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CHAPTER 42

Planning and building storage facilities

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SUMMARY

This chapter describes methods for developing effective storage facilities, a process in which supply system managers play a key role.

Storage facilities are of three basic types—

- Mechanized warehouses rely on the use of mechanical handling equipment. They are appropriate where most goods are stored in bulk on pallets.
- Manual warehouses are appropriate where goods are stored in smaller quantities, mostly on shelves.
- Storerooms are fitted with shelves, refrigerators, and a secure cupboard or safe. Every facility needs a location where medicines and medical supplies can be stored safely.

Satisfactory storage accommodation may be obtained by reorganization or renovation of an existing facility, lease or purchase of a commercial warehouse, or putting in a new building. A new building may involve ground-up construction or the erection of a prefabricated building that is purchased and assembled on the preferred site. Most of the chapter focuses on managing traditional construction.

There are six stages in the procurement and construction process—

1. *Inception*: conducting a needs assessment; setting up a project team; appointing consultants
2. *Feasibility*: carrying out a feasibility study; obtaining a budget allocation
3. *Site selection and acquisition*: selecting a site or building; obtaining the site or building
4. *Design*: preparing a detailed design brief; selecting storage methods and choosing materials-handling equipment; planning space; designing the building
5. *Tender and project planning*: selecting a procurement method; drawing up a contract; conducting the tender process; planning the project
6. *Construction and commissioning*: managing the construction contract; commissioning the facility

Following procurement and construction, building and equipment maintenance adds an ongoing stage to the process.

42.1 Types of storage facilities

Well-located, well-built, well-organized, and secure storage facilities are an essential component of a pharmaceutical supply system. An effective building provides the correct environment for the storage of medicines and commodities and assists the efficient flow of supplies. Storage facilities designed with these factors in mind will help maintain pharmaceutical quality and reduce operational costs. Storage facilities fall into three categories: mechanized warehouses, manual warehouses, and storerooms.

Mechanized warehouses are designed around modern methods of storage and materials handling. A mechanized warehouse typically has tiers of pallet racks. Mechanical handling equipment is used to unload and store goods received and often to load outgoing goods onto delivery vehicles. Mechanized warehouses can range from very simple buildings using manually operated handling equipment and manually operated stock control systems to highly complex operations that are entirely automatic and computer controlled. Mechanized medical warehouses are most likely to be primary stores at the national or regional level. Typically, they are located close to major transport routes.

Manual warehouses may also hold some stock on floor pallets, but most items are stored on shelves and are moved without mechanical assistance. Medical supply warehouses at the regional or district level are usually manual ware-

houses. They are often attached to a hospital, which they also serve.

Storerooms are needed in every health facility to store medicines and medical supplies safely. The smallest facilities may need only a medicine cupboard, but most facilities require a room fitted with shelves and refrigerators, along with a secure cupboard or safe for controlled drugs.

This chapter provides guidelines to help managers make rational choices about designing and constructing warehouses. This material focuses on management of construction from the ground up. There are six stages in the process: inception, feasibility, site selection and acquisition, design, tender and project planning, and construction and commissioning (see Table 42-1). Following the planning and construction process is the continuing activity of building and equipment maintenance, which lasts throughout the life of the building.

In recent years, options have emerged for purchasing prefabricated warehouses and placing them at prepared sites rather than going through a new construction process (see Box 42-1).

This chapter is not a comprehensive technical manual and is not intended to be a substitute for the advice of a specialist. In most cases, specialist staff or outside consultants will be needed to deal with design and construction management issues. The day-to-day management of medical stores is covered in Chapter 44.

Table 42-1 Steps to plan and build a storage facility

Stages and tasks	Principal responsibility of—
Inception stage	
State the aim of the project (needs assessment)	Supply system
Establish the project team and appoint consultants	Supply system
Feasibility stage	
Identify quantity and type of storage space needed	Project team
Review options for reorganizing existing warehouse space	Project team
Consider leasing or purchasing an existing building	Project team
Determine whether a building is needed. If so—	Project team
• Establish operational requirements and prepare outline brief	Project team
• Assess financial, material, and personnel resources required	Project team
• Contact relevant authorities	Project team
• Survey regulatory requirements	Project team
• Assess availability of incentives	Project team
• Establish outline budget and obtain budget allocation	Project team
• Establish a program for the design and construction stages	Project team
Selection/acquisition of site stage	
Short-list and evaluate potential sites and buildings	Project team
Select and acquire site or building	Supply system
ESTABLISH FEASIBILITY AND PROCEED WITH DESIGN	
Design stage	
<i>Outline proposals</i>	
Develop design brief	Project team
Survey site or building	Project team
Prepare outline proposals showing main dimensions, allocation of space, and construction methods	Project team
Prepare cost estimates	Project team
Select suitable design	Project team
Obtain development consent	Project team
<i>Scheme design and detail design</i>	
Design each room and fix sizes	Project team
Determine needs for storage and handling equipment	Project team
Decide on construction method and all materials	Project team
Make new cost estimate	Project team
Prepare and agree on final design drawings	Project team
DESIGN SHOULD NOT BE CHANGED AFTER THIS POINT	
Production information	
Prepare production drawings, specifications, and bills of quantities, giving all information needed to construct the works	Project team
Select all fittings, fixtures, and equipment	Project team
Obtain approval from building regulations authority	Project team
Make final cost estimate	Project team
Tendering and project-planning stage	
Select method of building procurement	Project team/supply system
Prepare short list of contractors, or prequalification tender	Project team/supply system
Assemble tender documents and invite tenders	Project team/supply system
Analyze bids and select the best	Project team/third-party observer
Make any changes required for cost reasons	Project team/supply system
Agree on contractor's program and procedures	Contractor/project team
Finalize insurances and sign the contract	Contractor/supply system
Tender for and obtain mechanical handling equipment	Project team/supply system
CHANGES BEYOND THIS STAGE WILL COST EXTRA TIME AND MONEY	
Construction and commissioning stage	
<i>Site work</i>	
Supervise work on-site	Project team
Hold regular progress meetings with contractor	Contractor/project team
Prepare valuations and make interim payments	Contractor/project team/supply system
<i>Handover</i>	
Witness tests, inspect the works, and list defects	Contractor/project team
Hold handover meeting and accept keys and building manual	Contractor/project team/supply system
<i>Commissioning and defects period</i>	
Commission building	Supply system
Check that the defects have been rectified	Project team
Settle final account by releasing the retention sum	Contractor/project team/supply system

Source: Adapted from Mein and Jorgensen 1988.

42.2 Inception stage

From a consultant's standpoint, a good client (the supply system) should be knowledgeable and discerning. Most of the key decisions in a building project are made during the inception and feasibility stages, when client input is critical. These decisions fundamentally affect the cost and ultimate effectiveness of the project and should not be made casually. Particularly when resources are limited, careful feasibility planning is necessary to design and build effective warehouses at the lowest cost, while taking future needs into account.

The logistics team should assume responsibility for identifying the most suitable locations for medical stores throughout the country, based on an overall analysis of the distribution system (see Chapter 22). After an individual store location has been selected and outline zoning approval has been obtained from the relevant authorities, the detailed building procurement process can start. This process begins with a broad needs assessment, which guides the decision about whether to procure a prefabricated building or construct a new building and defines the critical operational parameters for the proposed building (see Box 42-2). This needs assessment will form the basis for developing the

detailed design brief in conjunction with the project team and technical consultants.

The project team

A project team should be formed as soon as the decision to obtain storage space has been made. A senior pharmaceutical program manager or health official should direct the team. Its composition varies, depending on the size of the project and the project stage. The full team for the implementation stages of a large project such as a new central medical store (CMS) normally includes the lead consultant (usually an architect or engineer), a client representative, the supply system representative, a cost consultant, a structural engineer, a mechanical services engineer, an electrical engineer, an information technology specialist, a quality assurance/regulatory consultant, and a logistics and materials-handling consultant.

A wide range of other people and organizations should be consulted. Broadly based consultation is essential to the development of an appropriate building design. Too often, a project design takes shape without adequate consultation between the people who are to work in the building and the specialists who are designing it.

Box 42-1 Installing a prefabricated warehouse

Prefabricated warehouses offer an alternative to conventional warehouse construction methods. Such warehouses are built using technologically advanced materials, which simplify structure assembly. The kit consists of pre-engineered and prefabricated warehouse modules (framework, panels, doors, and other requested sections) produced to technical specifications in a controlled environment. While the warehouse is being manufactured to the client's design, the concrete slab foundation is poured at the selected site according to predetermined specifications; the slab is the only element that is "constructed." Once the slab is completed and quality tested, the necessary building components are shipped to the site. The manufacturer's staff supervise and certify warehouse assembly. This approach can be used to install any size warehouse facility (central, provincial, district, or health center). The process generally takes three to six months whereas a conventional construction project can take up to thirty-six months.

Advantages of opting for a prefabricated warehouse include—

- There is no need for engineers or architects on site (lower costs).

- Materials are produced by the supplier according to technical specifications.
- The structure can be installed in any location regardless of availability of local construction expertise.
- There is no need for an extensive design process (faster timeline and lower costs).
- Modular design allows for easy extension.
- Having few conventional construction steps results in less material loss, lower risk of accidents, and fewer delays.
- Composite materials used for the walls and roof require less repainting and fewer roof repairs, dramatically reducing maintenance and operational costs.
- Materials provide high thermal insulation and class 1 fire resistance.
- The possibility of prequalified suppliers simplifies complex procurement procedures (construction tender process), thus shortening the procurement phase.
- The cost of installation can be 65 percent of conventional construction, and operations and maintenance costs may be halved.

Box 42-2 Conducting a needs assessment for site planning

The needs assessment should consider the following factors—

- Who will own the store—public or private sector?
- Who will operate the store—public or private sector?
- What is to be stored—types of medicines and supplies and approximate annual volumes?
- Who are the major suppliers?
- Who are the major customers?
- In what formats will goods be stored (pallets, cartons, or individual packs)?
- Will bulk packages be “broken” to fulfill individual customer orders?
- What type of materials-handling equipment is likely to be appropriate?
- What are the likely restock and distribution frequencies?
- What temperature and humidity controls will be needed within the store?
- How will goods be protected against fire and theft?
- Will stock control be manual or electronic?
- What are the intended operating hours for the store?
- How many administrators and manual workers will be needed on the staff?
- What facilities should be provided on-site to ensure staff welfare?
- How will staff members reach the site?
- Who will monitor the performance of the store and how will this be done?

Appointment of consultants

If the project is complex, suitably qualified consultants should be appointed at the earliest possible stage for estimating building design costs, cost control, construction site management, and logistics and materials handling. The roles and responsibilities of the consultants are very much dependent upon the chosen procurement route to be followed (see Section 42.6). If the project is small and simple, professional consultants may be appointed after the feasibility stage, when alternative sites or buildings are being considered.

Building design. Professional design assistance is essential to ensure that a building satisfies the design brief and is constructed in accordance with building codes. There are various ways of procuring a design service.

In the *conventional* model, a lead consultant directs the project team; typically this person is an architect, but he or she could be an engineer. The lead consultant is appointed by the client to prepare the design, specifications, and bills of quantities, in liaison with the engineering and cost consultants. In some countries, all other consultants work directly for the lead consultant, and the cost of their services is included in the lead consultant’s fee. In other countries, each consultant is appointed separately by the client.

After the contractor is hired, the lead consultant monitors the building work and certifies the payments to be made to the contractor. Finally, the lead consultant certifies when the building is complete and agrees on a final account with the contractor. The principal advantage of this model is that the lead consultant acts as the client’s agent throughout, which helps ensure that the finished building is completed to an acceptable standard.

In the *design-and-build* model, the client appoints an architect to prepare a design with an agreed-upon level of detail. The contracting company quotes a fixed price for building this design but is allowed to modify construction details to suit its own working methods. The architect has no executive authority on-site but may continue to act as an observer for the client.

In the *turnkey* model, the client hires a contracting company to provide a complete building product for a fixed price. The contracting company is responsible for appointing the design team, which prepares a scheme in accordance with a design brief that has been agreed upon with the client. A variation on this model is where the contractor supplies a prefabricated building to erect at a client’s preferred site. The building may include warehouse equipment and even information systems.

In the *public-private partnership* model, the client contracts out the entire building construction, building operation, and building maintenance process to a private consortium for an extensive time period; in essence, the client pays an annual fee and gets a building and complete pharmaceutical storage service in return. At the end of the contract period, ownership of the building reverts to the client. Preparation of a clear and legally binding contractual agreement is essential.

The principal advantage of the last three models is cost. The principal disadvantage is that quality control is largely in the hands of the contracting company, which has a vested interest in saving money and increasing its profit margin.

Cost control. The cost consultant prepares a preliminary cost estimate for the project. This estimate is updated as the design evolves. This consultant may also contribute to the assessment of contractors’ tenders, assist the architect in

negotiating any variations in the contract with the contractor, and audit the final account.

Logistics and materials handling. If the project is large and complex and involves extensive mechanical handling equipment, the advice of a specialist is needed at an early stage. Without this advice, an accurate design brief cannot be prepared, and expensive mistakes may be made. Some architects have the appropriate expertise. Alternatively, advice can be obtained from a materials-handling consultant or a supplier of materials-handling equipment.

The appointed consultants should have relevant experience, the resources to manage the project, and a proven ability to complete satisfactory buildings on time and within budget. The selection process should not allow corruption or favoritism; a formal tender helps minimize such problems. The client and project team should prepare a list of qualified firms and invite each to submit a formal proposal for consideration by the team. The proposal should set out the consultant's approach to the project and specify the fee to be charged. Before making a final decision, the project team should visit the offices of the short-listed consultants, view some of their completed projects, and talk to other clients.

42.3 Feasibility stage

The first task of the project team is to establish whether more space is really required. It may be more cost-effective to achieve the desired results by reducing the order interval, by reorganizing stock within existing buildings, or by contracting out for supply chain services. If the team decides that new construction is the preferred option, the feasibility study should establish the following—

- Type of store required
- Approximate size of the store and site
- Options for obtaining space
- Assessment of prefabrication versus new construction
- Regulatory requirements
- Potential development incentives
- Short list of possible sites or buildings for the store
- Staff recruitment and training implications
- Outline budget or cost plan, including an assessment of operational and maintenance costs
- Workplan for project completion
- Site selection and acquisition for new construction

Rebuilding from scratch or buying a prefabricated building may be more cost-effective than renovation. Although it may appear at first that renovating an existing building would save money, such “savings” are often offset by lost opportunities for improving efficiency. Chances are that if the current structure is not adequate, a renovation alone would not be the best solution.

Identify type of store required

A mechanized warehouse is required if a large percentage of products will be received and stored on pallets. This type of warehouse requires powered forklift trucks and other equipment capable of moving pallets within the store. Pallets may be stored on the floor (pallet standing/block stacking) or on pallet racks. Pallet standing—especially block stacking—can be very space efficient, but limits the ability to handle goods on a FIFO (first-in, first-out) or FEFO (first-expiry, first-out) basis. Pallet racking generally makes the most efficient use of space consistent with FIFO or FEFO handling. If pallet racking is chosen, the number of tiers determines the internal height of the store. This critical decision of how to design the pallet storage needs to be made at an early stage; it is dictated largely by the type of handling equipment used. A mechanized warehouse should not be considered unless an effective supply and service network exists for mechanical handling equipment. Preferably, several sources of such equipment should be available. If battery-powered mechanical handling equipment will be used, building space estimates will need to include a battery-recharging area.

A manual warehouse is appropriate if the majority of products will be received and stored in packages that can be moved around by hand or with the assistance of trolleys. A manual store may also require some floor pallets. If pallets are to be handled, manual pallet trucks will be needed to off-load them from the delivery vehicles and move them around the store. Most items in a manual warehouse are likely to be stored on shelving units with a top shelf not more than 1.7 meters high and with no package weighing more than 25 kilograms, which means that the internal height of the store is not a critical factor.

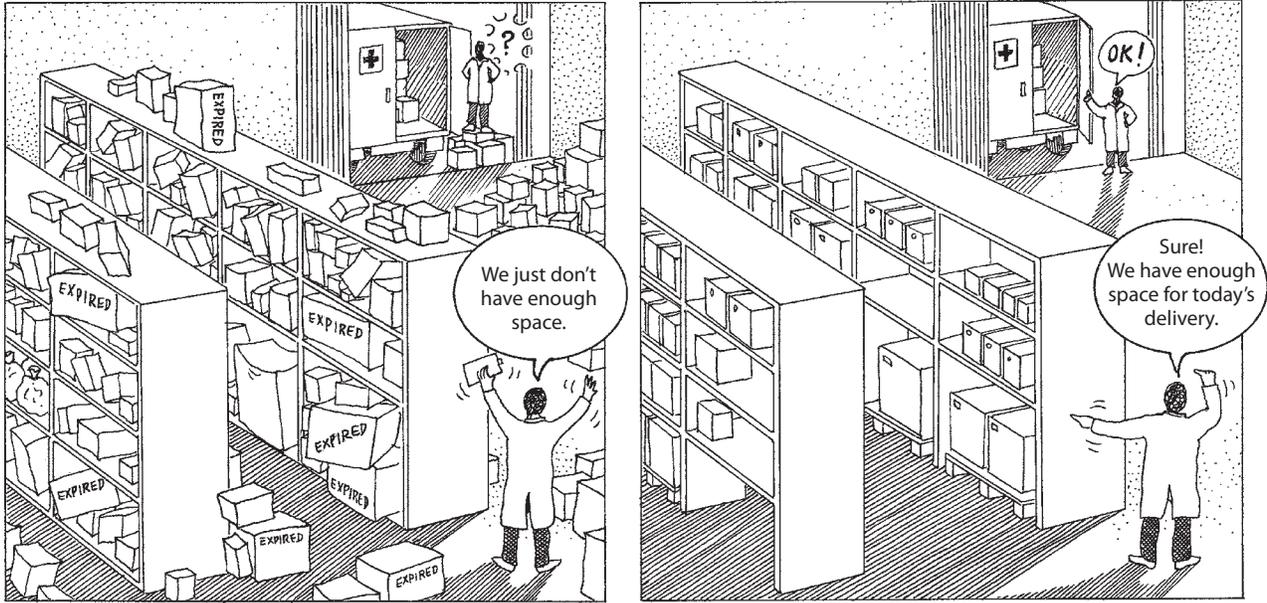
Establish approximate size of store and site

The final size of the warehouse and the detailed site layout are established during the design stage. It is essential, however, for the project team to establish approximate sizes during the feasibility stage for three reasons—

- To short-list suitable sites or buildings
- To establish a realistic design brief
- To prepare a budget estimate

Determining store size is complex, because the size of the store is affected by many factors. The most important factors are—

- The volume of individual items
- The maximum stock level for each item
- The way in which goods are stored (floor pallets, pallet racking, or shelves)



DE-JUNK OR EXPAND

- The efficiency of the inventory control and store-keeping systems
- The type of storage required (for example, climate control, refrigeration)
- Quarantine or isolation requirements
- Environmental regulatory and emergency response requirements
- Subdivision of the administrative facilities, if there are multiple users of the store

Stock volume can be estimated from calculations based on volume of past shipments, by analysis of shipping volumes for specific items, or by using item-by-item analysis.

Calculations based on the overall order value and volume of past shipments. If the total value and volume of a shipment are known, it is possible to calculate the value per cubic meter of mixed medicines and other medical supplies and to use this figure as a basis for store sizing. Adjustments may have to be made for inflation if the data are drawn from different periods. This method is most appropriate for calculating volumes at the CMS and other primary stores when a strict annual or periodic ordering system is used and the stock is “topped up” at known intervals.

Analysis of shipping volumes for specific items. For instance, 1 million aspirin, 300 mg, in tins of 1,000, in cartons, from a current supplier might occupy about 1.6 m³. A computer program (spreadsheet or database) can use this type of information for store sizing. This method is retrospective. It does not take account of differences in bulk for similar items from other sources.

Item-by-item analysis using average volumes taken from a range of suppliers. The WHO publication *How to*

Estimate Warehouse Space for Drugs (Battersby and Garnett 1993) provides a method for making an item-by-item analysis. This type of approach applies mainly to specialist areas, such as vaccine stores, where storage equipment costs (for example, cold rooms and freezer rooms) are high, and the risk of underestimating the specialized storage space has severe programmatic implications.

Whichever method of estimating stock volume is used, the store size and type are determined by—

- Maximum net volume of goods to be stored
- How goods are to be stored and handled (floor pallets, pallet racking, or shelving)
- Type of stock location system used (see Chapter 44)
- Climatic conditions
- Area of ancillary spaces, including loading bays; cold rooms; packing areas; locations for storing hazardous materials, climate and air management, and materials-handling equipment maintenance; offices; sanitary facilities; and staff lounges

Finally, the required site size is determined by—

- Size and type of store—a tall, mechanized warehouse has a smaller “footprint” than a manual warehouse that would handle the same volume of inventory
- Space and clearance needed for ancillary buildings, including those for the storage of fuels and hazardous chemicals—safety considerations determine how far away from other buildings hazardous substances should be stored
- Access and parking for delivery and staff vehicles

- Access for fire engines and other emergency services
- Office space
- Water runoff management
- Site security
- Site area needed for future expansion

Select method of obtaining space

There are seven ways of obtaining necessary storage space—

1. *Erect a temporary building.* These buildings are most suitable for use in emergencies, but erecting a temporary building is a rapid and effective solution to a short-term storage problem. A number of excellent temporary warehouse buildings are now available. Their main problem is that because they are fabric-clad, they are inherently less secure than a permanent building.
2. *Reorganize, renovate, or extend an existing health system warehouse.* This approach can be the quickest and cheapest, but only if suitable buildings are available.
3. *Lease a suitable commercial building.* This approach has the advantage of speed and avoids a large capital investment, but nevertheless there will be costs to outfit the space to suit the specific needs of a medical warehouse.
4. *Buy a suitable commercial building.* Again, this approach has the advantage of speed, assuming funds are available, but there will be fitting-out costs.
5. *Build a standard building.* Many countries have standard designs for health service buildings. Advantages of this approach are that design lead time is reduced, cost is more certain, and the design should be proven. The disadvantage is that the performance of standard designs has often not been evaluated effectively. Poor designs may be perpetuated.
6. *Build a purpose-designed building on an existing site, or obtain and develop a new site.* This approach is likely to have the longest lead time and may be the most expensive, but this may not necessarily be so, especially if the government already owns the land. It should ensure the closest fit to the specified requirements.
7. *Purchase a prefabricated building to install at the preferred site.* Assuming a vendor is able to accommodate design requirements, this may be more cost-effective than new construction.

Regulatory requirements

Before searching for potential sites, a review of the federal, regional, and local regulatory requirements that apply to stores facilities is essential. Zoning restrictions, water management laws, and permit or license requirements may all affect the viability of a particular site. In some cases, air or noise emissions or the impact of increased traffic within

the area need to be considered. These issues may require an environmental impact assessment; overlooking the implications to the project of such issues could have devastating consequences.

Potential incentives

Often, development incentives exist within territorial areas. Such incentives may include funding of employee training, project financing, land donation, tax reductions and deferrals, and assumption of some operational costs. Incentives can often be more important than logistics benefits when siting the store, particularly if the project has an element of private-sector ownership or operations. A ministry of health may even be able to defer operational or construction costs to other funding sources in the government.

Identify possible sites or buildings

When the sizes of the store and the site have been established, a short list of suitable sites or buildings should be prepared.

Identify staff recruitment and training implications

An assessment of personnel needs should be made at an early stage so that salaries and wages can be budgeted for and a recruitment and training program planned.

Establish an outline budget and obtain a budget allocation

Funding may be obtained from government sources, donor agencies, or commercial sources. The cost consultant should prepare a budget for submission to the funding authority (see Figures 42-1 and 42-2). The budget should include estimated costs for site acquisition, consultants' fees, and construction or installation costs. It should also include an assessment of annual operational and maintenance costs; if these items are not considered and budgeted for, the facility may not be sustainable. After funding is approved, site selection can begin.

The feasibility stage ends with the preparation of a detailed workplan for the design phase, setting out the tasks and timelines for the participants. An outline workplan for the construction phase should also be prepared.

42.4 Site selection and acquisition for new construction

When a budget allocation has been obtained, the project team should recommend the most suitable site or building from the short list.

Figure 42-1 Budget outline for constructing a medical stores from the ground up

Name of project:	
Date of budget:	Anticipated construction start:
Net area:	Gross area:
<p>Capital costs</p> <ol style="list-style-type: none"> 1. Site acquisition: total cost + commission and fees 2. Construction <ol style="list-style-type: none"> a. Off-site infrastructure (access roads, utilities, etc.) b. On-site infrastructure (roads, utilities, walks, paving, landscaping, security fencing, water management, etc.) c. Building (structure and works to 1.5 meters outside exterior walls) d. Fixed equipment (shelving, pallet racking, climate control and air management, refrigeration, water treatment, water storage for firefighting, etc.) e. Materials-handling equipment (forklifts, pallet trolleys, etc.) f. Information technology equipment (computers, bar-code readers, etc.) g. Furniture and other loose items 3. Professional services (surveys, soil analysis, water analysis, planning, architecture, regulatory licenses/permits and engineering) 4. Miscellaneous costs (utility connection fees, plan approval fees, legal fees) 5. Inspection and testing (job inspection, material testing) 6. Contingencies (cost escalation contingency, construction contingency) 7. Financing (loan fee, interim and permanent financing costs, bond legal fees) <p>Recurrent costs</p> <ol style="list-style-type: none"> 8. Annual operational costs (staff salaries and overheads, insurance, equipment maintenance, security, communications, utilities) 9. Average annual maintenance costs (repairs and renewals) 	

Figure 42-2 Budget outline example for a prefabricated warehouse

<ul style="list-style-type: none"> • Steel frame • Gable and cladding • Chromadek sheeting • Personnel doors x 2 • Roller shutter doors x 8 • Plans and engineer's certificate • Estimated concrete floor cost • Erecting the building • Storerooms for flammables and corrosives • Office block • Dock levelers • Cold room • Fitting out and contingency

Selection

In some countries, zoning laws completely prohibit development in certain areas and allow only buildings of a particular type in other areas. Other regulations may limit the size and position of buildings on a chosen site. A suitable site must satisfy all the regulatory requirements, be economical to build on, have convenient and unrestricted access for vehicles and staff, be adequately served by utilities and communications, be secure, and have potential for future expansion.

The Assessment Guide at the end of this chapter lists some criteria for site selection.

Acquisition

A site and the buildings on it, or both, may be purchased outright or leased on a long-term or short-term basis. Use of government land or outright purchase is the conventional route for government projects. Leasing may be a suitable method for an agency such as a nongovernmental organization (NGO) whose needs are limited in time. Whichever method is chosen, it is essential that the transfer of ownership or leasehold title be legally correct to avoid later disputes.

42.5 Design stage

There are four stages in the design for new construction. At the end of each stage, the project should be reviewed and a formal decision made to proceed to the next stage. The stages are—

1. *Preliminary proposals*: Preliminary design proposals are prepared and costed. An acceptable scheme is selected. If the building is to be procured on a turnkey or public-private partnership basis, the contractor may be chosen at this stage.
2. *Schematic design*: The design is developed in sufficient detail to enable the client to approve basic spatial

arrangements, materials, and appearance. A more detailed cost estimate is prepared. Mechanical handling equipment suppliers should be consulted where appropriate. At this stage, it may be necessary to obtain formal permission to build from the relevant government authority and seek agreement on the scheme with the fire department. The layout of the building and basic method of construction should not be altered after this stage.

3. *Detailed design:* The construction details are worked out. The cost estimate is refined. Specialist subcontractors and suppliers (such as cold-room manufacturers) are consulted, and quotations are obtained. Formal application is made for approval under local building regulations. If a design-and-build contract is to be used, the contractor is typically selected at this point. Major construction details should not be altered after this stage.
4. *Production information:* Final construction drawings are prepared, together with specifications and bills of quantities. These should be sufficiently detailed to enable contractors to tender for the project.

Client's role

Although executive responsibility for building design and monitoring of the construction contract rests with the project team, the client is responsible for establishing the initial project brief and for raising the necessary funds to cover design and construction costs. In addition, the client's representative on the project team has a project management role to play in the following areas—

- Attending meetings of the project team and monitoring progress
- Developing the brief
- Formally reviewing and approving the scheme as each design stage is completed (altering major decisions made at a previous stage is extremely disruptive and may cause delays and increase costs)
- Ensuring that communications within the team are timely, clear, and accurate
- Scheduling periodic and ad hoc reviews with the client as required
- Arranging payment of fees for planning and building control applications
- Arranging payment of consultants' fees
- Attending meetings with prospective contractors

If the project is large, the client may choose to employ a professional project manager to undertake some or all of these tasks.

All members of the project team, in turn, should ensure that the client is kept fully informed of progress and is pro-

vided with copies of drawings, correspondence, and other documentation.

Some of the general design features that should be considered during the design stages are outlined below. Note that most of these points apply to both ground-up construction and prefabricated building installation.

Detailed project brief

The detailed project brief is the key design document. It should be developed in discussion with the people who will operate, use, and regulate the building. The brief is not a fixed document. It will change and expand as the design develops in response to input from the client and from the project team. Typical elements of a brief are outlined in Table 42-2.

Store and site planning

Storage buildings and site layouts should be planned to allow for future expansion with minimal disturbance to existing building elements, roads, and other physical infrastructure. Air-conditioning, other climate-control elements, and fire management systems are often significant expenditures and dictate building design.

Storage buildings should be planned for maximum flexibility of use. The layout of shelving, racking, and ancillary spaces is certain to change during the life of the building, and the building's future uses will be either enhanced or limited based on the initial investment and design. Buildings with widely spaced columns (wide-span structures) are generally easier to reorganize than those with closely spaced columns. Wide-span structures are more expensive to build, but their long-term advantages are likely to justify the extra expense in all but the simplest manual stores. An alternative approach in "high-bay" warehouses is to use the racking system as part of the building structure. In such cases, the storage system is effectively fixed for the life of the building.

Stores that have a relatively square plan are generally cheaper to build and more efficient to operate than stores that are long and narrow. In a large store, cross aisles should be provided at reasonable intervals to reduce travel time from aisle to aisle. The most appropriate spacing depends on picking frequency. A rule of thumb is a cross aisle every 10 to 20 meters. When assigning storage locations, it is good practice to place slow-moving product lines in long aisles and fast-moving product lines in short aisles (see Figure 42-3).

Storage methods

Goods can be stored in four basic ways: shelves, floor pallets (pallet standing), pallet block stacking, and pallet racks. The choice of storage method depends on the form in which goods arrive: in bulk on prepacked or store-packed

Table 42-2 Typical elements of a project brief (“functional program”)

Brief	Elements
Operational brief	<ul style="list-style-type: none"> • Inventory management and stock control systems and stores management procedures • Description of major activities, including flow of goods and paperwork • Type of stock to be accommodated • Environmental and security (zoning) requirements for different types of stock (see Chapter 43) • Quality control and regulatory requirements • Approximate volumes of stock to be accommodated in each zone • Approximate throughput of store (maximum cubic meters per day received and dispatched) • Operational requirements for shipping goods to other countries (if relevant) • Type of store required (mechanized, manual, or manual to be upgraded) • Schedule of staff • Types and number of delivery vehicles • Number of staff and visitor vehicles to be accommodated • Phasing and program expansion
Site development brief	<ul style="list-style-type: none"> • Site development restrictions • Access and parking for vehicles and access for pedestrians • Access for emergency services • Water supply and water storage, including water storage for firefighting • Site security and lighting, including gatekeeper’s accommodation and barriers • Landscaping • Schedule of individual buildings (main store, flammables store, fuel store)
Building accommodation brief	<ul style="list-style-type: none"> • Storage <ul style="list-style-type: none"> – Loading bay – Incoming goods area (for checking, inspecting, sorting, unpacking, and palleting, including power outlets for refrigerated vehicles) – General storage areas (ambient, controlled temperature, controlled security) – Isolation and quarantining of goods – Order assembly and dispatch area, including secure storage for assembled orders – Handling equipment storage, including charging points for electric vehicles – Ancillary storage (office consumables, packing materials, waste) – Battery charging area (if required) – Generator room (if required) • Administration <ul style="list-style-type: none"> – Detailed schedule of accommodation and facilities required for record keeping (including computers, bar-code readers, RFID readers, and other IT equipment as appropriate), communications, pharmaceutical information, product testing, training • Staff welfare <ul style="list-style-type: none"> – Sanitary facilities and changing rooms – First-aid room – Lounges and cafeteria or lunchroom

pallets, or as smaller packages. The four storage methods are discussed more fully in Chapter 44. Figure 42-4 illustrates the major dimensional constraints of pallet racking. Figure 42-5 illustrates the major dimensional constraints of shelf storage.

Environmental control and energy conservation

Opportunities for energy conservation exist in all aspects of warehouse design, construction, and operation, from site selection to equipment selection. A well-designed store can significantly moderate internal temperatures in a passive way. Passive design works with the site’s microclimate by using trees for shade and shelter, orienting the building correctly for natural lighting and ventilation, and selecting appropriate building materials and methods to control internal temperatures.

In hot, dry climates, good construction and nighttime ventilation can maintain daytime temperatures sev-

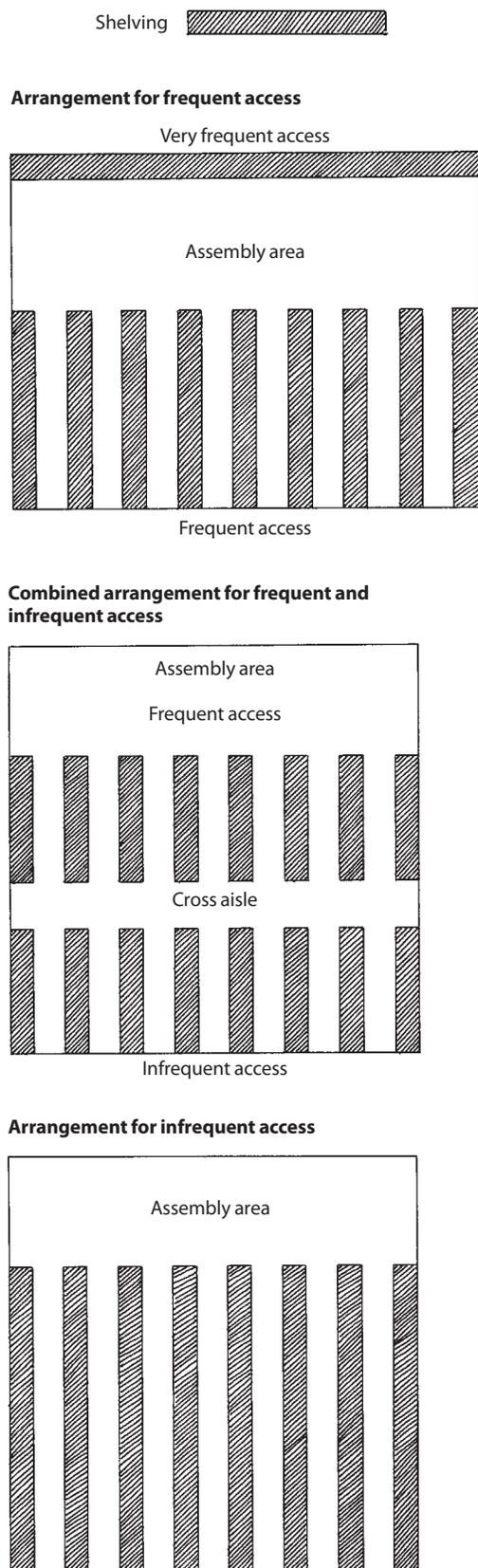
eral degrees below ambient temperatures. In hot, humid climates, effective cross-ventilation is required. In cold climates, storage buildings should be well insulated. Mechanical systems such as air-conditioning need to be chosen with a view to future maintenance. Sophisticated systems may not be sustainable.

Adequate electrical lighting is required throughout the store. Bright sunlight and fluorescent lighting affect some pharmaceuticals, and stores should be designed to prevent such damage.

A building design should always consider water management. Rainwater runoff from the site may require special permits or isolation and treatment. Sprinkler systems or fire water may need to be contained, sampled, or treated prior to release to a public system. Regulations should be reviewed carefully and requirements included in the site design.

In tropical climates especially, close attention should be paid to design measures that reduce or eliminate damage by pests, such as termites, reptiles, and rodents.

Figure 42-3 Options for layout of store aisles



Telecommunications and information technology

Good telecommunications and access to information technology (IT) are increasingly vital components of a pharmaceutical store. Modern IT equipment is already being used for stock control in remote areas, and reliable Internet connections will soon be an essential requirement for effective supply chain management. The pharmaceutical industry has used bar coding for many years. Radio frequency identification devices (RFID) are likely to supplant bar coding on products within the next decade, and their use should greatly improve the accuracy and speed of stock control operations (see Chapter 49 on pharmaceutical management information systems). Buildings should be enabled and ready to exploit this technology when it becomes available locally.

Special storage conditions

The building must provide specific storage conditions for different types of pharmaceuticals. Quarantine and isolation requirements must be incorporated into the design. The quality assurance consultant should provide detailed requirements. See Chapters 19 and 44 for more details.

Ancillary accommodations and loading bays

The design and sizing of ancillary accommodations should be carefully considered. These spaces include offices; staff rooms for rest, recreation, and eating as well as sanitary facilities and changing rooms; receiving and packing areas; and storage space for pallets and other packing materials. Chapter 44 details these requirements.

The vehicle loading bay area is particularly important. It must be protected from the weather and large enough to receive the maximum number of vehicles expected at any one time. In larger stores, the loading bay should be raised so that the floor of the vehicle is level with the floor of the warehouse. Dock-leveling devices are available to suit vehicles of different heights, but vehicles often do not have appropriate structures to be secured to the dock leveler.

Guidelines for security

Pharmaceuticals are small, valuable, and therefore prone to theft (see Chapter 43). The warehouse complex should be designed with security in mind.

- Unsupervised access from the loading bay to the store itself should not be possible. The main storage area where order picking takes place needs to be especially secure. The drivers' waiting area should be isolated from any area containing products and also from administrative offices.

- Ideally, the office area should have windows overlooking the loading bays and the warehouse access.
- The staff rest area, sanitary facilities, and changing rooms should not have direct access to the warehouse or from the outside.
- Visitors and drivers should have separate sanitary facilities.
- Staff parking should be well separated from the loading area.
- Adequate perimeter fencing and external lighting should be provided.
- Emergency evacuation doors should be alarmed to the main office.

Mechanical equipment specifications

The storage systems and mechanical equipment needed to operate the store effectively, including shelving, should be specified in the design. Some of this equipment will be supplied and installed as part of the building contract, but some may be supplied under a separate “fitting-out” contract.

Fire protection and emergency response

All sections of the warehouse should have adequate fire-detection equipment and be well supplied with firefighting appliances. Smoke alarms are inexpensive to install and provide warning in case of fire. The design should satisfy local building codes and the requirements of insurers in the following respects.

Site and building layout and construction. Key aspects of design planning for fire safety include—

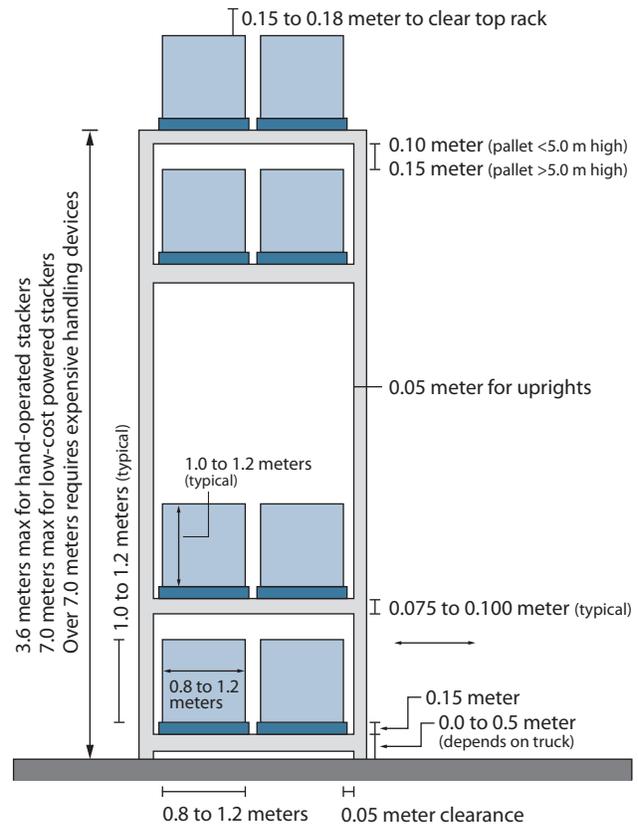
- Accessibility by the fire department
- Adequate escape routes and emergency doors with locks that do not prevent staff from leaving the building in an emergency (such as push bars with doors opening outward)
- Compartmentalized buildings to reduce the risk of a fire’s spreading
- Isolation doors with appropriate fire ratings between bays
- Electrical connections, wiring, and devices meeting fire safety codes
- Noncombustible building construction materials

Fire-detection and firefighting equipment. Essential components of a fire safety system include—

- Adequate provision of smoke alarms, heat detectors, and fire alarm sounders to ensure that fires are detected as soon as possible
- Correctly positioned fire hydrants and hose pipes with an adequate and reliable supply of water

Figure 42-4 Pallet racking: Dimensional constraints

Clearance for lights, sprinklers, etc.

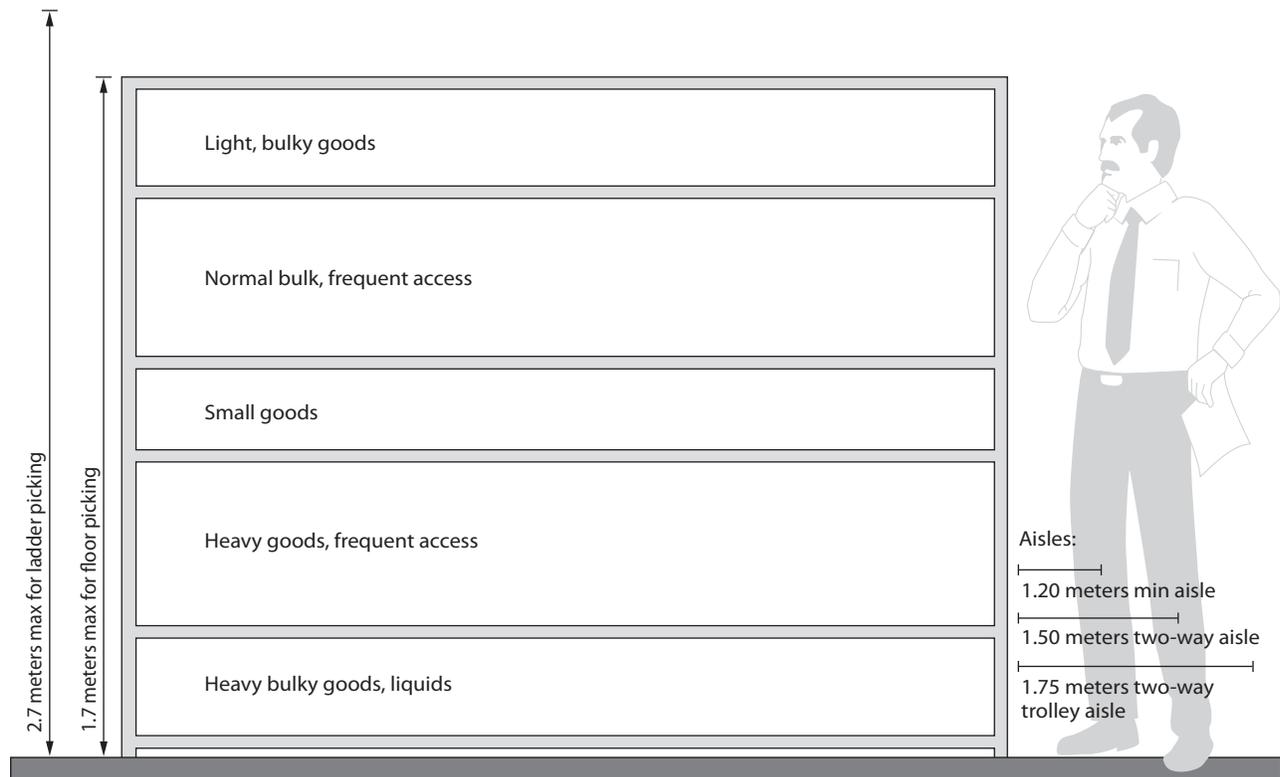


- Correctly designed sprinkler systems (because if a poorly designed system is set off by accident, water may ruin some stock; or if there is a fire, the system may soak stock that is well away from the core of the fire); choice of a dry or wet system must be made with the building managers and the insurers of both the building and its contents
- Adequate numbers and types of fire extinguishers suitable for chemical fires (so staff can extinguish small fires before they spread)
- An automatic or manual telephone link to the fire service

Construction standards

The method and standard of construction required should be agreed on as part of the project brief—development process or spelled out in prefabricated warehouse tender documents. These decisions are important because they affect the initial cost of the building and largely determine how long it will last and how much it will cost to maintain. The government may have standard equipment and construction requirements for all buildings of a particular type.

Figure 42-5 Shelving: Optimal layout with ergonomic considerations



Standardized requirements help simplify maintenance and reduce costs.

Before finalizing the design, it is essential to check that it complies with all relevant engineering and health and safety standards. Failure to do so could create many operational problems after the storage facility is completed.

42.6 Tender and project-planning stage

The tender stage marks the transition point between the design and construction phases. The five procurement routes described below illustrate a range of tendering possibilities. Variations exist, and the project team should recommend the most appropriate method.

Conventional procurement

In conventional procurement, tenderers submit bids based on a set of tender documents complete enough to enable the building to be constructed. There are variations on this method. In a “fast-track” contract, the contractor is appointed as early as possible in the design process and starts work on-site before the design work has been completed. The aim of this approach is to build more quickly by overlapping the design and construction stages.

Fast-track procurement should be considered only if all parties to the contract are experienced and extremely well organized.

Design-and-build procurement

In a typical design-and-build procurement, tenderers are provided with design drawings and specifications. The tender submission is a fixed-price offer to build the tendered design. The successful tenderer is free to change construction details within the limits set in the tender documentation. The client may appoint a professional representative in a monitoring role to report on the activities of the contractor and to ensure that the client’s requirements continue to be met as the scheme develops. Alternatively, or in addition, the successful design-and-build contractor may “take over” the client’s design team, which will then develop the design for construction.

Turnkey procurement and procurement of prefabricated buildings

In turnkey procurement and procurement of prefabricated buildings, the tender documents consist of a performance specification or schedule of requirements. Tenderers are required to submit preliminary design proposals as part of

their bid submissions. The successful tenderer then prepares a fully worked-out design for approval by the client before construction begins. Again, the client may appoint a professional representative to monitor the contractor's activities.

Public-private partnership procurement

A relatively new approach to building procurement is the public-private partnership model, which is essentially a long-term agreement that uses private financing for public services. Under this arrangement, tenderers are invited to bid not just for construction and outfitting of the building, but also for its day-to-day maintenance and operation for a defined period—typically thirty years. In the case of a medical store, the service agreement could include all aspects of inventory management, up to and including ordering and distributing medicines and commodities. The successful contractor charges an annual fee that covers the amortized cost of the building, its operation costs, and the contractor's profit. The contractor's performance is monitored against a set of predefined indicators, with financial penalties in the event of service failure. At the end of the contract period, the building and its equipment are handed back to the client organization in satisfactory condition, as defined in the original contract.

The contract

There should be a formal building contract for all building projects, however small. Informal arrangements lead to disaster. Various forms of contracts are in use, ranging in complexity from a simple letter of agreement to a complex document. Contracts are often country or organization specific. A few are widely used internationally.

The contract is the legal agreement that commits the contractor to carry out work for the building owner according to the drawings, bills of quantity, and materials specifications within a specified time. A financial penalty may be imposed if the building is not completed on time. The contracting agency (client) agrees to pay the contractor a specified sum of money at agreed-upon stages during the course of the work or upon satisfactory completion. Following completion, the contractor has an obligation to rectify any defects that arise within an agreed period after the handover date, which is typically six months or one year. The total contract sum may be varied if the nature or extent of the work changes. Under conventional procurement, the architect is a third party to the contract and can both represent the owner and act as arbiter in case of contractual disputes.

Tendering

A competitive tender is usually the best method of selecting a building contractor or source of a prefabricated building.

Negotiation with one contractor may be applicable when only one company is suitable for the job or when a government building agency (for instance, the ministry of works) is to undertake the project. In all other cases, the tender short list should be drawn up after careful screening. A list of each contractor's projects should be requested and verified. Commercial and bank references should be obtained. Previously completed projects should be visited, and it is helpful to talk with the architects and owners of these buildings about how the contractor performed.

Government clients generally have strict tendering procedures designed to prevent corruption and ensure accountability. There are three basic systems—

1. *Open tendering*: Under this arrangement, any suitably qualified contractor can submit a bid. The tender board then considers bids.
2. *Prequalification tendering*: The contract is advertised, and interested contractors make formal prequalification submissions. The tender board meets and agrees on a short list of contractors. They are invited to submit bids, which are considered by the tender board.
3. *Short-list tendering*: A short list of tenderers is drawn up by the project team or the client. Bids from this list are then considered by the tender board. This method is adopted by most private-sector and NGO clients. A minimum of three contractors should be invited, but the rules may require a larger number.

The tender instructions specify the date for the return of the bid, how it should be presented, and when bids will be opened. It is helpful to ask a trusted third-party observer, such as a bank official or lawyer, to observe the bid-opening process. The witness's testimony will be valuable in any future disputes from unsuccessful bidders. After the bid opening, the bids are analyzed by the project team, and the most economically advantageous one is selected. An economically advantageous bid is not necessarily the cheapest; all aspects of the bid require consideration, including time to completion and contractor reputation and reliability. A comprehensive and carefully constructed bid analysis template is absolutely essential in the case of the unconventional procurement routes described at the beginning of this section. If cost reductions need to be made, they should be negotiated before the contract is signed.

Project planning

Discussions are held with the successful contractor, and a construction or installation program is worked out, including site-access management and construction site security. All contractual matters, including the property and liability insurance obligations of the client and the contractor, are finalized and checked by both parties. If a performance

bond is required, it is finalized (see Chapter 39). Facilities for construction workers should meet appropriate standards, with special attention given to site safety and to providing welfare facilities. Injury and other health-related work stoppages or interruptions can significantly delay a project.

The client finalizes funding arrangements so that payments can be made to the contractor on time and at the agreed-upon stages. The contract is then signed.

42.7 Construction and commissioning

The contractual role of the client during the construction phase is largely confined to making payments to the contractor, approving any changes in the cost of the project, and attending formal site meetings. The contract supervising officer (usually the architect) is responsible for the day-to-day administration of the contract. The client should never issue direct instructions to the contractor; instructions should always be channeled through the supervising officer. The supervising officer should regularly provide the client with the following—

- Minutes of the site meetings
- Reports on the contractor's progress and changes in the program
- Reports on significant contractual or construction problems
- Reports on labor issues, including health-related or injury incidents
- A photographic record of the site preparation and construction, which may be carried out by the contractor's staff
- Payment valuations
- Details of changes to the design or specifications (variation orders)
- Details of changes in the cost of the project (cost reports)

In addition, the client must prepare to take over and commission the building. Staff must be allocated, recruited, and trained; equipment, furnishings, and stationery must be purchased; contract arrangements must be made with utility companies; and management systems for the new facility must be drawn up. Transport arrangements need to be established. These tasks are demanding and time-consuming, and adequate resources should be allocated to them.

Supervision

The supervising officer should carry out regular site inspections, preferably once a week, to ensure that the contractor is following the drawings and specifications. If the project is

large, a full-time site architect or a site monitor or clerk of works may be appointed by the client. The site monitor has no executive authority. His or her role is to act as the project team's "eyes" on-site and to report to the project team and the supervising officer.

Valuations and payments

The contractor's work should not be paid for until it has been approved by the supervising officer. Any unsatisfactory work must be corrected before it is included in a valuation. Typically, valuations and payments are periodic (often monthly), based on a measurement of work actually completed. Alternatively, for simple projects, they may be made in defined amounts at defined construction stages (for example, 10 percent of the total contract sum when the floor slab has been laid). Payment is made against a certificate issued by the architect. A percentage (usually 5 to 10 percent) of the value of the certificate is retained by the client until the contractor has rectified all defects after the end of the specified defects-liability period. The defects-liability period usually extends for six or twelve months after handover.

Handover

The building is handed over to the client after the design team has fully inspected the completed building and witnessed satisfactory tests of the water supply, drainage, fire protection, and mechanical and electrical services, and after the contractor has corrected any problems. A few outstanding items may remain to be finished, but the list should be short and completion should not interfere with the client's use of the building. The client should attend the pre-handover inspection and should not accept the building unless satisfied. The supervising officer then certifies that the contractor has achieved practical completion.

The contractor hands over all keys to the building and provides the client with instructions on the use of mechanical and electrical equipment. The design team provides a building manual containing a complete set of "as-built" record drawings (drawings revised to show changes made during construction) and general guidance on maintenance. The client's building maintenance officer should be briefed at this stage so that he or she gets to know the building during the defects-liability period.

Commissioning

The client or operator moves into the building and commissions it. At this stage, various "growing pains" can be expected. Some of these will be operational, and some will be caused by building defects. Building problems should be resolved by the contractor and the project team.

Defects liability

During the defects-liability period, the project team, the client, and the contractor agree on the final account. At the end of the defects-liability period, the supervising officer inspects the building again and instructs the contractor to rectify any defects that have arisen. The contractor should be given reasonable access to the building to do so. When all defects have been corrected, a final certificate is issued, and final payment is released to the contractor. If a major contractual dispute has arisen, the issuance of the final certificate (and payment) must be delayed until this dispute is resolved according to the terms of the contract.

Building or renovating a new medical stores facility is a major expense. The temptation to profit personally from the project by bribery or kickbacks is a reality that must be tackled head-on by the project team. Strict controls should be in place to prevent this problem. Advance payments should never be made to the contractor. The client should pay only for work that has been correctly completed and certified.

If the construction process runs into serious problems, a dispute may arise that the parties are unable to resolve. Arbitration is a method of settling such disputes without the need for legal proceedings. Informal hearings are held under the control of an arbitrator, whose judgment is final and binding on the parties to the dispute. This procedure is quicker and less expensive than judicial proceedings. However, arbitration may not be adequate if significant differences of opinion exist as to the quantity or quality of work performed. The type of arbitration procedure and scope of its application should be clarified in the initial contract.

42.8 Building and equipment maintenance

A building and its equipment will not continue performing satisfactorily unless both are regularly maintained. Buildings need both emergency and routine maintenance, but buildings and equipment rarely fail if they are looked after and serviced in a systematic way. A planned cycle of routine maintenance should include general cleaning, replacing lightbulbs, drain clearing, and maintaining fire extinguishers, mechanical equipment, and similar items. Similarly, there should be a planned cycle for periodic maintenance, including painting and replacing life-expired elements such as mechanical equipment and roof finishes. The client should have adequate recurrent and capital budgets and the human resources necessary to carry out these tasks over the life of the building. ■

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★ = Key readings.

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Glossary

Commissioning: The process of preparing a building for operation. It includes adjusting the heating, ventilating, and air-conditioning systems; establishing security procedures; and training occupants.

Contract sum: The total amount payable by the owner to the contractor for performing the contracted work. Depending on the contract terms, this amount may be adjusted at the end of the contract, to take account of variations approved during construction.

ASSESSMENT GUIDE

Is additional space really required, or can existing space be maximized by—

- Changing delivery intervals?
- Disposing of damaged and expired drugs?
- Reorganizing space within an existing warehouse?
- Contracting out for supply chain services?

If additional space is required, establish availability of funds and consider building procurement. What type of warehouse operation is required?

- Mechanical? If yes, are the necessary equipment and servicing infrastructure available?
- Manual? If yes, will this decision unduly limit future program development?
- Manual, upgradable to mechanical? If yes, are funds available to ensure that the building is designed and built to be suitable for upgrading?

What is the most practical and cost-effective way to obtain additional storage space?

- Erect a temporary building?
- Renovate an existing warehouse?
- Lease a commercial warehouse?
- Buy a commercial warehouse?
- Build a standard warehouse?
- Build a purpose-designed warehouse?
- Purchase a prefabricated warehouse?

What is the most cost-effective method of building procurement?

- Conventional design service?
- Design and build?
- Turnkey or prefabricated package?
- Public-private partnership?

Compare short-listed sites or buildings against the following criteria—

Site development potential

- Will the relevant authorities allow the site to be developed as intended?
- Is the site large enough to satisfy current and expected future needs?
- Is the existing building on the site suitable, or will it have to be demolished?
- Does a risk of contamination or interference exist from neighboring operations?
- Do rights-of-way, liens, and underground rights affect the development potential of the site?
- Is the site well drained? Is there any risk of flooding or other weather-related risk?

- Is the site protected from landslides, earthquakes, avalanches, and other natural hazards?
- Are ground conditions suitable for building economically?
- Will regulatory requirements (for example, environmental, labor, licenses, taxation) affect the development potential of the site?
- Can the site be developed at an acceptable cost?
- Are any fiscal or other incentives available to help fund the project?
- Are there any community issues that could affect the development potential of the site?

Access

- Is the site close to the relevant transport links?
- Do local access routes suffer from vehicle congestion?
- Is the site well served by public transport? (Public transport is needed by staff.)
- Are routes to the site accessible year-round by all types of vehicles?
- Is there adequate access for vehicles and space for parking?

Utilities and communications

- Does the site have a reliable main electricity supply?
- Does the site have a main water supply, borehole, or other reliable source of clean water?
- Is the water supply sufficient for firefighting?
- Does the site have main drainage? If not, are ground conditions suitable for a septic tank or other autonomous system?
- Is there an existing standby generator? If so, is it powerful enough to supply the cold rooms and refrigerators in the new store?
- Does the site have access to reliable telephone, Internet, and postal services?

Security

- Is the site likely to invite intrusion or vandalism?
- Can the site be properly monitored and supervised outside normal working hours?
- Is the site easily accessible by the fire department, police, and ambulance services?

Future conditions

- Will access to the site and the security of the electricity, water drainage, and communications systems be adversely affected by future development in the area?
- Will adequate resources be available to maintain the building and equipment over the life of the building?

Design-and-build procurement: In this method, the contractor takes responsibility for the detailed design and construction of a building based on an agreed-upon preliminary design.

Final account: A financial reconciliation prepared at the end of a building contract, in which the contract sum is adjusted to take account of all variations that have occurred during the construction process. (These variations include design changes by the client, design changes as a result of site conditions, claims for extra payment by the contractor for delays that are not its responsibility, and counterclaims by the owner for damages caused by the contractor's failure to keep to the program.)

Final certificate: A document issued by the architect or contract supervisor that states the amount of money owed by the client to the contractor (or vice versa) at the end of the contract.

Program or brief: A written statement of the owner's conditions and requirements for the project.

Public-private partnership procurement: A method in which the client pays an annual fee for complete building construction, maintenance, and drug storage service over an extended time period.

Record drawings: Drawings revised to show changes made during construction.

Retention: A sum (typically 5 percent) withheld from each payment made to the contractor during the course of construction. This money is usually released to the contractor after all defects have been rectified and the final certificate is issued.

Subcontractor: One who has a contract with the primary contractor to perform a portion of the work.

Turnkey procurement: A method in which the client hires a contracting company to provide a complete building product for a fixed price.