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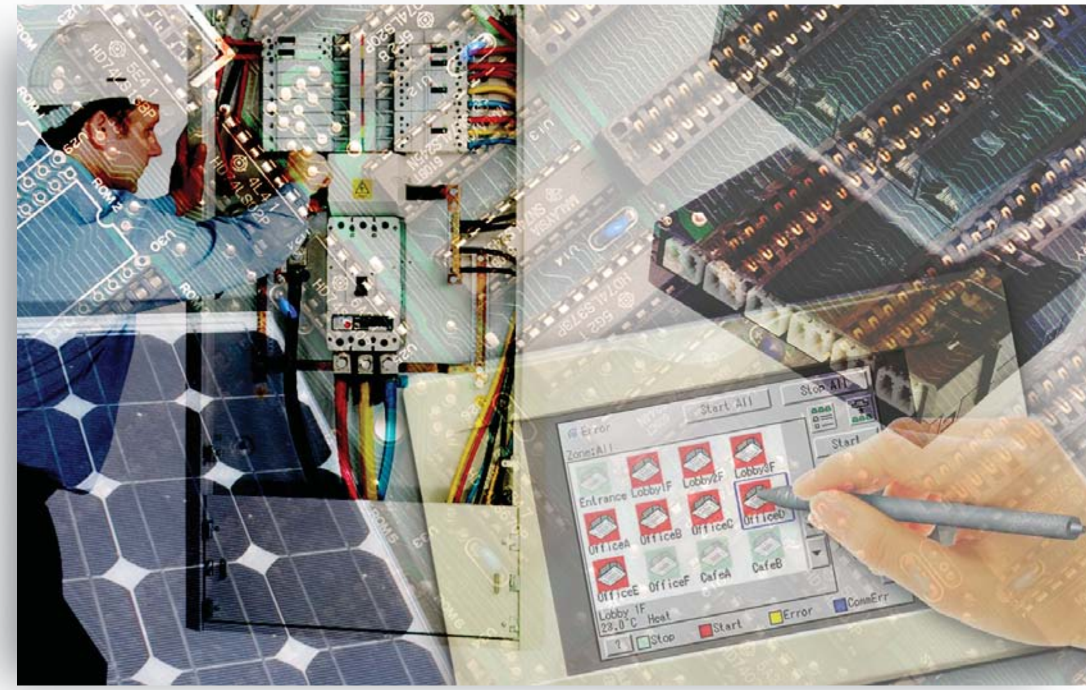
Design Checks for Electrical Services



A quality control framework for electrical engineers

By Kevin Pennycook

Supported by

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PREFACE

Donald Leeper OBE

The publication of *Design Checks for Electrical Services* is a welcome addition to the well received and highly acclaimed *Design Checks for HVAC*, published in 2002.

The design guidance sheets provide information on design inputs, outputs and practical watch points for key building services design topics.

The guidance given complements that in *CIBSE Guide K, Electricity in Buildings*, and is presented in a format that can be easily incorporated into a firm's quality assurance procedures. From personal experience I have seen the benefit of such quality procedures.

Once embedded within a process information management system, the guidance in this book will ensure consistent and high quality design information. When used for validation and verification, the design checks and procedures can also make a key contribution to a risk management strategy.

The easy-to-follow layout and the breadth of content makes *Design Checks for Electrical Services* a key document for all building services engineers.

Donald Leeper OBE
President, CIBSE 2005-06
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3. Plant space allowance
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References and bibliography

INTRODUCTION

Aim

The aim of *Design Checks for Electrical Services* is to improve the quality control and performance of the technical design process by identifying best practice. This should reduce the risk of design errors and omissions, improve the overall efficiency of the design process, and provide electrical services that better meet the needs of the client.

A comprehensive review of electrical services engineering practice and procedures was carried out in consultation with the industry to identify best practice and current problems, and to explore relevant design tools. The result includes:

- A map of the electrical services engineering design process
- Design guidance sheets giving information and guidance on design inputs, outputs and practical watchpoints for a range of key design topics, to aid the design process and reduce errors
- Design check-sheets which can be included in project quality assurance procedures.

These provide a formal framework to record and review design inputs and to encourage designers to consider the requirements for installation, commissioning, operation and control and subsequent maintenance of systems selected at the design stage.

This should lead to improvements in both the design process and in the subsequent implementation of that design, and reduce the risk of problems occurring during installation, commissioning or system operation.

This practical, easy to follow guidance can be incorporated into company quality assurance systems to become part of the daily routine of design. The guidance can also be used to demonstrate compliance with the relevant requirements of *ISO 9001:2000* [i] and *BS 7000 Part 4:1996.* [ii]

The guidance incorporates practical design watchpoints based on feedback from practising engineers and others experienced in design. These vary from avoidance of possible errors or misunderstandings that could be made by inexperienced, junior engineers, to very practical tips based on experience of installation, commissioning, maintenance and facilities management over many years. Use of the design checks will allow these lessons to be passed on to other engineers, particularly junior engineers, and future projects. This can help improve design quality, reduce risk and increase client confidence.

Intended users

This guidance is intended for practising electrical services design engineers. Clients, PII providers and others involved in the design process and its outcomes are also potential users. The guidance complements the *CIBSE, Guide K. Electricity in Buildings CIBSE 2004* along with other industry guides (see references and bibliography).

The check sheets and design inputs and outputs guidance are intended for use by all design engineers, whether to gather information and complete the sheets, or to check or sign them off as completed. While the more detailed guidance in the design watchpoints is obviously directly useful for junior engineers, experienced engineers will also find it useful when designing a less-familiar system.

Companies may also use the guidance to support formal design quality assurance procedures. While the check sheets may be photocopied, they are also available, for purchase in electronic format, thus enabling them to be customised for particular projects and kept in specific project files. For further information visit www.bsria.co.uk/bookshop.

Clients should consider this guidance as an indication of good design practice but should not make adherence to it a contractual obligation. Compliance with the guide in itself is not intended to show that the designer has complied with contractual obligations.

Note that the design of electrical systems involves working in a design team with other disciplines. This involves interactive efforts, co-ordination and project programming.

THE CASE FOR QUALITY CONTROL

Good design is central to the achievement of quality buildings satisfying client requirements, yet all too often defects and failures occurring after occupation can be shown to have their origin in design deficiencies. It has been shown that 50% of claims notified to PII insurers come from matters arising during the design stage of a project with 21% of these being attributed to building services elements (M&E) and 11% being attributed to public health systems.[iii]

Many quality assurance (QA) schemes are primarily concerned with general design management and the logging of project decisions, rather than the actual quality of the design itself. There has been no industry standard to assure technical design quality by ensuring that correct procedures are followed, thus exposing both the client and the design organisation to risk. Design procedures should meet adequate quality standards such as *BS 7000 Part4:1996* [ii] and be adequately checked, but there is insufficient guidance on how to do this for building services design. This publication meets the need for procedures which can be adopted across the industry.

More fundamentally, problems and errors can recur over many projects, with the same mistakes being repeated. An individual engineer may have learnt from experience, but that learning is often not passed on to others. If a solution to an error or problem is found during a construction project the cause of the initial problem may often not be recorded at all. Subsequent projects involving the same company may repeat the error. Ways to capture information effectively in a no-blame context need to be implemented for learning to be effectively transmitted not just within one organisation or one project but also across many projects and organisations. This guidance enables organisations to better implement technical design checks as part of their quality assurance process and to meet the relevant requirements of *ISO 9001:2000* [i] and *BS 7000 Part 4:1996*.[ii] It can also encourage design organisations to add to the design watchpoints to provide further dissemination of lessons learnt within the organisation.

Design errors-examples and case studies

Problems having their origin in design vary from minor omissions to major errors. Some are not realised until the building has been operational for some while. Others may be identified in time to make changes or remedy the situation prior to handover: eg recognised during a design review, at contract award stage, during installation or during the commissioning process. Although these errors can be remedied prior to occupation this is effectively fire fighting not fire prevention and is certainly not ideal. Design errors and omissions should be prevented or identified during the design process. All design errors identified subsequently are costly in time, rework and, potentially, in lost reputation and increased future PII premiums.

Specific examples of design errors, and issues which should have been considered during design, and have led, or could have led, to operational problems or subsequent litigation are numerous, including:

- Failure to allow adequate access space around plant items for maintenance
- Excessively high or low estimation of electrical demands resulting in oversized or undersized plant
- Inadequate space, resulting in unsafe working areas.
- Insufficient bending radii for cables which could lead to faults
- Inaccurate identification of possible fault currents, with the possibility of equipment and cable ratings being exceeded and resulting in explosions and failure
- Incompatibility of pre-fitted plugs and sockets from different manufacturers of prefabricated wiring systems
- Equipment not suitable for the environmental conditions
- The prime mover of the standby generator has insufficient capacity to handle the required step loads
- Exhaust from the standby generator diesel engine is close to HVAC air intakes, resulting in fumes entering the building
- Excessive light pollution from exterior lighting
- Use of excessively complicated BMS control strategies
- Insufficient metering and monitoring equipment resulting in difficulty in determining plant/system energy consumption
- Selection of CCTV camera lenses with insufficient field of view.

Many design errors can be remedied without recourse to litigation, although with obvious cost penalties. The following case studies illustrate design errors that have occurred in practice. Use of formal design quality assurance procedures and design guidance such as these design checks for electrical services can help prevent these kinds of errors and save companies concerned considerable time and cost.

The design guidance and check sheets include many watchpoints on operation and control, and access and maintenance issues, and provide a framework to support formal design quality assurance procedures. Their use ought to deliver improved client service and a basis for demonstrating that due care has been taken in design.

Designers should always consider alternative designs, methods of working, and the use of potentially more appropriate materials and equipment. The guidance in this book can help in that process.

THE CASE FOR QUALITY CONTROL

Case Study 1

The lighting consultant selected specialist bespoke light fittings for a key area of a development that required aesthetic qualities. A selection of fittings were proposed, and accepted by the client and architect.

During construction, the contractor suggested the use of proprietary alternative fittings which were readily available. This suggestion to the consultant was made to benefit the contractor's programme which had begun to slip.

On completion of the project, the alternative fittings neither performed as well as the original fittings nor were accepted by the client and architect as an aesthetic equivalent to the fitting the consultant had originally proposed.

The development was to be opened on a publicly-announced date in a blaze of local publicity. Temporary supplies and light fittings were installed at the consultant's expense and the additional costs of replacing the installed fittings with the originally specified fittings was also borne by the consultant in settlement of the claim.

Lesson

Every alternative needs to be considered with as much rigour as the original design - including approvals. Beware of the temptation to help others out of their problems at the expense of increasing your own liabilities.

Case study 2

On a design and build development where the contractor was the designer, the essential services to be powered by a standby generator did not meet the client's requirements due to an inconsistency in the client's brief of which the contractor was unaware.

The contractor’s consultant selected a motor control panel, intended to be run off the standby generator, that proved inadequate for the mechanical plant loads. This caused the generator to fail when the plant started up. Also a distribution board supplying the panel for the client's back-up computer equipment was not served, causing the client financial loss during failure of the mains supply.

The contractor's consultant became liable for the contractor's costs of rectifying the defective installation as the consultant, despite being in contract with the contractor, had been taking instructions directly from the contractor's employer.

Lesson 1

Always look after the interests of your client (the person with whom you have a contract). Do not have a meeting with the employer if you are the contractor's designer without the contractor being present to confirm the actions he requires of you.

Lesson 2

Ensure that there is consistency in the design proposals for redundancy in the electrical system and the supply to essential services. Do not assume that what one client wants is the same as another - go back to first principles.

THE CASE FOR QUALITY CONTROL

Case study 3

In a fire alarm system designed for a health facility, the sounders were specified by one member of the consultant's staff on the basis that they would be ceiling-mounted .

The system drawings were prepared by another member of the consultant's staff who indicated that the sounders were to be installed above the ceiling. This anomaly was not spotted until the system was tested at which time it was established that the sounders could not achieve the required sound level.

The sounders had to be replaced at the consultant's expense. To avoid any delay to handover, the consultants re-specified the sounders for all locations. In doing so, the consultant had failed to consider the effect of smoke barriers in the ceiling void and acoustic fill to the ceiling tiles in certain locations. Certain sounders were still shown to be inadequate at testing and had to be replaced again - all at the consultant's expense. The project handover was also delayed as a certificate of occupancy could not be given until the fire alarm system was fully operational.

Lesson 1

There needs to be single point accountability for design within any consultancy. Someone experienced needs to check for inconsistencies in specifications and drawings before they are issued to the contractor.

Lesson 2

If there is to be a change to the fundamental principles of the design the change needs to be looked at from first principles. It is tempting to suggest an easy solution to a problem without considering all possible consequences.

Professional indemnity insurer recommendations

Some professional indemnity insurance providers provide guidance to their clients on good practice to minimise the risk of claims. For example, Griffiths and Armour have published a lessons learned document based on analysis of professional indemnity claims.[iv] This includes recommendations during the design stage to:

- Ensure that a suitably qualified person checks all drawings, documents and calculations
- Follow in-house quality assurance procedures
- Consider all alternatives with the same rigour as the original design proposals

Griffiths and Armour advise that good quality control in the design office, including crosschecking of related work, is essential to avoid unnecessary design errors. Guidance is also provided on other issues which may arise during the design process, such as advice from other team members, the use of information or drawings prepared by others, the use of computers and innovative design.

THE CASE FOR QUALITY CONTROL

BS EN ISO 9000 series and BS 7000 requirements

The following section provides a brief summary of the relevant sections of the above standards.

BS EN ISO 9000 series

ISO 9000:2000 provides guidance on quality management fundamentals and vocabulary. Also *ISO 9001:2000* [i] (and which cancels and replaces the previous *ISO 9001, 9002* and *9003*) which covers the requirements for a quality management system. The main objective of the series is to give purchasers of a product or a service an assurance that the quality of the product and/or service provided by a supplier meets their requirements. The series of standards sets out and defines a list of features and characteristics which should be present in an organisation's quality management system through documented policies, manuals and procedures. The overall aim is systematic quality assurance and control.

Section 4.2 of *ISO 9001:2000* [1] refers to the documentation required for a quality management system, including the need for a quality manual and documented procedures. Section 7 covers product realization with 7.1 (c) referring to the requirement for verification, validation, monitoring inspection and test activities specific to the product and the criteria for product acceptance.

Section 7.3 addresses design and development. Specific requirements include the need for :

- Design input review and records (7.3.2)
- Design output review and verification (7.3.3)
- Design and development review (7.3.4)
- Design and development verification (7.3.5)
- Design and development validation (7.3.6).

There is therefore a clear requirement to review and record design inputs and outputs, to verify the design to ensure it can meet the design requirements and to review the design process to identify and remedy potential problems.

ISO 9004:2000 [v] complements *ISO 9001* by giving guidance on a wider range of objectives of a quality management system than *ISO 9001*, cross-referenced to the sections of *ISO 9001* and in particular focusing on continual performance improvement.

Under Section 7.3.3 design verification activities are suggested including alternative design and development calculations and evaluation against lessons learned from previous designs. Suggested design validation activities include the validation of engineering design prior to construction, installation or application, and the validation of software outputs.

BS7000: Design management systems

BS7000 covers design management systems and comprises:

- Part 1: Guide to managing product design
- Part 2: Guide to managing the design of manufactured products
- Part 3: Guide to managing service design
- Part 4: Guide to managing design in construction
- Part 10: Glossary of terms used in design management.

BS 7000 Part 4:1996 [ii] is the most relevant of the *BS 7000* parts as it is specifically tailored to the management of the construction design process, for all organisations and for all types of construction project.

Section 4 covers design process management, including the responsibilities of the design leader, the design brief and specific design stages and procedures, including design change control and design documentation.

Design procedures are covered in Section 4.7 with design input (4.7.3), design process (4.7.4) and design output (4.7.5) separately identified. The Standard states that formal procedures should be used for all projects, with design procedures clearly recorded and relevant design criteria and constraints listed. All design inputs should be validated and all design outputs should be subject to a stated verification strategy. To allow traceability, significant design assumptions and decisions should be recorded as the design proceeds.

Annex A provides some information on validation and verification and proposes that a risk assessment exercise be conducted. It points out that the important balance to be achieved is the cost of increased rigour against the risk of an increased penalty. The standard states that all design methods and sources of design data should be validated.

The use of the design checks guidance

The design checks guidance can be used to assist with compliance with the above standards as part of a quality assurance scheme, as it provides a formal method of recording and checking design inputs and outputs within a quality control framework. By asking for cross-referencing and data sources. The guide will assist with validation of design inputs, similarly relevant watchpoints and key design checks can assist with the verification of design outputs. An example of cross-referencing is mechanical plant selection required for the confirmation of electrical load provision in the electrical design.

THE BUILDING SERVICES DESIGN PROCESS

Design is a complex process which involves translating ideas, proposals and statements of needs and requirements into precise descriptions of a specific product(s)[i]. Design problems are often ill-defined, their solutions often not self-evident. Designers try to achieve a solution that is satisfactory or appropriate. There is rarely one correct answer to a design problem, different designers might arrive at different but possibly equally satisfactory solutions.

Two major features characterise the design process. First, design tends to evolve through a series of stages at which the solution is increasingly designed at greater levels of detail, moving from broad outline through to fine detail. Second, design tends to contain iterative cycles of activities during which designs, or design components, are continually trialled, tested, evaluated and refined. Feedback loops are therefore an essential component of design. Most models of the design process therefore involve many feedback and iteration loops; even some simple ones use a spiral model to illustrate the process.

Design within construction increasingly involves a number of interdependent professional disciplines with concurrent design processes. It is invariably iterative. Although design may originate with a client need and then a design brief, the design brief itself is not a finite object and often evolves during the design process. In practice, the design process involves constant communication and clarification between team members, with many design steps being revisited as the design evolves and develops. This is recognised to some extent with the standard process stages of outline design, scheme design and further/detail design.[vii] There are a number of models of the building process, most of which show this as a largely linear process, ranging from the stages in the RIBA Plan of Work to the Generic Design and Construction Process Protocol developed by Salford University[viii].

This breaks the design and construction process down into ten distinct phases which are grouped into four broad stages: pre-project, pre-construction, construction and post-completion.

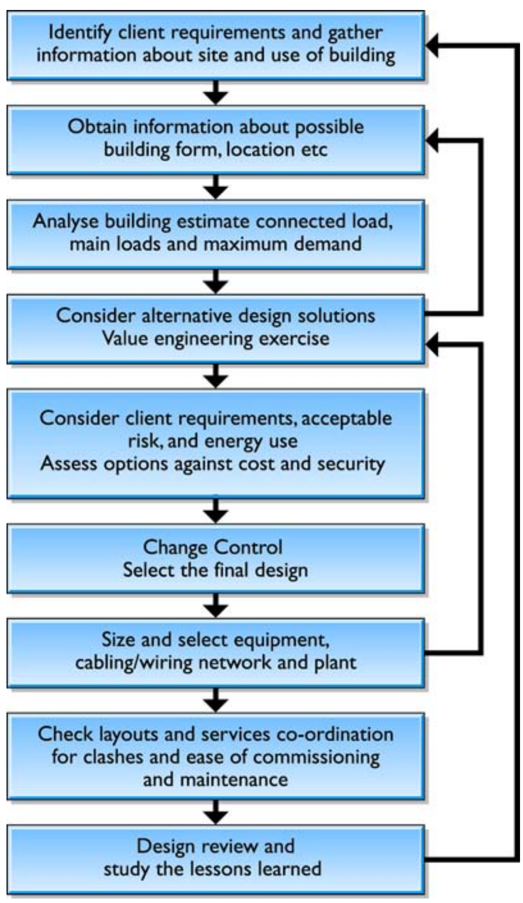
However, none of the commonly-used models show the design part of the process in detail, let alone the building services design process. One of the tasks proposed for this guide was to model the building services design process in order to provide relevant guidance and show the various design tasks that form part of the process in context. This proved to be very complex. If the integral iterative and feedback loops are included, the model effectively needs to be three dimensional (if not four, with addition of a time element), as it is not possible to represent it clearly in two dimensions.

In the event, a detailed analysis of design procedures and tasks was carried out for building services design. After considerable research and consultation with industry a model was successfully developed that departs from the evolutionary model of design, where design proceeds through a series of stages from broad outline through to fine detail. Instead, a simple linear model was proposed that is much closer to a pure design process. This provides a single design sequence, from statement of need, through problem analysis, synthesis and evaluation to final solution. This enables design tasks to be clearly linked to both preceding and succeeding actions.

The building services design process was mapped both as a sequence of design tasks and as a series of topics that make up the design process. This provides an overview of the design process to both inform the designer and enable design elements to be seen in context.

For simplicity, the processes set out in this guide are therefore presented as a sequential, linear flow. In practice, there will be overlap from one stage to another, and it may be necessary to revise calculations or modify assumptions at almost any stage. This may in turn lead to a series of knock-on revisions. These have associated cost implications which should also be considered in managing and controlling the overall process.

The design process



THE BUILDING SERVICES DESIGN PROCESS

Electrical services design tasks and design map

The flow chart below shows a very simplified linear version of the main electrical services design tasks. Some primary feedback loops are shown, but in practice there are often feedback loops between all tasks and even within specific tasks.

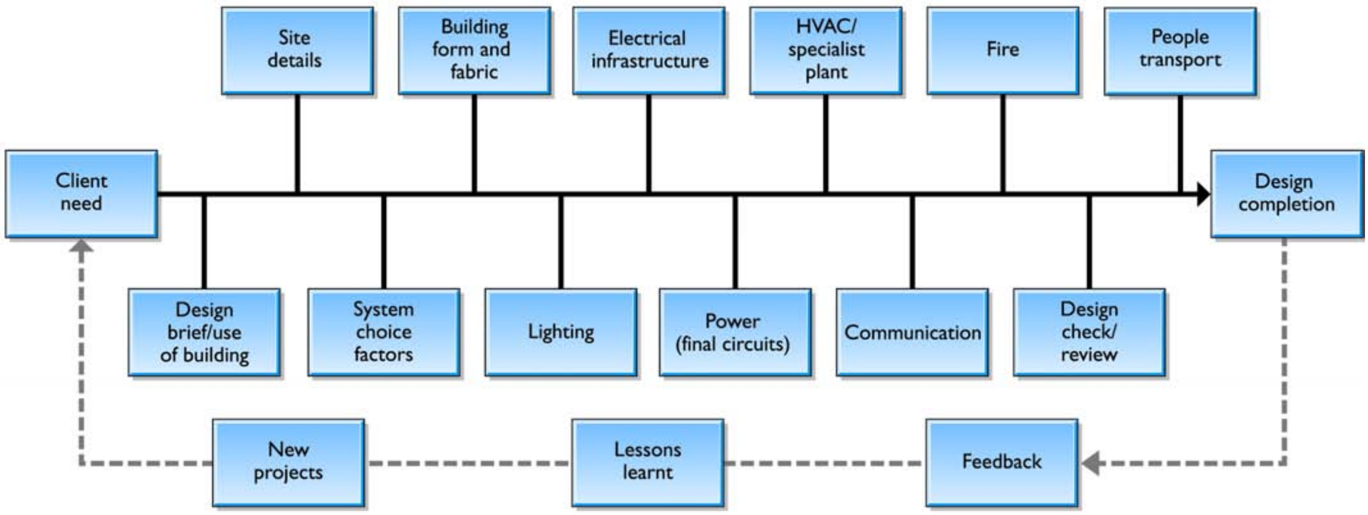
This sequence of design tasks was then linked to the detail of the design process and the various design choices and considerations in order to develop a design map. This is shown in the form of an Ishikawa or fishbone diagram, starting from client need on the left with various branches feeding into the main design line to eventually reach design completion. An essential part of this design process is the need for design feedback to inform future projects.

A simplified map is shown below and the full detailed design map for the electrical services design process is provided as a fold-out inside the back cover. As previously explained, the map presents a linear view of design, with iteration and intermediate feedback omitted. The main branches feed into a central spine in approximate sequence of design output.

The individual branches and sub-branches show relevant design topics which can be related to specific design guidance sheets. Some simplifications or expansions have been made for clarity. In practice, many design tasks would be carried out concurrently but the map illustrates an approximate design sequence.

Although the map inevitably simplifies what is a very complex design process, it does provide an overview of the electrical services design process to inform both designer and client. It can also show the effects of early assumptions or late changes on the design process, such as the amount of design assumptions that have to be made if a design task such as plant sizing were carried out at an initial stage in the project. Equally the effects of a late client change on design rework will be clearly visible for example where there is a change to occupancy, or to future needs when the design has already reached the stage of system selection and detailed sizing and layout.

A simplified design process map



OVERVIEW OF DESIGN GUIDE SECTIONS

The guidance is organised into four sections covering topics relevant to electrical services:

Design considerations

This section covers the key topics relevant to client requirements and the services strategy to be considered at design inception, such as future needs, design margins and plant space allowance. It also covers issues that relate to the whole design concept such as zoning, spatial co-ordination and maintenance requirements.

Design issues

This section covers the key topics relevant to analysis and definition of the client brief and client requirements to determine information on the site and use of the building. This includes site location factors, electricity supply, connected load and maximum demand, and energy conservation.

Calculations

This section covers the key base calculations used for electrical services design.

Systems and equipment

This section covers the main systems and equipment items for electrical services design, such as HV and LV distribution, cable management and wiring systems, UPS and standby generation, lighting systems, security systems, and metering and control systems.

Design considerations inform the whole design process, with the other sections following the approximate design sequence used in practice as shown in the diagram opposite.

For each topic the guidance provides two pages with a check sheet on the left hand page and a design guidance sheet on the right as shown on the opposite page.

Design guidance sheets

The design guidance sheet provides design inputs, design information, design outputs, key design checks and design watchpoints.

Design inputs

The technical input required for the design or selection of a particular design item, such as loads, resilience required, design temperatures and noise rating.

Design information

Design information which is necessary for design decisions, system layouts or selection of equipment such as the client brief, building plans, occupancy details and electrical supply details.

Design outputs

The required design output from a particular part of the design process to either inform future design or to form part of the specification or design production, this would include schematic diagrams, system layout drawings, schedules of equipment and cable sizes and duties.

Key design checks

Key design checks include items that should be checked as part of the design process.

Design watchpoints

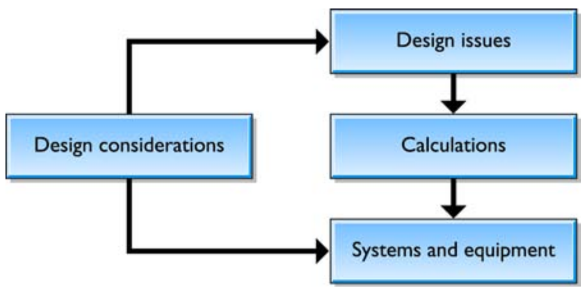
These provide guidance to inform the design process as a series of check-points or items to be aware of during the design. The watchpoints are grouped together in three to four linked sections to show that design decisions affect not only on the sizing and selection of systems, but also on installation, commissionability, future operation and control, maintainability, and capital and operating costs.

The watchpoints are based on the collected experience of many practising design engineers, but should not be taken to be an exhaustive or definitive list of everything to be considered. Every design project is different and has differing needs, and it is the responsibility of the design engineer to consider fully all the design requirements. Design engineers and design practices should be encouraged to add their own additional watchpoints and add to the pool of feedback knowledge to inform further design projects.

Design Check sheets

The design check sheet can be used as part of a quality assurance (QA) system to provide a formal record of inputs and outputs from different design stages, cross-referenced to the design file. This will facilitate compliance with the requirements of the quality assurance system and of *ISO 9001* as well as enabling a clear record to be kept of design progress and design information.

Example of the design sequence used in practice



OVERVIEW OF DESIGN GUIDE SECTIONS

The **design inputs and outputs** from the guidance sheet for each topic are reproduced here and can be checked off and cross-referenced to data sources, thus allowing easy tracking of design information in the case of design changes or queries.

Key design checks are reproduced to encourage designers to continually check and review their design. Space is also allowed for **project specific checks and notes**. No design guidance manual can be fully comprehensive for all design applications, therefore it is the responsibility of the designer to add additional information as required by a particular project.

Use of design checks guidance

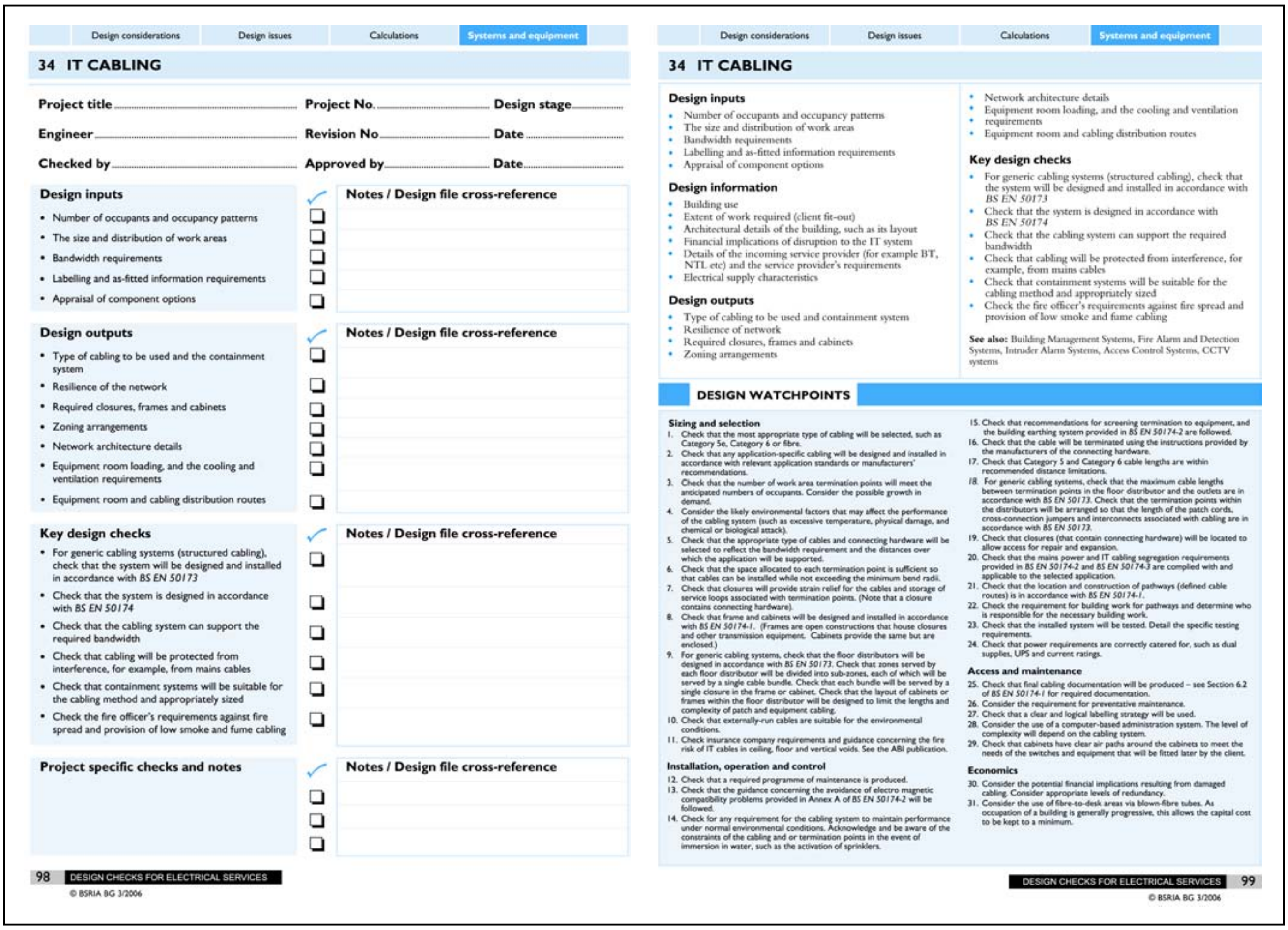
This design guidance is intended to inform the design process and provide detail to aid the designer. It does not cover the relative merits of different system or equipment choices, but provides guidance that will, for example, help engineers to design the selected system(s) after the initial design strategy has been agreed.

A design project is likely to refer to many of the guidance sheets during the design process. The example overleaf shows the sheets that may be relevant to the design of low-voltage distribution system.

References and bibliography

A references and bibliography section at the end of this guide provides reference to additional guidance that covers both general design issues and specific references that are relevant to the individual design topics.

Sample design check and design guidance page



Design considerations | Design issues | Calculations | Systems and equipment

34 IT CABLING

Project title .... **Project No.** .... **Design stage** ....

Engineer .... **Revision No** .... **Date** ....

Checked by .... **Approved by** .... **Date** ....

Design inputs — ✓ — **Notes / Design file cross-reference**

- Number of occupants and occupancy patterns ❑
- The size and distribution of work areas ❑
- Bandwidth requirements ❑
- Labelling and as-fitted information requirements ❑
- Appraisal of component options ❑

Design outputs — ✓ — **Notes / Design file cross-reference**

- Type of cabling to be used and the containment system ❑
- Resilience of the network ❑
- Required closures, frames and cabinets ❑
- Zoning arrangements ❑
- Network architecture details ❑
- Equipment room loading, and the cooling and ventilation requirements ❑
- Equipment room and cabling distribution routes ❑

Key design checks — ✓ — **Notes / Design file cross-reference**

- For generic cabling systems (structured cabling), check that the system will be designed and installed in accordance with *BS EN 50173* ❑
- Check that the system is designed in accordance with *BS EN 50174* ❑
- Check that the cabling system can support the required bandwidth ❑
- Check that cabling will be protected from interference, for example, from mains cables ❑
- Check that containment systems will be suitable for the cabling method and appropriately sized ❑
- Check the fire officer's requirements against fire spread and provision of low smoke and fume cabling ❑

Project specific checks and notes — ✓ — **Notes / Design file cross-reference**

❑ ❑ ❑

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Design considerations | Design issues | Calculations | Systems and equipment

34 IT CABLING

Design inputs

- Number of occupants and occupancy patterns
- The size and distribution of work areas
- Bandwidth requirements
- Labelling and as-fitted information requirements
- Appraisal of component options

Design information

- Building use
- Extent of work required (client fit-out)
- Architectural details of the building, such as its layout
- Financial implications of disruption to the IT system
- Details of the incoming service provider (for example BT, NTL etc) and the service provider's requirements
- Electrical supply characteristics

Design outputs

- Type of cabling to be used and containment system
- Resilience of network
- Required closures, frames and cabinets
- Zoning arrangements
- Network architecture details
- Equipment room loading, and the cooling and ventilation requirements
- Equipment room and cabling distribution routes

Key design checks

- For generic cabling systems (structured cabling), check that the system will be designed and installed in accordance with *BS EN 50173*
- Check that the system is designed in accordance with *BS EN 50174*
- Check that the cabling system can support the required bandwidth
- Check that cabling will be protected from interference, for example, from mains cables
- Check that containment systems will be suitable for the cabling method and appropriately sized
- Check the fire officer's requirements against fire spread and provision of low smoke and fume cabling

See also: Building Management Systems, Fire Alarm and Detection Systems, Intruder Alarm Systems, Access Control Systems, CCTV systems

DESIGN WATCHPOINTS

Sizing and selection

1. Check that the most appropriate type of cabling will be selected, such as Category 5e, Category 6 or fibre.
2. Check that any application-specific cabling will be designed and installed in accordance with relevant application standards or manufacturers' recommendations.
3. Check that the number of work area termination points will meet the anticipated numbers of occupants. Consider the possible growth in demand.
4. Consider the likely environmental factors that may affect the performance of the cabling system (such as excessive temperature, physical damage, and chemical or biological attack).
5. Check that the appropriate type of cables and connecting hardware will be selected to reflect the bandwidth requirement and the distances over which the application will be supported.
6. Check that the space allocated to each termination point is sufficient so that cables can be installed while not exceeding the minimum bend radii.
7. Check that closures will provide strain relief for the cables and storage of service loops associated with termination points. (Note that a closure contains connecting hardware).
8. Check that frame and cabinets will be designed and installed in accordance with *BS EN 50174-1*. (Frames are open constructions that house closures and other transmission equipment. Cabinets provide the same but are enclosed.)
9. For generic cabling systems, check that the floor distributors will be designed in accordance with *BS EN 50173*. Check that zones served by each floor distributor will be divided into sub-zones, each of which will be served by a single cable bundle. Check that each bundle will be served by a single closure in the frame or cabinet. Check that the layout of cabinets or frames within the floor distributor will be designed to limit the lengths and complexity of patch and equipment cabling.
10. Check that externally-run cables are suitable for the environmental conditions.
11. Check insurance company requirements and guidance concerning the fire risk of IT cables in ceiling, floor and vertical voids. See the ABI publication.

Installation, operation and control

12. Check that a required programme of maintenance is produced.
13. Check that the guidance concerning the avoidance of electro magnetic compatibility problems provided in Annex A of *BS EN 50174-2* will be followed.
14. Check for any requirement for the cabling system to maintain performance under normal environmental conditions. Acknowledge and be aware of the constraints of the cabling and or termination points in the event of immersion in water, such as the activation of sprinklers.
15. Check that recommendations for screening termination to equipment, and the building earthing system provided in *BS EN 50174-2* are followed.
16. Check that the cable will be terminated using the instructions provided by the manufacturers of the connecting hardware.
17. Check that Category 5 and Category 6 cable lengths are within recommended distance limitations.
18. For generic cabling systems, check that the maximum cable lengths between termination points in the floor distributor and the outlets are in accordance with *BS EN 50173*. Check that the termination points within the distributors will be arranged so that the length of the patch cords, cross-connection jumpers and interconnects associated with cabling are in accordance with *BS EN 50173*.
19. Check that closures (that contain connecting hardware) will be located to allow access for repair and expansion.
20. Check that the mains power and IT cabling segregation requirements provided in *BS EN 50174-2* and *BS EN 50174-3* are complied with and applicable to the selected application.
21. Check that the location and construction of pathways (defined cable routes) is in accordance with *BS EN 50174-1*.
22. Check the requirement for building work for pathways and determine who is responsible for the necessary building work.
23. Check that the installed system will be tested. Detail the specific testing requirements.
24. Check that power requirements are correctly catered for, such as dual supplies, UPS and current ratings.

Access and maintenance

25. Check that final cabling documentation will be produced – see Section 6.2 of *BS EN 50174-1* for required documentation.
26. Consider the requirement for preventative maintenance.
27. Check that a clear and logical labelling strategy will be used.
28. Consider the use of a computer-based administration system. The level of complexity will depend on the cabling system.
29. Check that cabinets have clear air paths around the cabinets to meet the needs of the switches and equipment that will be fitted later by the client.

Economics

30. Consider the potential financial implications resulting from damaged cabling. Consider appropriate levels of redundancy.
31. Consider the use of fibre-to-desk areas via blown-fibre tubes. As occupation of a building is generally progressive, this allows the capital cost to be kept to a minimum.

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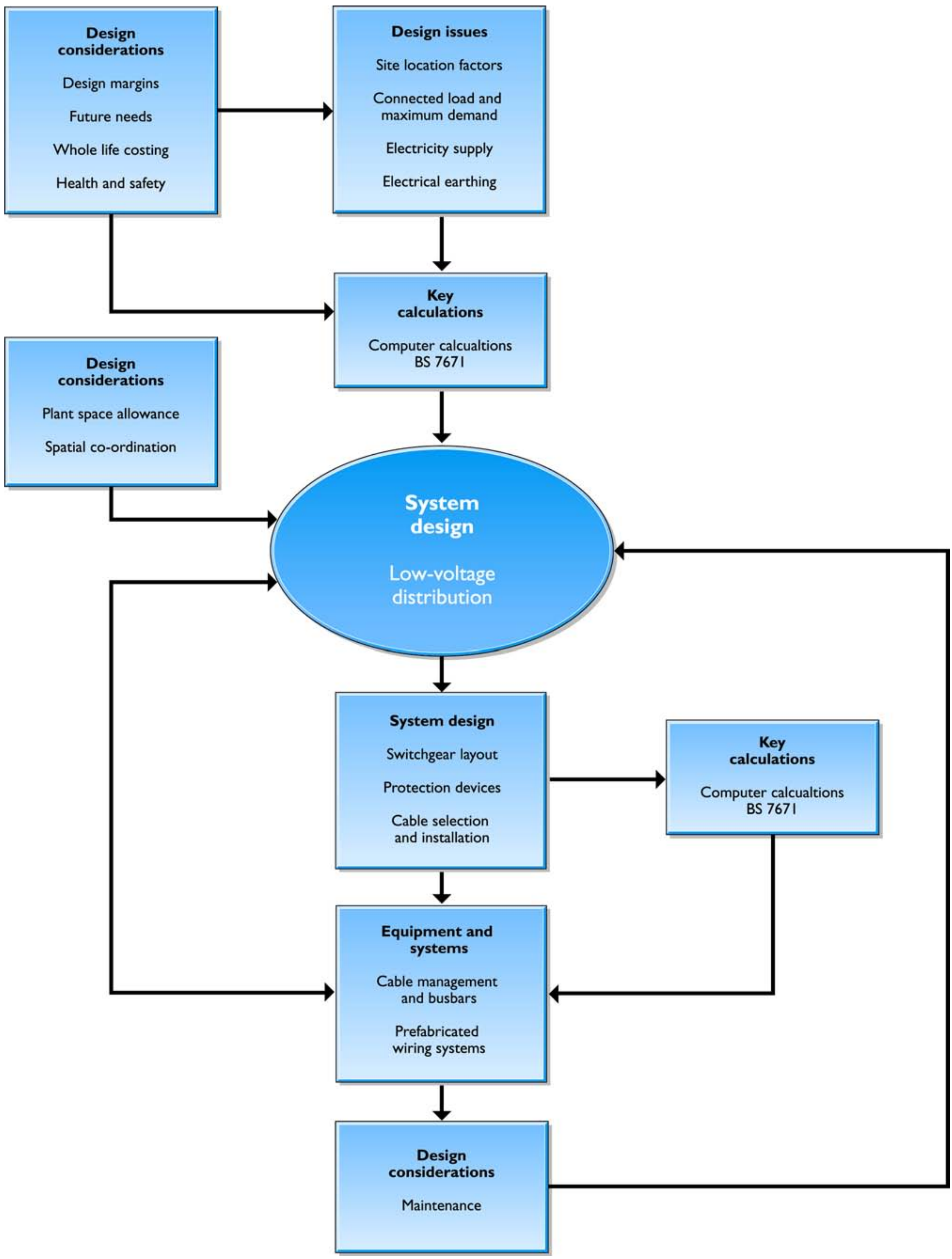
OVERVIEW OF DESIGN GUIDE SECTIONS

Example of guide use for a low-voltage distribution system, showing relevant topics



DESIGN CONSIDERATIONS

1 DESIGN MARGINS

Project title .... **Project No** .... **Design stage** ....

Engineer .... **Revision No** .... **Date** ....

Checked by .... **Approved by** .... **Date** ....

Design information	✓	Notes / Design file cross-reference
• The client brief, including future needs requirements and any specific requirements for system or plant duplication or critical systems	❑	
• Details of building and space use	❑	

Design outputs	✓	Notes / Design file cross-reference
• Overall design margin policy and design reviews	❑	
• A clear identification in the design file of any margins used within design calculations, together with a written justification for their use	❑	
• A clear statement of operating limits of the design for the client	❑	

Key design checks	✓	Notes / Design file cross-reference
• Agree the policy on design margins with the client	❑	
• Avoid possible double counting and remove excess margins	❑	
• At the design review stage, review the appropriateness of any design margins used	❑	

Project specific checks and notes	✓	Notes / Design file cross-reference
	❑	
	❑	
	❑	

1 DESIGN MARGINS

Why consider this?

- Avoidance of unnecessary oversizing of plant and systems
- Client's future needs
- Equipment selection
- Plant space allowance
- Avoidance of redesign and extension of programme

Design information

- The client brief, including future needs requirements and any specific requirements for system or plant duplication or critical systems
- Details of building and space use

See also: Future Needs, Plant Space Allowance, Space Planning

Design outputs

- Overall design margin policy and design reviews
- A clear identification in the design file of any margins used within design calculations, together with a written justification for their use
- A clear statement of operating limits of the design for the client

Key design checks

- Agree the policy on design margins with the client
- Avoid possible double counting and remove excess margins
- At the design review stage, review the appropriateness of any design margins

DESIGN WATCHPOINTS

General watchpoints

1. In the design file, clearly identify and justify the use of all margins added during the design process.
2. Reduce the need for margins where possible.
3. Provide the client with a clear statement of operating limits of the design to ensure that the client is aware of, and satisfied with, the anticipated performance of the system.
4. Inform the client of the anticipated performance of the system.
5. Clarify with the client the required level of system reliability. Consider that systems and services may benefit from enhanced design margins.
6. At the end of a calculation procedure, review all margins used to avoid possible double counting and remove excess margins.
7. At the design review stage, review the appropriateness of any design margins used.
8. Design margins can be added for legitimate operational reasons and these should be clearly identified.
9. Margins are sometimes added to allow for design or installation uncertainties and missing design information. Uncertainties or assumptions should be clearly flagged and reviewed when correct information is available. Reduce uncertainties in the design as much as possible by clarifying the brief.
10. Designers should always ensure that their reasonable design margins are retained when considering value engineering and cost-saving alternatives.
11. Consider that the use of a schematic will assist in justifying the scheme design and in identifying the application of design margins.

Installation, operation and control

12. If space has been allowed for the future extension of equipment, check that the equipment will be correctly positioned for this growth.
13. Check margins for plant are duplicated throughout the system, for example if a transformer has 25% spare capacity, check that the main busbars also have 25% spare capacity.

Economics

14. Agree the margins policy with the client as part of a value engineering strategy.
15. Sizing systems and equipment initially for anticipated future expansion can result in lower operating efficiencies and increased running costs.
16. Allow space for future plant items.
17. Where a known margin is to be applied to a system to cater for future expansion, consider selecting plant and equipment that can provide a variable supply, such as variable speed motors.
18. Applying margins to a system can lead to increased installation costs as well as increased capital costs.

17 CABLE SELECTION AND INSTALLATION

Project title.. **Project No.**........................ **Design stage**..................

Engineer.. **Revision No**........................ **Date**..................

Checked by.. **Approved by**........................ **Date**..................

Design inputs

- Maximum continuous current rating ❑
- Voltage drop in the circuit ❑
- Maximum circuit impedance for operation of short-circuit and earth-fault protection devices ❑
- Appraisal of component options ❑

Notes / Design file cross-reference

Design outputs

- Cable types selected ❑
- Cross-sectional areas of cables ❑
- Specified method(s) for connection ❑

Notes / Design file cross-reference

Key design checks

- Check that the cables will be sized and installed in accordance with *BS 7671:2001* ❑
- Check that the most appropriate type of cable has been selected ❑
- State the source of information where the sizing of cable systems is not described in *BS 7671* for example the sizing of cables for high voltage systems ❑

Notes / Design file cross-reference

Project specific checks and notes

❑

❑

❑

Notes / Design file cross-reference

17 CABLE SELECTION AND INSTALLATION

Design inputs

- Maximum continuous current rating
- Voltage drop in the circuit
- Maximum circuit impedance for operation of short-circuit and earth-fault protection devices
- Appraisal of component options

Design information

- Intended cable routes
- Environmental conditions
- Requirement for maintaining cable integrity during fire conditions

See also: LV Distribution, Cable Containment and Busbars, Prefabricated Wiring Systems

Design outputs

- Cable types selected
- Cross-sectional areas of cables
- Specified method(s) for connection

Key design checks

- Check that the cables will be sized and installed in accordance with *BS 7671:2001*
- Check that the most appropriate type of cable has been selected
- State the source of information where the sizing of cable systems is not described in *BS 7671* for example the sizing of cables for high voltage systems

DESIGN WATCHPOINTS

Sizing and selection

1. Check that the cables will be sized and installed in accordance with *BS 7671:2001*.
2. Check that the correct cable identification colours will be used (see *BS 7671*). Note that compulsory harmonised colours came into effect in April 2006.
3. Consider external influences when sizing and selecting cables. These influences include: ambient temperature, presence of thermal insulation, water/high humidity, corrosive or polluting substances, impact, vibration and other mechanical stresses, flora/mould growth, fauna, solar/UV radiation, structural movement.
4. Check that the most appropriate type of cable is selected. Check whether cables are required to continue to operate in the event of a fire. Consult with the fire or building control officer with regard to any particular requirements.
5. Check that armoured cable will be used for underground installations.
6. Check with reference to *BS 6360* that the class type is appropriate for the cable cross-sectional area.
7. Check that the cable cross-sectional area selected is actually available for the chosen type of cable.
8. Check that the correct code is used when specifying cables.
9. Check that the proposed method of cable installation matches the calculation assumptions in the original design.

Installation, operation and control

10. Select an appropriate means of connection (between conductors and equipment) taking into account:
    - conductor material and its insulation
    - number and shape of wires forming the conductor
    - cross-sectional area of the conductor
    - number of conductors to be connected together
    - terminal temperature under normal conditions
    - mechanical stress, vibration, and thermal cycling likely to be experienced.
11. Check that the manufacturer's quoted minimum bending radii will be adhered to.
12. Check that cables are straight when they enter switchboards.
13. Check that terminations are appropriate for the type of cable and equipment. Check that terminations will be installed correctly.
14. Consider fitting shrouds to cable glands especially for outdoor installations.
15. Eliminate cable jointing where possible. Check that the selected method of jointing is appropriate for the type of cable.
16. Check that the fire integrity of the building is not compromised.

Access and maintenance

17. Check that connection boxes will be accessible so that connections can be inspected and tightened if necessary.
18. Check that underground joints will be adequately protected.