

**TESTING & COMMISSIONING
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6 Testing and Commissioning

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BIM DIGITAL PLAN OF WORK 2013

Stage checklist

- *Key processes:* Commissioning services
 - Commissioning documentation
 - Quality management and control
- *Key objective:* 'Is it performing as designed?'
- *Key deliverables:* Commissioning documentation
- *Key resources:* Client team
 - Project manager
 - Design team
 - CDM coordinator
 - Constructor team
 - Commissioning team

Stage processes and outcomes

Part of the construction stage, this stage confirms that the building services systems have been installed in compliance with the design, have been fully tested and have been proven to be fully functional.

Outcomes:

- Commissioning strategy and schedule
- Commissioning outcomes in accordance with contractual requirements
- O&M manuals
- Certifications and warranties
- Records of testing and witnessing
- Training of client staff
- Update Health and Safety Plan and File
- Performance certificates

It must be stressed that the sequencing of this stage does not mean that the activities involved only take place at the end of the construction stage. Commissioning is a very important part of the construction process and must be addressed and considered very early on within the project. The following are suggested activities that must be considered well before this stage:

- Decide the most appropriate time within the project to appoint the commissioning contractor and their role/scope of work.
- Where appropriate, appoint a commissioning contractor to review the design drawings and working drawings to ensure commissionability.
- Ensure consultants clearly identify testing and commissioning requirements.
- Ensure consultants/client identify performance/environmental testing requirements.
- Ensure that the master development schedule includes sufficient time to undertake the specified commissioning and, in particular, the additional time required for any performance/environmental testing and statutory testing to authorities.
- Clearly identify the method of presenting, recording and electronically storing installed information.
- Although not strictly part of commissioning, ensure that the requirement for specialist maintenance contracts for equipment is carefully considered prior to awarding tenders for such equipment.

Project manager's duties and responsibilities

The project manager's objective is to ensure that the commissioning of the separate systems is properly planned and executed, so that the installation as a whole is fully operational at handover without delay to the programme and that any fine-tuning necessary after handover is carried out in liaison with the client and/or user.

Commissioning generally

Commissioning is carried out in four or sometimes five distinct parts:

- static testing of services

- dynamic testing of services
- performance testing of services (not always undertaken)
- undertaking statutory tests for various authorities
- client commissioning

Note that performance testing also includes environmental testing. The first four items, services testing, commissioning, performance testing and statutory tests, are part of the construction design and installation phases of the project. Client commissioning is an activity predominantly carried out by the client's personnel assisted, where required, by the consultants. This is dealt with in Stage 7. The services testing and commissioning process objectives and main tasks are as described within this chapter.

Procurement of commissioning services

Smaller projects

There are many ways to procure the commissioning specialist. On smaller projects, via the main contractor, the mechanical and electrical subcontractors are most likely to be responsible for the testing and commissioning of their installations. Electrical contractors will normally use their own resources, except where specialist items of equipment require the manufacturer to assist with their testing. Mechanical contractors will usually appoint a commissioning specialist to work on their behalf.

Again, where specialist items of equipment are installed, the mechanical contractor will request the manufacturer to assist with testing where appropriate. However, it should be noted that often these commissioning specialists are no more than balancing engineers. Where more complicated systems are involved or specific commissioning and performance tests are required, specialist inputs will be required.

Careful specification of the requirements within the design documentation is required when tendering the installation work. This is all too often ignored or given insufficient time and effort which inevitably creates problems later in the construction process.

Larger projects

On larger projects, the method of procuring the commissioning specialist can take many forms. In traditional forms of contract, it can again be via the main contractor/ services contractor; however, in construction management or similar forms of contract, a specialist commissioning contractor is often appointed. This commissioning contractor normally fulfils one of two roles: the role of managing the testing and commissioning process (the actual work being done by the installation contractors as detailed for small projects above), or the role of undertaking the commissioning work. In this latter role, the point of delineation for testing/commissioning between the installation contractor and the commissioning contractor is usually at the end of static testing and the start of dynamic testing.

See the following for a definition of these terms. This latter role is gaining in popularity for the following reasons:

- It provides a degree of independence to the commissioning process.
- The commissioning contractor is likely to be under the control of the client/construction

manager/main contractor and reports directly to them, giving greater control and transparency to the process.

In either role, the benefit to the project is that the commissioning contractor can be brought into the project very early to manage the whole testing and commissioning process.

Role of the commissioning contractor

What follows are some of the activities that can be included within the scope of work for the commissioning contractor:

- Review the design drawings near the end of design to ensure familiarity with the design intent and to add their expertise in to the commissionability of a scheme.
- Ensure that the testing and commissioning is correctly specified in the tender documentation.
- Review the services contractor's working drawings for commissionability.
- Set up the testing and commissioning documentation to create consistency between the various contractors.
- Define the method, media type, style and content of the as-installed information to create consistency between the various contractors.
- Manage the specialist equipment manufacturers' tests.
- Liaise with building control and other organisations to witness relevant statutory tests (including insurer's tests).

All of these functions are often given insufficient thought on projects, so if they are not to form part of the commissioning contractor's brief, then it should be recognised that some other part of the project team should undertake this work.

The testing and commissioning process and its programming

Flowcharts relating to the various stages of testing, commissioning and performance testing are given in Figure 6.1 and Figure 6.2. It is important for the project manager to understand the differences between the terms testing, commissioning and performance testing, and for him to ensure that the programme has sufficient time within it to enable these activities to be undertaken. Unfortunately, with this stage of the project being so close to handover, there is often pressure to gain time by shortening the testing, commissioning and performance/environmental testing schedule. This should be strongly resisted. Rarely, if ever, after the project will such an opportunity exist to fully test the services to ensure that they work individually, as a system, and, that they work under part-load and full-load conditions. Many issues with respect to the underperformance of services within an occupied building can be related back to either insufficient quality in the testing and commissioning, or insufficient time to test and commission.

It should also be borne in mind that various statutory services will need to be demonstrated to building control (or the relevant government department if a Crown building) and insurers. Time should be allowed for within the programme since these activities are often taken as separate tests after the main commissioning has been undertaken.

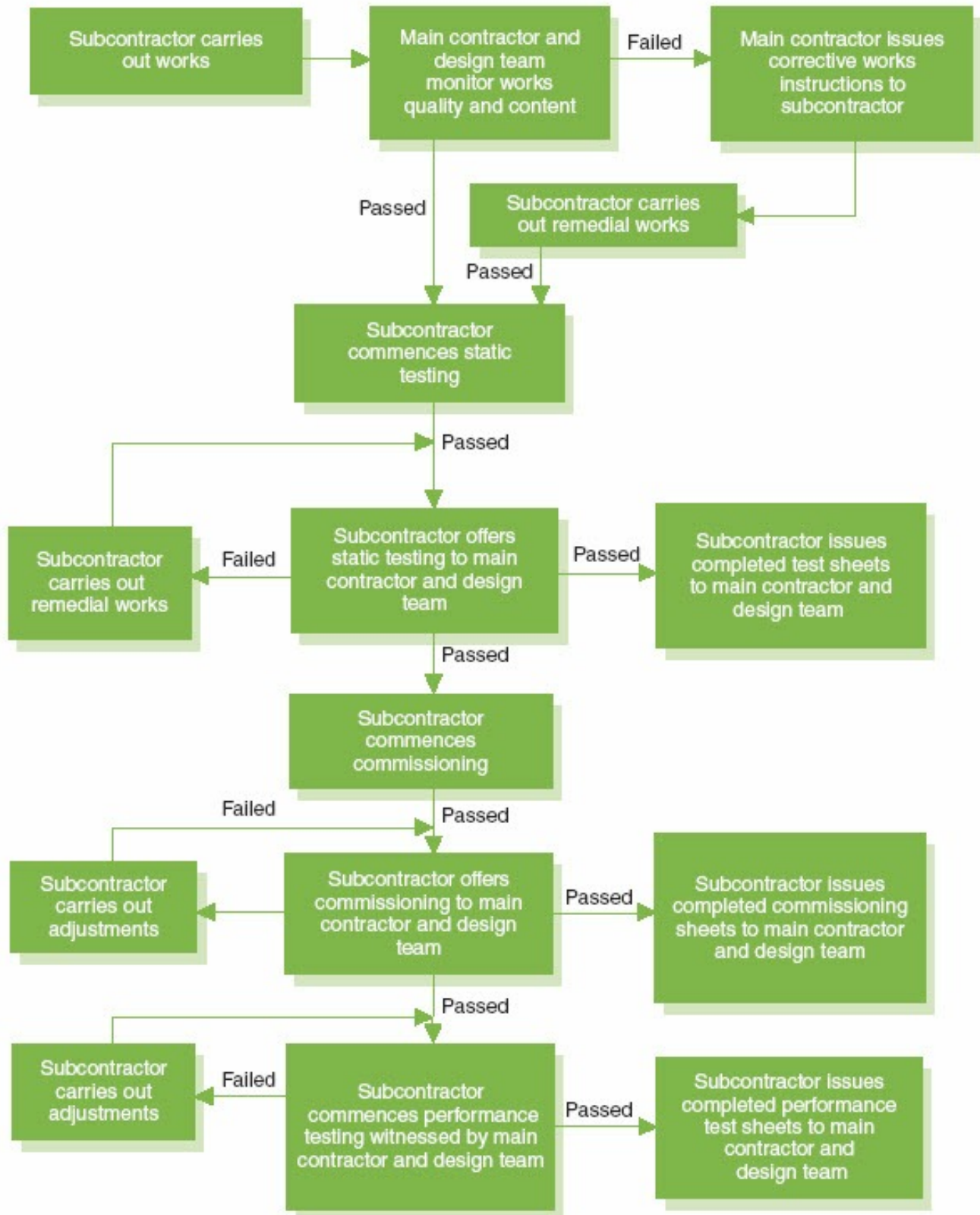


Figure 6.1 Small project installation testing and commissioning process and sign off

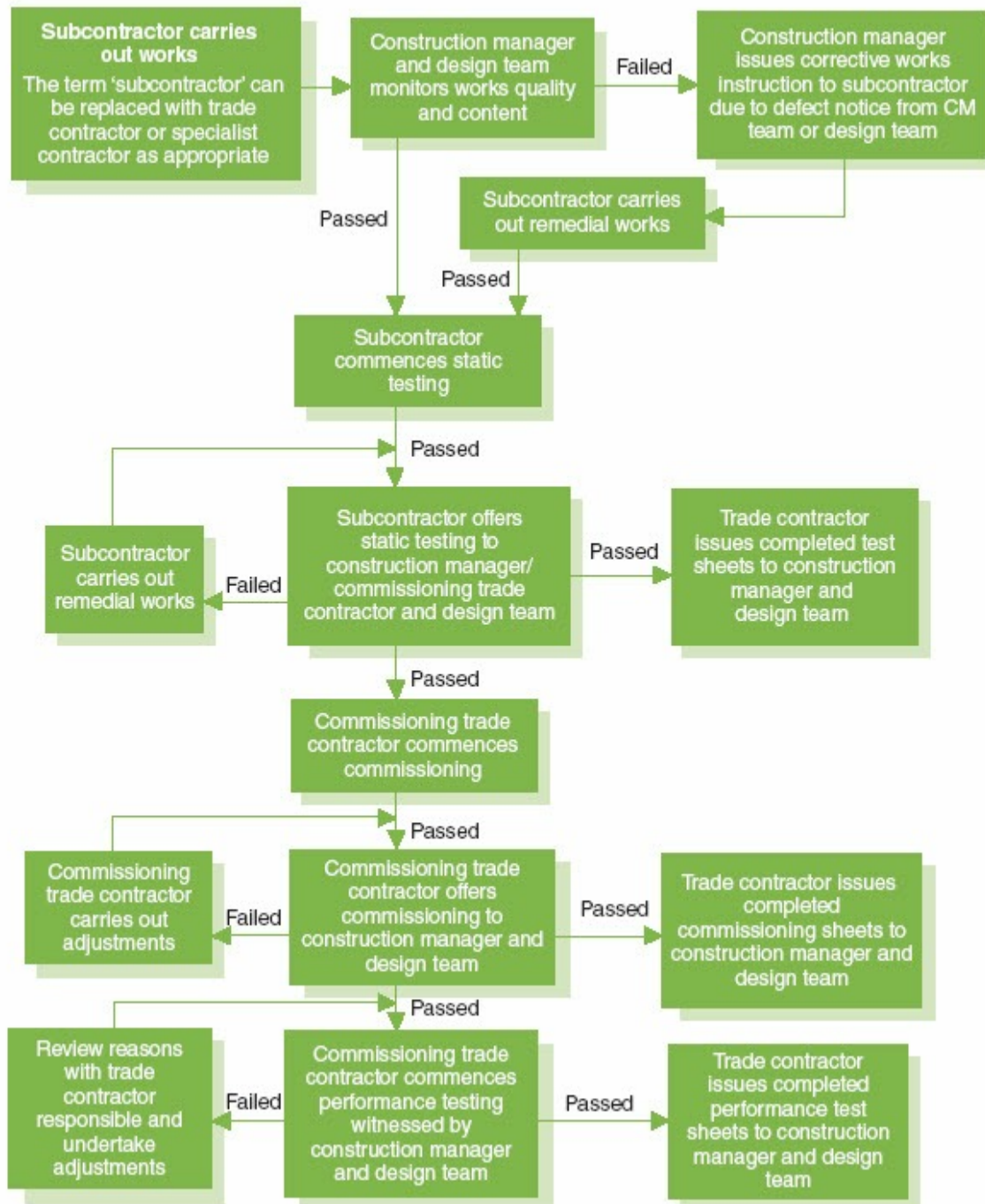


Figure 6.2 Large project installation testing and commissioning process and sign off

Differences between testing and commissioning

Testing

During the services installation, various testing will be undertaken known as 'static testing'. This testing is normally undertaken to prove the quality and workmanship of the installation. Such work is undertaken before a certificate is issued to 'liven' services whether electrically or otherwise.

Examples of systems tested are:

- pressure testing ductwork and pipe work
- undertaking resistance checks on cabling

Commissioning

On completion of the static testing, dynamic testing commences: this being the commissioning.

Commissioning is undertaken to prove that the systems operate and perform to the intended design and specification. This work is extensive and normally commences by issuing a certificate permitting the installation to be made live, that is, electrical power on. After initial tests of phase rotation on the electrical installation and checking fan/pump rotation (in the correct direction), the more recognised commissioning activities of balancing, volume testing, load bank testing and soon begin.

Performance testing

On completion of the commissioning, performance testing can commence. Some may not distinguish between commissioning and performance testing. However, for the purposes of the master development schedule, it is worth distinguishing the difference between commissioning plant as individual systems and undertaking tests of all plant systems together, known as performance testing (and including environmental testing). Sometimes this performance testing is undertaken once the client has occupied the facility, for example, for the first year because systems depend on different weather conditions. In such cases, arrangements for contractor access after handover to fine-tune the services in response to changing demands must be made.

However, for some facilities it is desirable, if not essential, to simulate the various conditions expected to prove that the plant systems and controls operate prior to handover, for example, in the case of computer server rooms.

Main tasks to be undertaken

To assist the project manager, the following has been provided to summarise the main tasks to be carried out during the three main stages of pre-construction, construction and post-construction.

Pre-construction

The following items will need to be confirmed:

- The consultants/client recognises engineering services commissioning as a distinct phase in the construction process which has an important interface with client commissioning.
- The relevant consultants identify all services to be commissioned and define the responsibility split for commissioning between designers, contractor, manufacturer and client. Responsibility for specialised plant/services is defined early, particularly wear and tear and the cost of consumables, fuel, power, water, etc.
- The services designers, and commissioning contractor if relevant, audit the final layout drawings to ensure that they make provision for the systems to be commissioned in accordance with the relevant codes of practice.
- The consultants/client, and commissioning contractor if relevant, identify all required statutory and insurance approvals relating to services commissioning, and see that plans are made for meeting requirements and obtaining the approvals (see Stage 7).

- That the client understands the importance of the presence of the client' own maintenance/engineering department/maintenance contractor during the commissioning process
- That the client considers whether an aftercare engineer needs to be appointed to support the client/user in the first 6–2 months of occupancy.
- There is a schedule showing the timescale and sequence of commissioning and testing and handover events, system by system. This is essential.
- There should be a person nominated by the client to act on behalf of the client in terms of commissioning activities, who should be a member of the client' team as defined in Stage 7 –Completion, Handover and Operation. This does not preclude more than one person having the benefit of witnessing the commissioning process.

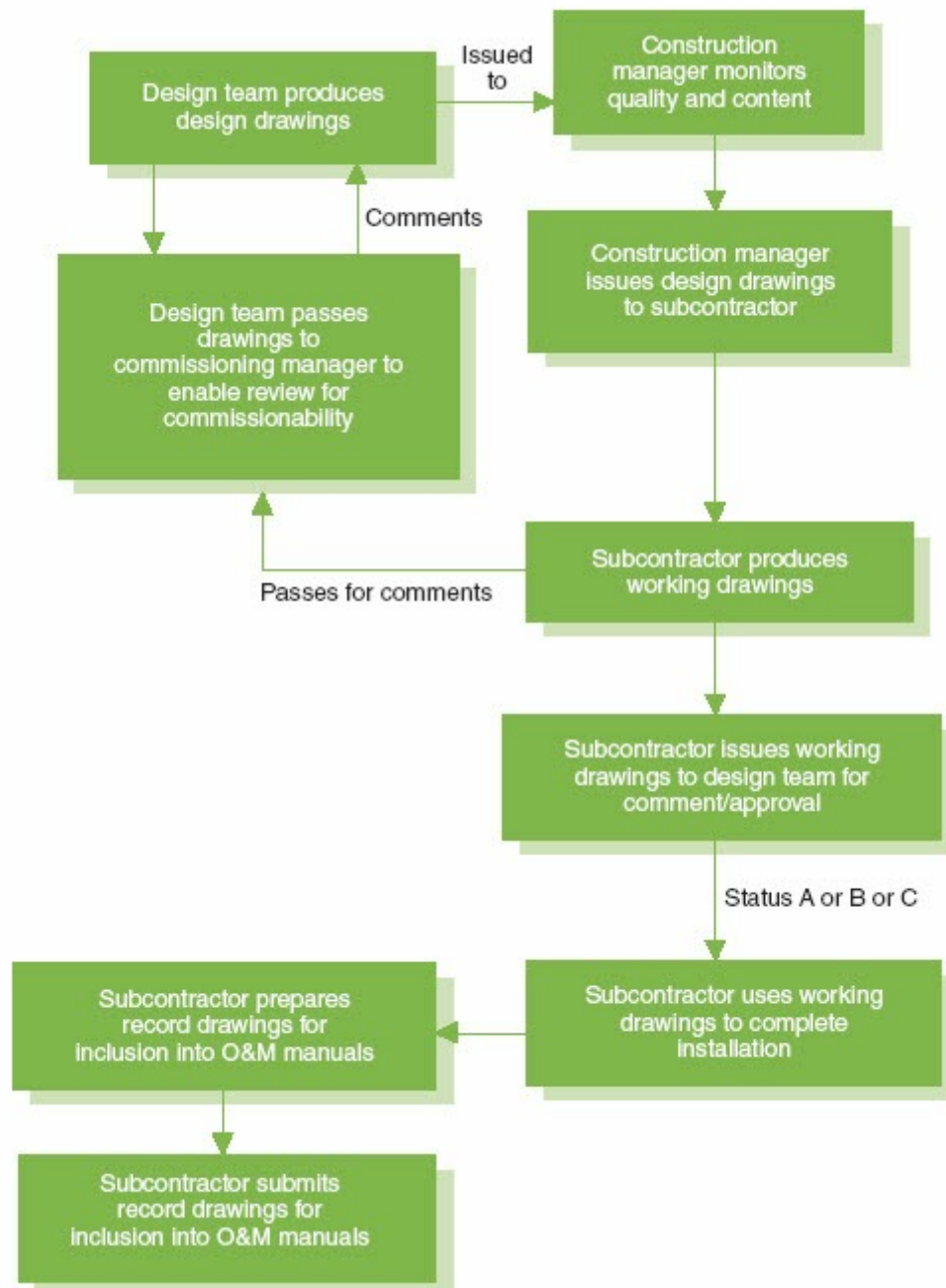


Figure 6.3 Project drawing issue flowchart

- The contract documents *must* make adequate provision for testing, commissioning and performance testing. Confirmation on warranties, defects period, environmental testing at this stage will set out what level of commissioning is required and ensure that responsibility for plant and systems is still with the contractor during an extended commissioning period (see Stage 7) (Figure 6.3).

Construction and post-construction

- The consultants must inspect the work for which they have design responsibility, and report on progress and compliance with contract provisions, highlighting any corrective action necessary. A commissioning management specialist may be appointed to carry out much of this work.
- There must be confirmation that all the contractor's working schedules include commissioning activities and that they are properly related to preceding construction activities. Activities must be complete, timings reasonable and compatible with planned handover, and properly related to preceding activities.
- Coordination of the consultants' arrangements is required for client involvement in, or observation of, contractor's commissioning against contract arrangements.
- Monitoring and reporting progress of commissioning will be carried out to ensure that activities start as scheduled and that the requirements for completion before handover are met. Corrective action will have to be initiated as necessary. It is important that commissioning activity durations do not become eroded due to late or incomplete construction work.
- All completed construction documents should be in place before commissioning an individual system commences, for example, cleaning out, testing the electrical power and controls to it. Also, the requirements of permits to work and health and safety should be met; and responsibility for insurance should be clearly defined.
- Statutory/insurance tests should be arranged and undertaken, witnessed by the relevant authority, for example, building control, utility companies, fire brigade, insurers, etc.
- Commissioning records, for example, test results, calibration requirements, certificates and checklists must be properly maintained and copies bound into the operating and maintenance manuals or in separate commissioning manuals to form part of the official handover documentation.
- Operating and maintenance manuals, as-installed record drawings and the client's staff training have to be provided by the contractor as required under the contract, although it is recommended that these are fully coordinated by others, for example, the commissioning contractor, if appointed.
- Adopting agreed structure and software for operating and maintenance manuals with copy disks provided for ease of updating.
- Record drawings being provided in a computer-aided drawing format for ease of updating.
- Using video recordings during client-training sessions for subsequent repeat visual reference and to assist new maintenance staff advance along the learning curve (Figure 6.4 and Figure 6.5).

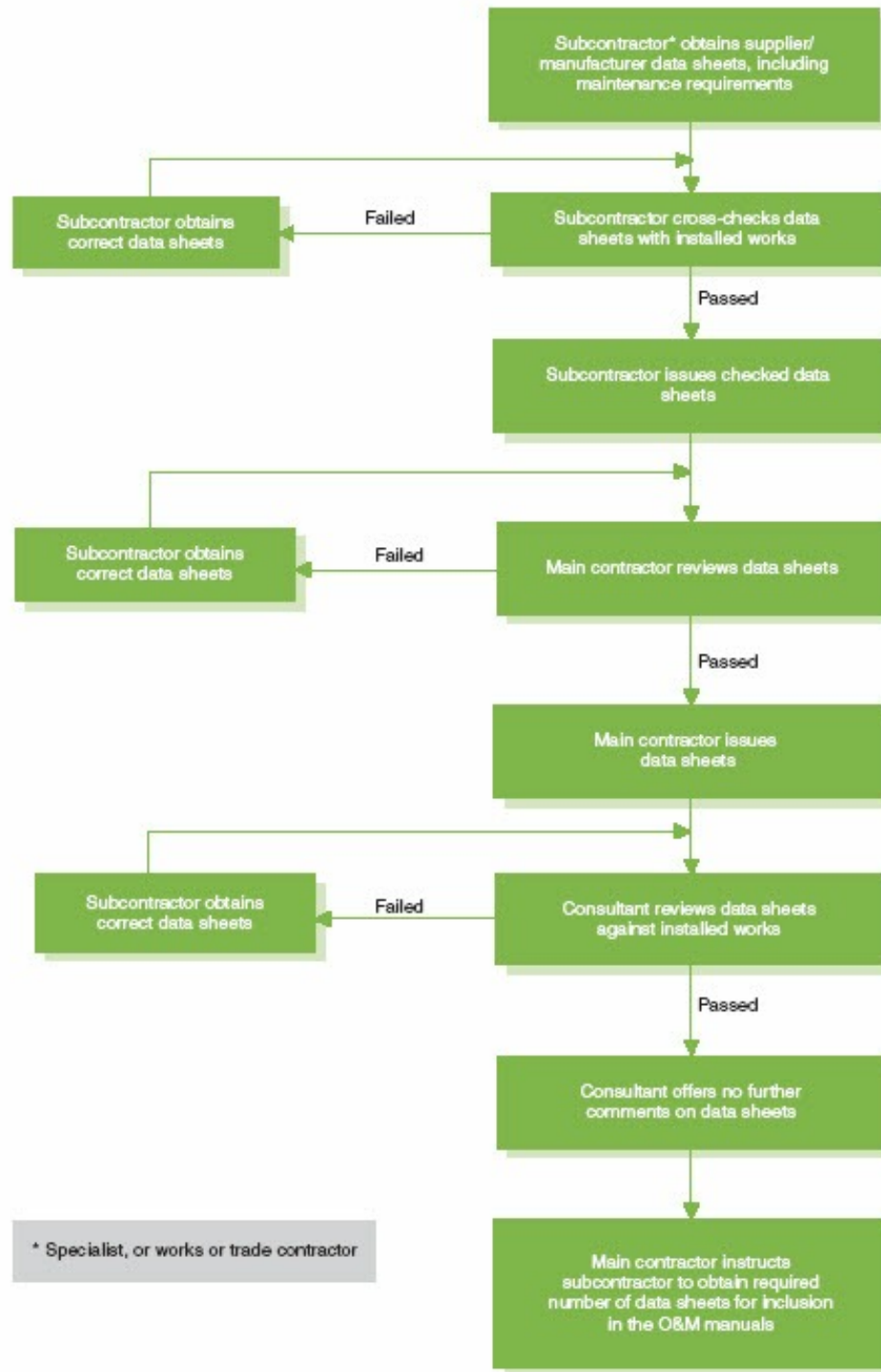


Figure 6.4 Services installation, testing and commissioning data sheets flowchart



Figure 6.5 Specialist maintenance contracts flowchart

Seasonal commissioning

Seasonal commissioning involves re-commissioning heating systems in winter and mechanical cooling systems in summer. But seasonal commissioning may also be applied to other systems, such as motorised windows and active solar-shading devices –or indeed any other any building system affected by seasonal changes. Ideally, the original project team (or independent commissioning engineer, if appointed) should remain engaged to perform the seasonal commissioning.

Many environmental assessment schemes award credits for the adoption of seasonal commissioning. However, in practice, sometimes it may be difficult to distinguish seasonal commissioning activities from continuous commissioning, or activities that were following on after handover due to programme, logistics or contractual issues.

Commissioning documentation

O&M manual (building owner's manual)

The building owner's manual, or operation and maintenance manual (O&M manual), contains the information required for the operation, maintenance, decommissioning and demolition of a building.

The building owner's manual is prepared by the contractor with additional information from the designers, suppliers and the CDM coordinator. It is a requirement that is generally defined in the preliminaries section of the tender documentation where its contents will typically be outlined, although there may be additional requirements regarding mechanical, electrical and any other associated services in the mechanical and electrical specification.

A draft version of the document should be provided for the client/project manager as part of the handover procedure prior to certifying practical completion. The final document is not usually available in full form until after practical completion, as commissioning information often needs to include summer and winter readings taken in the fully occupied building. The preliminaries may require several copies of the building owner's manual and might often require an electronic version.

The building owner's manual might include:

- A description of the main design principles.
- Details of the building's construction (such as finishes, cladding, doors and windows, roof construction, and so on).
- As-built drawings and specifications.
- Instructions for its operation and maintenance (including health and safety information and manufacturers' instructions for efficient and proper operation).
- An asset registers of plant and equipment.
- Commissioning and testing results.
- Guarantees, warranties and certificates.
- Particular requirements for demolition, decommissioning and disposal.

Much of this information will already exist in one form or another, so preparing the building owner's manual might simply be a matter of compiling and assembling its components.

Over the life of the buildings, the building owner's manual may be developed to reflect changes that take place to the fabric of the building or its systems, along with details of maintenance that has taken place.

The building owner's manual is different from the health and safety file which only needs to include information important to health and safety and does not need to include information about the construction process, contractual information or information about the normal operation of the completed structure (see Managing

health and safety in construction: Construction (Design and Management) Regulations 2007 Approved Code of Practice page 60).

The building owner's manual may also include a non-technical building user's guide with information for users about environmental controls, access, security and safety systems, etc., and record any training provided to the building users and the facilities management team for operating and maintaining these functionalities.

As-built documentation

'As-built documentation' is a fundamental part of the Works Contract, without these documents the Contract will not be deemed as complete. An advance copy of the 'As-built documentation' is submitted to the project manager prior to the proposed completion of the works. The project manager will appraise the submission (typically through the designers) and return the copy to the contractor together with any comments.

The contractor shall ensure that the comments submitted by the project manager are incorporated into the final 'As-built documentation'.

The as-built documentation, which will include the as built drawings and material data sheets, is often incorporated within the building owner's manual. If there have been specification changes during the project, then the as-built specifications including material data sheets are also recorded within this section.

As-built Information will include:

- civil engineering works including below ground drainage, substructure and foundation works
- structural information
- architectural information
- building services information
- specialist design and installation information

Health and safety file

The Construction (Design and Management) Regulations (CDM regulations) require that the CDM coordinator *'prepare, where none exists, and otherwise review and update a record ("the health and safety file") containing information relating to the project which is likely to be needed during any subsequent construction work to ensure the health and safety of any person, including the information provided in pursuance of regulations 17(1), 18(2) and 22(1)(j)'* and that at the end of the construction phase, they pass the health and safety file to the client.

The health and safety file need only include information important to enable future construction work including cleaning, maintenance, refurbishment, alterations and eventual demolition safety. If it contains all information about the building then genuinely important safety issues may simply be overlooked. It does not need to include information about the construction process (which may be included in the construction phase plan), unless it may affect future works. It does not need to include contractual information or information about the normal operation of the completed structure (which may be included in the building owner's manual).

The health and safety file may contain:

- a description of the project

- a description of any residual hazards that should be managed
- the structural principles of the design
- identification of any hazardous materials used
- procedures for the removal or dismantling of installed plant and equipment
- information about cleaning and maintenance equipment
- a description of significant services and their location
- information and as-built drawings of the structure, plant and equipment

The health and safety file must be kept up to date and is normally kept for the lifetime of the building, meaning that it should be passed on to the new owners if the building is sold, and the new owners should be informed of its purpose and importance.

There are no restrictions to the format that it has to be kept in, but it would be wise to ensure it is backed up. To be useful, the health and safety file has to be kept up to date.

If the building or part of it is leased, then the health and safety file must be made available to the leaseholder. If there are multiple leaseholders, then those parts of the health and safety file relevant to the part of the building leased by each leaseholder must be made available to them. In multi-occupancy situations, for example, where a housing association owns a block of flats, the owner should keep and maintain the file, but ensure that individual flat occupiers are supplied with health and safety information concerning their home.

Occupier's handbook

The purpose of this handbook is to:

- outline the services that the building occupiers can expect relative to health and safety and welfare
- highlight those areas where occupier cooperation is required by the property owner and/or their facilities managers relative to health and safety and welfare issues
- outline the minimum health and safety and welfare standards that are expected of the occupiers to observe
- provide guidance to occupiers on measures that can be taken to safeguard property, by the proper control of contractors
- provide general information regarding the insurances arranged by the property owner and the procedures for reporting any loss, damage, accident or other incidents

BIM strategy

Building services can represent more than 30% of a project's capital cost. Therefore, the design, integration and coordination of the services package with the structural and architectural elements of the design is a critical success factor. The BIM platform will have been used to integrate the services design into the project, with attached data sets including performance and technical data, and any maintenance and operations information. Using the Soft Landings process or similar, planning for handover and commissioning should begin at the latest mid way through the construction period.