.1(iii) apply. There is an exception for a dwelling if none of (i), (ii), or (iii) is reasonably practicable. It is worth noting that in this regulation the meaning of 'dwelling' is restricted to a self-contained unit designed to accommodate a single household.

Regulation 722.411.4.1(i) refers to a situation where a connecting point is supplied from a three-phase installation used to supply loads other than charging points and where the load is sufficiently well balanced.

Regulation 722.411.4.1(ii) requires a very low resistance earth electrode to mitigate the effects of an open circuit PEN conductor fault on the supply. Regulation 722.411.4.1(iii) also requires an earth electrode. Regulation 722.411.4.1(iii) is based on the installation requirements (from the 14th edition wiring regulations) for a voltage operated earth leakage circuit breaker. However, the device differs from the BS 842 voltage operated earth leakage circuit breaker. A product standard for a protective device for the purposes of (iii) is being developed by BSI Committee PEL/23/1.

The touch voltage threshold of 70V mentioned in 722.411.4.1(i) and 722.411.4.1(ii) and 722.411.4.1(iii) is on the basis that Table 2c (Ventricular fibrillation for alternating current 50/60Hz) of IEC 60479-5[ed1.0] gives a value of 71V for both-hands-to-feet, in water-wet conditions with medium contact area (12.5cm²).

Presence of water

Any wiring system or equipment selected and installed must be suitable for its location and able to operate satisfactorily without deterioration during its working life. The presence of water can occur in several ways, e.g. rain, splashing, steam/humidity, condensation, and at each location where it is expected to be present its effects must be considered. Suitable protection must be provided, both during construction and for the completed installation. For example, Section 722 requirements for a connection point installed outdoors requires IP44 in order to protect against water splashes (AD4). The IP classification code, BS EN 60529:2004, describes a system for classifying the degrees of protection provided by the enclosures of electrical equipment. The degree of protection provided by an enclosure is indicated by two numerals. The first indicates protection of persons against access to hazardous parts inside enclosures or protection of equipment against ingress of solid foreign objects. The second indicates protection of equipment against ingress of water. More information on the IP classification code is given in IET Guidance Note 1 - Selection and Erection.

Switchgear and controlgear

BS 7671:2008 (IEE Wiring Regulations) recognises four distinct types of isolation and switching operation: (i) isolation, (ii) switching off for mechanical maintenance, (iii) emergency switching, (iv) functional switching.

Whilst Section 722 does not demand emergency switching, it contains additional requirements stating that: "Where emergency switching is required, such devices shall be capable of breaking the full load current of the relevant parts of the installation and disconnect all live conductors, including the neutral conductor."

It is worth noting that the wiring regulations state that a plug and socket outlet or similar device shall not be selected as a device for emergency switching. Therefore, if emergency switching is deemed necessary the device will have to meet the requirements for emergency switching in Regulation 534.4.2 of BS 7671.

RCD protection

Regulation 722.531.2.101 requires every charging point to be individually protected by an RCD having the characteristics specified in Regulation 415.1.1. (RCD with a rated residual operating current not exceeding 30mA and an operating time not exceeding 40ms at a residual current of 5 I_{Δn}). The RCD shall disconnect all live conductors, including the neutral.

The Regulation requires the RCD protecting the charging point to be at least a type A RCCB complying with BS EN 61008-1 or RCBO complying with BS EN 61009-1. If it is known that the d.c. component of the residual current exceeds 6mA then a type B RCD complying with BS EN 62423 shall be installed.

Socket outlets and connectors

Socket outlets must be fit for purpose. They must be suitable for the load, and for the external influences such as protection against mechanical damage and ingress of water. Section 722 requires a degree of protection of at least IP44 where the equipment is installed outdoors. Portable socketoutlets such as extension leads are not permitted; however this does not preclude the use of tethered vehicle connectors which are allowed.

Section 722 recognises the following socket outlets for a.c. charging-point use (see 722.55.201.1):

- the 13A BS 1363-2 shuttered socket outlet where the manufacturer approves its suitability for use for an a.c. charging point;
- the industrial type socket to BS EN 60309-2 is also permitted for use as an a.c. charging point but must have an interlock system to prevent the socket contacts being live when accessible;
- for mode 3 charging only a Type 1 vehicle connector complying with BS EN 62196-2 or Type 2 socket-outlet (or vehicle connector) complying with BS EN 62196-2 or Type 3 socket-outlet (or vehicle connector) complying with BS EN 62196-2 are permitted. However, an electrical or mechanical system must be provided to prevent the plugging/unplugging of the plug unless the socket-outlet or the vehicle connector has been switched off from the supply.

Briefly, Mode 1 and Mode 2 charging uses standardized socket-outlets (Mode 2 has an in-cable control box with personnel protection against electric shock and has a control pilot function). Mode 3 utilises dedicated electric vehicle supply equipment and a control pilot function. For more information refer to definitions in section 722.

Conclusion

This new section has been introduced into BS 7671 in order to give the basic requirements for the connection of the electrical vehicle to the fixed installation. This article is only intended as a brief overview.

The amendment is available to view for free on the IET website at www. theiet.org/updates-bsi or to purchase for print at www.theiet.org/am2-bsi

WiringFeature #48



THE BASIC selection criteria for cable trays fall under seven headings:

 Equipotential bonding requirements
 Space utilisation and sizing
 Weight considerations
 Fire rating
 Cable ladders and support methods
 Corrosion and other electrochemical reactions
 Current capacity and de-rating factors.

A list is a useful start, but is inevitably short on detail and doesn't indicate degrees of importance between the different criteria. To help flesh out these crucial details, four professionals from the electrical installation industry were asked for their views on cable tray selection. The four experts comprised a consultant, an electrical installation contractor and representatives from NAPIT and the NICEIC.

The consultant

Barry Rendell, an independent electrical installation consultant, argues that cable can come crashing down if contractors get the cable tray fire rating wrong.

"A fire can last anything from half an hour to three hours," Rendell explains. "If the life-safety systems are installed underneath cable tray carrying ordinary circuits, then when there is a fire and the trays collapse, it's critical that they don't take out the life-safety systems with them. It is not so much damage from flames but from heat that causes problems. If you are carrying single-core 630mm cables, then you would probably want to use a proper cable tray rather than a wire basket.

He adds:"You can carry more weight by using more fixings but that can then get a little unsightly. Cable tray is often suspended by trapeze fixings from a ceiling but sometimes uses floor supports. Cables for data, emergency lighting and fire alarms can also be carried under false floors, particularly in data centres."

According to Rendell highstreet multiples and stores are now using cable tray for light fittings, so it becomes a general-purpose highway carrying emergency lighting, fire alarm cables as well as low-voltage mains cables. An approach which he says "may be feasible for short runs".

Cable ladder is more commonly used where heavier cables need to be carried, but is more expensive. Apart from the choice between solid or perforated cable tray and wire basket, as Rendell explains, more expensive fibre glass tray may be needed instead of steel in where corrosion is an issue, e.g. refineries, offshore and marine applications. However, fibre glass tray has poor fire rating and will just shrivel up in a fire.

The contractor

Paul Coffey is an electrical engineer at Lancashirebased William Dyer Electrical UK. Most of his company's cable containment fixing work is into steel purlins running across the top of a roof space or to the underside of mezzanine concrete floors in commercial installations.

Coffey explains: "Fixings are generally fastened to some part of the steelwork of commercial buildings, which is itself bonded back to the main earth bar anyway. Ladder racking can expand but jointing pieces can be used to overcome that. We always use steel cable tray for mains cabling, but for localised final circuit cabling, lighting trunking and data cabling we can use wire basket, which we tend always to fix with M8 threaded bar.'

"The only time we would make calculations is for submains, where we use ladder racking and heavy >



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duty cable tray. In this case we take advice from manufacturers on fixing distances and loading because the Wiring Regulations do not cover specific scenarios. The manufacturers have experts available to help sell their kit, but at the end of the day it is up to the installation contractor to decide what to use according to his liability."

Coffey says that most of the cable tray used by his company is constructed from 316 stainless steel, which affords some fire and temperature resistance, as well as low temperature resistance. Cable tray made from lower-quality steel would tend to deform in the colder climate north of the UK.

Corrosion issues arise in some of William Dyer's industrial projects in factories where chemicals may be stored. "Obviously we have to find out what environment the client wants us to work in, and they need

to advise us what chemicals they may have in that environment," says Coffey.

NAPIT

Frank Bertie, group technical director at the National Association of Professional **Inspectors and Testers** (NAPIT), explains that unlike cable trunking which requires an earth path, cable tray and wire basket does not need an earth path as it is only used as a support mechanism. However, equipotential bonding may still be needed, depending on whether it comes into contact with exposed or extraneous conductor parts.

When it comes to support methods from high-level steel beams, Bertie says steel clamps and screwed rods are effective, as well as Unistrut or steel channel. Most cable trays are mounted at high level, but some are fitted under raised flooring usually because the actual concrete floor may be rough and uneven. Alternatively, protective rubber or cloth

Cable basket (and tray) comes in a variety of sections in addition to straight sections, for example, four way or cross junctions, T junctions, corner or L junctions, and reducers. Reducers are used when connection two straight sections of different widths, for example 300mm connecting to 150mm.

matting can be used, but cable tray speeds up the installation process. Regarding the choice between cable tray and wire basket, Bertie says the latter is simpler to install, so is better for some types of cable but not for others.



The NICEIC

Bertie's positive comments on wire basket are echoed by Matt Darville, engineering manager at National Inspection Council for Electrical Installation Contractors (NICEIC). "There is a certain amount

of inertia among contractors who err on the side of caution and are reluctant to switch from heavy-duty cable tray to wire basket,' says Darville. "Wire basket is cheaper, easier to install and lighter, and makes more sense if, for example, you are carrying lighter weight control wiring.

"If you look at the continuum from heavy cable tray and ladder through to wire basket, you may also want to look at the aesthetics as well as technical issues such as space utilisation and sizing," says Darville. Few people would consider cable tray as having any sort of aesthetic appeal, but far from concealing cable tray in false floors and ceilings, modern buildings sometimes deliberately show cable tray as a decorative feature, a fashion trend which, according to Darville, says is catching on rapidly in the like of pubs, clubs and restaurants.

Straight Section

When it comes to fire rating, Darville maintains that all parts of the installation including clips and supports must have the same fire rating as the cable. Similarly, there is no point in carrying low smoke and fume (LSF) cable in non-LSF trunking.

On finishes, Darville argues that the many choice now available has done much to eliminate earlier problems with corrosion and electrochemical reactions, when users were limited to a handful of options like stainless steel and galvanised dip.

In the case of current capacity and de-rating factors, Darville reasons that cables in trays will have as good a rating as free air as long as they are not bunched too tightly.

On the issue of the need

to earth cable tray, opinions are divided. Darville points to certain manufacturers like Legrand who recommend earthing while some contractor trade bodies like Select do not. He adds: "Some professional trade bodies have agreed to differ on whether you need to earth cable tray. You need to earth cable tray if you use steel wire armoured (SWA) cable or something with the equivalent of double insulation, but this is not necessary if you just use twin and earth cable. Electromagnetic compatibility (EMC) issues also need to be taken into account as control cables can go into separate compartments in the same tray as that used for mains cable and extra low voltage cable."



A typical support for cable tray and ladder shown in ceiling mount orientation. It may be mounted upside down instead and fixed to a concrete floor under a raised floor. Angle brackets may also be used for wall fixing from which screwed rods may be suspended to support cable basket, tray or ladder. Steel beams may be used for substation cabling.

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THE HIGHS AND LOWS OF ACCESSORY MOUNTING

Determining the appropriate mounting height for accessories requires an informed and pragmatic approach to the

building regulations By Richard Foster

> Data point positioned too low for Building Regulations in buildings other than dwellings

WHAT'S THE right height for fixing socket outlets, switches and controls? It's a simple question; unfortunately there isn't a simple answer. It all depends on what sort of building you are working on and if it's new or existing.

New dwellings

In the case of new dwellings, refer to the Building Regulations Approved Document M (ADM) Section 8 or the IET On-Site Guide Appendix H6. Both sources stipulate that socket outlets, switches and controls should be installed at a height between 450mm and 1200mm above the finished floor level. Generally, this means it is a minimum of 450mm to the underside of an outlet and a maximum of 1200mm to the top of a switch or a control. Outlets and controls above a worktop can align with switches with a minimum 100mm gap between the worktop and the underside of the outlet.

align with switches with a minimum 100mm gap between the worktop and the underside of the outlet. In the case of consumer units, Building Regulations Approved Document P (ADP) states that they should be installed so that circuit-protective devices (CPDs) are between 1350mm and 1450mm above finished floor level. This contradicts BS8300:2009+A1:2010 Design of Buildings and their approaches to meet the needs of disabled people – Code of practice, which states that the maximum height of simple push-button controls – including isolator switches and circuit breakers that require limited dexterity – should be 1200mm. However, the Building Regulations take precedence, and in dwellings where it's highly likely children will be present it's best to locate a consumer unit as high as the Building Regulations allow.

Existing dwellings

In existing dwellings, switches and controls are generally higher and outlets lower than the mounting heights required by Building Regulations. An extension, or an alteration to an existing dwelling, means new or replacement switches, and outlets and controls can be installed (for aesthetic reasons) to match existing mounting heights.

However, the location of a replacement consumer unit could be moved to make it more accessible (for example, not under the stairs or high up near the ceiling), and a complete rewire would be an opportunity to install accessories in line with Building Regulations (provided the client agrees of course).

Buildings other than dwellings

Refer to the Building Regulations ADM and BS 8300. Outlets can be installed between 400mm and 1000mm above the floor. Switches for fixed equipment can be installed between 400mm and 1200mm above the floor (but can be higher if needed). Switches and controls that require precise hand movements can be installed between 750mm and 1200mm above the floor.

Simple push-button controls that require no more than limited dexterity should not be more than 1200mm above the floor. Controls apt for close vision can be installed between 1200mm and 1400m above the floor. Light switches for use by the general public need large push pad and should be aligned horizontally with door handles within 900mm to 1100mm above the floor.

Dado trunking

If outlets are to be mounted within the trunking, it needs to be positioned in the range 400mm to 1000mm above the floor. This raises a potential issue in offices, as the trunking could be lower than desk height, and, possibly, inaccessible when the desk is in place. Clearly, within the constraint of a 1000m mounting height, the trunking **>**

➡ profile, desk height, and wall openings need to be coordinated to ensure trunking outlets are accessible. A mounting height above the desk means the trunking, outlets, and cables will be in view. This might be an issue for the architect or client, and needs to be discussed before design or installation.

Skirting trunking, power poles and floor box outlets

Floor box outlets are an exception to the Building Regulations height requirements and are a standard fitting in open-plan offices where a high density of outlets is normal. The decline in the use of skirting trunking and power poles means more limited design options and architects can be against the use of dado trunking preferring a recessed installation. even though it is less flexible.

TP&N distribution boards

There used to be a regulation in BS 7671 that recommended a mounting height not exceeding 2250mm to the top and not less than 1400mm to the underside of a distribution board. Obviously, distribution board sizes vary greatly; so generally fix at 1800mm or 2000mm to the top, taking into account local conditions and requirements.

Accessibility and security are equally important at distribution boards. In all buildings there should be measures to prevent unauthorised access.

Meters

BS 8300 recommends that meters should be fixed in the range 1200mm to 1400mm above the floor so they can be read by a person standing or sitting. My local Distribution Network Operator (DNO) requires a domestic meter cabinet to be installed in the range 750mm to 1250mm from ground level to the underside of the cabinet. The median of this range is about right when you add on the distance from the bottom of the cabinet to the meter (the meter is usually fixed in upper part of cabinet). However, for blocks of flats and commercial installations there might be issues at common metering positions and sometimes just finding space at the appropriate height in an overcrowded plant room can be a real problem.

Fire-alarm manual call-points

BS 5839-1:2013 Fire detection and fire-alarm systems for buildings states that manual call-points should be fixed at 1400mm above the floor. However, a lower mounting height of 1200mm is allowed to align with light-switches for aesthetic reasons.



A mounting height outside this range may be considered a variation and recorded on the system certificate.

Sleeping accommodation

Sleeping accommodation comprises hotels, motels, and student accommodation, and is treated as buildings other than dwellings. In the case of hotel room consumer units, the location should be discussed with the architect and/or client.

Mixed-use development

Where part of a non-domestic building is used as a dwelling (public house, shop with firstfloor flat) the Building Regulations requirements for buildings other than dwellings apply in common parts.

Local authority

Local authorities can have their own electrical specification with mounting heights provided for equipment and accessories. Obviously, if any do not agree with Building Regulations, consult the contract administrator.

Agricultural and horticultural premises

Agricultural and horticultural premises should be treated as buildings other than dwellings, but refer to BS 7671 Section 705 and IET Guidance Note 7 Chapter 5. Socket-outlets shall be installed in a position where they are unlikely to come into contact with combustible material. Also, electrical equipment generally should be inaccessible to livestock.

Schools

In schools, access control request-toexit switches are likely to be fixed at a higher level than the range 1000mm and 1200mm recommended in BS 8300 – to prevent children exiting the building unaccompanied. Alternatively, instead of the manual release, a reader could Fire-alarm manual call-point aligned with light switch. Note, for reasons unknown, the emergency lighting test key switch has been installed much higher

be used (read-in and read-out). Only teaching staff will have reader tokens, allowing the reader to be lower.

Historic buildings

When it comes to historic buildings, the basic rule is to seek specialist advice and do not remove or replace existing electrical equipment without consent. Existing wiring accessories can have historic and or aesthetic value. Accessories can be retained in-situ even if they are no longer in service.

Special locations

Agricultural and horticultural premises have already been mentioned, and for other special locations refer to BS 7671 and IET Guidance Note 7. Mounting heights are provided for socket-outlets serving caravan pitches and marina berths.

Published guidance

After reiterating the Building Regulations' height requirements for switches and socket outlets in the dwelling, the Electrician's Guide to the Building Regulations goes on to say that if a dwelling is rewired there is no requirement to provide the measures described provided that, upon completion, the building is no worse in terms of the level of compliance with the other parts of Schedule 1 to the Buildings Regulations. Similar qualifying advice is provided in IET Guidance Note 1: Selection & Erection when it says that BS 8300 is not mandatory unless directly referred to in the specification, or the specification contains a general requirement to the effect that the electrical installation shall comply with all relevant standards and codes.

While such qualifications can be helpful, it could be argued that a better approach would be for designers and installers to follow Building Regulations and the recommendations in BS 8300, subject to the client's agreement and aesthetic considerations, such as required by the special case of historic buildings. Also, perhaps there's a case for the mounting height of outlets (450mm in a new dwelling and 400mm in other buildings) to be the same regardless of the type of building.

Ultimately, it's a case of striking the right balance – between regulations and guidance and the needs of specific locations.

Richard Foster is an electrical design engineer at Sutcliffe Consulting Engineers (www. sutcliffeconsulting.co.uk)

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COMFORTABLE BUILDINGS – THE WAY AHEAD

A new Voltimum expert panel is helping to save energy by supporting the adoption of modern heating and ventilation systems. By James Hunt

THE TREND towards airtight building design is resulting in indoor environments characterised by a complex mix of gaseous and particulate contaminants that can be harmful for building occupants and home owners.

The contaminants can arise from water vapour, emissions from cleaning products, construction activities, carpets and other furnishings, perfumes, cigarette smoke, electronic machines, microbial growth (fungal/mould and bacterial), as well as insects and external pollutants. Indoor temperatures, relative humidity and ventilation levels can also make life uncomfortable for buildings and their occupants. As a consequence, indoor air quality (IAQ) – combined with energy saving and emissions reducing activities – has become an increasingly important health-and-safety topic. Four basic factors can lead to IAQ problems:

- poor indoor environment – too low a temperature, excessive humidity and noise, plus certain lighting issues;
- indoor air contaminants
 as already described
 insufficient outdoor
- air intake; outdoor environment – e.g. radon gas.

To counter these factors, and to improve the comfort, wellbeing and health of building occupants, ventilation is used to replace the air in any building space to provide high indoor air quality. The link between good ventilation and productivity is well established within the work environment. Good ventilation can also save money by reducing building maintenance requirements by lessening damp and inhibiting mould growth.

Ventilation achieves these benefits by controlling indoor temperatures and replenishing oxygen, while removing unpleasant smells, smoke, dusts, airborne bacteria and carbon dioxide (CO_2) . Interior building air is kept circulating (in the spaces where ventilation is fitted), helping to reduce air stagnation.

Heating, whether using standalone heaters or central heating, is also used to make life more comfortable for building occupants in cold weather. It can also improve productivity at work.

A central-heating system provides warmth to part of or the whole interior of a building, from one point to a number of rooms. Combined with other systems to control the building climate, the whole may become a heating, ventilating and airconditioning (HVAC) system.

Both heating and cooling systems use energy, and there is a major drive towards making such



systems as energy efficient as possible, as required by regulations, such as Parts L and F of the Building Regulations. The result has been the rapid development of far more energy-efficient heating and ventilating products and systems using new technologies and clever control strategies. Alternative systems, such as heat pumps, also have their part to play.

A new HVAC Expert Panel

Reflecting the growing importance of HVAC, Voltimum UK and its partners involved in these two related sectors have recently formed the 'Electrical Heating, Ventilation & Control Expert Panel'. Its members will meet regularly, with the aim of bringing industry-specific issues and opportunities to both manufacturers and Voltimum UK users.

The panel's aims include furthering adoption of the latest, most energyefficient systems, and it will issue technical white papers about heating and ventilating systems and related equipment. It will also provide webinars and seminars, and will answer queries.

The Voltimum UK Partner companies currently involved are: BEAMA, Redring–Xpelair, Glen Dimplex, Horstmann, and Vent-Axia, with other leading manufacturers and organisations soon to join. BEAMA's marketing director Kelly Butler chairs the new panel.

A wide range of heating and ventilating topics are of interest to the panel, including:

Building Regulations Part G – sanitary hot water and water heating guidance;

- energy labelling for water heating;
- the ErP Directive' (Energy-related Products) regarding fans and heaters;
 Standard Assessment
- Procedures (SAPs).

Ventilation types

Ventilation systems can be categorised under two basic headings: natural ventilation and mechanical, or forced, ventilation.

As the name implies, natural ventilation uses the external air to ventilate a room or building without using a fan or other mechanical system. It can be achieved using opening windows and/or trickle vents (smaller systems), and in larger, more complex buildings, the 'stack effect' can be used, where cool outside air is drawn into the building naturally through low-level openings. It then rises, ventilates, and passes out of upper vents to the outside again.

In the case of mechanical ventilation, a room or a building's internal air is passed through an air handling unit (AHU) which conditions and circulates air as part of a heating, ventilating, and air-conditioning (HVAC) system. Alternatively, it can be passed directly into the space by a motordriven fan; a strategicallyplaced exhaust fan can improve air infiltration or natural ventilation. In this way, forced ventilation

controls indoor air quality so that excess humidity, smells and contaminants are diluted or removed.

A mechanical exhaust typically controls odours, vapours, airborne greases and humidity in kitchens and bathrooms. To obtain the best effect with the maximum energy efficiency, it is important to take into account flow rates (function of fan speed and exhaust vent size), and noise levels. Any exhaust ducting crossing unheated spaces should be insulated to prevent condensation on or in the ducting.

Ceiling fans don't provide ventilation, merely circulating air within a room. They reduce the perceived temperature because they help evaporate perspiration, but ceiling fans can keep rooms warmer in winter by helping to move warm air downwards from the space close to the ceiling.

Larger fans and AHUs can form part of building HVAC systems, and there are also 'hardened' industrial fan types, which range in size from the small to the very large.

Whole-house ventilation

Whole-house cooling is a sub-division of mechanical ventilation. It operates by drawing fresh air from open windows and expelling the exhaust air through the attic and roof. Such systems can substitute for air conditioning for most of the year. Whole-house fans should provide houses with 30 to 60 air changes per hour which, combined with ceiling fans and other circulating fans, can provide good domestic summer comfort.

With Part L of the Building Regulations in mind, to obtain the highest energy efficiency, modern homes should be fully insulated, be built as close as possible to airtight standards, and should be fitted with a central ventilation system incorporating heat recovery.





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Ventilation can be

intermittent or continuous. To compensate for lower operating times, intermittent operation requires the wholebuilding ventilation fan to operate at a higher flow than for continuous operation, so such systems need a programmable timer for control. Today, the trend is towards continuous lowspeed operation. This can meet the need for both local exhaust and whole-building ventilation.

There are various types of whole-house ventilation system - with a sometimes confusing number of different names - such as demand energy recovery ventilation system (D-ERV). One of the most important is mechanical ventilation with heat recovery (MVHR). Fresh air is continuously drawn into the home by a low-energy ventilation unit, typically mounted within the roof space or utility room. Once passed through the unit's heat exchanger, warm, clean, fresh, filtered air is distributed through ducting running to bedrooms and living rooms etc.

MVHRs can recover up to 95 per cent of the heat lost through open windows, trickle vents and extractor fans found in buildings, so as the move towards 'zerocarbon' homes gathers pace, they are gaining a foothold.

Standard Assessment Procedures (SAPs) are the government's recommended system for measuring the energy performance of residential dwellings and are cited as such in Part L of the Building Regulations. As Vent-Axia has said, "every point counts", and with SAP calculations, even half a point could contribute to a pass or fail in terms of the Dwelling Emission Ratings (DER).

Moving towards the government's zero-carbon home target specification

becomes harder as efficiency rates attain their maximum, yet as buildings become increasingly air-tight, it is more important than ever to ventilate effectively. Such considerations are driving the increasing adoption of MVHR systems, which provide a business opportunity for enterprising electrical contractors – following suitable training.

This is the background to legislation and technology designed to ensure healthy indoor air quality in tomorrow's new homes, especially as improvements to Building Regulations Part L require new homes to be built to increasing standards of air-tightness.

Electric heating

Electric heating, which is any process where electrical energy is converted to heat, has applications in water heating, space heating, industrial processes and cooking, among others. In this article, the focus is on water and space heating.

Ignoring the electrodetype of electric waterheating, which can have safety issues, the main type of heating is still mostly immersion, in which a hot water cylinder contains an insulated electric resistance heater and a temperature sensor. Although some manufacturers say otherwise, all electric resistance heaters are 100 per cent efficient at the point-of-use - all the electrical energy is converted to heat.

There are also tank-less heaters and electric showers, in which the immersion heater is turned on by water passing through and turned off when the flow is stopped.

Electric space-heating systems comprise domestic electrical underfloor types, plus radiative, convection, fan and storage varieties. Note that off-peak storage heaters for a given property will always be cheaper to run over a 16-hour day than an electric convector heater or radiator using the standard rate electricity.

With underfloor heating, electric current flows through a flexible conductive heating element (cables, pre-formed cable mats, bronze mesh and carbon films). Because of their low profile, they can be installed in a thermal mass. or directly under floor finishes. Either 110V or 230V, or extra-low voltage (8 to 30V) is applied to the electrical resistance heating element. The control unit typically contains a stepdown transformer; a floor thermostat controls the pre-set temperature. The floor heats the air, which circulates, heating the room spaces etc. Underfloor heating generally provides the most consistent room temperature from floor to ceiling compared with other heating systems.

Heat pumps provide another means of heating and cooling, a building using electricity. An electric motor drives a refrigeration cycle, drawing heat energy from a source (usually the ground or external ambient air), and then pumping it into the space to be heated. This is a reversible process, so heat pumps can also be used to cool spaces. Although heat pumps will not be suitable for every application, they are very energy-efficient and are sometimes labelled 'sustainable', contributing to their growing popularity.

Modern control strategies

Electric heating technologies may be for the most part mature, but just as with ventilation products, the drive for energy-efficiency is bringing significant improvements to the control of heating devices and systems. For example, responsiveness reflects the ability of the heater to match the heating needs of a home, which is important, not just from the perspective of being able to warm a space well, but also from an energyefficiency perspective.

High energy-efficiency and responsiveness combined with modern controls mean that, for example, users of storage heaters can use the stored heat as and when they need it. This is changing the peak / off-peak split of energy usage in storage heating. Being able to harness low-carbon, low-cost electricity saves end-users money and supports demand-side management. Dimplex is one company taking advantage of this with its new Quantum storage heater and sophisticated control system.

And finally...

This article has provided a brief overview of some of the HVAC technologies and related issues that the Voltimum UK 'Electrical Heating, Ventilation & Control Expert Panel' will be examining in detail. The work of the Expert Panel will be covered, in part, through the award-winning e-newsletter VoltiTECH, which covers topical technical and legislative issues. Nearly 120 editions of VoltiTECH have been produced since its launch in June 2003. One of the most recent was entitled 'Heating and ventilating, and the new HVAC Expert Panel introduced'. This article is based on the content of this issue, all provided by the Expert Panel. 🐱

James Hunt is the managing editor of the UK arm of the Voltimum UK electrical web portal





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