Energy efficiency of low-voltage electrical installations

Requirements for the design of new installations and the improvement of existing installations

By Geoff Cronshaw

THE IEE WIRING Regulations (BS 7671:2008) are based on European Standards, which in turn are usually based on international standards.

The UK participates in both European and international standards work. One new area of possible development within international standards is to integrate requirements for energy efficiency into IEC 60364.

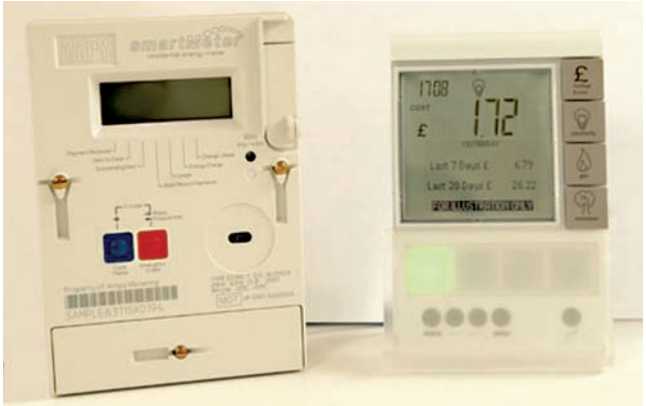
Electrical energy efficiency is intended to obtain the highest possible service from an electrical installation from the lowest energy consumption. Proposals include requirements for the design of new installations and the improvement of existing installations.

Basic concepts

Some key points when designing a new installation include determination of the load demand. This means establishing the type of application the electricity is used for.

A typical installation may include lighting, heating, ventilation, air conditioning etc. The design of the electrical distribution system needs to be carried out in such a way that will allow the metering and control of the various electrical loads.

Therefore, in order to make improvements we need to be able to measure the amount of electrical energy consumed and monitor and control energy effectively. For example in the UK the department of energy and climate change are planning to start a roll-out programme to introduce smart electricity meters into consumers' homes starting in 2014, which is expected to run through until 2020 with the ▶



Smart meter and consumer display unit

◄ aim of helping customers to reduce their energy bills. The smart meter will give customers information on energy consumed via a visual display and be capable of sending metering information to the energy supplier regarding the electricity consumed by the customer without the need for a meter reader. This should put an end to estimated bills. It will also allow the consumer to sell energy back to the energy supplier where the customer has a microgenerator installed such as a wind turbine or solar panels.

A smart meter is an electricity energy meter that incorporates a communications unit. The meter will measure the energy consumed and also measure any energy exported to the electricity network (where the consumer has micogeneration, such as a wind turbine or solar panels). The big difference is that the smart meter does not require a meter reader to visit the premises to read the meter.

Smart meters could use a number of communication options such as wireless, or data wire, or power line transmission (PLT), or mobile phone technology to transmit the meter-reading data to the energy supplier; it is not clear at this stage which option will be used. A smart meter may also be capable of controlling the consumers' load in the future by sending signals to consumer appliances to switch off at peak times, etc. It is also expected that the smart meter will be capable of providing flexible tariffs. It is expected that energy suppliers will be responsible for the installation of the smart meters.

Current-using equipment

Current-using equipment efficiency is based on control of the loads (the right energy at the right time).

Motor control

In the UK BEAMA have identified 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 almost the same.

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.

Lighting

Lighting can represent over 35 per cent of energy consumption in buildings depending on the application. Solutions for lighting control may save up to 50 per cent on the electricity compared to a traditional installation. 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 for residential buildings are easy-to-install devices which 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 important points to consider. First, it is important to take ►

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	Type	Overall luminous efficacy (lm/W)	Overall luminous efficiency
Incandescent	5w tungsten incandescent	5	0.7%
	40w tungsten incandescent	12.6	1.9%
	100w tungsten incandescent	13.8	2.0%
	200w tungsten incandescent	15.2	2.2%
	100w tungsten glass halogen	16.7	2.4%
	200w tungsten glass halogen	17.6	2.6%
	500w tungsten glass halogen	19.8	2.9%
	Tungsten glass halogen	24	3.5%
	Photographic and projection lamps	35	5.1%
Light-emitting diode	White LED	10 - 150	1.5 - 2.2%
Arc lamp	Xenon arc lamp	30-50	4.4 - 7.3%
	Mercury-xenon arc lamp	50-55	7.3 - 8.0%
Flourescent	9-26W compact flourescent	46 - 72	8 - 11%
	T12 tube with magnetic ballast	60	9%
	T5 tube	70 - 100	10 - 15%
	T8 tube with electronic ballast	80 - 100	12 - 15%
Gas discharge	Metal halide lamp	65 - 115	9.5 - 17%
	High pressure sodium lamp	85 - 150	12 - 22%
	Low pressure sodium lamp	100 - 200	15 - 29%

General luminous efficacies and efficiancies of common lamp types

◀ 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.

Energy efficiency of lamps

This section looks at the energy efficiency of lamps and is extracted from a previous *Wiring Matters* article. Incandescent lamps offer a low efficacy as the majority of energy consumed is converted into heat. A typical range would be 8-14 lumens per watt (lm/W). Luminous efficacy is a figure of merit for light sources and is the ratio of luminous flux (in lumens) to power (usually measured in watts).

As most commonly used, it is the ratio of luminous flux emitted from a light source to the electrical power consumed by the source and, therefore, describes how well the source provides visible light from a given amount of electrical power. This is also referred to as luminous efficacy. The table above shows general luminous efficacies and efficiencies of common lamp types.

Power-factor correction

A poor power-factor is undesirable for a number of reasons. Power-factor correction technology is used mainly on commercial and industrial installations to restore the power factor to as close to unity as is economically viable. Low power-factors are caused by reactive power demand of inductive loads such as induction motors and fluorescent lights. A poor power-factor reduces the effective capacity of the electrical supply, since the more reactive power that is carried the less useful power can be carried, also causes losses at transformers, and can cause excessive voltage drops in the supply network and may reduce the life expectancy of electrical equipment.

For this reason electricity tariffs encourage the user to maintain a high power-factor (nearly unity) in their electrical installation by penalising a low power-factor. There are a number of ways in which power-factor correction can be provided. The most common way that this can be achieved is by the installation of power factor correction capacitors. These can be installed in bulk at the supply position or at the point of usage on motors, for example. Persons involved in this type of work are recommended to seek advice from specialists on the most economic system for a given installation.

The future: LVDC distribution

A future area of possible development within international standards is LVDC distribution. More and more ▶

Consumer display unit

◄ electronic equipment is being introduced in buildings which use dc. There is also a wide range of micro generation technologies – including solar photovoltaic (PV) and wind turbines – being installed which generate dc. One of the main reasons for the proposal to introduce LVDC distribution in a building is to improve energy efficiency by reducing losses in the conversion of ac to dc for electronic loads and conversion of the dc output from micro generation to ac for mains distribution.

The challenges.

There are a number of challenges when designing a LVDC installation. Persons involved in dc installations need to have the necessary expertise. Electrical equipment used on a dc installation must be suitable for direct voltage and direct current.

Equipment approved to normal ac standards may not be suitable, especially switchgear. For example, the use of plugs and socket outlets for use on dc need careful selection depending on the current rating.

Given the nature of dc, additional requirements need to be taken into account when disconnecting a dc load by withdrawing a plug from a socket outlet. This is because an arc can occur when disconnecting a load, which is more difficult to extinguish compared with an ac load because there is no natural zero point on dc compared to ac.

It is understood that one possibility being considered is to use a switched socket outlet with a plug that is interlocked with the socket outlet. The plug and socket outlet is then designed in such a way that the plug cannot be withdrawn from the socket outlet while the plug contacts carry current.

Arc quenching

Circuit breakers for overcurrent protection is another area that needs special consideration. The arc produced when disconnecting a fault on a dc installation is more difficult to extinguish. Designers of dc installations will need to liaise with manufacturers of equipment and exercise careful consideration when selecting a circuit breaker for use on dc to ensure that the circuit breaker has suitable arc-quenching capabilities and are suitable for the operating voltage.

Cables for use on dc again need special consideration. A cable is given a voltage rating which indicates the maximum circuit voltage for which it is designed, not necessarily the voltage at which it will be used. For example, a cable designated 600/1000V is suitable for a circuit operating at 600Vac phase to earth and 1000Vac phase to phase. This cable is traditionally used in areas where mechanical strength is required such as industrial installations. For light industrial circuits operating at 230/400Vac it would be normal to use cables at 450/750Vac, and for domestic circuits operating at 230/400Vac, cable rated at 300/500Vac would often be used. The traditional rating of the cable 300/500V is the ac rating of the cable. The dc rating of this cable for core to earth is 300×1.5 (450V dc max) and the core to core voltage is 500×1.5 (750V dc max). Therefore, designers of dc installations need to give careful consideration when selecting a cable for use on dc to ensure it is suitable for the operating voltage and are recommended to seek advice from the manufacturer.

Note: It is important to consult the Building Regulations in the UK when designing electrical installations. The Building Regulations contain requirements for lighting controls etc. Please note this article is only intended as a brief overview of issues that are being considered at a very early stage and therefore may not become international standards. ■

Smart-meter installation