

Supplement 5

Maintenance of storage facilities

Technical supplement to
WHO Technical Report Series, No. 961, 2011

Annex 9: Model guidance for the storage and transport of time- and temperature-sensitive pharmaceutical products

May 2015

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Abbreviations

CM	corrective maintenance
EHS	environmental, health and safety
IPM	inspection and preventive maintenance
MoU	Memorandum of Understanding
PM	preventive maintenance
SLA	service level agreement
SOP	standard operating procedure
TTSP	time- and temperature-sensitive pharmaceutical product

Acknowledgements

The author of this document is Andrew Garnett, an independent consultant, London, England.

Glossary

Design–build: A project delivery system used in the construction industry. The design and construction services are contracted by a single entity known as the design–builder or design–build contractor, typically for an agreed lump-sum price.

Facility management: The professional management of building infrastructure. Responsibilities of the facility manager include day-to-day operation, space allocation and management of changes to the building, management of health and safety, fire safety, security, maintenance, testing and inspection, cleaning, contingency/disaster planning and tendering for outsourced contracts relating to any of these activities.

Maintenance management: The administrative, financial, and technical framework for assessing and planning building maintenance operations on a scheduled basis; a subset of facility management.

Pharmaceutical product: Any product intended for human use or veterinary product intended for administration to food producing animals, presented in its finished dosage form, that is subject to control by pharmaceutical legislation in either the exporting or the importing state and includes products for which a prescription is required, products which may be sold to patients without a prescription, biologicals and vaccines. Medical devices are not included.¹

Practical completion: In most construction contracts, the date at which the architect or contract administrator certifies that the works have been completed, and the end-user is able to occupy the building. Some minor works, called snagging items, may remain and must be completed by the contractor within a reasonable time period.

Refrigeration equipment: The term “refrigeration” or “refrigeration equipment” means any equipment whose purpose is to lower air and product temperatures and/or to control relative humidity.

Service level agreement (SLA): A service level agreement or contract is a negotiated agreement between the customer and service provider that defines the common understanding about materials or service quality specifications, responsibilities, guarantees and communication mechanisms. It can either be legally binding, or an information agreement. The SLA may also specify the target and minimum level performance, operation or other service attributes.²

¹ Definition from WHO/QAS/08.252 Rev 1 Sept 2009. *Proposal for revision of WHO good distribution practices for pharmaceutical products – Draft for comments.*

² Definition from International Air Transport Association (IATA). *2013/2014 Perishable cargo regulations (ePCR) & temperature control regulations (eTCR).*

Standard operating procedure (SOP): A set of instructions having the force of a directive, covering those features of operations that lend themselves to a definite or standardized procedure without loss of effectiveness. Standard operating policies and procedures can be effective catalysts to drive performance improvement and improve organizational results.

Time and temperature-sensitive pharmaceutical product (TTSP): Any pharmaceutical good or product which, when not stored or transported within predefined environmental conditions and/or within predefined time limits, is degraded to the extent that it no longer performs as originally intended.

Uniclass: Unified Classification for the Construction Industry, published in 1997 in the United Kingdom, is a classification scheme for the construction industry. It is intended for organizing library materials and for structuring product literature and construction project information.

1. Introduction

This Technical Supplement has been written to amplify the recommendations given in section 3.10 of WHO Technical Report Series No. 961, 2011, Annex 9: *Model guidance for the storage and transport of time- and temperature-sensitive pharmaceutical products*.³ It does not specifically deal with emergency maintenance or contingency planning. Related topics are covered in the Technical Supplement: *Maintenance of refrigeration equipment*.

1.1 Requirements

Implement a planned preventive maintenance programme to ensure that storage buildings and building utilities are well maintained. Keep records to demonstrate compliance with the programme.

1.2 Objectives

The objective of this Technical Supplement is to provide guidance on how to meet the above requirements. The document covers the maintenance of building sites, building structures and building services. It does not cover the maintenance of refrigeration equipment and cold store enclosures contained within those structures. This topic is covered by the companion Technical Supplement: *Refrigeration equipment maintenance*.

1.3 Target readership

This supplement provides guidance aimed at more senior operations staff. Principally these will be the owners and operators of warehouses, pharmacies and other buildings used to store time- and temperature-sensitive pharmaceutical products (TTSPs). Where appropriate the activities described in this supplement should be assigned to a qualified maintenance manager or facility manager.

³ <http://apps.who.int/medicinedocs/documents/s18683en/s18683en.pdf>

2. Guidance

Maintenance of buildings, when effectively carried out, ensures that the structure and its contents are protected from damage and loss. In the case of a large pharmaceutical warehouse, the value of the pharmaceutical products that are stored in the facility may well exceed the value of the building itself. Unfortunately, maintenance is often neglected and underfunded in the public sector. Defects accumulate and, if they are dealt with at all, this takes place in a piecemeal fashion.

This document focuses on planned maintenance. It gives a broad overview of building maintenance principles and it outlines some of the challenges that have to be overcome in order to implement a high standard of maintenance practice. It is not intended to be a comprehensive technical guide; readers are encouraged to consult the reference sources for a fuller understanding of the topic.

2.1 Associated materials and equipment

Suitable checklists and inspection and access equipment will be required to carry out the inspection activities advocated in this supplement. The tools and materials for carrying out actual maintenance tasks are outside the scope of this document.

2.2 What is maintenance and why is it important?

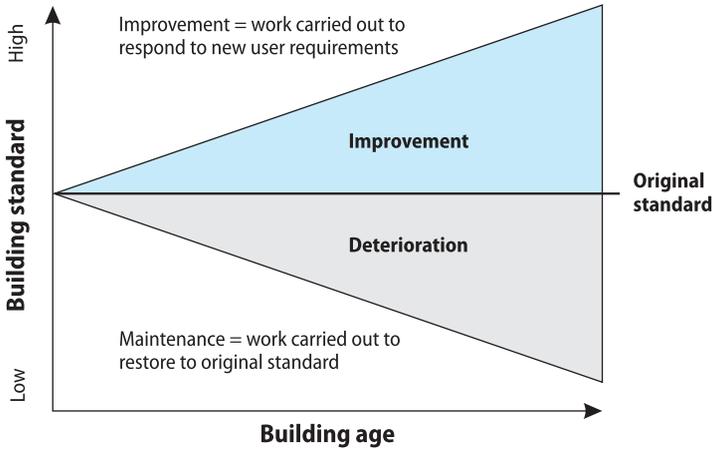
The purpose and scope of building maintenance has been defined in many ways. A good general definition is that:

Building maintenance is the totality of all actions that keep a building functioning effectively.⁴

All buildings deteriorate over time. Maintenance, if well carried out, rectifies this deterioration and returns the building to its original as-built state. Maintenance helps protect the financial assets tied up in the building; it is not the same as improvement. The purpose of improvement is to alter and/or extend the building in ways which respond to changing user requirements and this may increase its value. Figure 1 illustrates this distinction.

⁴ Wood B. Building maintenance. Oxford: Wiley-Blackwell; 2009.

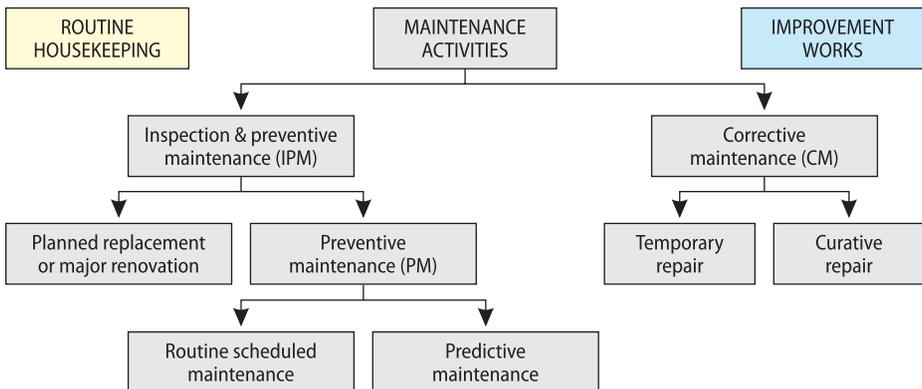
Figure 1
Relationship between improvement and maintenance



Adapted from Miles and Syagga, (1987) and Stanford, (2010).

Figure 2 illustrates the various types of maintenance and their relationship to related activities. Maintenance can be divided into two major categories: inspection and preventive maintenance (IPM), and corrective maintenance (CM). Note that housekeeping actions such as cleaning and pest control, even though they can and should be planned, are generally regarded as part of routine day-to-day operations rather than maintenance – a clean building is not necessarily a well-maintained building. As noted above, improvement work is also a separate activity.

Figure 2
Types of maintenance



Adapted from Stanford (2010).

To be effective, both financially and operationally, IPM activities should be *programmed*. If an effective maintenance regime is in place, CM should play only a minor part in total maintenance activity; however, some unplanned “emergency” maintenance will always be needed and adequate resources need to be allocated for this purpose.

IPM is subdivided into the following categories:

- a. *Planned replacement*: this ensures that building elements such as windows and roof finishes are replaced when they reach the end of their designated service life. Planned replacement minimizes the need for emergency maintenance and prevents the consequential damage which will occur if the element is left to fail.
- b. *Preventive maintenance*: this ensures that building elements are well maintained and that they do indeed attain their designated service life. This can be achieved by *routine scheduled maintenance*, for example regular redecoration of windows or regular lubrication of mechanical components, or by *predictive maintenance*, i.e. dealing with a minor problem identified during a routine inspection, such as vibration in an air-conditioning unit, before it develops into a major problem and becomes an emergency.

Corrective maintenance, also known as emergency maintenance, is required whenever an unexpected problem arises which must be dealt with immediately. An effectively managed IPM programme will minimize the incidence of these events, but they can never be entirely avoided. There are two possible CM responses:

- a. *Temporary repairs*: these aim to overcome the immediate problem and delay further consequential damage and loss – a temporary roof repair is one example. However, as soon as a temporary repair has been carried out, it is essential to schedule a permanent repair and to allocate funds for this work to be done promptly; otherwise the fault is likely to recur.
- b. *Curative repairs*: these resolve the emergency in a permanent fashion. For example, if a cold-room refrigeration unit fails unexpectedly, it may be replaced with a new unit. Curative repairs should ensure a long period of trouble-free operation.

2.3 The building design and construction phase

The future maintenance requirements of a building are largely determined during the design and construction phases. The original client brief establishes the requirements that the design and construction teams should meet; a poorly drafted brief often leads to an inadequate building, so this is a vitally important

document. The subsequent building design together with the choice of materials and components and the way they are put together are also critical. If the maintenance implications of all these decisions are not considered – including the need for safe access for inspection, repair and replacement – there is a risk that long-term problems will be created and that these problems will recur throughout the life of the building. Finally, it is also essential that the standard of construction is properly monitored and that the contractor is prevented from substituting inferior materials or components to save money; this is something that frequently occurs, especially with design–build contracts. For all these reasons it is crucial that the maintenance team are consulted when the brief is being drafted, during the design process and throughout the construction phase.

All buildings used to store TTSPPs will be fitted with cold chain equipment – either cold stores or refrigerators and freezers. It is vital that this equipment is qualified before it is handed over for use. Readers should refer to the companion Technical Supplement: *Qualification of temperature-controlled storage areas* for details of this critical activity.

A fundamental prerequisite for effective maintenance is comprehensive and up-to-date information about the building and its installed equipment. For this reason, every building should have an operation and maintenance manual (O&M manual). In the case of a new building, this document is prepared by the contractor and contains the information needed for the day-to-day operation, maintenance, decommissioning and demolition of the building. In the case of an existing building for which no manual exists, as much as possible of the information listed in sections 2.3.1 and 2.3.2 should be collected and assembled by the organization(s) responsible for operating and maintaining the building. The O&M manual is essential, but ideally there should also be a separate health and safety file. These documents are described in the following sections.

2.3.1 The operation and maintenance manual⁵

In the case of a new or refurbished building the document should be prepared by the contractor with additional information from the designers (in particular the mechanical and electrical services engineer), material and component suppliers and the person responsible for operational health and safety issues – likely to be the Environmental, Health and Safety (EHS) Manager. The requirement to prepare the manual should be written into the building contract.

A draft version of the document should be provided for the client as part of the handover procedure before the building is accepted at the “practical completion” stage. The final document is not usually available in its full form until

⁵ Sections 2.3.1 and 2.3.2 are adapted, with permission, from material at <http://www.designingbuildings.co.uk> relating to O&M manuals and health and safety files.

several months after practical completion because commissioning information often needs to include summer and winter or other seasonal readings taken in the fully occupied building. Both hard copy and electronic versions of the manual may be required and this should be clearly specified in the contract documents. For a large building the O&M manual will require multiple files and in all cases it is essential to assemble the material so that it is logically organized and easy to access. The elemental approach advocated in section 2.4.2 is one possible way to do this.

The O&M manual should include two main parts, namely, general operational guidance and detailed construction and operational information.

General operational guidance

This is an entirely separate, non-technical “building users’ guide” or “building log book” with information for all users about how to use the building, covering energy efficiency, environmental controls, access, security and safety systems, and so forth.⁶ This section requires particularly careful consideration because it will be widely used and needs to be easy to understand. In a warehouse used to store TTSPPs, the users’ guide must also include all necessary information on the routine operation of the cold store(s) and other cold chain equipment.

Detailed construction and operational information:

This part contains:

- a description of the main design principles governing the site layout and building construction. In a phased project this description might usefully include a master plan and phasing programme for the site;
- details of the building's construction, covering the structural frame, service installations, cladding, doors and windows, roof construction, finishes, and so on;
- maintenance recommendations for individual systems, components and building elements. These recommendations should include manufacturers' instructions for correct and efficient operation as well as relevant health and safety information;
- as-built drawings and specifications;
- a register of plant and equipment installed in the building;
- commissioning and test results;

⁶ See: Carbon Trust GPG348 Good practice guide: building log books – a user’s guide (<http://www.edocuments.co.uk/downloads/GPG348.pdf>).

- guarantees, warranties and certificates of compliance;
- particular requirements for demolition, decommissioning and safe disposal of the building, its systems and components.

Much of this information will already exist in one form or another, so preparing the O&M manual should simply be a matter of compiling and assembling the relevant material.

Over the life of the buildings, the O&M manual should be updated to reflect changes to the fabric of the building and its systems, together with details of maintenance that has taken place.

2.3.2 The health and safety file

As noted above, the O&M manual should contain health and safety information relating to specific systems, components or building elements. However, the format of the O&M manual can make this information difficult to find and genuinely important safety issues may be overlooked. It is therefore good practice to have a separate health and safety file; this should include the specific information needed to enable cleaning, maintenance, refurbishment, alterations and eventual demolition to be carried out safely.

The contents of the health and safety file will vary depending on the nature of the works being carried out; however, it 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;
- information about cleaning and maintenance equipment;
- information about safe working in cold stores;
- procedures for the safe removal or dismantling of installed plant and 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. It must be available for inspection by all interested parties so that any work to the building can be planned and carried out safely with full knowledge, and potential hazards can be managed.

The health and safety file is normally kept for the lifetime of the building; 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.

2.4 Maintenance management

In the public health sector, one of the underlying reasons for inadequate maintenance is that the building and the site on which it is located may not be under the direct control of the ministry of health, but may be managed by a separate property services or public works department. Under these circumstances health sector managers may not have the authority or knowledge that is needed to implement an effective maintenance regime, even if they understand what actions need to be taken. At the same time, the property services or public works department may not understand, or be able to meet, the specific maintenance needs of a pharmaceutical warehouse, especially one equipped with complex refrigeration equipment.

A further challenge, especially in low- and middle-income countries, is that the annual budgeting process and competing demands for scarce resources make it difficult to fund and manage multi-year planned maintenance programmes of the type advocated in this document. Maintenance activities involve both capital and recurrent expenditure; some planned maintenance activities, such as servicing of mechanical plant, may fit into an annual funding cycle whereas others, such as redecoration or the replacement of roof finishes, carried out at infrequent intervals of years or decades, may not be regarded as a funding priority, and may be delayed until damage to the building and contents has occurred.

2.4.1 Establish an institutional or contractual framework

Ideally, maintenance management should be assigned to an existing facility management agency or department, staffed by professionally qualified facility managers. If such an organization does not exist, it is essential to establish an effective institutional framework to manage maintenance activities.

In situations where building maintenance is a direct programme responsibility, the responsible personnel should know how to inspect buildings, how to instruct and supervise basic building work, how to liaise with specialist contractors and how to plan and control a maintenance budget.

In all situations where responsibility for maintenance rests elsewhere in the government sector, a Memorandum of Understanding (MoU) should be drawn up with the responsible agency or department; this document should incorporate a service level agreement (SLA) stating the specific maintenance standards and emergency response times that are required in order to protect valuable pharmaceutical products from damage or loss. Similarly, in situations where maintenance activities are outsourced to a commercial operation, there must be a comprehensive contractual agreement and SLA which includes a clear statement of the responsibilities of the contracting parties, measurable key performance indicators, and financial penalties for non-compliance.

In all cases, roles and responsibilities should be clearly defined; responsible personnel should receive appropriate specialist training in pharmaceutical

warehouse maintenance and should know with whom to liaise in the relevant ministries, departments and external maintenance service providers.

2.4.2 Preventive maintenance and replacement: standards and schedules

It is important to establish objective evidence-based maintenance and replacement standards from the outset; this will enable maintenance personnel to make rational decisions during routine periodic inspections of the building and will provide managers with the evidence needed to advocate for funding and action.

As an extension to the O&M manual, the first step is to develop a systematic maintenance planning and costing system incorporating these standards. A standard coding structure should be used to identify and characterize the key parts of the building. A widely used classification system is Uniclass, which divides a building up into individual elements – see **Annex 1**.⁷ Table 1 is a simplified list of these codes as they might apply to a steel-framed warehouse; the example ignores external works such as perimeter fencing and underground drainage.

Table 1
Coding system for a simple warehouse

G2 – Fabric	G21 – Foundations
	G22 – Floors
	G23 – Stairs
	G24 – Roofs
	G25 – Walls
	G26 – Frame
G4 – Fittings/furniture/ equipment (FFE)	G44 – Sanitary, hygiene FFE
	G45 – Cleaning, maintenance FFE
	G46 – Storage FFE (e.g. pallet racking)
G5 – Services	G50 – Water supply
	G51 – Gas supply
	G52 – Heating, ventilation and air conditioning (HVAC)
	G53 – Electric power
	G54 – Lighting
	G55 – Communications
	G57 – Protection (e.g. firefighting systems)
External decoration	
Internal decoration	

⁷ See also: <http://en.wikipedia.org/wiki/Uniclass>

Each of these elements can be further subdivided as needed. Thus a roof assembly might be broken down into ceiling linings, thermal insulation and roof covering if these are separate components, or classified as a single element in the case of a factory-made composite panel. An inspection timetable, an evidence-based planned replacement schedule and a preventive maintenance standard can then be set for each element. This information can be recorded in an electronic database or in tabular form on paper. The database can then be used as a basis for maintenance planning and for drawing up IPM checklists. Table 2 shows an example of an entry for a composite panel roofing system. In this case, the replacement interval and the preventive maintenance actions are based on the hypothetical manufacturer's warranty and maintenance recommendations. Other elements may require the professional judgement of the facility or maintenance manager.

Since these records will accompany the building throughout its lifetime, it is important to list all changes made as they occur. For example, if the roof cladding is replaced by another product, the record needs to reflect this change because the maintenance schedule and appropriate actions may also change. Construction drawings and other technical information (if they exist) should also be referenced in the record so that the relevant as-built construction and product details held in the O&M manual can easily be accessed and checked when needed.

Finally, if an electronic database is used, the record could be extended to include details of work periodically instructed and carried out, together with payments made. With a paper-based system this information can be classified using the same coding system and filed separately.

Table 2
Example of an elemental maintenance record

Element inspection, replacement and maintenance task record	
Location	South Warehouse
Element	G24 – Roof
Sub-element	G24.1 – External cladding
Description	Supaclad TS100RW composite panels, 70 mm PIR insulation, through fixed
Relevant drawings	SW-L1003B, SW-D1050D
Technical information	O&M manual section G24.1
Replacement interval and rationale	25 years (25-year thermal performance warranty, 30-year coating warranty)

Table 2 *continued*

Element inspection, replacement and maintenance task record			
Inspection schedule	5 yearly, starting December 2008		
Inspection tasks	<ul style="list-style-type: none"> • Check for leaks • Check for build-up of dirt and organic matter which can trap water and cause corrosion • Check for damage and corrosion to external and internal surfaces, especially at cut edges, laps and overhangs • Check fixings and fixing caps • Check sealant tape at laps 		
Safe access requirements	<ul style="list-style-type: none"> • Mobile access platform for internal lining inspection • Use fall arrest harness with access by fixed ladder at north end 		
Preventive maintenance actions	<ul style="list-style-type: none"> • Wash off organic build-up • Prepare and recoat damaged or corroded areas using Supaclad TS100RW repair kit • Replace loose or damaged through fixings and replace missing caps • Replace damaged or displaced joint sealant tape 		
Revision date	Change summary	Reason for change	Approved
10 Dec 2008	Original	Nil	AG
20 Dec 2013	Sealant tape check added	Omission corrected after first 5-year inspection	IM

2.4.3 Establish a multi-year maintenance plan

Once maintenance standards and schedules have been set for the various building elements, as described above, the next step is to develop a multi-year maintenance plan for the building. This plan should be updated once a year, should cover a rolling period of at least five years, and should include the following elements:

- *An itemized maintenance plan*, based upon a thorough inspection of the building and site. The plan should cover the following items: major renewal work that can be foreseen, such as re-roofing; periodic external redecoration; periodic internal redecoration; routine annual maintenance of mechanical equipment such as heating systems, air-

conditioning units, refrigeration units and ventilation fans; periodic maintenance of drainage systems, including cleaning of drainage ditches, septic tanks and the like.

- *A maintenance budget* based upon the requirements of the maintenance plan. It is essential that the budget is realistic, accurately reflects the anticipated costs for each item and takes account of anticipated inflation over the period covered by the plan. On the assumption that budgets are set annually, the first year's budget will form the basis for the annual funding application to the relevant ministry or other funding authority. The budget for the second and subsequent year's anticipated work should be submitted for information so that the funding authority is alerted to the need to set aside funds in these years.
- *A financial control and costing system* to ensure that funds are disbursed correctly. This process is highly context dependent and specific guidance on procedures cannot be given here.
- *A programme of work* that will achieve the targets set in the maintenance plan. Where maintenance activities are outsourced, the programme should reflect the bidding process and/or the process of contract negotiation when long-term service agreements are up for renewal.
- *An effective reporting system.*

Planned maintenance must then be carried out in accordance with the schedule to ensure that the building and site remain in good condition.

Arrangements must also be in place to ensure that emergency maintenance takes place promptly so that TTSPs and other supplies are protected from damage – see section 2.4.6.

2.4.4 Planned periodic inspections

To ensure that maintenance problems are detected, systematic inspections of the building must be carried out. These should be conducted at regular planned intervals, using facility-specific and element-specific checklists. When preparing an inspection plan, consider the following:

- a. *When should inspections take place?* Typically there should be a general annual inspection of the entire building. These inspections should be used to validate the timing of planned cyclical maintenance activities, such as redecoration, and should also be used to identify defects that require immediate attention and cannot

be left until their scheduled maintenance date. Other planned inspections may focus on specific elements and should take place at the intervals specified on the maintenance record sheets. For example, comprehensive inspection and testing of the electrical system might take place every 15 years. Finally, unscheduled emergency inspections should be carried out whenever the building users report a significant problem or failure.

- b. *What should be inspected?* As noted above, the annual inspection will be a general inspection. Element-specific inspections may be grouped together by interval and the inspection procedure should follow the items listed in the element record. **Annex 2** gives an example of a checklist for the external envelope of a cold store.
- c. *Who should carry out the inspection?* Many inspections will be conducted by the facility or maintenance manager or his or her nominated staff. However, some inspections need to be carried out by a qualified specialist or technician. The 15-yearly electrical system inspection referred to above is one example – in a smaller building this would be carried out by a qualified electrician; in a larger building with complex systems, by an electrical engineer. Another example of a specialist inspection is a planned service visit of the type described in section 2.4.5.
- d. *When should elements be repaired?* There is an old saying that “a stitch in time saves nine”. Cyclical repairs and redecorations, carried out at planned intervals, prevent degradation and extend service life and it is a false economy to extend these intervals. Similarly, emergency repairs should be carried out promptly in order to prevent further damage to the element itself and knock-on damage to other elements.
- e. *When should elements and components be replaced?* Some building elements – for example structural frames and masonry external walls – are expected to last the lifetime of the building. Repairs, such as redecoration, repointing or re-rendering may be needed at intervals of years or decades but, generally speaking, any fundamental failure of these elements will indicate the end of the building’s economic life. Other building elements and components that are designed with periodic replacement in mind should be replaced at the point where the disruption caused by failure and the cost of emergency repairs makes this the best option. For initial planning purposes, the material or component manufacturer’s estimate of service life can be used as a basis for budgeting. However, actual conditions of use, user

behaviour and the quality of routine preventive maintenance will affect the replacement date. Good maintenance, careful users and a benign climate will lengthen service life; poor maintenance, careless users and harsh climatic conditions will all shorten it. Accordingly, the replacement date should be kept under review and reassessed at the time of each planned inspection.

There may also be other reasons for replacement. For example, increases in energy costs might make it economically attractive to replace or over-clad a poorly insulated building envelope with a highly insulated product, even though the existing envelope is still in good condition. This would be an example of improvement – see Figure 2.

2.4.5 **Planned service inspections**

Service inspections are different from planned periodic inspections. Typically they apply to mechanical equipment, are carried out by a qualified technician, and involve specific maintenance actions such as lubrication, replacement of consumable parts such as filters and other time-dependent actions recommended by the equipment manufacturer. Such inspections may take place several times a year.

2.4.6 **Curative maintenance**

Curative (emergency) maintenance should be carried out as rapidly as possible, consistent with the identified risk. For example a failed refrigeration unit in a cold room with a duplicate refrigeration unit might reasonably be repaired within seven days because the duplicate unit can protect the stored TTSPPs in the meantime. However, if there is only one refrigeration unit, the risk of immediate product damage is acute; unless the product can be moved to another cold room, a 12–24 hour service response would be essential.

It is important therefore to carry out a risk assessment exercise to identify and classify critical maintenance emergencies and to establish a contingency plan to deal with them. Where time is of the essence, as in the example above, a maximum response period should be written into the relevant MoU or maintenance contract.

2.4.7 **Organizing and managing the work**

Maintenance can either be carried out using direct labour employed by the maintenance department, or it can be contracted out to an independent contractor. Table 3 and Table 4 show the opportunities and risks associated with

each option. The choice between the two approaches depends on the context and the type of maintenance work involved. For example, it might be appropriate to carry out general building maintenance using a direct labour team and contracting out the maintenance of specialist equipment such as standby generators, cold rooms and refrigerators to one or more specialist contractors. Under these circumstances, spare parts may be held by, or obtained through, the contractor or held by the government maintenance department and issued to the contractor as needed.

Table 3
Opportunities and risks for maintenance carried out by direct labour

Opportunities	Risks
Maintenance department controls workforce	<ul style="list-style-type: none"> • Controlling a workforce is time-consuming • Unless in-house planning is excellent, workers may be idle and workforce productivity will be low • Quality can only be maintained if the department has excellent supervisory skills
Workforce is on call and can be redeployed at short notice to deal with emergencies	<ul style="list-style-type: none"> • A full range of skills may not be available to deal with all tasks • If emergency call-outs are frequent, the workforce may be demotivated by unpredictable working patterns
A stable workforce will know and understand the buildings that they maintain	<ul style="list-style-type: none"> • Trained workers may leave for higher paid work in the private sector, leading to high staff turnover and poor skills retention
Bulk purchase of materials and spare parts can lead to financial savings	<ul style="list-style-type: none"> • The maintenance department has to operate supply depot(s) and manage a comprehensive inventory of tools, building materials and spare parts; this ties up capital • Infrequently required items may have to be bought in; this can lead to delays • Time-expiring materials, such as cement, may be wasted • Security can be a problem and materials and parts may be misappropriated

Table 4

Opportunities and risks for contracted out maintenance

Opportunities	Risks
Potential access to a wide range of outsourced maintenance service providers	<ul style="list-style-type: none"> • Poorly drafted outsourcing contracts and SLAs and/or poor contract management can lead to poor levels of service and contractual disputes • Service levels can be affected if the contractor prioritizes other clients • In lower income countries, some of the specialist skills required may not be available in the private sector
Risk and management responsibility is outsourced	<ul style="list-style-type: none"> • Cost control can be a problem unless the contract has tightly defined remuneration rates for specific tasks • Standards of work may be unsatisfactory unless rigorously monitored by the facility or maintenance manager
Poorly performing contractors can be delisted and replaced	<ul style="list-style-type: none"> • Contract termination is time-consuming and disruptive and may lead to disputes unless contract terms and conditions, performance indicators and penalties are tightly defined
Payment is only made on completion of the task (or on a retrospective interim basis for longer-term works)	<ul style="list-style-type: none"> • Payments to the contractor may be delayed unless the maintenance department is granted adequate working funds and authority to disburse them • Delayed payments can lead to contractual disputes, delays to the work and poor performance • Corrupt relationships with outsourced contractors are possible unless there is tight financial control and oversight

2.4.8 Inspecting and signing off the work

It is essential that the quality and completeness of all significant maintenance work should be inspected and signed off. Generally this function should be carried out by a supervisor attached to the management team. However, in some circumstances a specialist contractor may certify work as complete and satisfactory by providing the client with a signed copy of a completion and/or test certificate. This applies particularly to the servicing of mechanical and electrical

equipment and services, especially where the original equipment manufacturer publishes clearly defined service instructions. In countries with effective trade certification procedures, this form of self-certification is common practice; in the event of a dispute, the contractor's certifying body can be brought in to adjudicate. In countries without such schemes, self-certification is more risky and the quality of self-certified work should be independently checked.

Bibliography

- British Standards Institution (BSI). BS 8210:2012: Guide to facilities maintenance management. London: BSI; 2012 (<http://shop.bsigroup.com/ProductDetail/?pid=00000000030231187>, accessed 15 February 2015).
- Carbon Trust. GPG348 Good practice guide: Building log books – a user’s guide (<http://www.edocuments.co.uk/downloads/GPG348.pdf>, accessed 15 February 2015).
- Designing buildings Wiki (<http://www.designingbuildings.co.uk>, accessed 15 February 2015).
- International Air Transport Association (IATA). Perishable cargo regulations (ePCR) & temperature control regulations (eTCR). IATA; Geneva: 2013/2014 (<http://www.iata.org/publications/Pages/temperature-control-regulations.aspx>, accessed 15 February 2015).
- Miles D, Syagga P. Building maintenance – a management manual. London: Intermediate Technology Publications; 1987 (<http://developmentbookshop.com/building-and-construction>, accessed 26 February 2015).
- Stanford HW. Effective building maintenance: Protection of capital assets. Lilburn (GA): Fairmont Press; 2010 (<http://books.google.co.uk/books?id=-wVV5g0UQnsC&printsec=frontcover#v=onepage&q&f=false>, accessed 15 February 2015).
- Wood, B. Building maintenance. Wiley-Blackwell: Oxford; 2009.
- World Health Organization. Model guidance for the storage and transport of time- and temperature-sensitive pharmaceutical pharmaceuticals. In: WHO Expert Committee on Specifications for Pharmaceutical Preparations: forty-fifth report. Geneva: World Health Organization; 2011: Annex 9; WHO Technical Report Series, No. 961: <http://apps.who.int/medicinedocs/documents/s18683en/s18683en.pdf>, accessed 15 February 2015).
- World Health Organization. EVM standard operating procedures (SOPs) EVM-SOP-E5-01. Looking after store buildings. Geneva: World Health Organization; effective date: 7 October 2011 (http://www.who.int/immunization/programmes_systems/supply_chain/evm/en/index2.html, accessed 15 February 2015).

- Ziken International: “How to manage” series for healthcare technology. Procedures for health facilities and district authorities. St. Albans: Teaching Aids at Low Cost (TALC); 2005:
 - Guide 1: How to organize a system of healthcare technology management (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide1.pdf).
 - Guide 2: How to plan and budget for your healthcare technology (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide2.pdf).
 - Guide 3: How to procure and commission your healthcare technology (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide3.pdf).
 - Guide 4: How to operate your healthcare technology effectively and safely (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide4.pdf).
 - Guide 5: How to organize the maintenance of your healthcare technology: management (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide5.pdf).
 - Guide 6: How to manage the finances of your healthcare technology management teams (http://www.healthpartners-int.co.uk/our_expertise/HCTGuide6.pdf).

Annex 1

Uniclass: building elements

Note: External and internal decoration have been added to the list; these essential global maintenance items do not appear in the Uniclass system.

G1 – Site preparation	G11 – Site clearance
	G12 – Ground contouring
	G13 – Stabilization
G2 – Fabric	G21 – Foundations
	G22 – Floors
	G23 – Stairs
	G24 – Roofs
	G25 – Walls
	G26 – Frame/isolated structural members
G3 – Fabric: parts of elements	G31 – Carcass/structure/fabric
	G32 – Openings
	G33 – Internal finishes
	G331 – Floor finishes
	G34 – Other parts of fabric elements
G4 – Fittings/furniture/equipment (FFE)	G41 – Circulation FFE
	G42 – Rest, work FFE
	G43 – Culinary FFE
	G44 – Sanitary, hygiene FFE
	G45 – Cleaning, maintenance FFE
	G46 – Storage, screening FFE
	G47 – Works of art, soft furnishings
	G48 – Special activity FFE
	G49 – Other FFE

G5 – Services: complete elements

- G50 – Water supply
- G51 – Gas supply
- G52 – Heating, ventilation and air-conditioning (HVAC)
- G53 – Electric power
- G54 – Lighting
- G55 – Communications
- G56 – Transport
- G57 – Protection
- G58 – Removal/disposal
- G59 – Other services elements

G6 – Services: parts of elements

- G61 – Energy generation/storage/conversion
- G62 – Non-energy treatment/storage
- G63 – Distribution
- G64 – Terminals
- G65 – Package units
- G66 – Monitoring and control
- G69 – Other parts of services elements

G7 – External/site works

- G71 – Surface treatment
- G72 – Enclosure/division
- G73 – Special purpose works
- G74 – Fittings/furniture/equipment
- G75 – Mains supply
- G76 – External distributed services
- G77 – Site/underground drainage

External decoration

Internal decoration

Annex 2

Checklist for building weatherproofing

An example checklist for inspecting and repairing metal roof cladding and gutters is given in Table A2.1. A similar checklist could be used for metal wall cladding. This particular list is adapted from one prepared by the International Association of Cold Store Contractors (European Division).

It is crucial that the external envelope of a warehouse building protects the interior of the building, including cold store enclosures. There should also be a regular inspection of the inside of the roof, including crawl spaces above insulated cold store enclosures to check for roof leaks or significant build-up of condensation through insufficient air movement. Regular inspection and effective remedial action will prevent damage occurring. See companion Technical Supplement: *Maintenance of refrigeration equipment*.

Water leaks are most likely to arise from weather damage to the cladding or from overflowing gutters as a result of blockage. Accordingly, such inspections are best carried out during the rainy season, during or just after heavy rain.

Items in the Table that are marked with an asterisk should be checked shortly after the building is completed and thereafter annually. Other items should be checked at the intervals recommended by the cladding manufacturer.

Table A2.1

Example checklist for inspecting and repairing metal roof cladding and gutters

Inspection checklist		
Location:	South Warehouse	
Element:	G24 – Roof	
Check for	Reason	Action
*Leaks	Leaks may cause serious damage and corrosion within the building and may saturate insulation within the cladding system	Identify source of leak and repair in accordance with cladding manufacturer's recommendations
*Blocked gutters, downpipes and drainage	Blockages may cause overflow into the building	Clean and wash out any blockage

Table A2.1 *continued*

Check for	Reason	Action
*Local damage	Breakthrough of protective paint coating could cause corrosion of steel substrate	Assess extent and type of damage Possible actions: <ul style="list-style-type: none"> • Touch-up affected area in accordance with manufacturer's instructions • Over-paint affected area in accordance with manufacturer's instructions • Replace damaged sheet using matching material supplied by the original manufacturer
*Drilling swarf, rivet stems and other fixing debris	These can rust and cause staining	Remove debris
Dirt retention in areas of cladding not washed naturally by rainwater e.g. overhangs	This affects the appearance of the building and could, if left, cause breakdown of the coating	Wash down in accordance with manufacturer's instructions
Mould growth	This rarely occurs but can arise in extreme conditions and may affect appearance	Wash down and treat in accordance with manufacturer's instructions
Condition of fasteners	Faulty or inappropriate fasteners can cause leakage, or rust staining on the surface of the cladding, or both	Replace faulty fasteners and any missing caps
Corrosion of cut edges	Corrosion of cut edges at sheet overlaps and at overhangs can, if neglected, spread up the sheet	Apply treatment recommended in manufacturer's instructions
Changes in condition of the coating	Changes should be noted	Seek manufacturer's advice

* Check this item shortly after the building is completed and thereafter annually.

Revision history

Date	Change summary	Reason for change	Approved

