AVIATION SAFETY DEPARTMENT

Aerodrome Maintenance

Guidance Material

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FOREWORD

This guidance material consolidates in one document a review of the maintenance practices required at an airport to maintain the safety, efficiency and regulatory aircraft operations. It is only concerned with those facilities which are normally the responsibility of the airport authority. In other words, maintenance of such facilities as radio navigational aids and meteorological equipment is not discussed.

Proper maintenance of airport facilities is important both for the safe operation of aircraft and extending the life of the facilities. Nevertheless, maintenance is frequently overlooked or reduced when establishing budgets for airport. It is hoped that this guidance material will establish the proper position of maintenance in the over-all airport program.

Differences between the facilities provided at an airport, differences in the local environmental conditions and differences in use make it impossible to name specific maintenance requirements. This guidance material attempts to overcome this by identifying the various types of maintenance required for airport facilities. It remains for each airport authority to decide if a particular maintenance check is appropriate for its airport and to establish the appropriate maintenance schedule.

Aviation Safety Director

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CHAPTER l

GENERAL

1.1 AIM OF THIS GUIDANCE MATERIAL

1.1.1 This guidance material is directed at authorities responsible for the operation of airports and/or individual facilities on airports other than meteorological or electronic navigation aids. It is compiled in a manner suitable for those who have responsibility for the operational safety of airport facilities and equipment, and for ensuring the undisturbed operation of air traffic on the ground. Reference is made to specifications and other relevant material in CARC documents which require authorities to take care of special tasks in the interest of safety and regularity of air transport.

1.1.2 While this guidance material addresses maintenance of airport components regardless of the airport's size or role, the description of tasks has been restricted to the maintenance of those facilities which are unique to or typical for airports. As airports are comparable to other kinds of industrial plants, many other maintenance functions have to be carried out to ensure serviceability and function of buildings, facilities and equipment. This guidance does not deal with any of these normal industrial maintenance tasks except in areas where a functional failure would impair safety or regularity of aircraft operation and/or passenger handling.

1.2 USE OF THIS GUIDANCE MATERIAL

1.2.1 This guidance material is intended to give guidance to authorities on planning and conducting maintenance work on an airport. the guidance has been developed from various airport operators' practices and reflects long-term experience in the field of airport operation. Since wear and sensitivity of any technical component depend on material, utilization, age, climate and other environmental conditions, none of the recommendations on the type and intervals of maintenance action described in this guidance material should be considered a specification. Local needs, local experience, recommendations of manufacturers of components and -if relevant - national or local rules should govern the plan on what and when maintenance asks are to be carried out.

1.2.2 The recommendations compiled in this guidance material more or less describe the air carrier airports' needs for maintenance. For commuter-type and general aviation airports less extensive maintenance will suffice, since neither their type of traffic nor the economic situation of such airports generally warrants as high a level of maintenance, except for runway surfaces and -if provided-visual aids. Nevertheless, the information given in this guidance material may also guide operators of commuter-type and general aviation airports in setting up maintenance programmes tailored to the needs of then- facilities.

1.3 ORGANIZATION OF THIS GUIDANCE MATERIAL

1.3.1 This guidance material is organized in such a way as to cover primarily the airport maintenance tasks required for maintaining safe aircraft operation during the landing, taxi and take-off phrases. In addition, some of the maintenance tasks supporting the airport efficiency have been included.

1.3.2 The requirements for safety reasons dominate the first part of the guidance material's contents, wherein the maintenance of visual aids, electrical infrastructure, pavements, unpaved areas and the drainage system is dealt with. Availability of suitable equipment is the tool for complying with the maintenance requirements of fixed facilities. Therefore, the maintenance of vehicles and equipment has been included as an elementary part of the over-all airport maintenance task. Aircraft removal equipment represents a very special type of airport equipment.

1.3.3 Chapter 8 concerns one aspect of the large field of maintenance tasks for the serviceability of handling facilities on an airport, i.e. the maintenance of some of the technical passenger-handling facilities in the terminal building.

1.4 PURPOSE OF AIRPORT MAINTENANCE

1.4.1 Airport is an important part of the aeronautical infrastructure, has to meet high safety standards. The required level of safety can only be achieved by proper maintenance of all the elements composing an airport.

1.4.2 Maintenance includes measures to keep or restore the operational function as well as measures to check and to evaluate the present function of an element. The basic components of maintenance are:

a) inspection;
b) servicing and overhaul; and
c) repair.

1.4.3 Inspection comprises all measures to check and evaluate the operating condition including spontaneous and scheduled checks. Scheduled checks are carried out in accordance with a plan specifying the preparation of the check, the sort of check, the report on the result and the evaluation of the results. From the evaluations the operator decides whether or not extra servicing or even repair has to be undertaken.

1.4.4 Servicing and overhaul comprise all measures to maintain or return a facility or device to its required operating condition. These measures should be carried out according to a plan specifying the time for the service, the nature of the service and the report of compliance.

1.4.5 Whenever inspection or servicing discovers deficiencies, repair measures have to be planned and carried out as soon as practicable. Repair can comprise minor or major work as, for instance, runway surface treatment with consequential traffic interruption.

1.4.6 Efficiency and safety of operation can only be expected from facilities that are in good operational condition. The maintenance of facilities, i.e. the sum of all measures

described above is the perquisite to such a condition. Furthermore, maintenance minimizes wear and tear, thus controlling and extending considerably the life span of technical components. In this respect maintenance becomes an economic requirement to keep investment and capital costs for the aeronautical infrastructure within acceptable limits.

1.5 ORGANIZATION OF AIRPORT MAINTENANCE

1.5.1 Complete assessment of all parts of the airport is the basic requirement of the maintenance organization. Buildings, pavement sections and unpaved areas in between have to be numbered, as well as all machinery, technical and mechanical inventory, including vehicles. The numbers define the objects, for which the maintenance requirements can be specified individually. These requirements should be recorded on cards or computer tapes.

1.5.2 Maintenance programmers will be developed from experience with the needs of the different objects or in accordance with the manufacturer's advice. For economic reasons and in order to split responsibility equitably, a precise breakdown of the total work by fields of maintenance is recommended (e.g. for a building-roofs, walls, (including doors and windows), machinery and mechanical facilities and electric installations). Each team or expert responsible for one special task can then work in accordance with a systematic work program that will achieve optimum efficiency.

1.5.3 A fundamental task of the maintenance organization is to translate the maintenance requirements into manhours and monetary value. This evaluation is the bases of staffing budget planning. It is, furthermore, a tool for decision-making when contracting third parties for maintenance tasks instead of employing extra personnel.

1.5.4 All maintenance programs should be "screened" once a year, preferably at the time of budget planning. It is useful not only to rely on recorded data but to inspect the condition of all major objects at that time. In contrast to machines, whose operating hours give a good measure of wear, the deterioration of buildings is more dependent on weathering, utilization under heavy load, concealed construction deficiencies or other unpredictable sources of damage.

1.5.5 Updated maintenance programs will allow:

a) appropriate staffing;
b) compliance with the recorded maintenance needs; and
c) flexibility to the timing of action when unexpected circumstances have affected the planned work schedule.

When management checks the work carried out against scheduled tasks, it gains thereby full control of the maintenance progress and budget. Compliance reports are the feedback and have to be recorded, as well as observations or any reported deficiencies.

1.5.6 Computer assistance can be helpful and economical if the volume of maintenance is high. The computer is particularly capable of controlling preventive maintenance tasks typical of electrical systems and machines. Furthermore, evaluation of the

aging of inventory and of maintenance budget control can be facilitated by suitable computer programs. The computer is less effective for maintenance control of buildings and pavements, where repair work upon notice will always prevail.

1.5.7 To maintain the operation of the technical facilities at an airport, a sufficient number of technicians must be available during airport operating hours so that deficiencies can be overcome immediately. The team available should comprise, as appropriate, engineers, automotive technicians, locksmiths, tinsmiths, air conditioning and heating technicians, electricians and HF-technicians. If control/monitoring centres for technical facilities exist, they should be manned permanently.

1.5.8 This standard team can be reduced outside the operating hours to such a degree that vital components necessary for the technical function of the airport (e.g. electrical circuits, heating or air conditioning, telephone system etc.) can be kept serviceable and additional technicians can be called upon to arrive promptly in cases of se110US disturbance. In all other cases the reduced maintenance team has to take care of provisional repair work and will report on maintenance needs to the standard team at the beginning of their duty hours.

1.5.9 The standard team need not be capable of doing all of the airport's maintenance tasks. The airport authority may use contractors to carry out those maintenance tasks which can be easily organized on a time schedule. However, apart from the normal maintenance tasks (which according to the experience of the airport authority the maintenance staff can fully take care of special tasks may occur unexpectedly dale to the very nature of air transport and its sensitivity to external impacts. Reasons to extra maintenance work can be:

a) snowfall or ice forming on operational areas;
b) sandstorm;
c) rain, heavy thunderstorm with consequential damage;
d) aircraft accidents or incidents; and
e) technical or criminal emergencies.

1.5.10 To cope with these inevitable work requirements and especially in view of the airport emergency plan, the airport authority will have to have a certain reserve of skilled craftsmen employed. This requirement reduces the scope for contract maintenance by third party companies.

1.5.11 To ensure the whole airport's smooth operation the provision of workshops at the airport is necessary from both an operational and economic standpoint. The selection of the kinds of workshops depends largely on the local situation, i.e. size of airport, traffic volume, ownership of facilities and equipment, share of work between airport users (airlines) and airport operator etc. Individual solutions for the provision of workshops have to consider:

a) local maintenance requirements;
b) compliance with the airport emergency plan; and
c) economic aims,

The economic aims may involve performing other business in the airport's workshops, for example, aircraft maintenance for home base carriers and/or general aviation. Alternatively, economic needs can require that outside workshops or craftsmen be used for maintenance work and even emergency assistance. A sound balance between the capacity of the airport's basic maintenance workforce and their system to comply with peak and emergency workloads is important for an economic airport operation.

CHAPTER 2

MAINTENANCE OF VISUAL AIDS

2.1 INTRODUCTION

2.1.1 The basic purpose of visual aid systems is to aid in the safe operation of aircraft. Therefore, the highest standards of maintenance are required. Once a system has been installed, its usefulness is dependent on its serviceability which in tum depends upon the effectiveness of the maintenance work carried out. KCASR 14 Vol. I define a light to have failed when its light output falls
below 50 per cent of that specified for a new light. The causes for the loss in light output can be contaminants outside and inside the light unit, and degradation of the lamp and optical system due to aging. The light can and should be restored to its original condition by cleaning or replacing the lamp and any parts which have apparently become degraded. For this purpose, it is essential to establish a comprehensive routine maintenance system for servicing lights and other equipment so that the installation complies with the specified requirements.

2.2 PERSONNEL

2.2.1 The task of maintaining lighting aids should be entrusted only to reliable and skilled electricians who have had experience with high voltage, series circuits and lighting. These individuals should be present or on call during the operating hours of the airport to correct any deficiencies that might develop. Training programs should be established to maintain the competence of maintenance
personnel and to keep them abreast of new developments.

2.3 SPARE PARTS

2.3.1 An adequate stock of spare parts should be available. The level of stock will vary depending on the time required to re supply a particular item and its shelf life.

2.4 AS-BUILT DRAWINGS

2.4.1 A set of as-built drawings should be kept readily available. These drawings must be kept up to date and any changes at site should be reflected immediately on these drawings. The completeness and the accuracy of all circuit diagrams, drawings and descriptions should be checked at least annually.

2.5 LIGHT MAINTENANCE SCHEDULE

2.5.1 Standards for Airfield Lighting System Maintenance

The following is a summary of ICAO's mentioned documents that define the expectations from a maintenance plan:

- Airfield lights are considered unserviceable if their beam intensity is less than 50% of the standard.
- Light replacement is recommended when its output falls below 70% of the standard.
- Light measurements should be carried out regularly to detect early light output reduction.
- As a general rule, an unserviceable light shall not be permitted adjacent to another unserviceable light.
- For taxiways that operate with an RVR of less than 350m, no two adjacent taxiway centre line lights be unserviceable.
- For Cat II and III runways, the light measurement frequency should be based on local factors, but it should be at least twice a year for in-pavement lights and once a year for other lights.

The table below shows the minimum serviceable lights ratio for different types of runways:

Light Type	Cat II or III	Cat I	RVR<550m*	RVR>550m*
Approach (inner 450m)	95%	85%		
Approach (beyond 450)	85%	85%		
Runway Center Line	95%		95%	
Runway Threshold	95%	85%		
Runway Edge	95%	85%	95%	85%
Runway End	75%	85%	75%	85%
Touchdown Zone	90%			

*A runway meant for take-off in stated RVR conditions

2.5.2 When servicing lights the instructions of the appropriate authority and recommendations of the equipment manufacturer should be followed to ensure the required service standard. Service records showing maintenance schedules recommended by the manufacturer or local standards should be prepared for each piece of equipment.
These can be arranged in a dated reminder file to make sure all equipment is serviced regularly. This record should have space to enter observations, measurements and initials of the servicing individual. If local conditions indicate a change in time interval of servicing to be desirable then the schedule can be altered in consultation with the equipment manufacturer.

2.5.3 The frequency at which routine inspection, cleaning and servicing are to be performed will vary according to the type of equipment, its location and usage. A maintenance program must be drawn up for each individual airport based on past experience and its aim should be to achieve the required service standard. The following schedules are presented as guidance material in establishing a preventive maintenance program. More frequent checks may be necessary for the lights serving precision approach category II and III runways. The time schedules shown should not take precedence over manufacturers' instructions or be applied to similar equipment not mentioned. Each check should be followed by appropriate corrective action. Basic maintenance program for approach, runway and taxiway lighting systems

2.5.4 Maintenance for all types of approach, runway and taxiway lights should include checking and, if necessary, taking the indicated corrective action, as follows:

Daily:

a) system for burnt-out lamps; replacing burnt-out lamps
b) system for gross misalignment (if applicable); adjusting
c) control equipment for proper operation on each brightness step (if applicable); correcting or
repairing malfunctions;
d) glass for breakage; replacing broken parts.

Annually:

a) tightening fasteners of each light unit;
b) painting or replacing rusted parts of lights for corrosion;
c) cleaning or replacing reflector of each light unit (if applicable);
d) cleaning or replacing glass of each light;
e) cleaning or replacing lamps of the whole system;
f) replacing of the unserviceable lamps or entire system (see 2.6.18)
g) adjusting elevation setting (if applicable);
h) adjusting horizontal alignment;
i) plug connections for cleanness and faultless contact;
j) cleaning or replacing of dirty parts of light fittings and their supporting structure (if existing) for adequacy of fastening and for corrosion and rust; tightening fasteners; painting or spraying.
k) general condition of the whole system, and recording Result.

Unscheduled:

a) adjusting elevation sitting and the horizontal alignment (if applicable) of the light units after severe storms and snowfalls;
b) light units for obstruction by grass or mow. etc. (not applicable for Inset lights); removing any obstacles found.
Additional maintenance program for special types of lights

2.5.5 In addition to the maintenance program Specified 2.5.3, the following should be carried out for visual approach slope indicators, runway threshold and end light, and inset lights.

2.5.6 Visual approach slope indicator maintenance should include checking and, if necessary, taking the indicated corrective action, as follows:

Twice monthly:

a) adjusting elevation setting (vertical angle) of the light units;
b) Cleaning spreader glasses, filters and lamps for cleanness;

Annually:

a) adjusting system from the air and recording results; and replacing lamps
b) repairing supporting structure and the foundation of each unit;

2.5.7 Runway threshold and runway end light maintenance should include checking and, if necessary, taking the indicated corrective action as follows:

Twice weekly:

a) tightening fasteners of the lights;
b) replacing glass of each light for wear and tear;

2.5.8 Inset lights (runway centre line lights, touchdown zone lights, taxiway centre line lights, stop bar lights) maintenance should include checking and, if necessary, taking the indicated corrective action, as follows:

Daily:

a) lenses for cleanness; cleaning

Twice weekly: (not applicable to taxiway and stop bar lights)

a) cleaning of the light lenses, output of lights within 900 m from each threshold including
measuring and recording the results;
b) replacing top parts of lights within 900 m from each threshold.

Quarterly: (not applicable to taxiway and stop bar lights)

a) cleaning of the light lenses, output of all lights within the system including measuring and recording the results;
b) replacing top parts of the lights.

Semi-annually: (not applicable to taxiway and stop bar lights):

a) cleaning lights for cleanness inside and out;
b) drying lights for moisture;
c) tightening electrical connections of the lights; spraying with contact agent
d) adjusting alignment of light.

Annually:

a) cleaning or replacing prism and filters;
b) resealing sealing compound;

Unscheduled:

a) tightening top parts of the lights two to four weeks after replacement.

Item	Asset/Task	Frequency	Work Scope
1	Inspection of Runway/Taxiway Lighting	Daily	• Check system for burnt-out lamps and report for maintenance service if any discrepancy found
2	Maintenance of Runway/Taxiway Lighting	Daily	• Replace the defective light and adjust any misalignment
		Bi-annually	• Check fasteners of each light unit; tightening as required • Check lights for corrosion; painting or replacing rusted parts • Cleaning or replacing reflector of each light unit (if applicable) • Cleaning or replacing glass of each light, if necessary • Check lamps of the whole system; replacing of the unserviceable lamps or entire fixture • Adjust elevation setting of required • Check horizontal alignment and adjust if required
		Annually	• Check plug connections for cleanliness and faultless contact if required; cleaning or replacement of dirty parts, if required • Check light fittings and their supporting structure for adequacy of fastening and for corrosion and rust; tighten fasteners; painting or spraying • Check general condition of the whole system, record results
		Un-scheduled	• Check elevation setting and the horizontal alignment (if applicable) of the light units after severe storms; adjust, if required • Check light units for obstruction by grass (not applicable for inset lights), removing any obstacles found
3	Maintenance of Visual Approach Slope Indicator (PAPI)	Twice monthly	• Check elevation setting (vertical angle) of the light units; adjust if necessary • Cleaning of spreader glass, filters, and lamps
		Quarterly*	• Perform bulk replacement of PAPI lights
		Annually	• Adjust and replace lamps, if required • Check supporting structure and the foundation of each unit and repair, if required
4	Maintenance of Runway Threshold and Runway End Light	Twice weekly	• Check tightness of the lights and fittings to the seats • Replace glass of each light for wear and tear
		8 months*	• Perform bulk replacement for Runway Threshold
		10 months	• Perform bulk replacement of Runway End Light

Item	Asset/Task	Frequency	Work Scope
5	Maintenance of Inset Lights: Runway Centre Line Lights and Touchdown Zone Lights	Bi-weekly	• Check lenses for cleanliness, clean if required • Re-tightening of the light fitting, if require
		Bi-annually	• Light output of all lights within the system, including measuring and recording results • Check lights for cleanliness inside and outside; cleaning, if required • Check electrical connection of the lights; tighten; spray with contact agent, if required • Check alignment of lights; adjusting, if required • Check prisms and filters; cleaning or replacing as required • Check sealing compound; reseal, if required
		Un-scheduled	• Check top parts of the lights two to four weeks after replacement and tighten, if required
6	Maintenance of Inset Lights: Runway Exit Lights and Stops Bar Lights	Bi-weekly	• Check lenses for cleanliness; clean, if required (for stop bar light only) • Re-tightening of the light fitting, if required (for stop bar light only)
		Bi-annually	• Check or replacing prisms and filters • Check sealing compound and reseal, if required • Sample checking of light output for Taxiway Centre Line Light, including measuring and recording the results; cleaning of the lenses
		10 months	• Perform bulk replacement for stop lights and runway exit lightst
		Un-scheduled	• Tightening top parts of the lights two to four weeks after replacement
7	Maintenance of Approach Lights	Bi-weekly	• Inspection of elevated approach lights
		Bi-annually	• Clean the elevated approach lights
		Annually	• Check light fittings and their support structure for adequacy of fastening and for corrosion and rust • Check general condition of the whole system and record result • Check alignment
8	Maintenance of Strobe Lights	Bi-weekly	• Inspection of the strobe lights
		Bi-annually	• Clean strobe lights • Check the function of the control and operation of the lights are in correct sequence and frequency • Check the supply boxes, control and supervision box, and its electrical accessories
		Annually	• Check light fittings and their support structure for adequacy of fastening and for corrosion and rust • Check general condition of the whole system and recording result • Check alignment
9	Maintenance of Runway Guard Lights	Bi-weekly	• Check lights for cleanliness; clean, if required • Check the light fitting for tightness; retighten, if required
		Annually	• Check electrical connection of the lights, spray contact agent, if required • Check alignment

Table 2-1: Maintenance Interval

2.5.9 Other airport lights include, for example, airport beacons, obstacle lights and wind direction indicators. These normally need less maintenance than approach, runway or taxiway lighting systems. Their maintenance should include checking and, if necessary, taking the indicated corrective action as follows:

Daily:

a) lamps replacing; if necessary
b) correcting or repairing control equipment for proper operation (not applicable in the case of obstacle lights);
c) fabric of the wind cone repairing or replacing.

Semi-annually (only for airport beacon):

a) cleaning or replacing power supply (brushes and slip-rings);
b) tightening electrical connections;
c) fastening rotating parts.

Annually:

a) optical system of the airport beacon;
b) cleaning or replacing glasses and the gaskets of obstacle lights;
c) cleaning, repairing or replacing function of the flashing relays and of the twilight switches of the obstacle lights;
d) repairing or replacing power supply and the lighting of the wind direction indicator;
e) tightening; spraying with contact agent electrical connections;
f) fasteners of obstacle lights
g) tightening or repairing the structure and the fasteners of the wind direction indicator;
h) painting lights for corrosion;
i) replacing colour of the fabric cone of the wind direction indicator;
j) arranging of change the location if required and possible of obstacle lights for easy access for maintenance.

Unscheduled:

a) wind direction indicator after severe storms; repairing.

Docking Guidance Systems

2.5.10 Maintenance programs for various types of aircraft docking guidance systems are provided at airports and it is very difficult to describe a generally applicable maintenance program for these very different systems. Principal requirements to be checked and maintenance action to be taken, if necessary, include:

Daily:

a) repairing system for over-all operation;
b) replacing burnt-out lamps.

Semi-annually:

a) adjusting alignment of the system;

Annually:

a) cleaning, tightening and replacing electrical connections (if provided) for tear and wear.
b) cleaning or replacing function of relays (if provided);
c) repairing structure of the system and the function of all mechanical parts;
d) cleaning and drying system for cleanness and moisture.

2.6 LIGHT MAINTENANCE PROCEDURES

General hints for maintenance of lights

2.6.1 For reasons of efficiency the maintenance of lights should, as far as practicable, be carried out indoors. inconveniences of working out of doors, such as heat, cold, precipitation and aircraft noise can be avoided and traffic restrictions or interruptions will be reduced to a minimum. The quality of service will also be higher in workshops than out of doors. This is particularly applicable when, in the interest of unrestricted traffic flow during day hours, the work has to be carried out during the night.

2.6.2 The maintenance procedure commonly used comprises two steps:
a) removal of defective lights and immediate replacement by new or repaired ones
b) servicing and overhaul of defective lights in the workshop where all required tools, measuring and adjusting equipment are available.

2.6.3 This procedure has proven to be practical, particularly for the maintenance of inset lights. Provision of a sufficient number of stored spare lights is a prerequisite. The number of spare parts depends on the over-all requirement of the airport and the experience with the sensitivity to damage of the various types of lights on the airport.

It is useful to select lights which are designed to permit removal and installation within a short time, without the use of very sophisticated technical equipment. Furthermore, all mechanical and optical parts of the light should be incorporated in the removable part.

Cleaning procedures for lights

2.6.4 The type and degree of contamination of the various lights on an airport will be different. While elevated approach and edge lights are normally contaminated by weather effects only (dust carried by wind and rain), more severe contamination can be observed on inset lights, particularly on runways. Rubber deposits from tires on touchdown and exhaust from engine reverse thrust procedures create firmly sticking deposit on the exterior glassware of lights. The very different degree of contamination must be reflected in the maintenance schedule of different categories of lights or sections in the runway/taxiway system.

2.6.5 When cleaning the glassware of lights, the manufacturer's recommendations should be observed. Normally, cleaning is accomplished by washing the glassware with a cleansing mixture of water and a special solvent that will neither affect the sealing material nor produce a residual film on the glass.

The solvent must be given sufficient time to dissolve the deposits. If necessary, rubber spots may be scraped off by using plastic tools or powder before using the solvent. Other mechanical aids for cleaning may be sponges, cloths, hand brushes or electric rotating brushes. The cleaning technique and the materials used should not scratch or groove the glass surface nor damage the sealing material.

2.6.6 Dry cleaning of glassware should be avoided. However, if cleaning becomes necessary for some reason, no sand or other abrasive material should be used. In such cases cleaning can be done by using clean ground-up walnut or pecan shells and dry compressed air. Special treatment can normally be avoided by following a maintenance schedule with wet cleaning at suitable intervals.

2.6.7 For cleaning light fittings on site special maintenance vehicle equipped with air compressors, vacuum cleaner and solvent tanks should be used. A low working seat at the rear or front, or an opening in the bottom of the maintenance vehicle facilitates the work considerably. In some cases, these vehicles can carry the required tools for all types of maintenance work, including the removal of old lights and the installation of new ones.

2.6.8 Thorough cleaning of the interior of the light to remove mud, moisture or rust should be carried out in workshops. Only minor contaminants, such as dust, should be removed on site.

Light measurement

2.6.9 The light output will diminish with the lapse of time due to lamp aging. Contamination of reflector and lens will result in a further degradation of light output. According to KCASR 14 Vol. I a light is considered to have failed when its output is less than 50 per cent of the required intensity.

For practical reasons replacement of a light is recommended when its output falls below 70 per cent of that specified for a new light.

2.6.10 Light measurements should be carried out regularly to detect early light output reduction. Appropriate equipment for both field and bench measurement of light output is available. The equipment produced by light manufacturers does not, however, indicate the absolute intensity values but provide ratios between measured and original light intensities of each individual type.

2.6.11 Field measurements are particularly necessary for inset lights. Wheel loads on inset lights may frequently cause damage. One type of measuring equipment offered by the light manufacturers for field use consists of a photocell and a microammeter. Such measuring devices are placed over the light fitting and the

meter reading observed is compared with the calibration value. Before measuring, the lights should be cleaned and switched to the highest available intensity setting.

2.6.12 Light measurements can also be made by using a photographic 10 spot meter, which is not placed on the light casing directly, but moved vertically and horizontally through the light beam at a fixed distance. The intensity is checked by comparison with the results of a calibration test with a new light.

2.6.13 The measuring procedures described above are quite time-consuming. With the special device each measurement it will take about 2 minutes. Often a much faster visual observation carried out by experienced personnel will achieve comparable results for discovering and reporting single lights with unacceptable light output. For visual checks the level of brightness must be switched to "LOW" (3 to 10 percent of maximum).

2.6.14 For adjustment of the correct angle of the beam, lights are normally furnished with alignment markings. Furthermore, light manufacturers offer suitable adjustment equipment for their product. Beam misalignment caused by displacement of the optical system inside, however, cannot be corrected by adjusting the casing. When such misalignment is observed visually, the light should be adjusted in the workshop.

2.6.15 For measuring light output in the workshop, the measuring equipment produced by the light manufacturer concerned should be used. The equipment consists of a bench to fix the light and a photocell sensor element. Microammeter readings should be compared with the calibration value. Directional adjustments can be made using the alignment screws.

2.6.16 Where light measurements have to be accomplished without the manufacturer's special equipment, a useful technique is to check the isocandela curve on a vertical surface located approximately 3 m in front of the light unit. With photocells at the vertical and horizontal limit lines of the isocandela curve, comparison with the light output of a new light will be possible. Lights should be switched to the maximum brightness level before testing.

2.6.17 Photometric Testing, based on ICAO standards and guidelines, should be conducted **regularly** to assess the condition of the airport's lights. This is the only way to prove that the airport complies with the minimum light serviceability levels defined for each runway and taxiway type. Airports to determine the frequency of the measurements depending on traffic, pollution, reliability of the installed equipment, and continuous in-field measurements. However, airports with precision approach runways with Cat II or III operations should conduct photometric testing at least twice a year for their inset lights and once a year for other lights.

Lamp replacement and Removal of water

2.6.18 The life span of lamps varies from 100 to some I 000 hours of operation. The life time depends on the percentage of operation at high brightness levels and on the

number of switching. Also, dynamic stresses imposed by aircraft wheel loads (inset lights) and temperature-induced stresses inside the casing affect the lamp life. Lamps which have failed should be replaced as soon as possible since the lighting system of an airport has to meet specified serviceability requirements.

2.6.19 Lamp replacement can be organized in two different ways:

a) only lamps which have failed or lamps showing major output reduction are replaced upon checking; this method requires checks to be carried out at short intervals;
b) bulk changing of lamps in certain sections of the entire lighting system, in accordance with a fixed time schedule. The intervals between replacements have to be derived from local experience with the average life of lamps in use. Lamps should be changed when they have been operated for 80 per cent of their average life.

For this maintenance method a reliable record of operating hours for the individual sections of the airport's lighting system is a prerequisite. This method requires less frequent checks.

2.6.20 Lamp replacement in the workshop is preferable, particularly with inset lights. The unserviceable light should be removed from its position and replaced by a serviceable light. Lamp replacement of elevated lights may be carried out on site provided that the casing can be opened easily and quickly, and the socket of the lamp needs no realignment afterwards.

2.6.21 Inset lights may sometimes collect water. Water inside the light increases corrosion, causes damage to electrical parts and deposits on lens and lamp and, furthermore, reduces the life of the lamp. Before insetting a light into the pavement good drainage of the opening must be ensured. Nevertheless, penetration of moisture and accumulation of water cannot be precluded completely. Regular inspection is necessary to check lights for the presence of water. Lights found to be wet inside should be removed and replaced, if such a procedure is possible with the type of light. Otherwise, drying must be carried out on the spot. After drying, the sealings should be checked carefully and replaced when necessary. Before closing a dried light, the lamp should be switched on for some time to permit any residual moisture to evaporate due to the temperature increase inside.

2.6.22 Attention should be paid to the presence of water on and in front of the glass of inset lights. Water may bend the light beam, thus misaligning the light direction. If such a situation is observed, the drainage has to be improved.

LED Lights

2.6.23 While LEDs could last for many thousands of hours under certain conditions, the life of the LED itself, and more importantly, that of the complete luminaire including the electronics, still depends on the system integration and the actual conditions in which the luminaire is used. Application conditions that could have an impact

on the expected life of the luminaire include, primarily, the temperature of operation, on-off cycling patterns and humidity. Because LEDs do not have filaments that break or deteriorate, when operated under normal conditions, they tend to last for a long time. However, their light output decreases and the colour of their light shifts over time, with the rate of depreciation increasing at higher operating temperatures. The implication for practice is that at some point in time the loss of light output or the colour shift may render the LED source outside the specifications for a given application or purpose; while the LEDs may technically still be operating, they would no longer be considered useful.

2.6.24 Therefore, the long life of the LED in comparison to that of an incandescent lamp should not be taken as reason for "install and forget". A system of preventive maintenance should remain in place as the LED light does eventually fail. As well, there are other factors which can reduce performance such as contamination on the lens of in pavement fixtures.

2.7 SIGNS

2.7.1 Signs give pilots directional information for taxiing and holding. Maintenance should ensure integrity and perfect legibility of the information provided by the signs. The design and construction of signs varies considerably but the following general checks and, if necessary, maintenance action, are recommended for each sign:

Daily:

a) lighting; replacing burnt-out lamps;
b) inscriptions for legibility and absence of obstructions; repairing the signs and removing obstructions.

Annually:

a) repairing mounting of both the sign and its lighting if provided;
b) cleaning, repairing or replacing structure and its paint.

Unscheduled:

a) after rainy season for legibility; removing obstructions.
b) after severe storms; re-positioning tumbled signs and repairing damaged signs.

2.8 MARKINGS

2.8.1 All markings on paved areas should be inspected at least semi-annually. Local conditions will determine when to inspect. In general, a spring and fall inspection will suffice to detect deterioration due to the winter and summer weather extremes.

2.8.2 Markings which are faded or discoloured by soil should be repainted. When rubber deposits have been removed from the pavement all defaced markings should be restored as soon as possible.

CHAPTER 3
MAINTENANCE OF AIRPORT ELECTRICAL SYSTEMS

3.1 GENERAL

3.1.1 The serviceability and operational reliability of air navigation equipment and installations are requirement, for the safe operation of aircraft in the airport area. Apart from visual aids, the air navigation equipment and installations include electronic landing aids, navigation equipment, radar and equipment of the meteorological services. Guidance on the maintenance of visual aids is given in Chapter 2 of this guidance material, maintenance programs for other equipment and installations are to be established by the appropriate authorities (ATC, Meteorological Services).

3.1.2 The required serviceability of installations and equipment will only be achieved as long as a constant power supply is maintained. To this end, regular maintenance work is required for airport equipment and installations distributing primary power and equipment supplying the secondary power when there is a circuit breakdown. The following paragraphs contain guidance on establishing maintenance programs for the individual elements of the power supply systems, such as power cables, control cables, transformers, transformer stations, regulators, relay and switch cabinets and secondary power supply equipment. Furthermore, guidance is given on the regular maintenance of the floodlighting systems for aprons. Chapter 8 of this guidance material includes guidance on the maintenance of lighting systems in and around passenger terminal buildings.

3.2 PERSONNEL

3.2.1 Maintenance work on airport electrical systems should be assigned to skilled electricians, fully acquainted with the work to be done. As work is often required in high voltage areas, they should be well informed and kept up to date all safety measures. To protect personnel the required safety devices should always be kept in good condition.

3.2.2 The maintenance personnel should be present or on call during the operating hours of the airport. It may be advisable to have the same persons take care of maintenance of both electrical systems and visual aids.

3.3 SCHEDULE OF MAINTENANCE

3.3.1 Schedules of routine maintenance of the individual elements of the airport electrical system should be based on manufacturers' recommendations adjusted to the operator's own experience regarding the frequency of malfunctions. Therefore, a record of maintenance work carried out will need to be maintained.

3.3.2 As the frequency of servicing depends on the type of equipment, it is not possible to set up generally applicable maintenance programs. Therefore, the following

schedules provide only general guidance on the setting up of a program of preventive maintenance.

Power cables and distributors infield

3.3.3 Cables and distributors outside of buildings can only be checked where installed in channels. Preventive maintenance is not possible where power cables are buried in the soil. In such cases, work is restricted to repair when malfunctions have been noticed. Their maintenance should include semi-annual checking and, if necessary, taking the indicated corrective actions follows:

a) cleaning and drying distributors located in manholes for cleanness and moisture;
b) tightening and spraying plug-in and clamp connections in the distributors for good contact;
c) pumping-out, drying up or cleaning manholes for condition of the interior;
d) insulation resistance by measuring the earthing resistance of each circuit; recording readings and taking necessary corrective action.

Transformers and regulators (including standby units)

3.3.4 Maintenance of transformers and regulators should include checking and, if necessary, taking the indicated corrective action, as follows:

Monthly:

a) power supply transformers and regulators and oil losses; cleaning and replacing oil;
b) restoring switches at all light intensity positions for malfunctions;
c) restoring switch over to standby units for serviceability.

Annually:

a) transformers for noise; investigating reason for any unusual sound and repairing
b) repairing over-all condition;
c) repairing or replacing insulators;
d) cleaning collector bar system;
e) voltage and amperage at all intensity levels, measuring and recording; adjustment of voltage to nominal level.

Transformer stations for electric power supply

3.3.5 Maintenance of transformer stations for electric power supply should include checking and, if necessary, taking the indicated corrective action, as follows:

Weakly:

a) over-all condition visually; restoring
b) fuse boxes for completeness of contents; adding missing fuses.

Semi-annually:

a) insulators and electrical connections; cleaning and Restoring
b) station for dirt and moisture; cleaning and drying
c) locks to stations for serviceability; repairing and locking.

Annually:

a) adjusting protection relay;
b) high voltage cable insulation; recording condition of each cable; taking preventive measures
c) cleaning earthing and its resistance;
d) repairing electrical supply system for noise and damage;
e) cleaning and painting for rust, corrosion or defective coating;
f) cleaning or replacing warning signs and safety devices are present and in correct positions;
g) completing, cleaning and painting safety grids for completeness, rust or coating deficiencies;
h) safety grids for stability and earthing; tightening and restoring proper earthing, Relay and switch cabinets (including switch cabinets in sub-stations)

3.3.6 Maintenance of relay and switch cabinets should include checking and, if necessary, taking the indicated corrective action as follow:

Semi-annually:

a) turn and plug-in connections for cleanness and good electrical contact
b) cleaning or replacing relays for positive closing of contacts;
c) cleaning and replacing electrical contacts for corrosion and wear;
d) cleaning and repairing cabinet condition including proper weather seal, cleanness and
mechanical damage;
e) repairing monitoring relay of series circuits for proper feedback;
f) repairing voltage switch-over, if available, of two circuits for serviceability.

Annually:

a) cabinet outer condition for dirt, moisture, easy access; cleaning and drying
b) cleaning and spraying sockets and replacing fuses (if provided) and fuse sockets;
c) voltage output for all series circuits; recording results; taking corrective action.

Control cables, monitoring units, control desk

3.3.7 Maintenance of control cables, monitoring units and control desk should include checking and, if necessary, taking the indicated corrective action, as follows:

Daily:

a) optical and acoustical signal for feedback; restoring

Weekly:

a) nominal control voltage; charging battery
b) voltage and ammeter readings; adjusting
c) acid level in batteries; adding distilled water.

Monthly:

a) functions of the monitoring unit
b) parts for cleanness and condition; cleaning and repairing or replacing.

Quarterly:

a) tightening, repairing or replacing system components for loose connections;
b) control desk for over-all operation; investigating any malfunctions; repairing or replacing parts
c) correcting or adjusting mimic panel indications for conformation to field conditions;
d) repairing mechanical structure of the desk for stability.

Semi-annually:

a) replace lamps in monitoring units.

Annually:

a) cables and distributors; cleaning and repairing
b) relays for cleanness; cleaning
c) control and monitoring units; replacing
d) connections; tightening and spraying.

Unscheduled:

a) insulation of cables after each lightning strike, i.e. insulation between wire and wire, and insulation between wire and ground; improving insulation.

Item	Asset/Task	Frequency	Work Scope
1	HV Switchboard	Bi-annually	• Check for any abnormal temperature rise and hissing sound of the switchboard and components • Check the switchboard for signs of damaged or loose fittings • Check all indication lights/bulbs, meters, and over-load protection relays and replace faulty parts where required • Check whether the switch handle, lifting trolley and spare fuses are available and in good condition
		Annually	• Check and record the operating status of all switches • Visual inspection of insulators and carry out necessary testing and replace any defective components as required. Investigate for signs of dusting or contamination on insulating surfaces and discoloration due to overheating and ensure that terminations are secure • Check and calibrate all the measuring meters • Manually operate tripping device of each protective circuit to check functionality • Perform interface and functional test. Check operation of all associated switch gears. Rectify any abnormalities found • Perform supply transfer tests in connection to LV emergency generators, LV switchboards and LV distribution panels/boards, etc. Check operation of all associated switch gears. Report the testing results and rectify any abnormalities found • Perform supply transfer tests in connection to LV emergency generators, LV switchboards and LV distribution panels/boards, etc. Check operation of all associated switch gears

2	HV/LV Transformers	Bi-annually	• Check the operator station for obvious signs of physical damage • Check all indication lights/bulbs • Check the output voltage
		Annually	• Check and record unit and winding temperature and general condition of the transformer • Check temperature sensor, remote indication and alarm (if any) for proper functioning, adjust and calibrate where necessary • Observe any abnormal hissing sound from the transformer and report • Carry out earth loop impedance tests • Carry out functional test of the associated exhaust fans by virtue of the associated temperature sensor control switch • Carry out trip function test between HV switchgear and temperature sensor control switch • Carry out insulation resistance test for transformer windings
3	LV Switchboard	Monthly	• Check for any abnormal temperature rise, vibration, hissing sound or notable smell of the switchboard and components • Check and record the supply voltage
		Bi-annually	• Check LV terminal connection bushings are not damaged, and bushings are clean • Check the tightness of the earthing system connections • Check and record the operating status of all switches • Check and record the reading of all voltage/ampere meter • Check for any burnt out/faulty components such as protection fuses, meters, relays, cards, electronic parts, etc.

3	LV Switchboard	Annually	• Check operation of automatic change-over mechanism • Visual check for any sign of overheating or oxidation at cable/busbar joints • Check and calibrate all the measuring meters • Carry out tripping device functional test • Carry out ductor test
4	DC Battery and Charger System	Monthly	• Observe any abnormal hissing sound and overheating from the charger and battery • Use battery tester to check the battery terminal voltage and internal resistance. Replace defective battery or rectify the charger as required • Check the condition of contact points for any sign of oxidation or deterioration • Check indication lights and replace as required • Check for any burnt out/faulty components such as protection fuses, meters, relays, cards, electronic parts, etc. • Check the condition of control fuses and charging current and voltage • Check the battery electrolyte level and top up with distilled water if required • Check the charging voltage and current
		Annually	• Check condition of all electrical wiring and components for damage and rectify as necessary • Check the battery electrolyte level and top up with distilled water if required • Carry out comprehensive functional test on the charger unit • Measure the terminal voltage of individual battery
5	HV Cable	Annually	• Check for any loosened cable clamp and re-tighten fixture if necessary • Conduct thermos-scan analysis to check for any overheating, deterioration, damage, or abnormality • Perform ductor test • Carry out ultrasonic measurement • Carry out insulation resistance test and dielectric test to ensure the apparatus is in good insulation condition
6	HV Bus Duct	Bi-annually	• Examine all monoblocs for signs of dirt accumulation, discharge marks, and tracking paths • Examine busbar joints and insulation for signs of deterioration and discharge marks • Perform ductor test • Perform insulation test for busbar • Carry out ultrasonic measurement
7	LV Cable	Annually	• Check for any loosened cable clamp and re-tighten fixture if necessary • Conduct thermos-scan analysis to check for any overheating, deterioration, damage, or abnormality
8	LV Bus Duct	Bi-annually	• Check for any loose cable clamp and re-tighten fixture if necessary • Conduct thermos-scan analysis to check for any overheating, deterioration, damage, or abnormality • Carry out insulation resistance test

Table 3-1: Maintenance Interval

Secondary power supplies (generators)

3.3.8 maintenance of secondary power supplies should include a monthly test run and checking and, if necessary, taking the indicated corrective action, as follows:

b) switch-over time from primary to secondary power supply for conformation to the requirement
c) voltmeter readings to ensure that the voltage remains within acceptable tolerances
d) transfer equipment for excessive heating and malfunctions
e) generator for vibrations and excessive heating
f) diesel engine for any irregularities and oil leakage
g) fuel level in the tank after the test run; refilling with fuel if necessary
h) abnormal or undesirable performance; taking corrective action and repairing
i) recording the meter readings of the test run and comparing with former records to detect potential deficiencies.

Fixed 400 Hz ground power supplies

3.3.9 Maintenance of ground power supplies should include checking and, if necessary, taking the indicated corrective action, as follows:

Daily:

a) plugs, cables and cable holdings; repairing.

Weekly:

a) proper functioning
b) tightness (oil spillage) and loose connection; repairing.

Monthly:

a) serviceability of control lamps; replacement
b) screw connectors at the contact rail for potential temperature rise; improvement of contact
c) cleanness of cables;
d) cleaning ventilator flaps and orifices for cleanness;
e) cone belts, driving the ventilator system; adjustment of belt stress.

Quarterly:

a) current-input cables for potential deformation; removal of deficiencies
b) connector boxes for:
   i) mechanical damage;
   ii) proper mounting of plug sockets;
   iii) condition of contact clips in the plug sockets.
c) bearings for lubrication.

Semi-annually:

a) cables (wires and insulation) for serviceability; repairing or replacing

b) removal of discovered deficiencies main conductor cables for temperature rise under nominal electric power;
c) plugs and cable holdings; adjusting and tightening connectors
d) switch elements for proper operation; removing of dust and dirt
e) fixings holding the regulator and switch cabinet housings; tightening of mounting screws or bolts.

Apron floodlighting

3.3.10 Maintenance of apron floodlighting should include checking and, if necessary, taking the indicated corrective action, as follows:

Daily:

a) lamp outage; replacing lamps
b) switching operation from remote control; repairing.

Annually:

a) tum and plug-in connections for cleanness and good electrical contact
b) relays for serviceability; cleaning or replacement
c) contacts for corrosion and wear; cleaning or replacement
d) relay cabinet condition including proper weather seal, moisture, cleanness, mechanical damage; cleaning, drying and repairing
e) fuses and fuse sockets; cleaning and spraying sockets and replacing fuses
f) relay cabinet outside condition including free access thereto.

CHAPTER 4

MAINTENANCE OF PAVEMENTS

4.1 SURFACE REPAIR

General

4.1.1 The surface of a runway should be maintained in a condition that precludes harmful irregularities or breaking off of pieces that would be a hazard to aircraft operation. This specification requires continuous monitoring of pavement condition, and repair when necessary. Repair of pavements is costly and often imposes restrictions on the airport traffic even when damaged areas are small. Preventive maintenance is therefore of high importance for airport pavement management.

Portland cement concrete pavements.

4.1.2 Surface damage on Portland cement concrete pavement normally sterns from design or construction failures, such as insufficient cement, too high-water content in the mixture, improper treatment during hardening, frost reaction on unsuitable aggregates or penetration of chemical dicing fluids into micro cracks or pores. Typical forms of surface damage are:
a) porous or disintegrated surface;
b) separation of thin top surface layer;
c) extreme smoothing of the surface created by polishing under traffic;
d) breaking up of pavement where cracks extend into the inner layers.

4.1.3 Surface Repair Techniques

Where the damaged layer of pavement is very thin and damage is identified as being the result of improper surface treatment during construction, surface scoring or grinding is often sufficient to correct the condition. Where the loss of thickness does not create problems and the concrete below is in good condition, no other treatment is required to restore the concrete pavement section. It should be checked that this kind of repair does not lead to unevenness or formation of puddle areas.

4.1.4 Porous Surface Treatment

Where the surface has been found to be too porous, but no other pavement quality deficiencies have been observed, pores can be filled by sealing or coating. Epoxy resin solutions have proven to be suitable. The liquid penetrates into the surface material down to a depth of 5 mm. When applying epoxy resin sealing, the formation of closed surface films must be avoided. Such a film would hamper moisture evaporation from within the concrete, causing early destruction of the repaired surface. Furthermore, the surface will become too smooth and slippery when wet.

4.1.5 Severe Surface Damage Repair

Where concrete surface material is more severely damaged with deep cracks, the damaged material has to be ground off until sound concrete material is reached. After grinding, the surface must be fully dry and free of dust before being refilled. The new surface has to be pretreated with a diluted solution of synthetic resin to create good adhesion. Where reinforcement steel is exposed, all rust has to be eliminated, and wires must be covered by a new coating of epoxy resin or equivalent. A layer of epoxy grout is put on top of the pretreated area and leveled at the required thickness. A lean mixture of grout is recommended to permit the patch material to conform to the physical characteristics of the pavement. Similar shrinkage characteristics are most important for the grout to avoid chipping off after hardening. The grout can be made of special quartz sands or ceramic material. To prevent the surface from becoming too smooth, coarse quartz sand can be strewn on the still wet grout. Joints between concrete slabs should not be filled with grout in the course of repair.

4.1.6 Quick-Hardening Cement

For urgent provisional pavement surface repair, special quick-hardening cement products are available which gain high strength within one hour or less. Experience has shown, however, that the durability of such material is rather short.

4.2 Repair of Joints and Cracks

Joints in Concrete Pavements

4.2.1 Joints are provided in concrete pavements to eliminate stress induced by length variations of the concrete material due to temperature changes. Joints must be closed with a fuel-resistant elastic material (bituminous sealant or hose-type plastic sealant) to prevent surface water from penetrating into the sub-base or subgrade and hard debris or stones from being pressed between adjacent concrete slabs. Once a joint becomes permeable, the subgrade may be washed out, and voids below the slabs may weaken the supporting capability of the base material. Where there is not a frost-resistant, well-drained subgrade under the pavement, it will suffer from frost impact. Both effects will result in the destruction of the concrete. Basically, it is the sensitivity of the subgrade to water that determines the joint maintenance requirements.

4.2.2 The first sealant of a concrete joint will remain serviceable for a period of four to six years, depending on the mechanical and thermal impact of the pavement. Later on, the sealing material will lose part of its original elasticity and, due to shrinking, it will fail to adhere to the side flanks. Mechanical forces applied to such aged sealant will start the sealant breaking off, and rotary brooms of sweeping or snow clearing machines will accelerate the process. To protect concrete pavements from severe damage, a renewal of all joint sealants is necessary when the material in the joints is observed to fail and break off.

Concrete Joint Maintenance

For concrete joint maintenance, all old sealing material has to be removed. A so-called "joint plough" may be used to carry out this task. Then the bare slab flanks should be cleaned thoroughly of soil, grease, and dust. Where edges are damaged, they should be repaired with a suitable synthetic resin grout. After inserting a new inlay to limit the depth of the sealing material, the joint may be refilled with the liquid sealing material. Attention should be paid not to fill the joint up to the top. A surplus of sealing material in the joint will swell above the top when the pavement expands under thermal stress. This may lead to surface contamination later on. The selected material must be fuel-resistant, particularly in pavement sections where fuel spillage may occur occasionally.

4.2.3 When joints are to be closed by plastic material, such as hollow Neoprene profiles, the same method for joint cleaning and preparation is applicable. To improve the sealing capacity of plastic material, the concrete flanks should be covered with an adhesive before placing the sealing profile into the joint. At joint intersections and ends, the plastic material must be welded together to prevent water from entering at the insert and acting as a hose distributing water to the entire joint system.

Joints in Bituminous Pavements

4.2.4 Recent experience indicates that it is useful to provide for joints in bituminous pavements. For airport asphalt construction, hard types of bituminous material are required. Reaction to temperature changes in such pavements is quite comparable with that in concrete. Unpredictable crack formation is very likely to occur in bituminous pavements due to thermal stress. Stress reliever joints not wider than 8 mm and not deeper than two-thirds of the thickness of the wearing course may be cut into the pavement to control the crack formation. When the pavement shrinks at low temperatures, cracks will only appear under the joints, and these can be sealed to prevent water penetration.

4.2.5 Joints in bituminous pavements should be filled with a hot bituminous sealing material without any synthetic components. The chemical relationship between the pavement and the sealing material, and the almost identical thermoplastic reaction of both, provides a reliable closure of the joint.

4.2.6 Where joints in bituminous pavements are damaged, they normally can be repaired by filling with a hot sealing material if the opening is not wider than about 3 cm. The same type of repair should be carried out where the sealing material is observed to have sunk into the joint.

Cracks in Concrete Pavements

4.2.7 Reasons for cracks in concrete slabs can be:

a) Incorrect forming of expansion joints which has resulted in a transfer of force between concrete slabs;

b) Delayed cutting of hinged joints (dummy joints) in the construction phase so that shrinkage due to hardening was able to generate random strain cracks;
c) Improper treatment during the initial hardening phase, as, for instance, due to strong sun radiation on fresh concrete;
d) Incorrect compacting of sub-base and therefore uneven settlement of subgrade so that slabs are not supported equally;
e) Insufficient dimensioning of concrete slabs in view of the load applied on them.

4.2.8 "Wild" cracks in concrete always go through the full depth of the slab. On the surface, the crack will appear in the form of a hair crack or a break, the latter giving the separated parts the freedom to move one against the other. Repair of cracks in concrete can never restore its capability of load transfer. The purpose is only to avoid water penetration from the surface into the subgrade.

4.2.9 Cracks in concrete slabs should be repaired by transforming the breaks into expansion joints. The crack has to be widened by cutting a slot along its length about 1.5 cm wide and 1 cm deep. The widened crack must be filled with a fuel-resistant thermoplastic sealing material.

4.2.10 When the subgrade is particularly affected by water, and optimum water tightness is required, a channel about 20 cm wide and 2 cm deep should first be cut along the track of the crack and then the crack widened to a slot as described in the preceding paragraph. The cleaned slot is filled with a flexible dummy insert. Then, after appropriate cleaning and priming, the channel is filled with an epoxy resin grout. When the resin has hardened, the insert is removed from the widened crack and the resulting void filled with a fuel-resistant thermoplastic sealing material.

4.2.11 Hair crack repair can be accomplished by sealing the crack zones with epoxy resin solvents. Since the solvent will not penetrate very deeply into the crack, damaged slabs should be inspected regularly and sealing repeated when necessary. A hair crack slab has not lost much of its bearing capacity and thus does not represent a severe deficiency to the operational serviceability of the pavement.

Cracks in Bituminous Pavements

4.2.12 Cracks in bituminous pavements result from thermal stress building up in vast pavement areas when there are no expansion joints. Other reasons can be an insufficient adhesion of construction joints between adjacent lanes or deficiencies of subgrade bearing strength at isolated points due to construction mistakes. Repair of such cracks is essential to avoid penetration of water or de-icing agent into the sub-base or subgrade. It is, however, not possible to stick the cracked parts firmly together and to retain the original stability of the pavement.

4.2.13 Cracks in bituminous pavements can be filled with a sealing emulsion without prior grinding. Special emulsions of high fluidity are available that will penetrate deeper into the crack than hot bituminous sealings. The filling can be carried out manually by using cans or mechanically by using special pouring equipment. With a first run, the crack's interior flanks will be covered; with a second run, the crack can be filled up. The procedure should be repeated yearly or at longer intervals, depending on local climatic conditions.

4.3 Repair of Pavement Edge Damage

General

4.3.1 Broken edges occur most frequently at pavement joints. The reason for this type of damage is the undesirable transfer of force across the joint, mostly produced by incorrect joint design or stones pressed into the joint. The pavement material above the point of contact is split off due to the induced compressive stress. Another reason can be the application of extreme point loads near to a slab joint or slab edge, as is sometimes caused by snow removal equipment. Corners are particularly sensitive to overload when, for some reasons, the slabs are insufficiently supported by the sub-base.

4.3.2 Broken edges produce loose parts of various sizes which create a substantial risk to aircraft. Furthermore, surface irregularities on pavement are undesirable for aircraft and ground vehicles. Therefore, broken edges should be repaired as soon as possible. At least, imminent danger to aircraft should be minimized by removing all loose material from the pavement surface and closing provisionally deeper openings in the pavement surface.

Edge Repair

4.3.3 Part of the maintenance should be to carry out careful investigation of the damaged section to find out the reason for the failure. When making the repair, the treated area should be made big enough to cover all damage. The boundary should be cut to a depth of at least 2 cm, and all inside pavement material removed down to such a depth that all loose material is eliminated. Cutting can be done manually or by means of an electric hammer. When the damage is at a joint, the joint sealant must be removed to a length and depth of 5 cm beyond the cut-out section. The joint's flanks have to be cleaned, and dust and debris removed from the opening, preferably by compressed air. After preparing the cut surface with a primer and after putting a form into the emptied joint, the opening can be refilled with a suitable synthetic resin mixture. It is most important that in the course of filling the cut area, no bridge is built up between the two neighboring slabs, since sooner or later it would become the source of a new break in the repaired edge. Compacting should be done layer by layer, and when smoothing the surface, a chamfer should be provided at the edge. After hardening, the form in the joint can be removed, flanks in the joint cleaned, and the joint filled with a hot sealing material.

4.3.4 A filler material that meets the requirements of the climatic impact on the airport's pavement should be chosen. It is essential to add sufficient aggregate (quartz, glass pearls, or other ceramic) to achieve a lean mixture with a small shrinkage ratio. Filler material which obtains its nominal strength no sooner than 24 hours after mixing has proven to be more suitable than quick-hardening material.

4.3.5 For provisional repair, some special cold asphalt materials have been developed which gain sufficient strength by compacting or hammering. Such material can be used for quick repair of both concrete and bituminous pavement. The costs are comparatively high, and duration is limited, particularly on concrete pavement.

Corner Repair

4.3.6 Broken corner repair will be carried out in the same way as described for edge repair. Attention should be paid to the slab's need to expand in two directions. Furthermore, the surface of the repaired slab must be level with both neighboring slab surfaces.

4.4 Repair of Other Pavement Surface Deficiencies

4.4.1 High-quality requirements have been specified for runway pavement surfaces. The surface texture shall provide good friction characteristics, and the runway surface shall be constructed without irregularities that could adversely affect the landing or take-off of an airplane. Where the friction characteristics of the runway surface have been found to be below the level specified, remedial action will have to be taken. Repair measures may range from cleaning the surface of contaminants to major repair. According to experience, the following three techniques are in use:

a) Surface dressing;
b) Grooving of surface;
c) Scoring of surfaces.

4.4.2 With lime, a surface may become uneven without generating cracks. Where the unevenness occurs in spots and is moderate, scoring or milling the surface can help to restore the required surface quality. Where the deficiencies are found to be more severe, corrective action, such as the construction of an overlay, may become necessary. Such work is generally not considered a matter of maintenance but rather a matter of airport design practice.

4.5 Sweeping

Purpose of Sweeping

4.5.1 For safety reasons, the surfaces of runways, taxiways, and aprons have to be clean of sand, debris, stones, or other loose objects. Reference is made to KCASR 14 Vol. I. Aircraft engines can easily ingest loose material and suffer severe compressor blade or propeller damage. There is also the risk that propeller or jet engine blast may cause loose objects to be "shot" like bullets against adjacent aircraft, vehicles, buildings, or people. Also, the tread on tires of taxiing aircraft or any other moving vehicle may throw up objects and cause damage. Maintenance of movement areas requires constant monitoring and regular sweeping of surfaces.

Surface Monitoring

4.5.2 Runway and taxiway contamination. Objects to be found on runways and taxiways stem from the following sources:

a) Debris from damaged pavement;
b) Debris from joint sealings;
c) Rubber debris from aircraft tires;
d) Stones from grass mowing;
e) Metal or plastic parts from aircraft;
f) Sand and soil from heavy storms or engine blast of aircraft;
g) Dead birds or other small animals hit by aircraft.

4.5.3 Visual checks on runways and taxiways. Visual checks should be carried out regularly and at least every six hours during operating periods. Immediate checking is necessary upon advice of pilots on the existence of objects or debris. Special attention should be paid to the cleanliness of runways and taxiways when construction work on or near operational surfaces is going on. When construction machines or trucks use surfaces also used by aircraft, more frequent checking than normal is recommended.

Cleaning of Surfaces

4.5.4 Frequency of sweeping. Surfaces intended to be used by aircraft and ground vehicles have to be swept regularly. The interval between sweepings depends on local needs and experience. Certain areas, such as aircraft stands or freight handling zones at busy airports, may require sweeping at least once a day.

4.5.5 Sweeping Equipment

To accomplish the task of regularly sweeping all paved portions of the movement area, the use of truck-type cleaning equipment is practicable. The efficiency of the sweeper required depends on the size and traffic volume of the airport.

4.5.6 Integral Sweeper-Blowers

Integral sweeper-blowers, as used for snow removal, have the highest efficiency. They are useful for sweeping runways, taxiways, and wide-open areas such as the outer portions of aprons, but because of their greater turn radii and the tendency to blow up dust clouds, they are not suitable for aircraft-populated apron areas close to buildings.

4.5.7 Truck-Type Street Sweepers

Truck-type street sweepers are the right equipment for sweeping populated apron areas, service roads, access roads, walkways, parking lots, and even hangar or shed floors. They are available in many different sizes and work like vacuum cleaners, suppressing dust generation. To enable them to pick up heavy iron metal parts, a magnetic beam can be mounted close to the sucking orifice or to a trailer pulled by the sweeper truck.

4.5.8 Personnel Discipline

Even with regular sweeping, the airport authority cannot fully guarantee the absence of contamination in the areas where work is continually being carried out.

Regular training courses for the apron personnel on accident risks and the benefit of discipline are useful to minimize careless attitudes on the movement areas. Sweeping can only keep foreign object damage low when the whole staff takes notice of the problem and keeps the movement area as clean as possible.

4.5.9 Apron Contamination

Aprons are more likely to become contaminated than other aircraft movement areas at the airport due to the greater number of users of this area, traffic concentration, and the loading process going on there. Objects found on aprons include stones, bottles, cans, stoppers, bottle caps, lost hand tools, personal belongings, nails, screws, bolts, paper, rubber, wire, plastic material, wooden, textile, synthetic, and metal parts of all sizes from boxes, cases, pallets, containers, and other packing devices. Contamination is worst in freight handling areas and, of course, near construction areas. Another kind of contamination to the pavement surface is by hydraulic oils, fuel, and lubricants. Special cleaning measures to be taken are described in Section 4.6.

4.5.10 Visual Checks on Aprons

Through training programs and regular reminders, personnel working on the apron can be taught to watch and visually check the condition of the apron and report on cleaning needs. The apron management service or the unit/service responsible for traffic on the apron should take immediate action to clear the apron of any dangerous contamination or debris observed or reported. Furthermore, inspection tours or walks should be carried out—when traffic activities justify—several times a day to ensure that the need to remove objects or any contamination on the apron is recognized in time.

4.6 Cleaning of Contaminants

Purpose of Cleaning Pavements

4.6.1 Paved surfaces on airports can be contaminated by fuel, lubricants, hydraulic oils, marking paint, or rubber. Contaminants may cause slipperiness and cover surface markings. Oil and rubber deposits on runways adversely affect the braking action of aircraft, particularly when pavements are wet. A clean runway surface, therefore, is a safety requirement.

Removal of Rubber Deposits

4.6.2 Aircraft wheels contact the runway surface at high speed on touchdown, resulting in a build-up of rubber deposits. Due to the friction-induced high temperature in the wheel contact area, the rubber melts and is smeared into the surface texture. The rubber film is sticky and, with the passage of time, increases in depth. Layers of up to 3 mm thick may build up within 12 months in the touchdown zone of a busy runway. The aim of rubber removal is to restore the

original macro roughness of the pavement surface. Such restoration is important to provide good drainage under the wheel in wet conditions.

Rubber Deposit Removal Frequency	
Number of Daily Minimum Turbojet Aircraft Landings per Runway End	**Suggested Rubber Deposit Removal Frequency**
Less than 15	2 Years
16 to 30	1 Year
31 to 90	6 Months
91 to 150	4 Months
151 to 210	3 Months
Greater than 210	2 Months

Table 4-1: Maintenance Interval

4.6.3 Three methods are described below for removing rubber:

a) Chemically;
b) By mechanical grinding;
c) By high-pressure water blast.

d)

The three methods are all effective; however, they differ in terms of speed, cost, and erosion of surface material.

4.6.4 Rubber should be removed from runways when friction measurements under wet conditions indicate significant loss of braking quality in critical runway sections.

4.6.5 Chemical Method

The area of pavement to be treated is sprayed with a liquid chemical from a tank vehicle having a spray bar, or by hand with a hose and nozzle. The chemical's reaction time ranges from 8 to 15 minutes, depending on the depth of the rubber film. During this time, the rubber (and paint) swell up and can be flushed away with high-pressure water jets. Sweeper trucks or other equipment must clean the water-flooded area, sucking up the loose rubber from the surface. Special equipment has been developed combining flushing and sucking in one vehicle. The chemicals dissolve not only rubber but also paint markings and bituminous material. When applied to asphalt pavements, sufficient water flushing is important to protect the pavement. The treatment must not be interrupted before treated patches have been flushed thoroughly with water.

4.6.6 Mechanical Grinding Method

There are various methods of grinding pavement surfaces. As runway maintenance should preserve the integrity of the original surface, a milling method has proven to be satisfactory.

Milling rollers composed of metal discs on a rotating shaft are passed over the surface. The distance between the shaft and the pavement is controlled so that the discs just hit the pavement, but without much pressure. With three rollers fixed to the vehicle's chassis, a strip of about 1.8 m can be cleaned in one run. Working speed goes up to 400 m^2 per hour if rubber deposits are not too thick. The milling not only removes the rubber layer but, depending on the height control of the roller shaft, also roughens the pavement surface. While this can effectively improve the surface texture, the milled depth should be kept as small as possible. All mechanical methods must be applied very carefully to avoid severely damaging inset lights and joints between slabs. Sweepers must follow the milling vehicle to clean the strip of dust and rubber debris.

4.6.7 High-Pressure Water Blast Method

Rubber removal is accomplished by high-pressure water jets directed at oblique angles to the pavement surface. The equipment normally consists of a tank vehicle with motors pumping water at high pressure, e.g., 40 MPa, through a nozzle bar guided closely above the pavement surface. Water consumption is high, about 1000 L per minute. The angle of attack of the water jets can be varied, e.g., by rotation of the nozzle bar. Working speed will range from 250 m^2 to 800 m^2 per hour. Cleaning has to be done by sweepers following the removal truck at some distance. Where a water supply is not a problem, the high-pressure water blast method is most efficient. As opposed to the chemical method, there are no special measures required for environmental protection.

4.6.8 Fuel and Oil Removal

Contamination by fuels, lubricants, and oils can be found in many apron areas, such as aircraft stands and areas used regularly by loading vehicles. Contaminants can be removed by spraying grease solvents followed by water flushing. If necessary, water jet cleaning may follow to achieve optimum results. Where fuel or oils are spilled accidentally, the spillage must immediately be covered by oil-absorbing material, as developed by the oil industry. This material is a powder or granulate which, when scattered on the spillage, absorbs the liquid and can be easily removed later by sweeping. However, it does not absorb oils already soaked into the pavement material. Repeated oil soaking of concrete and/or bituminous asphalt may deteriorate the surface material and require surface repair instead of cleaning. Since surface drainage from apron and workshop areas normally runs into the sewage system, national rules on environmental protection have to be borne in mind when cleaning pavements by means of chemicals.

CHAPTER 5

DRAINAGE

5.1 General-Drainage of the Airport Area

5.2.1 Drainage of the airport area is necessary:

a) To maintain sufficient bearing strength of the soil for the operation of vehicles and/or aircraft at any time during the year.
b) To minimize the attraction of birds and other animals representing a potential hazard to aircraft.

5.2.2 Surface drainage is required to clear all parts of the movement area of standing water and prevent the formation of ponds or puddles. The quick run-off of water is particularly important on runways to minimize the hazard of aquaplaning.

Layout

5.2.3 For practical reasons, an airport should have two drainage systems: one system which drains "clean" areas such as runways, taxiways, aprons, service roads, public roads, and parking lots, and another system which drains areas more likely to be polluted by oil, grease, or chemicals such as hangars, aircraft maintenance areas, workshops, and tank farms.

5.2.4 The drainage system intended to serve the "clean" area may be built in a way to sink the drain water (from precipitation) into the adjacent ground. Where the natural ground is not suitable to drain the surface water, it must be collected in slot drains or other artificial sinks which are connected with a drain pipe, culvert, or canal ducting the water to nearby creeks, rivers, lakes, etc. To protect these natural water courses from pollution, collector basins with oil separators should be installed.

5.2.5 The drainage system intended to serve hangars, workshops, tank farms, and other pollutant-generating areas should be connected to a regular sewage system which ducts the water to sewage treatment plants. For pretreatment, the collected drain water should pass through fuel separators before entering the sewage culvert.

5.2.6 Generally, the airport operator will have to comply with rules on water treatment issued by the national or local authorities responsible for water conservation, water supply, and environmental protection. The layout of airport drainage systems depends on local conditions, and so does the maintenance program.

5.2 Cleaning of Slot Drains

5.2.1 To facilitate the cleaning of slot drains, openings should be provided at 60 m intervals along the whole line. They must give good access to the bottom of the slot drain and serve as sand traps at the same time. Cleaning of a slot drain can be carried out most effectively by flushing all sections with water at high pressure, forced into the duct at 18 MPa or more. Where necessary, mud and sand deposits must be vacuumed off by special mobile cleaning equipment.

5.2.2 The time intervals for cleaning depend on local experience with drain lines. One cleaning action per year has proved to be the minimum. When sand has been used for winter services, a second cleaning right at the end of the winter is recommended. Regular inspections should be carried out to detect the need for additional cleaning. After sandstorms or heavy rain showers which flood unpaved areas near the slot drain, immediate checking of the drain capacity is highly recommended.

5.3 Drain Pipes or Culverts Between Surfaces and Collector Basins

5.3.1 Drain pipes should have manholes at intervals to allow cleaning the pipe of deposits. Sections between consecutive manholes should not exceed 75 m, and manholes should have a cross-section of at least 1 m^2. The cleaning can be accomplished by means of flushing with water at high pressure.

5.3.2 Time intervals for cleaning depend on local experience. Cleaning once a year seems to be the operational minimum to ensure good drainage capacity of pipes and culverts collecting surface water from precipitation. Where the cross-section of the pipes is less than 30 cm, cleaning twice a year may be necessary.

5.4 Oil and Fuel Separators

5.4.1 Oil separators are integral parts of water collectors. The number and size of collectors depend on the drained area and quantity of precipitation. The capacity of a separator shall be such that the flow speed will at any time be slow enough to prevent oil passing by the separator wall into the collector basin. The oil layer depth at the surface of the separator must be checked weekly, and oil pumped off when necessary.

5.4.2 The bottom and the banks of the drain water collector basins should be kept clear of plants. Embankments should be mowed regularly. Once a year, the bottom should be cleaned.

5.4.3 Fuel separators are components of the drainage system of hangars, workshops, and other technical working areas which must be provided with separator installations. Their capacity will be determined by the expected maximum drain water throughput. The amount of trapped oil and/or fuel should be checked in accordance with a maintenance plan for the facility, describing the time intervals of pumping off oils. The intervals must be derived from local experience and can vary widely.

To avoid accidental overflow of the fuel collector, automatic monitoring can be provided. Oil and fuel separated from the drain water must be pumped or carried to a demulsification plant.

5.4.4 For removal of oil and fuel from separators, the employment of specialists (under contract) can be practical since special tank vehicles are required, and the deposits have to be removed in accordance with environmental rules on the treatment of waste oil.

5.5 Water Hydrants

5.5.1 The capacity of the airport's water supply system should comply with the requirements of firefighting. All valves and flaps in the pipeline network should undergo functional testing once a year. Additional monitoring by checking the water consumption weekly can be useful to detect undiscovered leakages at an early date.

5.5.2 All fire hydrants, including those at buildings, must be checked regularly (see 8.12.1). Any subsurface hydrants should be kept clean of soil or mud so that they can be found without delay in cases of emergency.

CHAPTER 6

MAINTENANCE OF UNPAVED AREAS

6.1 GENERAL

6.1.1 The maintenance of unpaved areas on an airport is essential for the following major reasons:
a) Safety of aircraft on operating areas (this concerns runways, taxiways, strips, and runway end safety areas);
b) Safety of airborne aircraft (this concerns areas on the airport and in its nearby vicinity within the defined flight pattern where trees and bushes may grow); and
c) Reducing bird hazards to aircraft (this concerns grassland within the airport's boundaries).

6.1.2 The maintenance of unpaved areas need not necessarily be carried out by the staff of the airport operator. The airport operator may contract with nearby farmers who will take care of the task upon advice. The farmers can use the grass for cattle feed and can provide their own equipment. Work performed by contractors must be monitored by authorized personnel to safeguard air traffic safety requirements.

6.2 Maintenance of Areas within Strips

6.2.1 Requirements as to the quality of surface grading and bearing capacity of strips and shoulders are specified in KCASR 14 Vol. I.

6.2.2 After construction work in strip areas, attention should be paid to retain the specified surface conditions. Where the bearing capacity has been reduced, it must be improved by soil compaction. Humps and depressions should be eliminated. To protect the surface against blast erosion, a sound matting of grass should be provided. On normal soil, this condition can be achieved by seeding with grass. Poor soils will need fertilizing. Sometimes this can be accomplished by adding arable soil or humus from composted hay.

6.2.3 The use of urea for winter service on runways and taxiways will often kill the grass along the edges of treated pavement areas. If it is not possible to avoid this damage by reducing urea consumption, seeding must be repeated regularly after the winter period. In many cases, soil replacement will become necessary. A biologically acceptable sealing material may have to be used for fixing the loose soil containing the fresh seed until the grown grass is capable of protecting the soil against blast erosion. Where poor drainage along the edges of pavement increases erosion effects, hard surface shoulders may have to be built to overcome the problem.

6.2.4 Grass in the strips should not exceed 10 cm in height. Regular mowing will be necessary to keep the grass low, with the frequency depending on the climate.

The cut material should be picked up since otherwise it might be sucked into jet engines, thus creating a potential hazard to aircraft operation. Where applicable, growth retardant can be used to control growth rate. Its application, however, is often limited by national or municipal rules for groundwater protection, since some growth retardant chemicals can detrimentally affect the quality of drinking water. As these chemicals may also be expensive, it is useful to consider their cost-effectiveness in comparison to more frequent mowing.

6.2.5 Mowing attracts birds as the freshly mowed areas are rich in bird food. To minimize the ever-present risk of bird strikes, mowing should take place preferably before periods of lowest air traffic. In other cases, bird protection measures may have to be increased after mowing to keep the collision risk low.

6.3 Maintenance of Grass on Unpaved Runways and Taxiways

6.3.1 Grass height should be kept as low as practicable on unpaved runways and taxiways, as rolling drag increases markedly with grass height. Take-off distances can increase by some 20 percent when grass on runways is too high. For treatment, refer to Sections 6.2.4 and 6.2.5.

6.4 Equipment for Maintenance of Grass

6.4.1 As there are different types of mowers available, the choice should be determined by local conditions, i.e., the size of the area to be maintained and the types of grass and plants on it. The following types are being used on airports:

a) Spindle mowers
b) Cutter bar mowers
c) Rotary mowers
d) Flail mowers

6.4.2 Normally, spindle mowers are trailing equipment. They are efficient on areas of low grass height, such as unpaved runways, taxiways, etc. With the mowers arranged in groups (so-called mounted gangs), strips up to 8 m wide can be mowed in one run. Under favorable conditions, the capacity can be 7 hectares per hour. Separate loaders are required to pick up the cut grass.

6.4.3 Cutter bar mowers are appropriate for both high and low grass. The cutter bar is generally a separate piece of equipment attachable to various tractor types, often in combination with a trailed self-picking hay loader.

The cutting width is less than 2 m, thus resulting in a low mowing capacity of about 0.5 hectares per hour. A special type of bar mower, the so-called chaff-cutters, cut strips up to 4 m wide and, in combination with hay loaders, achieve a mowing capacity of almost 2 hectares per hour.

6.4.4 Rotary mowers are specialized for extremely high grass. They are produced in trailer form and mow a strip up to 5 m wide, thus achieving a mowing capacity of 4 hectares per hour.

6.4.5 Flail mowers are most effective for meadows with harder types of grass and plants, including low bushes. They are attachable to various types of towing equipment, have a maximum mowing width of 5 m, and achieve a capacity of some 2 hectares per hour.

6.4.6 Capital and operating costs of the different types of mowing equipment vary widely, with trailed equipment being cheaper. Operating costs for automotive equipment, including automatic hay loading equipment, will be three to four times higher. However costly the equipment and procedures are, the reduced bird strike hazard at the airport is a benefit.

6.5 Treatment of Cut Grass

6.5.1 Since grass should be removed immediately after mowing as a protection against birds and for other safety reasons, considerable quantities of cut grass will be collected on larger airports. If grass cannot be given away to nearby farmers or ranchers, two options exist:

a) Composting at a suitable site and recycling as fertilizer for the airport, or for sale to gardeners or farmers. Cut grass needs approximately three months for composting before it is usable;
b) Disposal in a dump. The dump should be far away from the airport since cut grass will, without proper treatment, decay, producing a wet and very polluting waste.

CHAPTER 7

MAINTENANCE OF EQUIPMENT AND VEHICLES

7.1 General

7.1.1 By preventive maintenance, facilities on an airport can be kept in such a condition as to maintain safety, regularity, and expeditious operation of air traffic. This specification covers the following equipment and vehicles:

a) Rescue and fire fighting vehicles;
b) Devices for snow and ice removal;
c) Devices for applying sand and de-icing agents;
d) Pavement surface friction measuring devices;
e) Sweepers for removal of contaminants from aircraft operating areas; and
f) Mowers and other vehicles for control of grass height on unpaved areas.

7.1.2 There also may be many other vehicles in operation for aircraft ground handling (fuel, water, electric energy, high- and low-pressure air), passenger handling, freight handling, and transport. All these vehicles require preventive maintenance work in accordance with the manufacturer's advice. Operators of the vehicles have to make appropriate arrangements for keeping their equipment serviceable at any time as part of the airport maintenance task.

7.2 Organization of Vehicle Maintenance

7.3.1 Airport vehicle maintenance can be organized according to three different principles:

a) Maintenance is carried out by the airport in its own workshops;
b) Maintenance is carried out by contractors in workshops located on the airport; or
c) Maintenance is carried out by contractors outside the airport.

7.3.2 The main reasons for providing workshops at the airport are:

a) The difficulty of moving specialized and very big vehicles, which are not licensed for use on public roads, outside the airport area; and
b) The time and manpower needed to move vehicles from the airport to remote workshops and vice versa.

7.3.3 Reasons for providing airport-owned workshops are:

a) Personnel can be supervised by the airport management and their schedule or work adjusted to fit the airport's needs;
b) Personnel can be trained to specialize in maintenance tasks for all airport equipment and will gain much experience;
c) Personnel can be organized in such a way as to carry out stand-by tasks outside the normal duty hours;

d) Personnel can carry out maintenance tasks on installed equipment; and
e) Other duties like snow removal, aircraft removal, assistance in emergencies, etc., can be assigned to workshop personnel upon short notice.

7.3.4 Reasons for contracting with maintenance companies outside the airport are:

a) Availability of expert knowledge, plants, and tools for standard equipment overhaul and repair (e.g., motors, gear boxes, generators, drive axles of standard automotive design);
b) Lack of own personnel or specialists for economic reasons (e.g., number of vehicles too low to warrant workshop installations and manning); and
c) Need to overcome peak or bottleneck situations.

7.3 Schedule of Vehicle Maintenance

7.3.1 The basis for vehicle maintenance is a schedule of the services required and the intervals between servicing. The schedule can be developed by the maintenance workshop or by the vehicle operating branch. For maintenance of standard vehicles, the manufacturer's advice should be considered. In the absence of such recommendations, the schedule should be based on experience with maintenance needs.

7.3.2 Inspection schedules for self-driven vehicles can be related to the kilometers driven or operating hours recorded. For other equipment, fixed time intervals are practical. Special procedures are applied for winter equipment, which should undergo inspection and overhaul twice a year, i.e., once before the winter season and then again shortly after it.

7.3.3 Fixed time intervals offer the advantage of a well-balanced workshop utilization. Equipment with a low number of operating hours per year should be inspected regularly. Maintenance to protect from true wear, however, cannot be met by the fixed interval method, since the individual use of equipment is not considered.

7.3.4 Where the hours driven are the basis of the schedule, the user must maintain a record of the hours operated. The equipment user should take care to rotate the use of equipment and check the operating hours record. An easy way of controlling the operating hours can be achieved by marking the limit of the vehicle on a label attached to the driver's panel or screen. Monitoring can also be carried out by fueling personnel.

7.3.5 The user (or proprietor) of the vehicles will define the maintenance intervals in accordance with experience, manufacturer's recommendation, and workshop capacity. No standards can be given. Numbers given in Table 7-1 result from airport experience and may serve as guidance.

7.3.6 The maintenance program is individual for each type of vehicle or equipment and depends on its function, wear and tear characteristics, and manufacturer's recommendation. Inspection must be carried out by specialists.

7.3.7 In the interest of safety, operating personnel must be advised to check the functioning of all essential components, e.g., brakes, control, tires, lights every day before using any vehicle or piece of equipment. Whenever deficiencies or failures are discovered, the unserviceable equipment should be taken out of service and repair should be carried out as soon as practicable.

7.3.8 An important element of the maintenance of airport vehicles is the servicing of installed radio telecommunication equipment, since, by the very nature of traffic control on an airport, the radiotelephone has to be serviceable at any time.

S/N	Equipment	Maintenance Intervals	km driven	Operating hours
1	Firefighting and rescue vehicles, ambulances	3,000 to 5,000	100 to 200	
2	Winter service vehicles (snow ploughs, snow blowers, sweeper-blowers, spread and spray vehicles)		100 to 200 (twice a year)	
3	Standard cars, station wagons, and buses	Up to 5,000		
4	Special passenger buses		100 to 200 (at least twice a year)	
5	Standard trucks, tractors (aircraft tractors)		100 to 200	
6	Self-driven aircraft handling equipment (lifters, power trucks, water trucks, etc.)	electric	100 to 200	
7	Other aircraft handling equipment (dollies, stairs, etc.)		Once or twice a year	

Table 7-1: Maintenance Interval

7.4 Workshops

7.4.1 Workshops on airports should be concentrated, if possible, to form a workshop center. The capacity and equipment to be provided depend on the workload, which is a function of the size of the airport's equipment fleet. The availability of the following workshops is most useful:

a) Automotive engine with test bed;
b) Chassis (garage) with paint section;
c) Automotive electric workshop;
d) Mounting platform and car hoist;
e) Brake test bed;
f) Hydraulics;
g) Tinsmith;
h) Washing.

7.4.2 7.4.2 Workshops should be manned by specialists. At intervals, the personnel should be sent to equipment manufacturers for training.

CHAPTER 8

BUILDINGS

8.1 General

8.1.1 Many airports are sites for various industrial activities generated by aviation or related business. The built-up area of an airport therefore can be covered by a great number of buildings, only part of which house the primary aviation functions. Typical buildings to be found on airports are:

a) Passenger buildings;
b) Freight handling sheds and cargo stores;
c) Air traffic control buildings;
d) Aircraft hangars;
e) Fire stations;
f) Workshops and aircraft/engine maintenance plants;
g) Vehicle and equipment sheds;
h) Fuel farms and fuel tanks;
i) Depots and silos;
j) Aircraft catering buildings;
k) Administration and office blocks;
l) Hotel/restaurant buildings;
m) Convention centers; and
n) Parking garages.

8.1.2 All these buildings require maintenance; however, little of this work is airport-specific. In the context of airport maintenance practices dealt with in this guidance material, normal building and technical facilities maintenance is not described. Descriptions will be limited to elements, the proper function of which is a prerequisite to efficient passenger or baggage handling, or passenger safety.

8.1.3 The building on an airport that directly affects passenger and baggage handling is the passenger or terminal building. Its purpose is the interchange between ground and air transportation, and transfers between flights. While the safety requirement is the same as for any other public facility, the outstanding requirement is for a speedy flow of passengers and baggage through the facility.

8.1.4 In order to meet this efficiency requirement, the following components of the terminal building should not suffer from operational deficiencies during the operating hours:

a) Lighting system for the passenger terminal buildings and associated landside forecourt and car parking area;
b) Passenger flight information system;
c) Air conditioning system;
d) Heating system;
e) Mechanical (automatic) doors;
f) Baggage conveyor belts;

g) Baggage delivery equipment in claim areas;
h) Fixed passenger loading devices (nose loaders or loading bridges);
i) Lifts (elevators);
j) Escalators;
k) People movers;
l) Fixed fire protection installations; and
m) Emergency exits.

8.1.5 A great deal of the maintenance work described in the following section is particularly appropriate to contract work. Maintenance contracts on servicing and overhaul of such facilities as automatic doors, conveyor belt systems, passenger loading bridges, lifts, escalators, and moving walkways have proven to be useful and economical.

8.2 Lighting and Electric Equipment

8.2.1 The complete lighting system of the passenger building and forecourt has to be checked daily. Visual monitoring should cover all lamps, illuminated signs, and information boards. Any deficiencies that would adversely affect passenger orientation or handling should be corrected quickly. Other reported deficiencies should be noted for repair within the schedule of the maintenance plan.

Daily:

a) Visual inspection of all lamps for proper operation.

Weekly:

a) Replacement of fluorescent tubes and their ignition starters in accordance with the replacement schedule that the terminal operator has laid down in the maintenance plan.

Monthly:

a) Repairs which have been found necessary by inspections according to the maintenance plan for electric installations;
b) Checking of accumulator (battery capacities);
c) Replacement of light bulbs according to plan.

Quarterly:

a) Checking of lighting control units;
b) Adjustment of dimmers.

Semi-annually:

a) Checking of supply lines and cables, switches, and distributors;
b) Cleaning of plugs, contacts, and terminals in the electric wiring.

Annually (or less frequently):

a) Cleaning of lamps;

b) Checking of insulation capacity by overload voltage.

8.2.2 Lighting system for roads and parking lots. Basically, the maintenance program is the same as for apron lighting systems, described in Section 3.3.10. A functional check during daylight, however, is not required, since the serviceability of the total system is maintained in spite of single lamp failures. The unserviceable lights can be identified more easily during regular night inspections. Other possible failures will be noticed by the operator of control desks, particularly where the lighting system is connected to a control center equipped with appropriate electric monitoring meters.

8.3 Communication Facilities

8.3.1 Means of communication in passenger terminals can be flight information boards, television monitors, loudspeakers, and electric clocks. Normally such installations are self-monitoring, i.e., deficiencies are identified electronically and indicated at the technical control center. Maintenance should include checking of:

Daily:

a) Control unit for flight information board;
b) Readability of television monitors;
c) Electric clocks' control unit;
d) Electric circuit of the loudspeaker system.

Whenever possible, adjustments should be carried out immediately.

Semi-annually:

a) Servicing of all components of flight information boards and television monitors;
b) Electric clock system;
c) Amplifiers for the loudspeaker system.

Annually:

a) Cleaning of information boards, e.g., all drives and flaps of electro-mechanical systems, screens, or lights used for giving information visually to passengers.

8.4 Air Conditioning System

8.4.1 The operational condition of the system has to be monitored constantly from the control centre so that any failures can be detected early and corrective action taken in time. Maintenance should include checking the following:

Daily:

Inspection of all machinery and air ducts concerning temperature, pressure, and leakage including:

a) Moisture controls;
b) Energy consumption of electric motors;
c) Freezers;

d) Cooling water flow meters;
e) Timer control.

Findings should be recorded and, in case of deficiencies, remedial action taken.

Weekly:

a) Activated carbon filters; changing when necessary;
b) Other air filters; changing when necessary;
c) Energy consumption of freezers (refrigerators), air supplies, fans, electric motors, flaps, valves, regulators, and pumps;
d) Insulation for damage;
e) Cone belts.

Monthly:

a) Servicing of all air ducts, fans, electric motors, flaps, valves, regulators, and pumps;
b) Cleaning of all dirt traps in the pipe network;
c) Energy consumption record;
d) Air ducts.

Semi-annually:

a) Servicing of refrigerators and switching units;
b) Cleaning of heat exchangers and fans;
c) Output data and adjustment of performance of all components to desired standards;
d) Servicing of hot air curtains including air filters;
e) Cleaning of fire protection gates and other closing devices in the system.

Annually:

a) Chemical and mechanical cleaning of condensers and evaporators;
b) Servicing of fire protection gates.

Unscheduled:

a) Activated carbon has to be replaced at intervals of between two and three years according to experience with the air conditioning system in use.

8.5 Heating Facilities

8.5.1 Maintenance of heating facilities should include checking of:

Daily:

a) Temperatures, pump and regulator performance;
b) Water heaters, pumps, and valves for leakage;
c) Serviceability of safety installations.

Weekly:

a) Servicing of packings at pumps and valves;
b) Limiter gauges at heating ovens;
c) Switching units;
d) Monitoring of the indicators for energy consumption and data comparison with expected theoretical quantities.

Monthly:

a) Cleanliness in burner chambers and cleaning if necessary;
b) Regulators by comparison of true with theoretical performance data;
c) Repair or replacement of deficient pumps, if necessary, according to the record of daily checks;
d) Lubrication of taps and valves;
e) Inspection of stand-by boilers for potential corrosion.

Semi-annually:

The following tasks must be carried out before or after the heating period, i.e., when burners are turned off:

a) Checking of heating elements (radiators) and their valves;
b) Repair of faulty valves and packings;
c) Removal of air from pipes and heating elements;
d) Decalcifying (declaiming) of heater coils in boilers;
e) Repair of heater coils in water boilers;
f) Cleaning of dirt traps and non-return flaps.

Unscheduled:

a) Indicators and consumption meters should be checked and calibrated at intervals of two or more years to ensure reliable and precise system monitoring during the heating period.

8.6 Automatic Doors

8.6.1 Automatic doors may be operated electrically, hydraulically, or pneumatically. Any observed deficiencies of such doors should be reason for immediate repair or

closure of the unserviceable entrance/exit to avoid damage to the door and, even more importantly, to avoid the risk of injuries to people.
Unserviceable automatic doors should be marked by warning signs that at the same time give guidance to people on where to walk. Maintenance should include:

Weekly:

a) Checking of control mechanism at all automatic doors;
b) Adjustment of the level of sensitivity if necessary;
c) At pressured air operated doors: checking of compressed air tanks and pipes for tightness.

Annually:

a) Full overhaul including cleaning of the door drives and at compressed air operated doors also the overhaul of compressors;
b) Checking on wear at activator rods, chains, and guide rails of the driving mechanism;
c) Replacement of worn parts;
d) Checking of serviceability and if necessary adjustment of all safety installations.

8.7 Baggage Conveyor Belts (Fixed Installations)

8.7.1 Baggage conveyor belts are normally installed between baggage check-in areas and sorting or baggage make-up areas as well as between unloading stations for incoming bags and luggage reclaim areas. To ensure uninterrupted operation, the condition of all belts has to be monitored continuously. Short cracks at the edges can be eliminated by cutting off the damaged edge material. Maintenance should include:

Weekly:

a) Visual checking of belts for damage such as cuts and cracks;
b) Checking on smooth movement and low noise; whenever necessary, replacement of noisy or squeaking rollers;
c) Adjustment of loose spring rollers;
d) Adjustment of belt movement and stress.

Monthly:

a) Cleaning of joints and dirt trapping boxes;
b) Removing of paper and other waste from underneath the belt by vacuuming.

Annually:

a) Checking and overhaul of drives;
b) Cleaning of driving motors, oil change or refilling of gear boxes;

c) Cleaning and lubrication of driving chains.

8.8 Baggage Claim Units

8.8.1 Weekly maintenance should include checking for:
a) Damage and cracks;
b) Smooth movement and low noise, and, when necessary, replacement of noisy rollers.

8.9 Passenger Boarding Bridges

8.9.1 Passenger boarding bridges (fixed and apron drive) are exposed to weather impact. Major maintenance work should follow immediately after rain or winter seasons to counteract corrosion. Bridge gear and lift device maintenance should include:

a) Weekly check of tires for surface damage and wear and replacing if necessary;
b) Inspection of wheel brakes;
c) Inspection of electric driving motor and cleaning of drive chains;
d) Inspection of lifting jacks for wear;
e) Checking of lubrication of lifting jacks;
f) Inspection of hydraulic system.

Intervals of regular maintenance work depend on experience and/or manufacturer's advice.

Bridge body maintenance should include:

Weekly:

(a)Checking of all bridge movements, i.e., extension, retraction, lowering, raising, and steering.

Semi-yearly:

a) Checking of bearings and their lubrication;
b) Replacement of worn or corrosive rollers;
c) Checking of drive chains and adjustment of chain stress;
d) Checking of floor covers for damage and fixing or replacement of loose parts;
e) Warm water cleaning of outer skin of bridge tunnel;
f) Renewal of paint, if necessary.

8.10 People Lifts (Elevators)

8.10.1 In general, lifts will be monitored by the safety authorities of CARC or municipality. Maintenance responsibility of the building owner or operator is limited to observation of the lift's function and to cleaning. All other maintenance work, i.e., regular inspection, replacement of parts, and repair, remains with the

manufacturer. A complete overhaul of ropes, drives, and other moving elements has to be carried out at least once a year. National safety regulations for lift manufacturers, however, should be consulted for the extent of maintenance and intervals between inspections.

8.11 People Movers (Escalators, etc.)

8.11.1 In general, people movers will be monitored by the safety authorities of CARC or municipality. Maintenance responsibility of the building owner or operator is limited to observation of the people movers' or escalators' proper function and to cleaning. All other maintenance works, i.e., regular inspection, replacement of parts, and repair, remains mostly with the manufacturer. The operator can check movement and wear of guide rails, rollers, steps or lamellae, handrails, and refill lubrication pots. Complete overhaul of moving elements has to be carried out (by the manufacturer) at specified intervals. National safety regulations for manufacturers of such facilities should be consulted for the extent of maintenance and intervals between inspections.

8.11.2 No general guidance can be given on the maintenance of train-type people movers since they are complex systems that have to be operated in compliance with locally approved rules or technical requirements. The operator must, however, make provision for the daily checking of the emergency escape capability from the cabins.

8.12 Fixed Fire Protection Installations

8.12.1 Maintenance of fixed fire protection installations should include checking of:

Weekly:

a) Fire extinguishers within the whole building for integrity;
b) Emergency exits for access clearance and removal of obstacles.

Quarterly:

a) Serviceability of all components of the fire warning and fire alarm system in the building.

Semi-annually:

a) Serviceability of fire doors designed to close automatically in case of fire or smoke;
b) Serviceability of all fire extinguishers in the building.

Annually:

a) Functioning of smoke doors and flaps;

b) Serviceability of emergency exit locks;
c) Serviceability of pumps and fire hydrants;
d) Hose condition.

Note: National rules for the provision and maintenance of fire protection installations have to be observed carefully.